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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INFORMATION MANAGEMENT SYSTEM

A SUMMARY DISCUSSION

By R. Stuart Sayers

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Space Station Project Office
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THE INFORMATION MANAGEMENT SYSTEM

INTRODUCTION

The space shuttle sortie, the modular space station, the tracking data relay satellite (TDRS), and the ground support for these programs require a data management system for acquisition, transfer, storage, processing, control, and display of data. (See fig. 1.) The most economical and operationally efficient manner available to provide these functions is to integrate the information management functions into an information management system of the type discussed in this presentation. The following are the specific aspects of the space vehicle elements, the ground support, and the communications links covered between the spacecraft and the ground that are included within the information management system:

1. Space vehicle communications and data relay
2. Data acquisition
3. Control and display
4. Data processing assembly
5. Software
6. Manned Space Flight Network (MSFN) and TDRS's
7. Ground data management
8. Mission scheduling
9. Mission management
10. Logistics
11. Subsystem status and performance monitoring

The vehicle portions of the information management system are the data management subsystem or information subsystem. For clarity, the onboard space vehicle data handling electronics will be referred to as the information subsystem.

CURRENT ACTIVIT MODULAR SPACE STATION PHASE B

The modular space station Phase B study has defined in detail the onboard information management requirements and a preliminary design of the selected information subsystem. The information management requirements have been developed fc a six-man space station operating in low earth orbit (approximately a 260-nautical-mile altitude). The crew is to perform selected experiments in agriculture, oceanography, hydrology, atmosphere investigations, and related disciplines. Previous manned space flight activities have helped to define known requirements and to estimate as yet undefined requirements for the operation and support of an experimental modular space station. During the 1980 time frame, the space station is to be assembled in earth orbit and will use the space shuttle for the initial delivery of modules and subsequent logistic support. A high degree of onboard autonomy to support inflight operations (including onboard subsystem checkout) is incorporated to reduce substantially the number of ground and flight support personnel required for real-time monitoring of onboard subsystems and experiments. The current space station activities in information management system studies are shown in figure 2.

The modular space station Phase B study includes a special task for advanced development of an onboard information subsystem including the external communications terminal. The purpose of this advanced task is to design and provide the NASA Manned Spacecraft Center (MSC) with a functioning breadboard of the modular space station information subsystem.

Key elements of the development include:

1. Data acquisition and control subsystem

2. Digital data bus breadboard

3. Data bus control unit (DBCU)

4. Remote acquisition and control units

5. Communications terminal breadboard

6. Software standards

An experimental data ground processing study is planned for the purpose of developing an approach to predict ground experiment data handling and distribution requirements that result from shuttle sortie and modular space station orbital operation. The base-line configuration for each orbital element used in the development of the proposed information management system concept is shown in figure 3. The orbiter stage is basically the 360-day-review shuttle operating in a sortie mode. The crew complement is four men, with two crewmen primarily responsible for orbital payload operation. The network model was provided by the Office of Tracking Data Acquisition (OTDA) to provide support for low earth orbiting manned and unmanned satellites in the late 1970's. The OTDA network model consists of two TDRS's plus one on-orbit spare TDRS, one TDRS ground station in the United States at some unspecified location, and five MSFN ground stations. The network model will provide communications links between the orbital elements (operating at 28.5° to 90° inclinations) and the ground, 85 percent of each day. The TDRS design is based on (1) use of K-band frequencies to improve transmission efficiency and (2) near saturation of the S-band frequencies. The vhf link to the TDRS serves only as a command link to activate the K-band channel and is not used for communications direct to ground. The S-band communications are used among the modular space station, the shuttle, and the ground MSFN sites that are required for deep space and launch communications. The S-band channel is also used as a direct communications backup for the TDRS and for space station buildup before delivery of the command module that contains the K-band terminal and antenna.

PROGRAM REQUIREMENTS

Evolution

In definition of the information management system concept, data handling methods used at present in the Apollo Program and planned for use for the Skylab Program were considered. The results of the operational and experiment data handling requirements from the study of a 33-foot-diameter, 12-man space station (fig. 4) operating in earth orbit for 10 years have also been analyzed. The Skylab approach is based on using modified Apollo equipment, which provides for more flexibility in data formatting and transmission to the Mission Control Center through the MSFN.

To define the 33-foot-diameter space station data requirements (fig. 4), the approach to an information subsystem was based on a complete onboard information subsystem at launch, using S-band direct communications links with the MSFN and no data relay satellite. The requirements for data handling were based on the capability to accommodate a large experiment program over a 10-year operational period. The 33-foot-diameter space station was to be logistically supported by a shuttle vehicle that would return approximately 60 percent of experiment data such as digital tapes, specimens, and film.

Increasing emphasis on the Space Shuttle Program brought about two significant impacts on the information management system concept. The first impact involved the modular approach of an orbital space station buildup, and the second involved the development of the shuttle sortie payload. In addition, the experiment program was reviewed to select those experiments that would have an early return. Some of the more scientifically oriented experiments were scheduled for later time periods, decreasing the total amount of experiment data to be handled initially.

Use of the shuttle for module delivery to the space station orbital assembly necessitates a modular approach to the onboard information subsystem. The subsystem must meet operational command and control requirements at each stage of orbital assembly and must also accommodate experiment changes as the program advances. Support requirements for the experiments include experiment operational considerations, pointing and stability requirements, electrical power, size, weight, and experiment duration. Another payload constraint for the shuttle sortie is a standard shuttle interface for data handling. Experiment and application payloads should be designed to accommodate a common set of interface requirements. This requirement avoids unnecessary impact on the shuttle side of the payload interface, which — unless considered — places unrealistic payload constraints on the shuttle subsystems. The capability of the base-line shuttle includes operation with the TDRS orbital communications system, which enables the shuttle to meet large payload experiment data handling requirements.

Operational Requirements

The operational information management system requirements of the shuttle operating in a sortie mode are as follows:

1. Mission management

2. Onboard information subsystem

3. Experiment data management

For the sortie mode, mission management will be performed on the ground because of the relatively short mission durations and the individual sortie payloads. The onboard information subsystem of the individual payload modules operating in a sortie mode must interface with the standard shuttle payload interface. The sortie module information subsystem is dependent upon the shuttle subsystems and the crew for command and control data, data routing to the ground, data storage, pointing, and related functions. Experiment data management is somewhat simplified for the sortie mode because each payload accommodates limited, definable experiments, and the mission is limited to 30 days (the shuttle capability considered).

The modular space station operational requirements are considerably more complex than the requirements of the shuttle sortie mode of operation. Ground support is required during the buildup and early development phases to ensure satisfactory space station subsystem performance. However, real-time ground support for flight control, status monitoring, consumable status, flight planning, onboard checkout, minor maintenance, fault isolation, and similar operations is not economical for a 10-year space station operational life. The following are the modular space station information subsystem requirements (fig. 5):

1. Experiment and subsystem data processing

2. Command control and subsystem monitoring

3. External communications

4. Internal communications

5. Software programing

The space station experiment data management differs significantly from the sortie mode in that the modular space station contains many scientific experiments, and careful experiment scheduling is required, on the basis of priority, opportunity, crew availability, experiment status, station status, and consumables.

Experiment Requirements

The scientific disciplines for experiments and applications were evaluated to provide a balanced experiment program, which emphasized early performance of experiments that have the most application to problems on earth. The selected experiments were divided into two groups: those that could be accommodated by a six-man modular space station in an internal (attached) mode, and those that could be accommodated in a precursor shuttle sortie mode (fig. 6).

The experiments selected for the six-man space station were grouped further into three categories: (1) high scientific benefits, (2) high socioeconomic benefits, and (3) a balanced program of scientific and socioeconomic benefits. The three experiment groupings were compared as to data handling, electrical power, logistic support, vehicle stability, contamination levels, and crew man-hour requirements. The results of the comparison indicate that the modular space station designs and subsystems are not influenced greatly by experiment grouping.

OPERATIONAL ANALYSIS

Subsystems

The information management concept — based on the modular space station operational requirements for flight and experiments, the requirements for a modular orbital assembly, the configuration flexibility during the operational life of the station, and technology — incorporates the use of a digital data bus to serve as the command and response link between the central control and the remote subsystems and experiments (fig. 7). A single coaxial cable is used as the digital data bus to connect the central data processing assembly with the remote acquisition and control units, which serve as interface units between the subsystems and experiments and the digital data bus. By using the data bus concept, new experiments can be added and subsystems can be located at various remote modules within the space station, and no modification to the information subsystem is required. Additional control consoles may be located at remote experiments and, by using the central data processing assembly, may operate the experiments or perform maintenance and tests on subsystems. Thus, large cable bundles are eliminated, which would otherwise be required to connect all subsystem and experiment control and monitoring sensors to the central control console and the data processing assembly. Elimination of long lengths of large cable bundles throughout the station also reduces the requirement for test, verification, damage protection, and electromagnetic interference protection of cable bundles in flight.

The digital data bus concept provides for bidirectional data transmission between the remote acquisition and control units and the central control. Redundant digital data buses are planned for safety and maintenance, but only a primary digital bus is shown in figure 7. The data bus requirements can also be met by the use of two unidirectional digital data buses, where one bus provides control signals to the subsystem and the second digital data bus provides subsystem sensor feedback to the central control. Again, redundancy can be provided by incorporating two sets of unidirectional data buses.

Command and Control

The subsystem and experiment interface with the digital data bus (fig. 8) is made through the remote acquisition and control unit. The unit is standard, and several of these units may be used for a single subsystem. For certain applications, a preprocessor may be used at the remote acquisition and control unit level to perform noncritical local processing and to reduce the total data flow between the subsystem and the central data processing assembly. The forward electronics of the remote acquisition and control unit on the digital data bus side is basically a modem. The modem accepts digital data addressed to the subsystem that the modem serves, performs some shaping of the received data waveforms which may have degraded during transmission through the data bus, and identifies the particular subsystem data for transmission to the central computer assembly. The remote acquisition portion of the remote acquisition and control unit interfaces directly with the subsystem sensors and receives subsystem signal outputs. The control function is performed by the remote acquisition and control unit for command and control inputs to the individual subsystems and experiments.

Figure 9 shows an example of a preprocessor used at the subsystem level. In the example, the inertial assembly output is approximately 12 000 bps. The preprocessor performs certain computations such as coordinate transformations. The resultant computed data outputs to the central processor are approximately 1000 bps. Other preprocessor applications reduce the subsystem input data required from the central processor.

The 10-year on-orbit life expectancy of the modular space station necessitates a capability for onboard checkout (fig. 10). This requirement is fulfilled by (1) using the central data processing assembly to perform diagnostic tests of subsystem status with minimum crew procedural involvement and (2) grouping and sizing of replacement parts such that all components which may fail or wear out during flight are modularly replaceable as inflight replaceable units. Tradeoff analyses compared costs of (1) ground maintenance of individual station modules by returning them on the shuttle and (2) onboard maintenance by using the onboard checkout concept and inflight replaceable unit concept. These analyses indicated that the onboard maintenance approach was much more efficient and economical.

The onboard checkout concept for inflight maintenance is essentially the same technique as is planned for ground integration testing of the modular space station and for prelaunch checkout. For the ground tests, a unified test approach (fig. 11) that uses a ground digital data bus is planned to connect directly to the vehicle data bus. Thus, the digital data bus will provide access to all onboard subsystems for test and verification at the manufacturing facility and the launch site. The test equipment includes a test station that is computer operated and contains the necessary diagnostic and test programing and test oriented display and control language. Use of common or unified test equipment at all test locations provides program economy in test equipment costs. With an onboard digital data bus that provides access to all onboard subsystems, ground test setup time involved primarily with special carry-on cabling and other equipment is eliminated. The necessary ground support equipment (GSE) is controlled by the test station through the ground digital data bus. The GSE provides necessary electrical power, hydraulic pressure, and air flow for vehicle ground testing. The approach of a unified test equipment interface with an onboard data bus for subsystem access for test and verification is particularly applicable to the shuttle 2-week-turnaround requirement, because the test setup time takes approximately 40 percent of the total ground test time. Figure 12 shows a comparison between current ground test support capabilities and the ground data bus concept.

Figure 13 shows the capabilities of the information subsystem data processing assembly with regard to computer operations per second, operating memory, mass memory, data bus rate, consoles, station communications, and experiment operational analyses. The total capability in communications does not necessarily represent the sum of individual requirements because a few of the required capabilities serve both station operations and experiment activities, although not simultaneously.

Experiment Analysis

An experiment model summary and an experiment analysis summary of the goals of the different experiment disciplines are presented in figures 14 and 15, respectively. The experiment interface with the onboard information subsystem is the same as the subsystem interface with the information subsystem. A second control center is included; this control center provides a backup flight control capability for emergencies and for maintenance or modification of the primary control center in flight. This second control center is normally used for experiment control and data handling.

A special feature of the data bus concept shown in figure 15 was defined for one high-priority experiment in earth surveys. The multispectral scanner output can exceed the digital data bus transmission capability which, with exception of this one experiment, can accommodate all station operations and all other experiments at a data rate of 3 megabits/sec. To avoid sizing the complete space station information subsystem for one single experiment, the control of the multispectral scanner was retained through the digital data bus. However, the initial multispectral scanner output, which is analog, is routed either to the data recorder or to the communications terminal as required, using the analog data bus. The analog data bus is sized to accommodate as many as six closed-circuit color television channels for experiments and has a capability of 39 megahertz. The multispectral scanner output is approximately 3.5 megahertz and creates no impact on the analog data bus sizing.

For the sortie mode, the payload must interface with the shuttle orbiter in a standard manner to avoid shuttle configuration change requirements for each different payload. Figure 15 shows a unit which serves as an interface unit between the shuttle information subsystem and the payload electronics. This unit accepts standard shuttle digital and analog command and control signals for relay to the payload module. The unit also receives payload data outputs for conversion to standard shuttle input requirements for signal level, type, and format. The interface unit can be located either within the shuttle or within the payload. An interface unit of this type will be required independently of the shuttle information subsystem concept selected.

Within the shuttle payload module itself, standard remote acquisition and control units can be used to interface the different experiments to the payload side of the digital data bus in the same manner that experiments interface with the modular space station digital data bus. Payload experiment data may then be transmitted to the ground through the shuttle radio frequency links for evaluation. The shuttle radio frequency capability to transmit data dictates the amount of data storage required within each payload module.

Network Analysis

The TDRS system is considered an integral part of the overall information management system planned for the late 1970's. During the initial buildup phase of the modular space station, communications between the ground and the unmanned station modules are provided by S-band channels, using the MSFN (fig. 16). The capability to use the TDRS as a communications link for the space station is made available by installing the third station module (containing the central control facility and the K-band communications terminal and antenna).

The types of data to be transmitted between the modular space station and the ground are shown in figures 17 and 18. The K-band and S-band bandwidths are also indicated for the space station.

SOFTWARE ANALYSIS

Applications

In addition to an onboard central processing requirement for the space station to accommodate flight and experiment operations with a reasonable degree of autonomy, the requirement also exists to provide the necessary computer programing (fig. 19). Similar programing requirements exist for the ground computers for mission management and for inflight mission management. The depth of programing requirements for specific functions may vary between flight and ground. For example, inflight logistic requirements for consumables and replacement items may be forecast on board only until the next scheduled shuttle resupply flight, but the ground must forecast logistic requirements much further in advance to provide the logistics at the launch site. The type of software programing is similar in both instances, but the ground software programing must consider more variables and a longer time period.

Computer programing for subsystem inflight monitoring and for ground prelaunch monitoring, test, and verification is similar because the level of monitoring and test in flight and before launch is similar. The computer program used for prelaunch subsystem testing can serve the inflight test and verification requirements with little or no change of computer instructions, because both prelaunch and inflight tests are performed through the information subsystem digital data bus. Some software programing requirements, such as simulation programs for crew training or special ground tests, may be unique to ground operations. However, even then, a degree of commonality can be maintained with other ground and flight programs.

Languages

Previous space programs have used many computer programing languages for ground, flight, and simulation computer programs. Much of the inflight programing has been performed by using assembly or machine level language. This programing language is most basic. By comparison with mathematics, for example, this language limits computer programing to addition and subtraction; the use of multiplication or division in problem solving is not permitted.

By using addition and subtraction capabilities in various logical orders or compilation methods, groups of higher level computer instructions — such as multiplication, division, search routines, matrix solutions, logic statements, and functional do loops — are created. The resultant computer language is of a higher level than the basic machine language. The logic instructions used to convert the higher level language to machine language reside in the computer compiler. FORTRAN, for example, was created specifically for mathematical problem solving.

The U.S. Air Force has specified that all programing is to be done in JOVIAL, COBOL, or SPL (fig. 20). JOVIAL serves as the mathematical and scientific programing language, COBOL is an accounting-oriented language, and SPL is being designed as the space programing language.

Space programing creates certain requirements for programing, particularly in the area of solutions to large matrices. Currently, NASA is developing a higher level computer language, known as HAL, that is specifically tailored to manned space flight and computer applications. Concurrent with HAL development, NASA is developing a user-oriented computer language that does not require operator knowledge of computer programing for ground test and inflight use. A user language for ground test, checkout, and inflight operations is currently being developed, and working computer demonstrations are available for review in several laboratories at MSC.

Standards

Development of software standards is necessary to reduce the interface problems of using various computer programs. The onboard requirements for the modular space station have been grouped into five categories (fig. 21). Within each category, types of requirements are listed for computer programs. The programing requirements are organized to provide visibility of the total onboard space station vehicle programing requirements. Other requirements (language word length, verification requirements, and related constraints) are common to all individual programs for the flight vehicle and the ground computers.

Data Base

The data base for the modular space station must satisfy two primary types of requirements: the software requirements and the hardware design requirements. Data base development for a particular program should begin with the hardware design. This beginning ensures the capability of the subsystem design (1) to accept the required computer command and control inputs and (2) to provide the necessary data output to operate over a long duration in an automated mode with minimum manned intervention for test and checkout. Early knowledge of the software programing requirements makes possible more efficiency in preparing correct, properly formatted data required by the computer programs for vehicle test, checkout, flight, and documentation.

PRELIMINARY DESIGN SELECTION

A block diagram of the preliminary design selected for the modular space station is shown in figure 22. The launch sequence of the individual modules is indicated by the number in the upper left corner of each block; the core module is launched first and contains a small buildup command and control unit which serves as the flight controller until the third module (SM1), which contains a complete central data processing assembly and control console, is attached. The modular space station is manned to a six-man level when seven modules have been assembled. At this level, the modular space station has the necessary environmental control and flight control redundancy for safe occupancy.

ADVANCED DEVELOPMENT BREADBOARD

A block diagram of the advanced development breadboard is shown in figure 23. Delivery to MSC of all components of the space station information subsystem breadboard is scheduled for June 30, 1972. Individual contractor responsibility for portions of the breadboard is indicated. Current plans include initial tests to be conducted with a Government-furnished preprocessor until the 4 pi EP flight-configuration computers are available. The 4 pi EP computers are scheduled to support shuttle development until mid-1973. Nonhardware delivery items included in the advanced development task are listed, with the responsible contractor, at the bottom of figure 23.

The communications terminal breadboard functional block diagram is shown in figure 24. Key features of the design include external antenna-mounted K-band electronics with passive thermal control and use of the S-band frequency for internal vehicle-mounted electronics. This approach permits the use of existing lunar module S-band electronics in fabricating the communications terminal breadboard.

A summary of MSC data bus development is shown in figure 25. The performance of each data bus and the use of each particular data bus are listed. All the data buses (except the last two) are currently being used at MSC.

FUTURE ANALYSIS NEEDS

Additional development is required to bring the level of technology to a compatible level of development with most information subsystem components. The following areas require future emphasis:

1. Subsystem signal conditioning standards at the remote acquisition and control unit interface

2. Software standards

3. K-band antenna

4. Shuttle payload interface design requirements

SUMMARY

Commonality

Because of the flexibility of the information subsystem concept described in this presentation, many areas of commonality exist for space station and shuttle sortie development. Figure 26 lists those areas within the onboard space vehicle information subsystem that can share common development. The concept should be relatively unchanged by program time phasing if the goal is to develop an integrated electronics system for space application.

Mission Management

The information management system concept includes an approach to mission management that differs significantly from other space programs. (See fig. 27.) To support an orbital space station for 10 years with onboard autonomy and to support a Space Shuttle Program with many flights, widely varying payloads, simultaneous missions, and large amounts of operational and scientific data, automation of the ground flight operation functions and the data handling requirements is necessary. Communications access requirements for multiple orbital operations strongly support the TDRS as part of the overall information management system.

Advantages

The major advantages of the data bus concept of the information management system are shown in figure 28. Central control of modular space station subsystems located in different modules is provided, and local control is retained for subsystem maintenance and repair. Remote control of the space station by the ground is also a design fallout. The data bus concept requires standard remote acquisition and control units. These units provide a standard interface for the design of subsystems and experiments. The standard approach to higher level languages and the required supervisory programs provide other areas of commonality between programs. The capability to add new subsystems or experiments to the data bus with only software modifications provides design and configuration flexibility.

Onboard autonomy is provided by automating many control and monitoring functions which now require manned attention; thus, the crew is free for inflight experiment operations. Automation of the space vehicle subsystem and flight control functions also relieves the ground real-time control and monitoring requirement and will permit more concentration in the area of mission planning by fewer personnel.

The advantages of nearly continuous real-time communications between the ground and orbital elements provided by the TDRS are most important in the real-time transmission of critical experiment or subsystem data. The data acquisition capability provided by the station or shuttle sortie operating continuously can be compromised, if the flow is checked at any point before routing to the data user.

Ground and onboard test, checkout, and turnaround provide the flight autonomy and rapid ground testing with minimum test setup time. All these advantages address manning requirements for design, development, test, and long-duration operation of multifaceted space programs. The information management system concept is directed toward permitting NASA to conduct space operations in the most economical and efficient manner that can reasonably be supported by available technology.

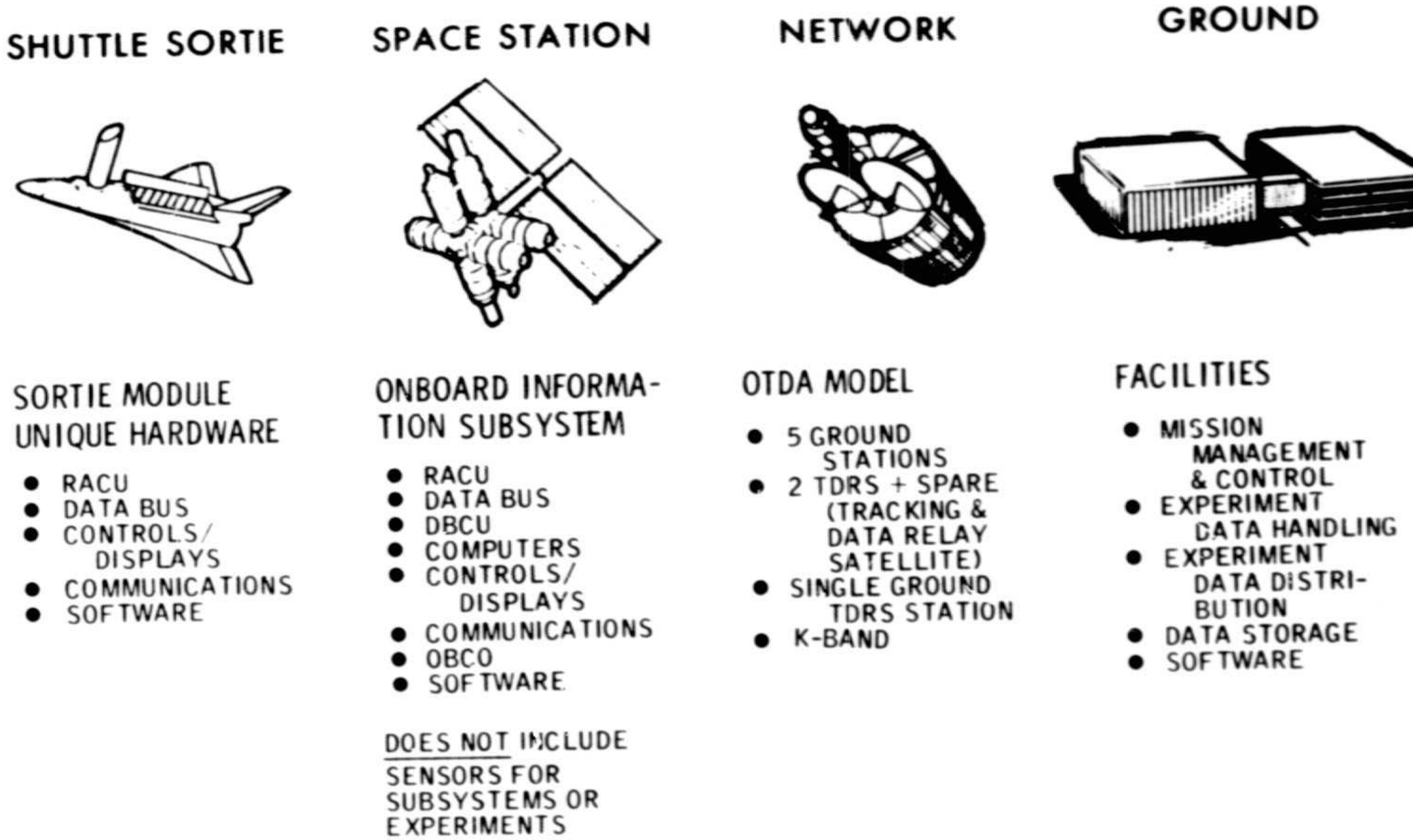


Figure 1.- Scope of the information management system.

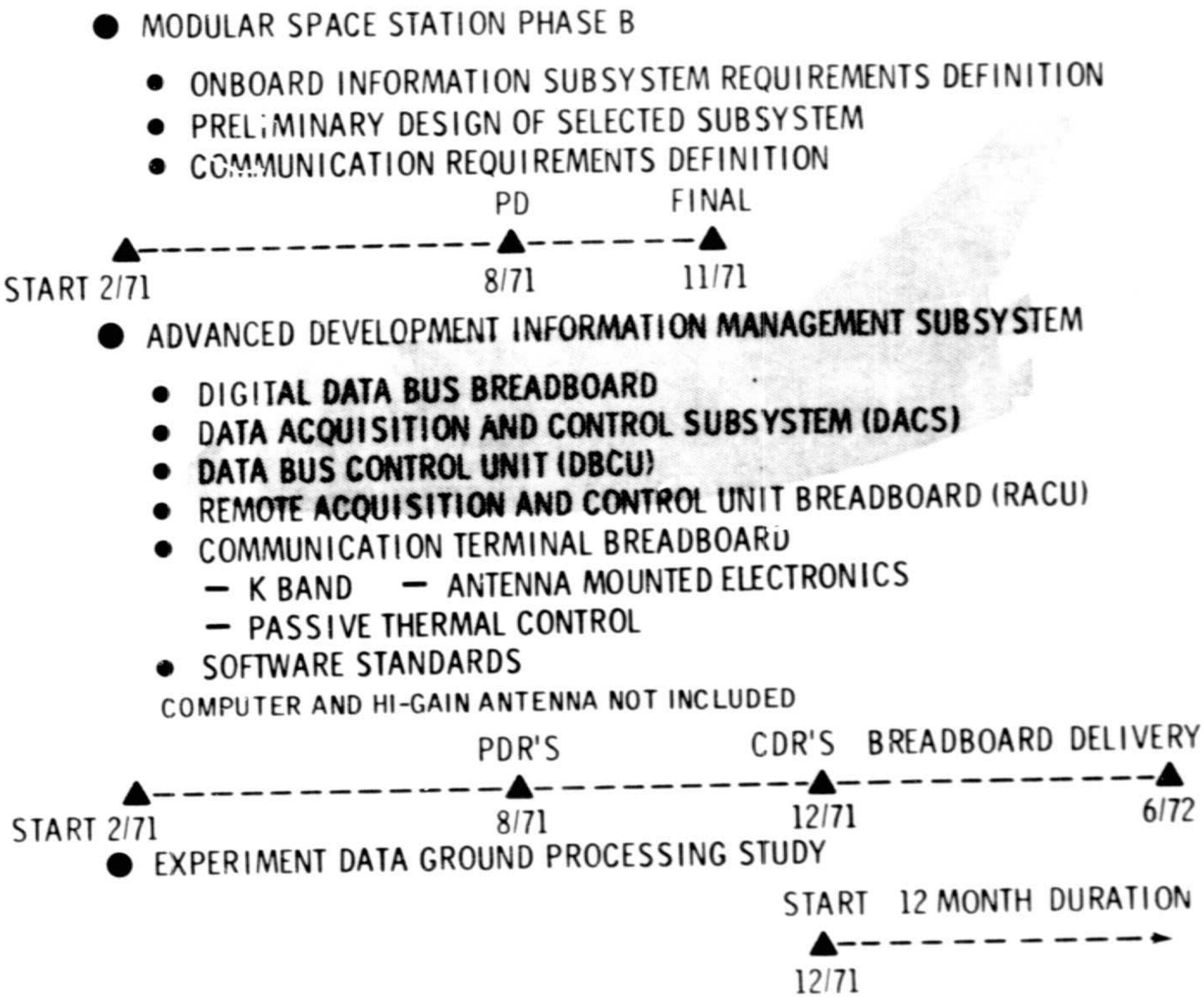


Figure 2.- Information management system activities at MSC.

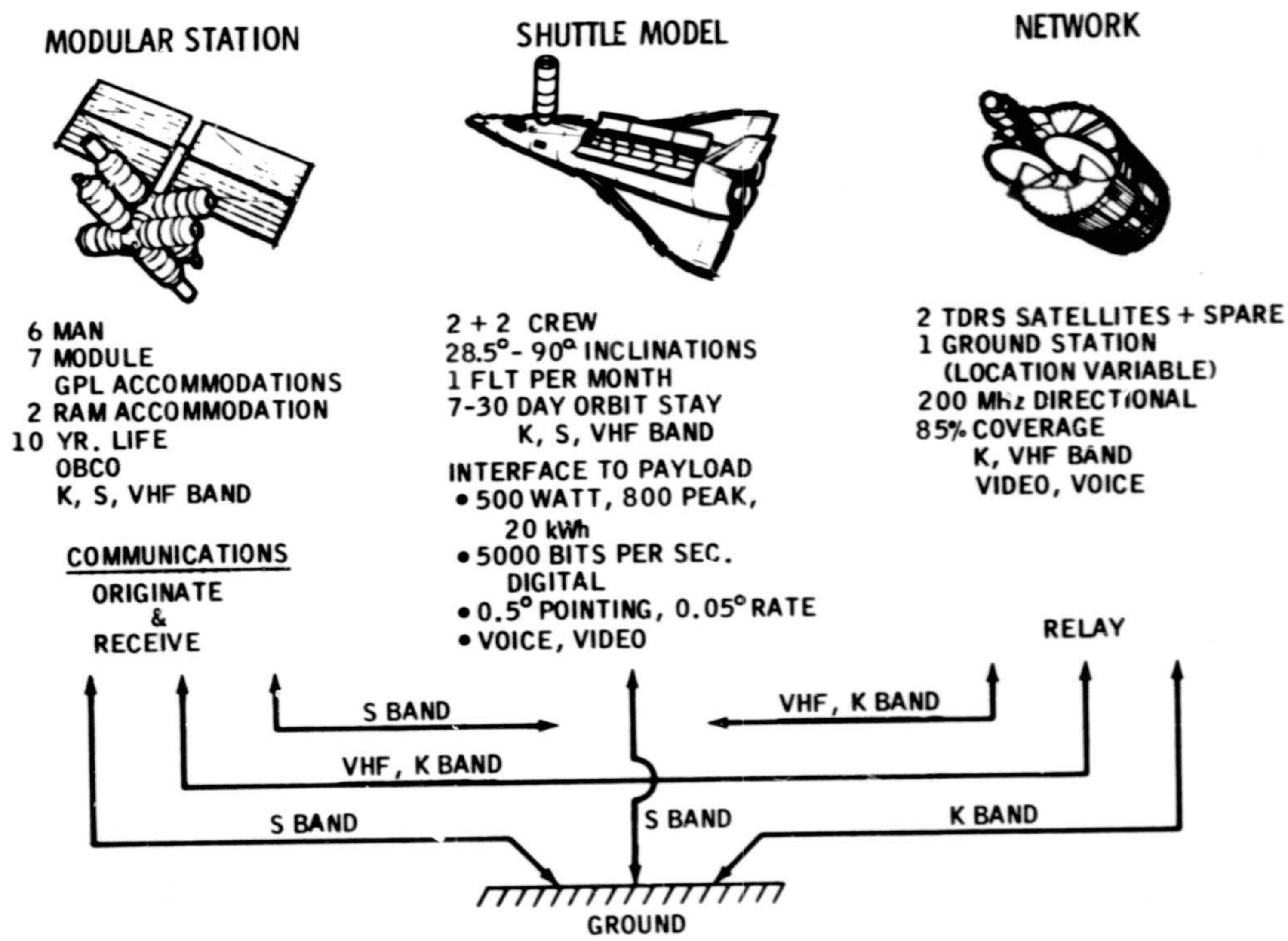


Figure 3.- Base line configurations of the MSC modular space station study.

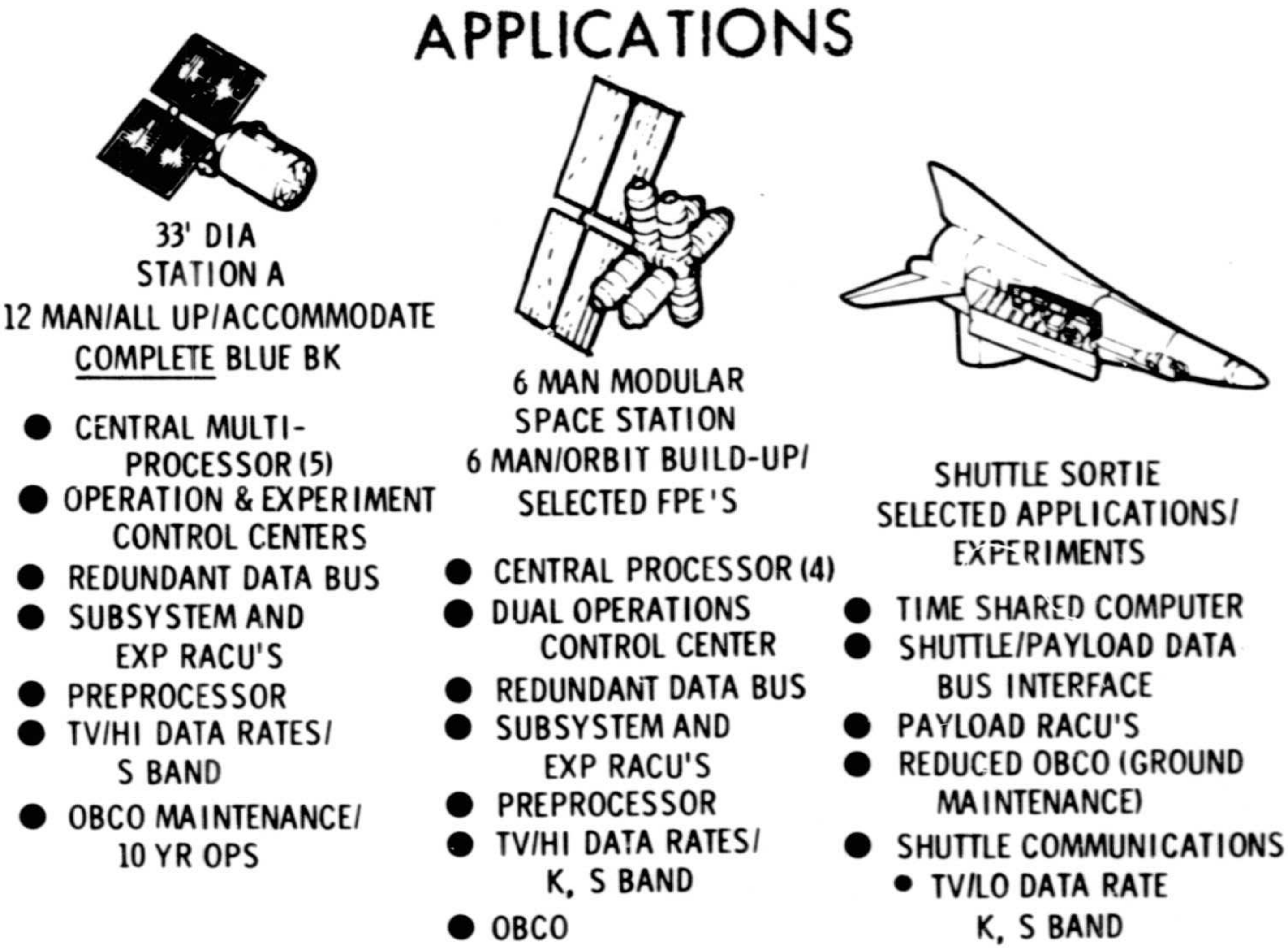


Figure 4.- Evolution of program requirements.

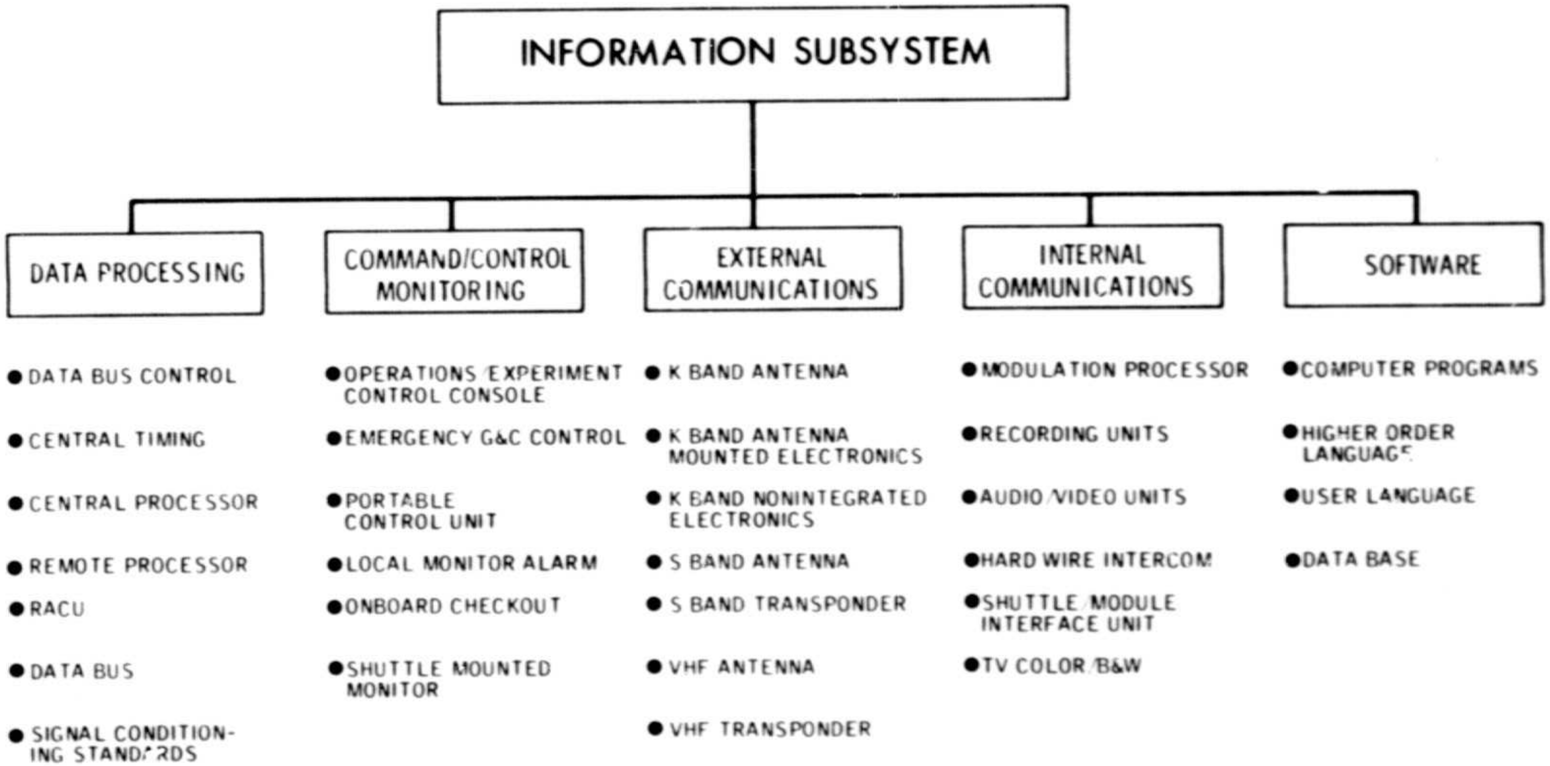
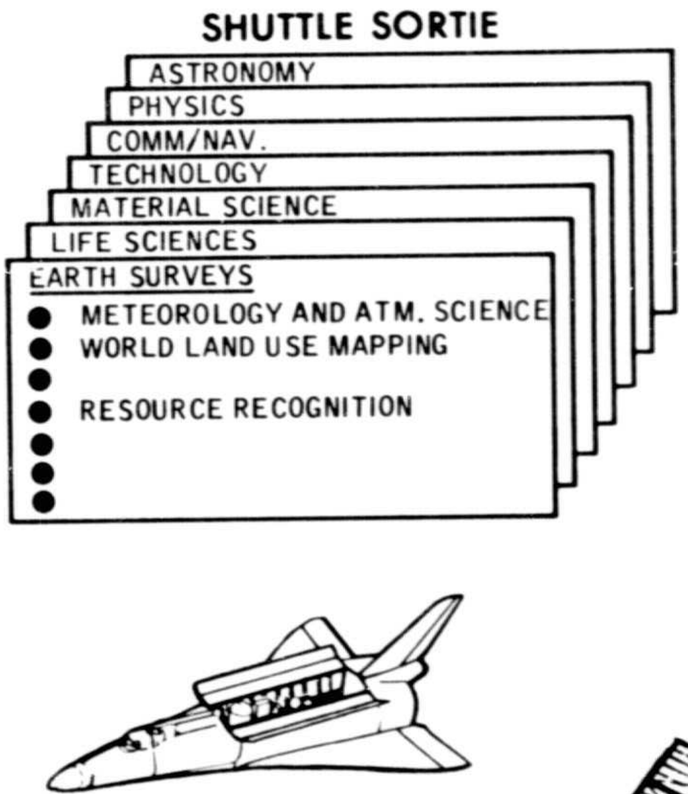
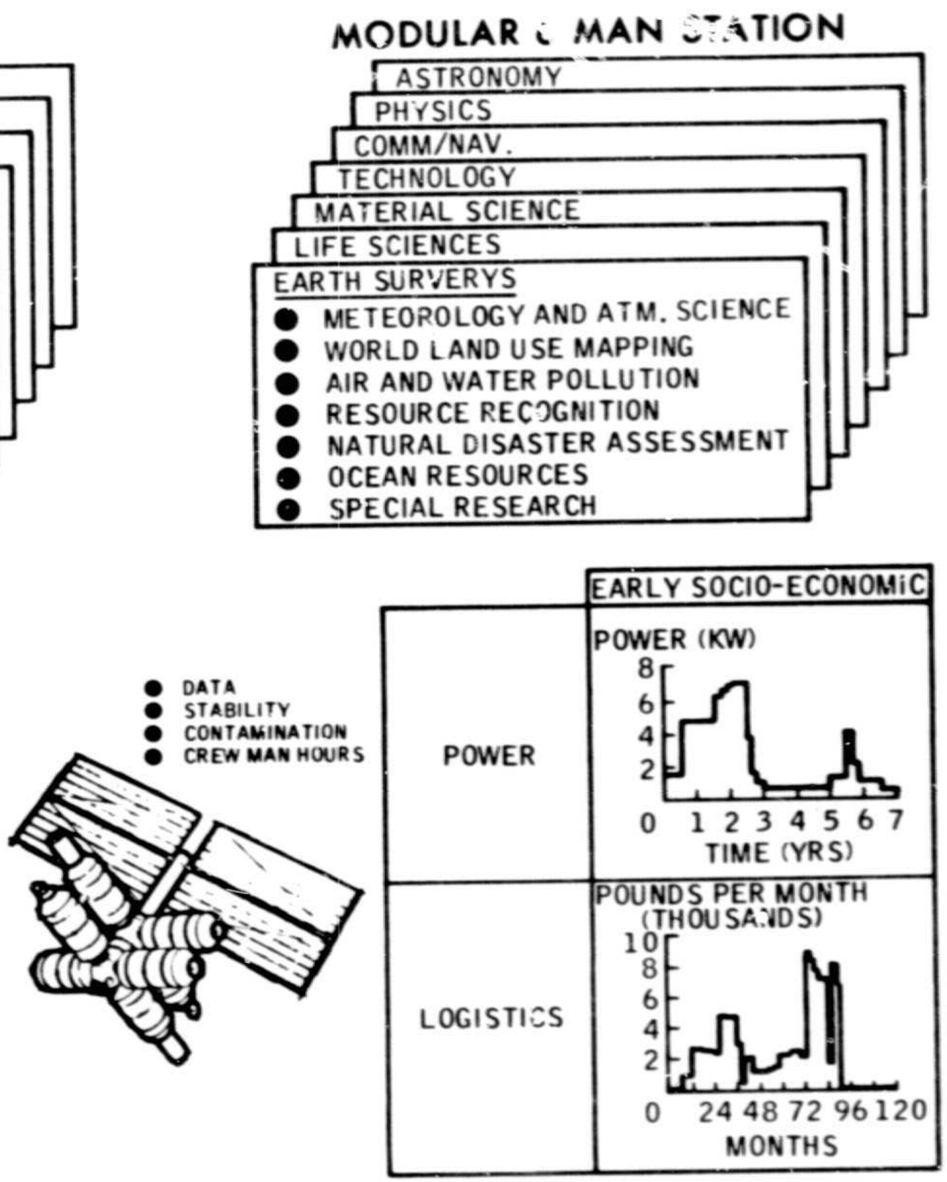


Figure 5.- Requirements of the modular space station information subsystem.





DISCIPLINE	7-DAYS EXP PKG	30-DAYS EXP PKG
ASTRONOMY		5
PHYSICS	3	3
EARTH OBSERV	2	1
COMM/NAV	1	2
MATL SCIENCE	1	
TECHNOLOGY	5	2
LIFE SCIENCES	2	4
TOTAL	14	17

Figure 6.- Experiment requirements for the shuttle sortie and the modular six-man station.

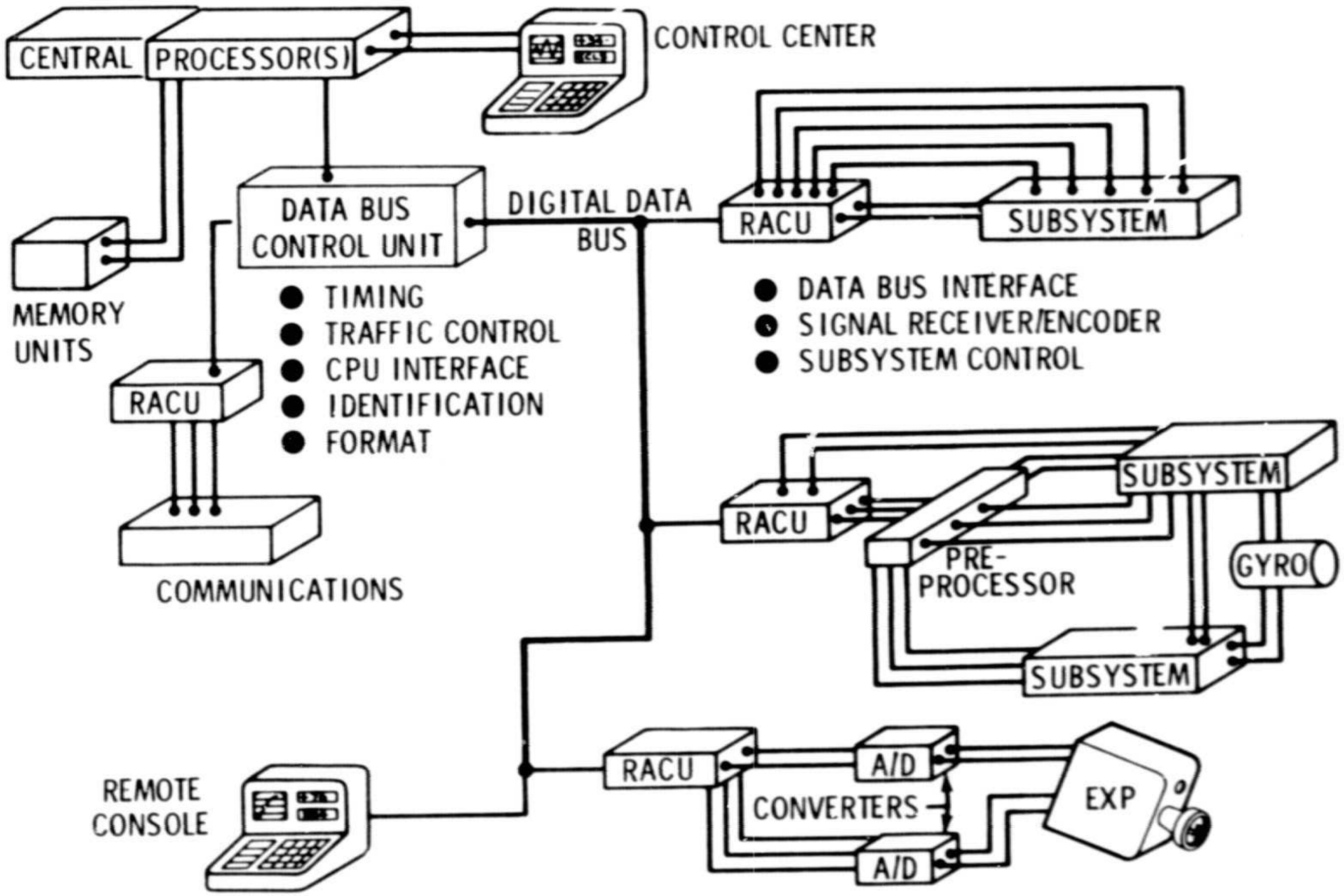


Figure 7.- Operational analysis of the information management system concept.

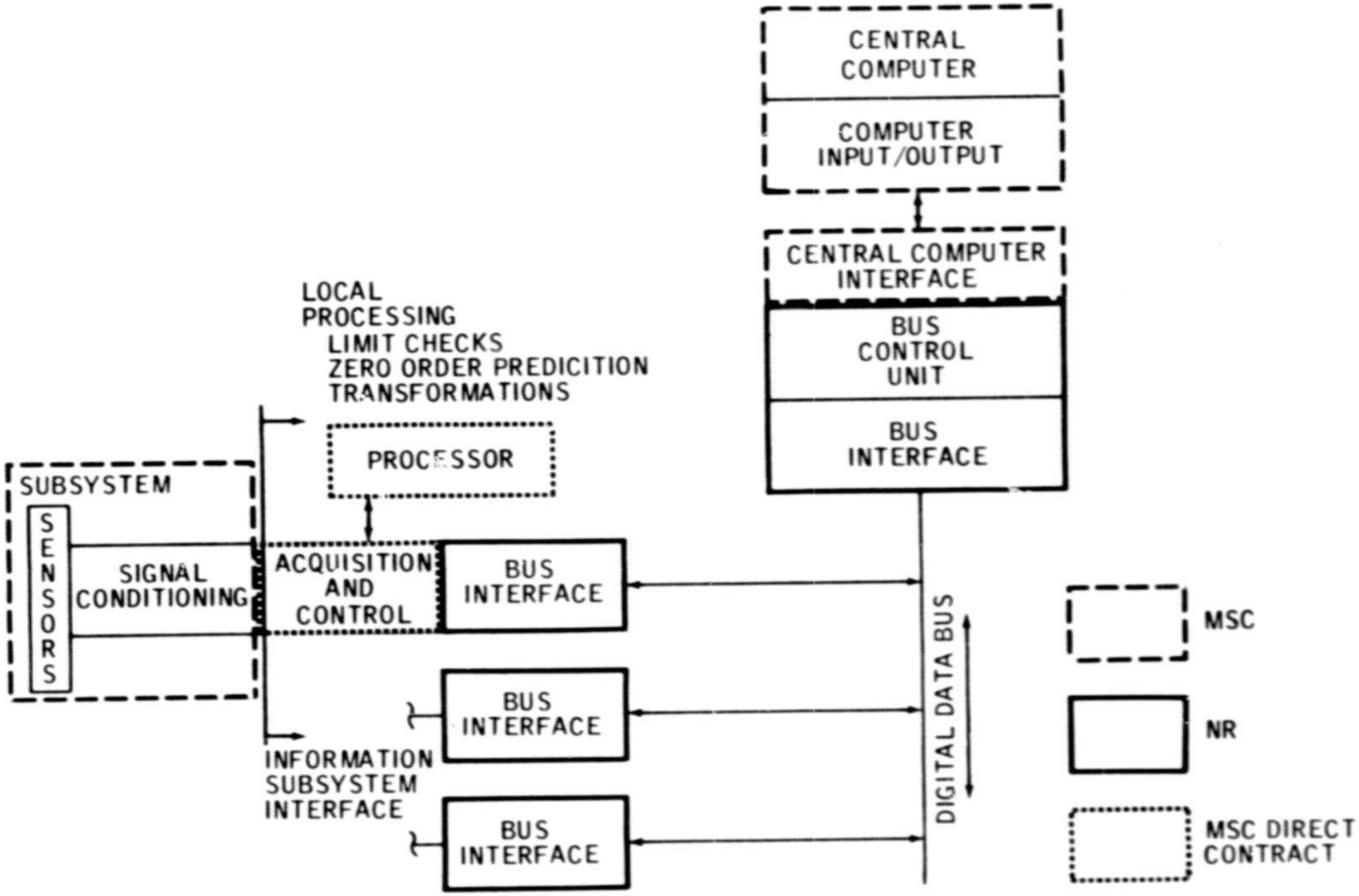


Figure 8.- Interface between the information subsystem and other subsystems.

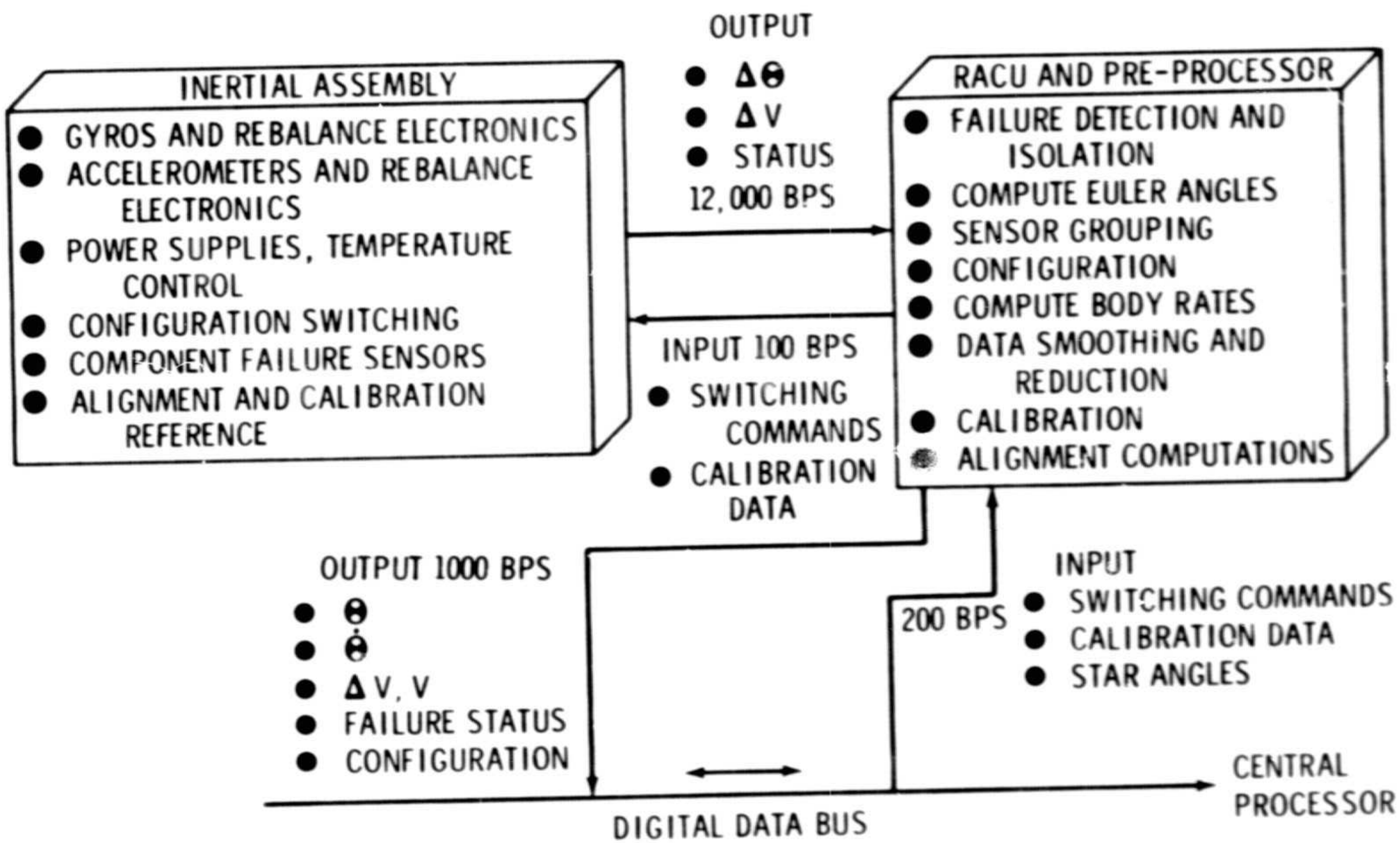


Figure 9.- Inertial reference assembly.

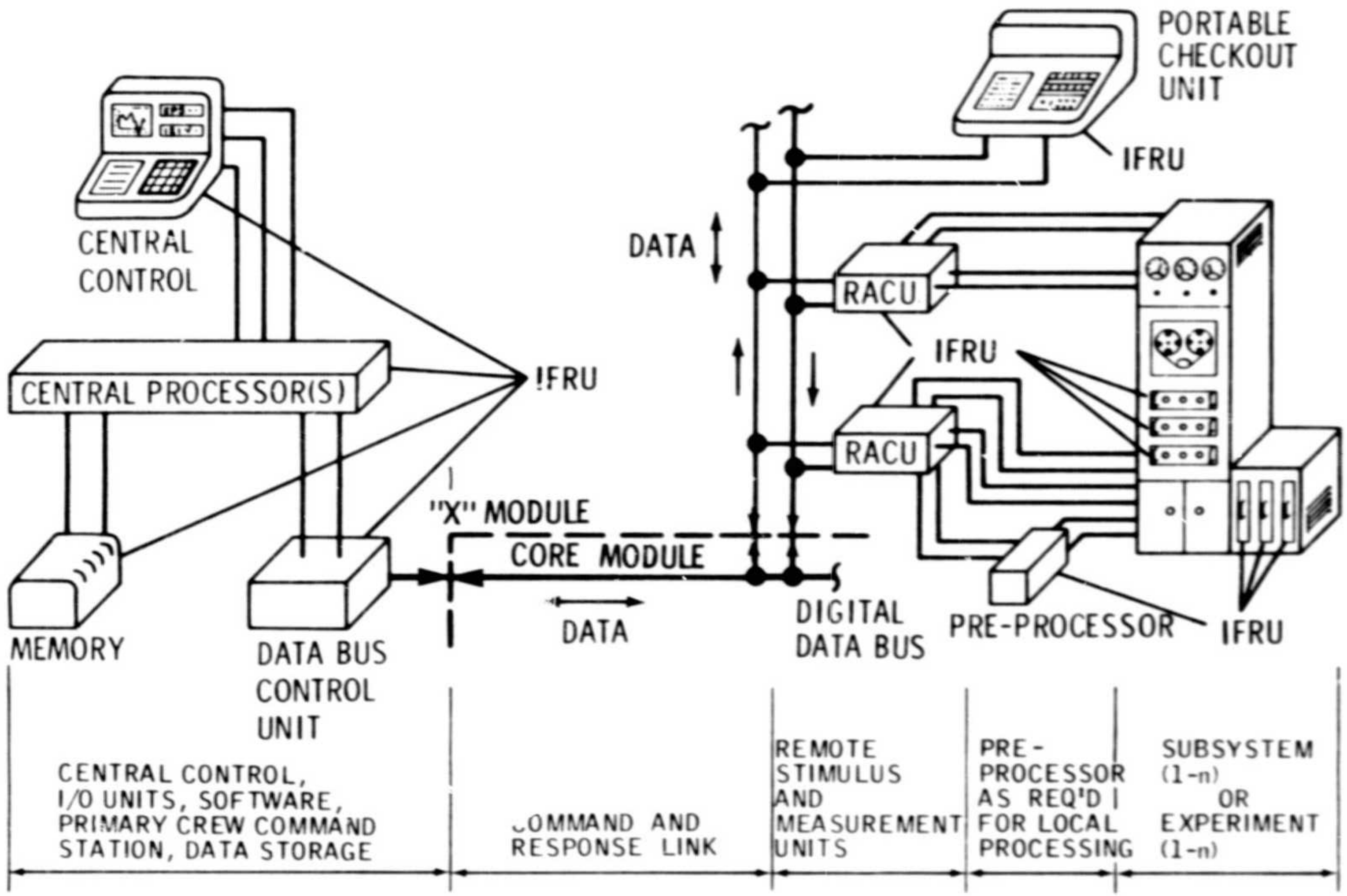


Figure 10.- Operational analysis for onboard checkout.

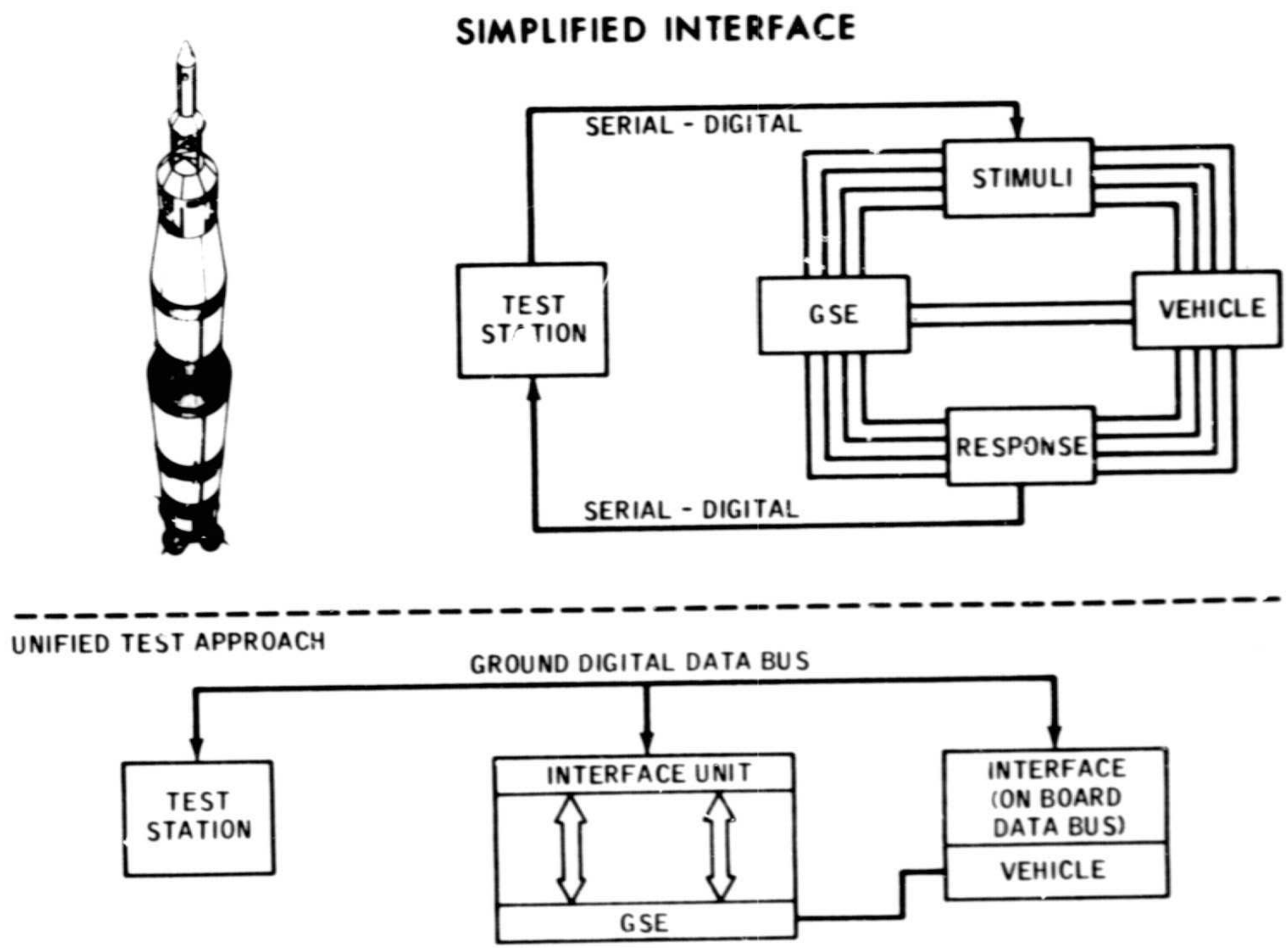
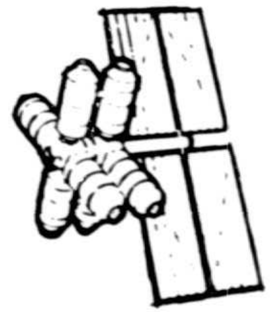


Figure 11.- The ground test/turnaround concept.

FUNCTION	CURRENT	DATA BUS CONCEPT
● COMMAND GENERATION	MANUAL INITIATION	COMPUTER CONTROL
● RESPONSE EVALUATION	VISUAL	COMPUTER EVALUATION/ DECISION
● GSE MONITOR AND CONTROL	MANUAL	AUTOMATED
● DOCUMENTATION		
DATA LOGGING	MANUAL	MACHINE/AUTOMATED
TEST PROCEDURES	COOK BOOK/VERBAL	CRT DISPLAYS/ PROGRAMMED OPTIONS
● DISPLAYS		
TEST INFORMATION	ENGINEERING UNITS/ RAW DATA	RESULT SUMMARIES/ PROCEDURE MILESTONES
● TEST SET-UP	MANUAL	BUILT-IN TEST (BITE)

Figure 12.- Ground test support for test, checkout, and turnaround.



FUNCTIONS	STATION OPERATIONS	EXPERIMENT OPERATIONS	TOTAL
DATA PROCESSING ASSY			
COMPUTER SPEED	950 K OPS/SEC	1050 K OPS/SEC	2000 K OPS/SEC
OPERATING MEMORY	80 K WORDS	64 K WORDS	144 K WORDS
MASS MEMORY	680 K WORDS	22 K WORDS	700 K WORDS
DATA BUS RATE	800 K BPS	2000 K BPS	2800 K BPS
COMMAND, CONTROL, MONITOR OPERATING CONSOLES	1	1	2
EXTERNAL COMMUNICATIONS			
K BAND LINKS	1	1	1
S BAND LINKS	1		1
VHF BAND LINKS	1	1	1
INTERNAL COMMUNICATIONS (VOICE)	12	12	12
VIDEO, (CCTV) CHANNELS	4	4	6
VIDEO, RECORD/PLAYBACK	1	2	2
DIGITAL, RECORD/PLAYBACK	1	1	2
AUDIO, RECORD/PLAYBACK	1	1	2

Figure 13.- Operational analysis of the information subsystem for the six-man space station.

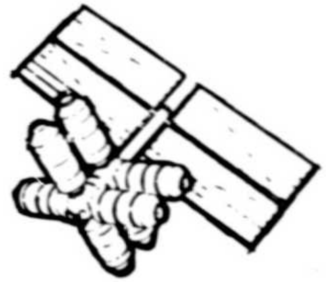
		
DISCIPLINE	SHUTTLE SORTIE	MODULAR SPACE STATION
ASTRONOMY	● INSTRUMENT DEVELOPMENT ● SELECTED OBSERVATION SURVEY	● SYSTEM EVALUATION ● OBSERVE SELECTED STRONG SOURCES ● CONTINUE SURVEY
PHYSICS	● SENSOR CHECK ● ORBIT FLEXIBILITY ● LAB. ENVIRONMENT DEFINITION	● ESTABLISH LABS: PLASMA, COSMIC, PHYSICS AND CHEMISTRY ● ARTICULATED BOOMS FOR PLASMA - SURVEY ATMOSPHERE
EARTH OBSERVATIONS	● SENSOR PERFORMANCE ● SIGNATURE RESEARCH ● SLOWLY VARYING PHENOMENA	● SENSOR GROUP EVALUATION ● DEVELOP MAN-IN-LOOP CAPABILITY ● BROAD SPECTRUM
COMM/NAVIGATION	● TEST TECHNIQUES AND EQUIPMENT ● WEATHER EFFECT	● DEVELOP SATELLITE-TO-GROUND TECHNIQUES ● EARLY DATA ON HI BENEFIT EXPERIMENTS

Figure 14.- Experiment model summary.

DISCIPLINE	SHUTTLE SORTIE	MODULAR SPACE STATION
MATERIALS SCIENCE	● TECHNICAL FEASIBILITY ● EQUIPMENT PERFORMANCE	● DEVELOP EQUIPMENT/ TECHNIQUES ● DETAILED PROPERTIES AT ZERO G
TECHNOLOGY	● LOW G FLUID BEHAVIOR ● EVA PROBLEM IDENTIFICATION ● PRECURSORS	● CONTAMINANT COMPOSITION ● OPERATIONAL EVA SKILL DEVELOPMENT ● NEW TECHNOLOGY DEVELOPMENT
LIFE SCIENCE	● VERIFY MEDICAL/ LIFE SUPPORT TECHNIQUES HUMAN TISSUE STUDY	● PREDICTION CRITERIA FOR SPACE EFFECTS ON MAN, CELLULAR FUNCTIONS AND MICRO-ORGANISMS
	● ≈70 EXPERIMENTS ● ≈30 EXP. PACKAGES ● ≈16 EXP. PAYLOADS ● ≈150 SORTIES (100-7 DAY, 50-30 DAY)	● CONTINUOUS OPERATIONS/ EXPERIMENTS

Figure 14.- Concluded.

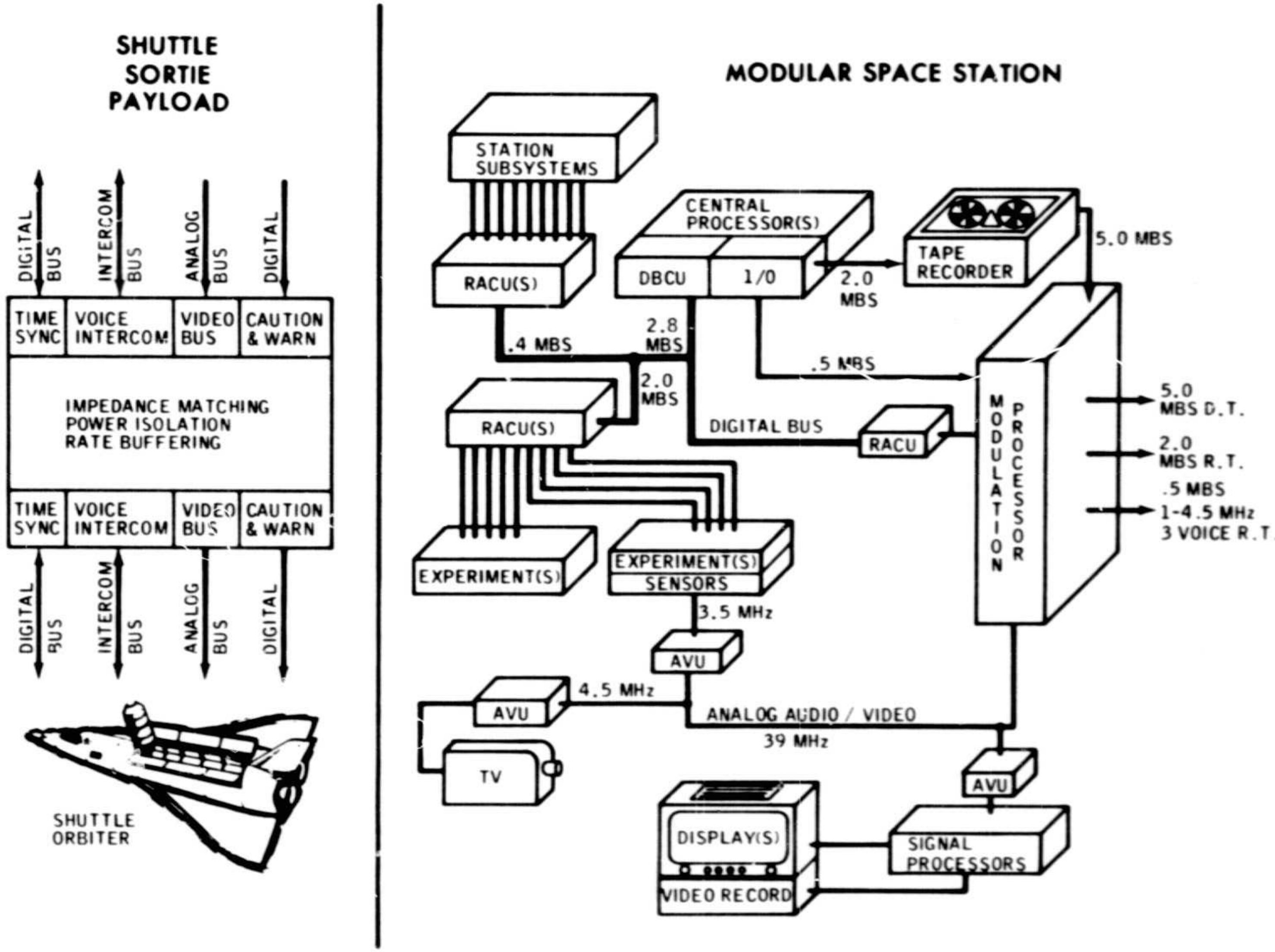


Figure 15.- Experiment analysis summary of the information management system.

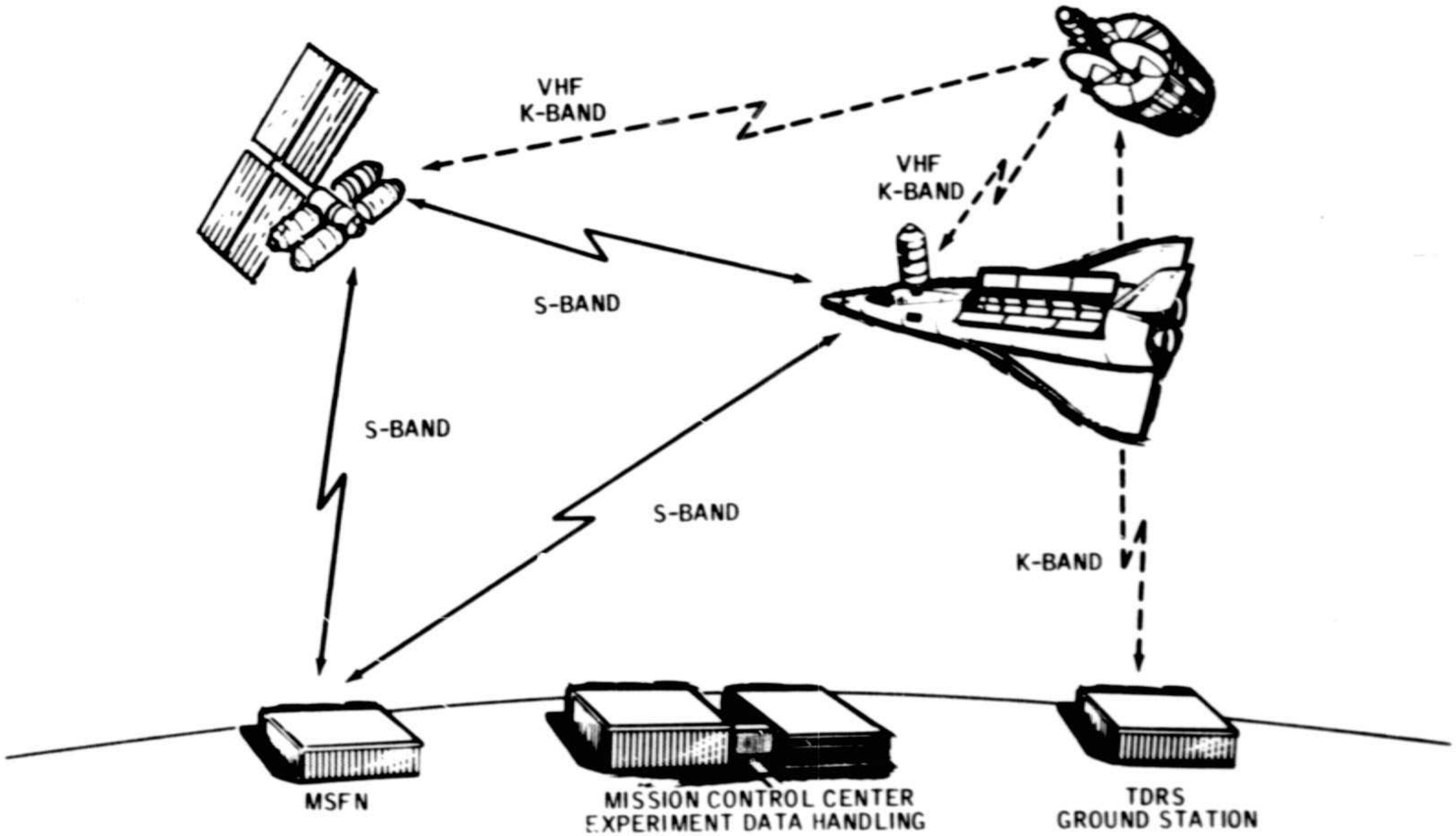
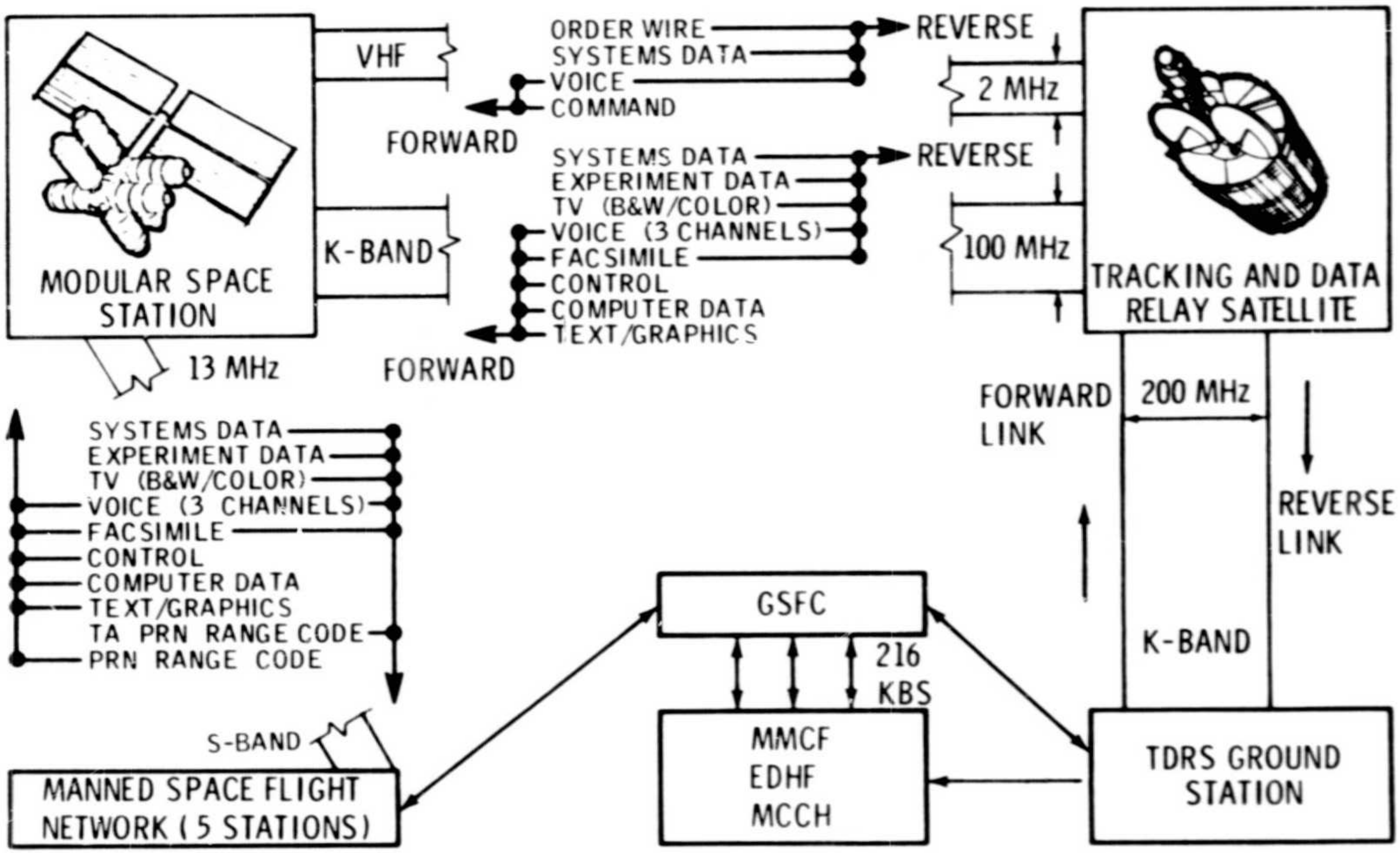


Figure 16.- Network analysis.



MMCF - MISSION MANAGEMENT CONTROL FACILITY
EDHG - EXPERIMENT DATA HANDLING FACILITY
MCCH - MISSION CONTROL CENTER HOUSTON

Figure 17.- Network analysis of the modular space station/ground communications model.

TEXT/GRAPHICS	DIGITAL SIGNAL REPRESENTING COMPUTER-GENERATED INFORMATION TO BE DISPLAYED AND/OR RECORDED BY A HIGH-SPEED PRINTER OR DIGITAL TELEVISION DISPLAY SYSTEM IN THE FORM OF TEXT, CHARTS, GRAPHS, ETC
CONTROL DATA	DIGITAL SIGNAL REPRESENTING COMMANDS WHICH CAUSE SYSTEM RESPONSES IN THE RECEIVING ELEMENT
COMPUTER DATA	DIGITAL SIGNAL REPRESENTING COMPUTER INPUT DATA REQUIRED FOR COMPUTATION OR THE OUTPUT RESULTS OF COMPUTER COMPUTATION
SYSTEMS DATA	DIGITAL SIGNAL REPRESENTING SYSTEM PARAMETERS USED TO MONITOR PERFORMANCE AND CONFIGURATION OF SYSTEMS
EXPERIMENTS DATA	SIGNALS REPRESENTING SCIENTIFIC DATA PRODUCED BY EXPERIMENTS
PRN RANGE CODE	DIGITAL CODE SIGNAL USED FOR RANGING
TRACKING	SIGNALS REPRESENTING POSITION AND/OR VELOCITY OF ONE ELEMENT WITH RESPECT TO ANOTHER
VOICE	COMMERCIAL TELEPHONE QUALITY VOICE OR MULTIPLEXED TELETYPE SIGNAL; 4-kHz BASEBAND
VOICE/MUSIC	COMMERCIAL QUALITY MUSIC; 10-kHz BASEBAND
COLOR TELEVISION	NSTC STANDARD COLOR VIDEO SIGNAL; 4.2-MHz BASEBAND, PLUS 4.5-MHz SUBCARRIER FOR 15-kHz AURAL SIGNAL
B&W TELEVISION	BLACK AND WHITE RESTRICTED BANDWIDTH VIDEO SIGNAL WITHOUT SOUND; 2.9-MHz BASEBAND
FACSIMILE	VIDEO SIGNAL REPRESENTING EXISTING HIGH RESOLUTION COLOR PHOTOGRAPH OR OTHER HARD COPY MATERIAL SUCH AS TYPED OR HANDWRITTEN PAGES

Figure 18.- Modular space station communications types.

APPLICATIONS PROGRAMS FOR GROUND AND FLIGHT

- LOGISTICS/INVENTORY CONTROL
- EXPERIMENT DATA MANAGEMENT
- SCHEDULING
- FLIGHT OPS COMMAND AND CONTROL
- SYSTEM MONITORING AND VALIDATION (OBCO)
- OPERATIONS DATA MGT/SUBSYSTEMS
  - EPS
  - ETCLSS
  - ISS
    - COMM
  - G&C
    - STABILIZATION
    - RCS
- GROUND ONLY
  - VEHICLE TEST
  - SIMULATION

Figure 19.- Software analysis.

SOFTWARE ANALYSIS

LANGUAGES

- HIGH ORDER COMPUTER LANGUAGE
  - FORTRAN
  - PL-1
  - JOVIAL
  - COBOL
  - SPL
  - HAL
- USER ORIENTED COMPUTER LANGUAGE
  - TEST
  - OPERATION
- STANDARDS
- DATA BASE

Figure 20.- Computer programing languages.

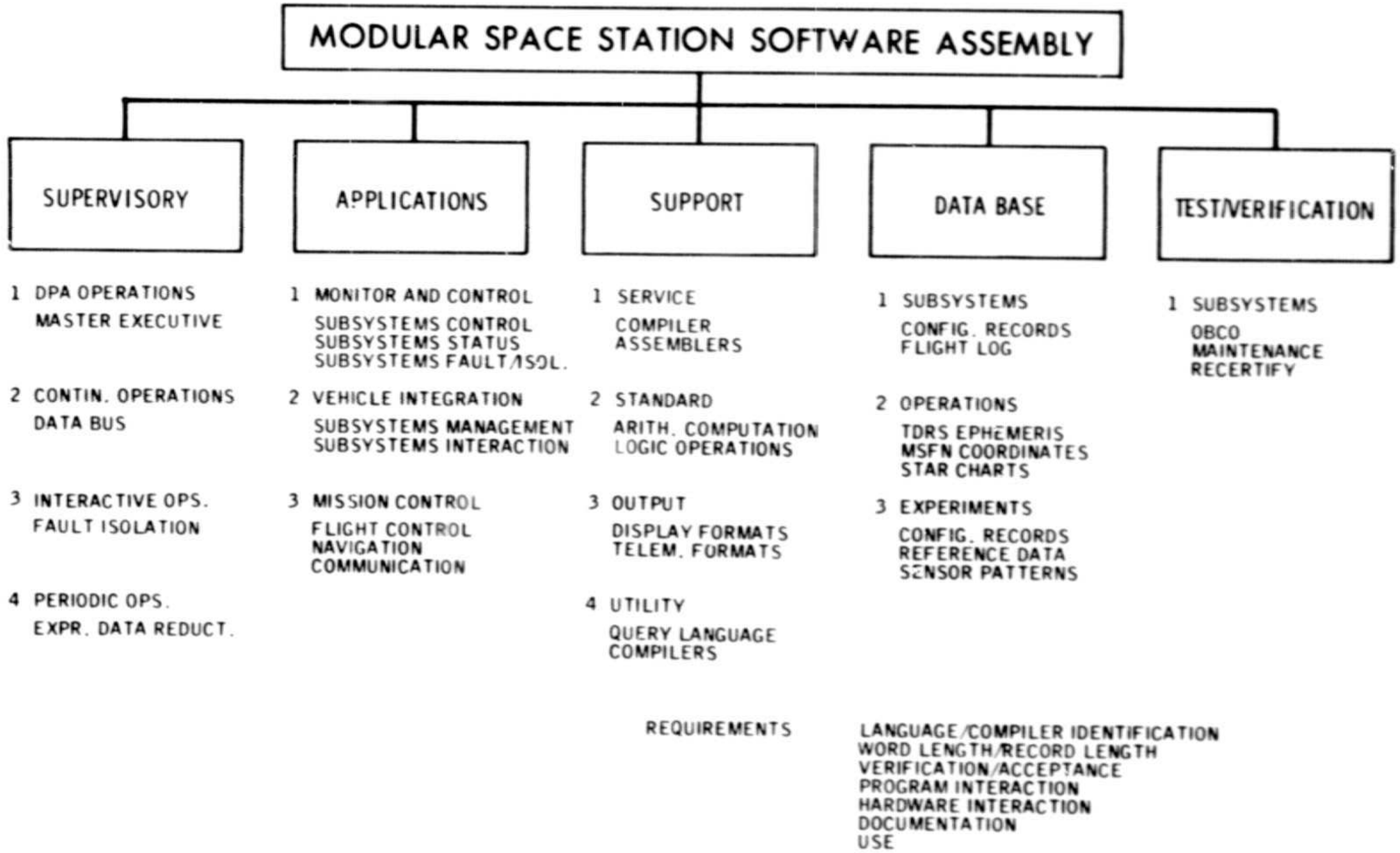


Figure 21.- Onboard requirements of the modular space station.

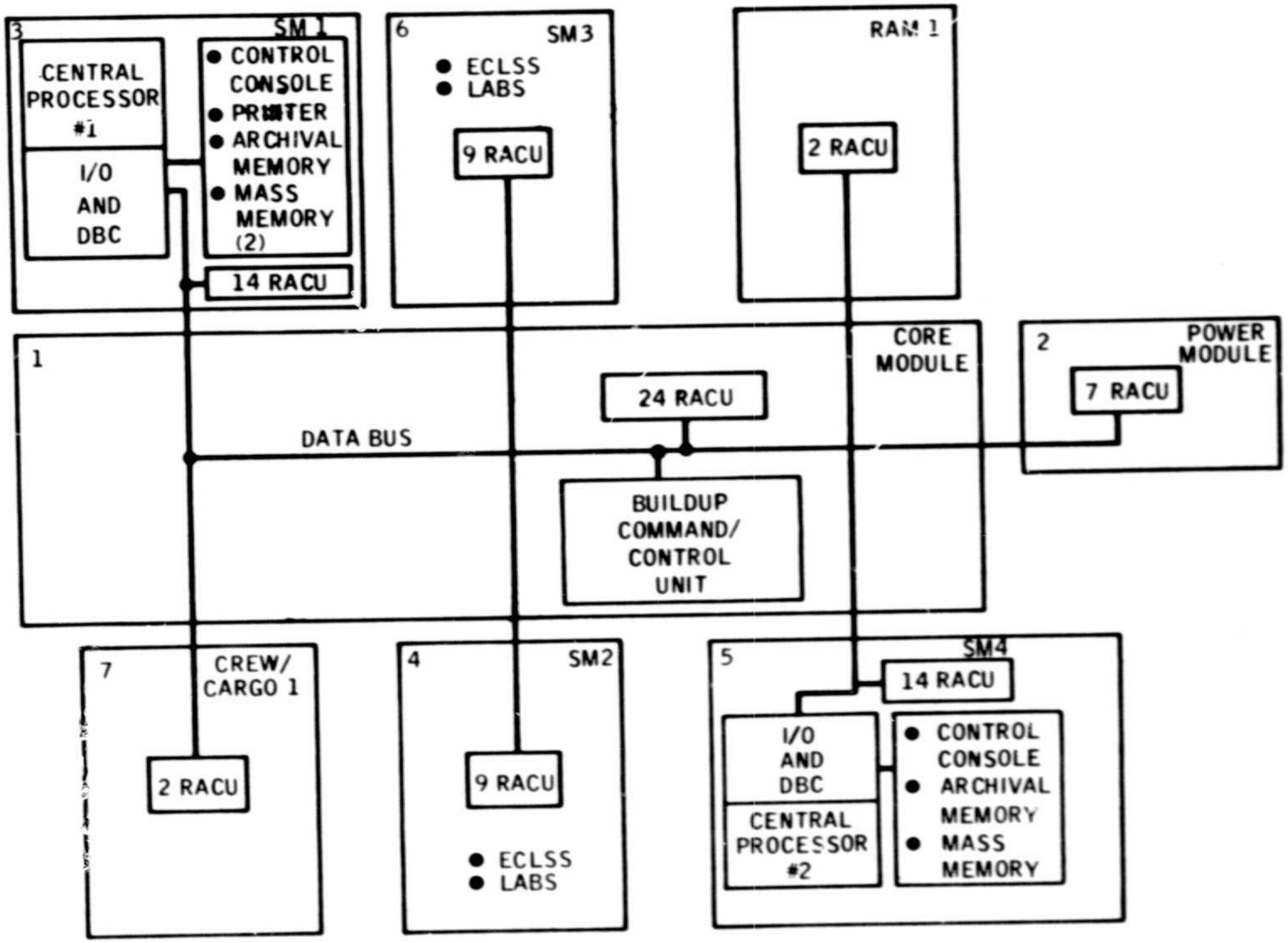


Figure 22.- Preliminary design selection for the modular space station.

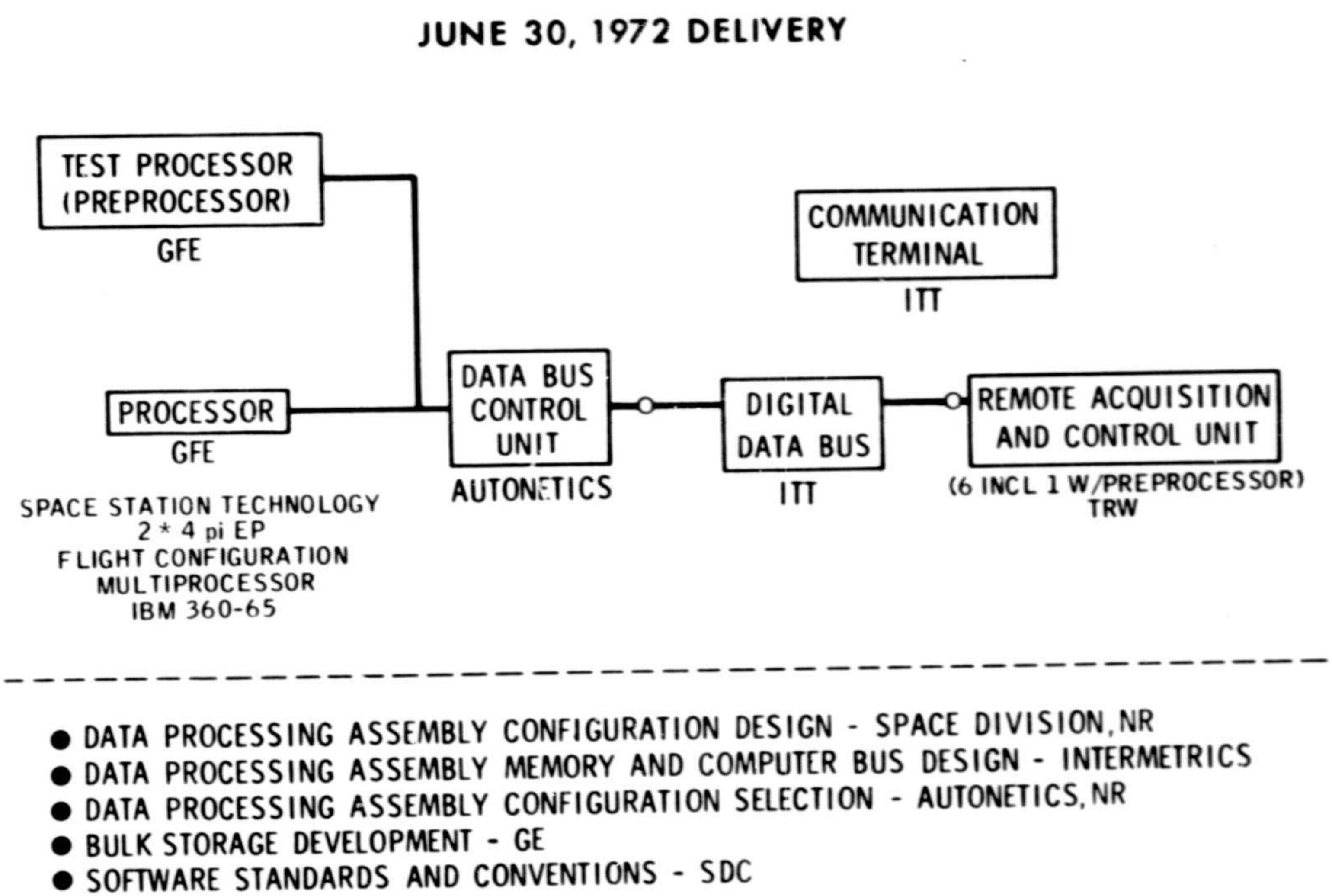


Figure 23.- Advanced development breadboard.

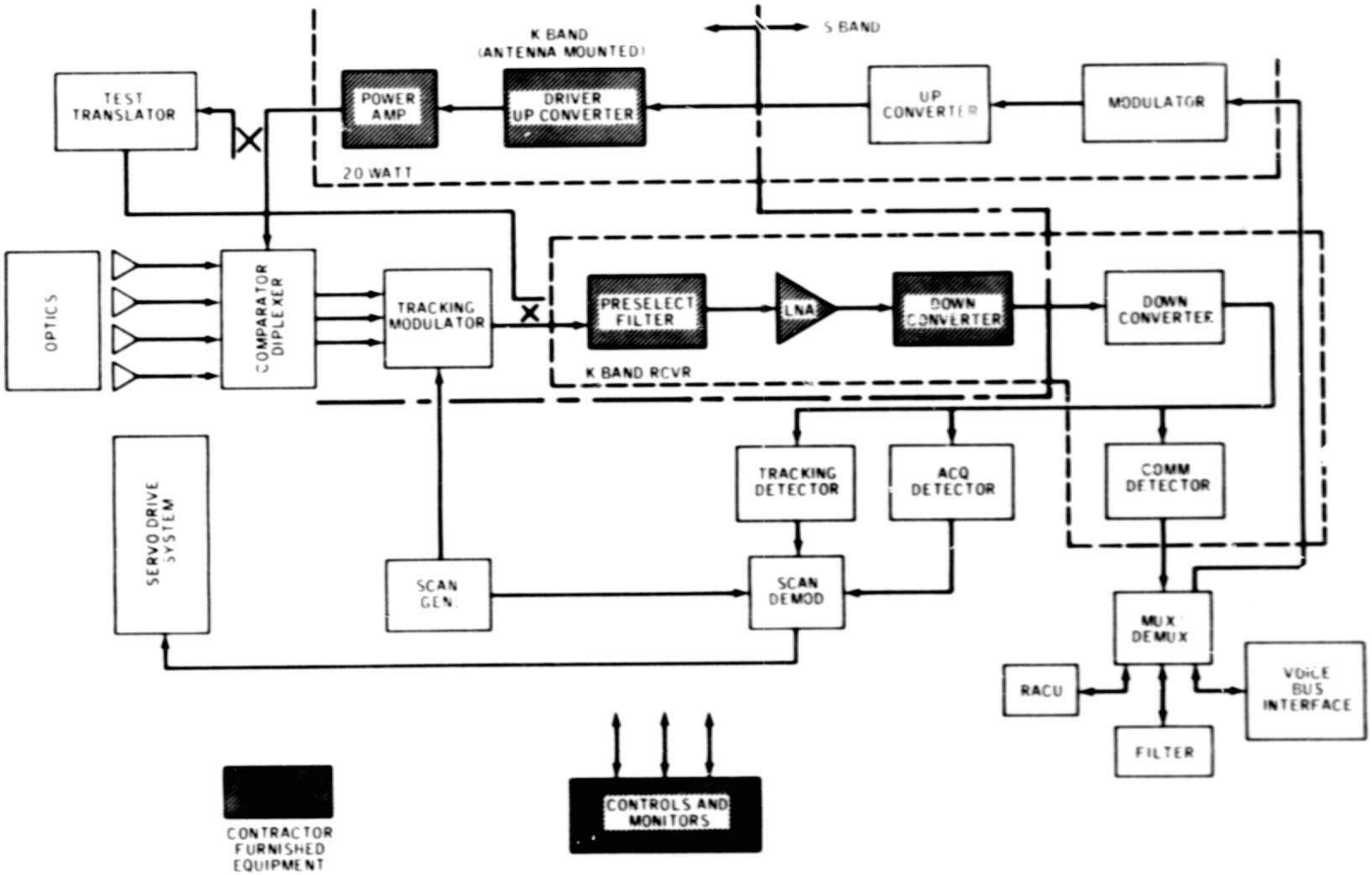


Figure 24.- A functional block diagram of the communications terminal breadboard.

DATA BUS	PERFORMANCE	USE
GUIDANCE AND NAVIGATION	1 MEGABIT/SECOND	2 COMPUTERS (1 FLIGHT AND 1 NAV.) CONNECTED TO FLIGHT CONTROL SYSTEM.
CONFIGURATION I BREADBOARD	1 MEGABIT/SECOND	4 II EP COMPUTER CONNECTED TO SHUTTLE SIMULATION AND SHUTTLE SUBSYSTEMS SIMULATORS. F-III DISPLAY INTEGRATION AND EVALUATION.
ONBOARD CHECKOUT SYSTEM (OCS)	2 MEGABIT/SECOND	4 II EP TO APOLLO BLOCK I SCS FOR OCS AND LANGUAGE DEVELOPMENT. INTEGRATION WITH SPACE STATION ECLSS.
STORED PROGRAM DATA PROCESSOR (SPDP)	250 K BITS/SECOND (12,800 WORDS/SECOND)	APOLLO/SKYLAB TM SYSTEM WITH VARIABLE DATA FORMAT. PERMITS RF SOFTWARE CHANGES FOR TM DATA RATES, FORMAT.
GROUND CHECKOUT UNIFIED TEST EQUIPMENT (UTE)	5 MEGABITS/SECOND	GROUND CHECKOUT OF SHUTTLE AND STATION SUBSYSTEMS.
DATA BUS SYSTEM DEVELOPMENT	60 K TRANSACTIONS/SEC ≈ 5 MEGABITS/SEC	SYSTEMS INTEGRATION LAB (SIL) COMBINES G&C, ISD, & TCSD DEVELOPMENTS.
SPACE STATION ADVANCED DEVELOPMENT	10 MEGABITS/SECOND	SPACE STATION ADVANCED DEVELOPMENT BREADBOARD

Figure 25.- Summary of data bus development at MSC.

FUNCTION	COMMENTS		
	SPACE STATION		SPACE SHUTTLE
	12 MEN	4 TO 6 MEN	2 TO 4 MEN
COMPUTER	CENTRAL CONTROL	CENTRAL CONTROL PREPROCESSORS	CENTRAL CONTROL
DATA BUS	DIGITAL AND ANALOG	DIGITAL AND ANALOG	DIGITAL LOW RATE
RACU	PREPROCESSORS	PREPROCESSORS	PAYLOAD PREPROCESSORS
DISPLAYS AND CONTROLS	GENERAL-PURPOSE DISPLAYS CENTRAL AND REMOTE TERMINALS	GENERAL-PURPOSE DISPLAYS CENTRAL AND REMOTE TERMINALS	GENERAL-PURPOSE DISPLAYS REMOTE TERMINAL FOR PAYLOAD ONLY
SOFTWARE	STANDARDIZED AND CONVENTIONAL	STANDARDIZED AND CONVENTIONAL	STANDARDIZED AND CONVENTIONAL
COMMUNI-CATIONS	HIGH-GAIN-ANTENNA DATA RELAY	HIGH-GAIN-ANTENNA DATA RELAY	HIGH-GAIN-ANTENNA DATA RELAY

[dashed box] SOME CONCEPTS ARE COMMON
[solid box] COMMON CONCEPTS

Figure 26.- Commonality summary.

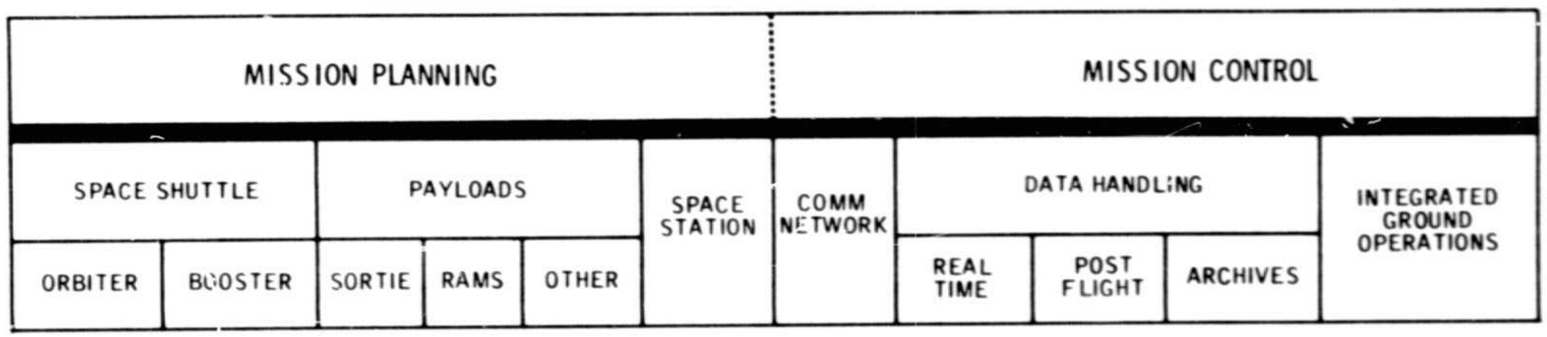


Figure 27.- Mission management concept.

- CENTRAL AND REMOTE CONTROL
- STANDARD SUBSYSTEM AND EXPERIMENT INTERFACE
- STANDARD SOFTWARE
- CONFIGURATION FLEXIBILITY
- ONBOARD AUTONOMY
- MISSION MANAGEMENT
- COMMUNICATIONS
- AUTOMATED EXPERIMENT DATA HANDLING
- TEST, CHECKOUT, TURNAROUND
- MANNING REQUIREMENTS

Figure 28.- Advantages of the information management system.

NASA — MSC — Coml., Houston, Texas