SPACE QUALIFICATION PROCEEDS ON THE COMMON DATA LINK PROGRAM

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ABSTRACT

A modular Communication, Command, and Control (C^3) architecture has been developed for use in a variety of Department of Defense (DoD) applications by the Office of the Secretary of the Air Force/Defense Support Project Office (OSAF/DSPO). The C^3 architecture is implemented under the direction of the SAF/DSPO's Common Data Links Program Office using government defined and controlled common modules. This set of common modules is now being qualified for space applications. The family of common modules provide the building block to satisfy a wide range of unique operational requirements while achieving commonality, tri-service interoperability, multi-system connectivity, and a flexible baseline for technology insertion.

SAF/DSPO has also been involved for many years in utilization studies and mission assessment analysis of small dedicated satellites as one method of providing required support to many tactical missions.

This paper reviews the Common Data Links Space Qualification Program and provides an understanding of how the CDL Common Modules fit into small satellite type programs of interest in satisfying tactically oriented missions. Emphasis is placed on describing the types of missions, user interactions with CDL and typical C^3 implementations on board the small satellites.

Background. Historically, little commonality and very little interoperability have existed between and among independently developed DoD satellite systems and command level users because of the absence of interface standards which have often been impractical to establish across many different programs. Usually, each program has its own set of complex specialized mission objectives with unique constraints, and the cost of the satellite segment relative to the ground segments make the usage of dedicated ground assets optimized for the satellite segment an acceptable and preferred approach.

With the potential emergence of small satellites performing dedicated missions and reduced launch expenses, the cost of the space segment appears not to be the driving system expenditure. The ground segment must be considered to be the driver in total system cost and in mission performance. The DoD has carefully considered combining ground systems through the use of interface standards and common hardware. The approach selected was to start a development of a common and interoperable Command, Control, and Communications (C^3) system that could be used by national, strategic, or theater command level users to achieve a desired operational capability. The Common Data Link program provides the joint management development and deployment of the necessary hardware and software to implement the interoperable C^3 system.

The interoperable C^3 architecture traces its history to the late 1960's when requirements for duplex communications between command users and associated platforms created the development and deployment of several high speed data link systems in DoD applications. These data links, referred to as L-2, included both airborne platform and ground segments. The success of this system resulted in follow-on developments that increased command capability for the required applications. These developments were known as L-5, L-15, L-52, L-52M, and L-60.

By the late 1970's, critical tri-service interoperability requirements pushed for higher operating data rates and frequencies, jam resistant data link systems to permit connectivity and mutual support necessary in joint service operations. In response to these requirements, the Interoperable Data Link (IDL) development was initiated as a centrally managed government program to ensure that system C^3 architecture and equipment interface standards were established to achieve interoperability between platforms, platform prime mission equipment, and system DoD users. Again, the IDL system included both airborne and ground segments, and over one hundred IDL systems are deployed by the DoD.

By the early 1980's, with rapid changes in technology occurring and the variety and number of applications increasing, the Government established the development of the Common Data Link and set up the office of the Common Data Link with the Secretary of the Air Force/Defense Support Program Office. The objectives of the CDL program encompassed not only the need to preserve existing interoperability and commonality as established by the IDL but to enhance the interoperability and commonality by inserting current technology and by making CDL available for other platforms that would interface directly with the command level users. This direction developed a more flexible system architecture based on the Open Systems Interconnect (OSI) model, with standard internal, external, physical, and functional interfaces to support the family of Common Data Link implementations for Government users past the year 2000.

Each platform implementation is configured from a hierarchial set of common modules, providing cost effective commonality. Specialized mission requirements and constraints for a wide variety of programs are accommodated by the open system interfaces, not only preserving but significantly enhancing interoperability. The Open Architecture interfaces also provide the mechanism to insert Very High Speed Integrated Circuitry (VHSIC), Monolithic Microwave Integrated Circuitry (MMIC), and other emerging technologies as required.

The Space Qualified Common Modules are based functionally on the Airborne Common Modules. Figure 1 is a photograph of one version of Airborne equipment; Figure 2 is a photograph of one common module. The Space Qualification effort evaluates the Airborne design and then while maintaining the same functionality, form, and fit, provides the necessary design changes to account for environmental changes and implementation of reduced power and increased reliability.

Since CDL serves as a fundamental program to provide interoperable communications needs through the year 2000, the "point design" architecture for IC^3 was adopted as a planning tool to allow preplanned product improvement (P^3I) for both functional and technology enhancements.

Figure 3 shows the overall IC^3 concept. The concept promotes the direct operational control of the platform, prime mission equipment, and CDL equipment by a dedicated user. Platform assets may be shifted among users at the direction of higher level headquarters but the platform (once dedicated to a user) becomes a "virtual" asset for the user during the time it is in the user area of control. As can be seen, this concept requires the addition of various functions (storage, data management, local area networks, and compression) each of which have been planned for through enhancements to the basic Miniaturized Interoperable Data Link (MIDL) equipment. In addition, more RF assemblies, antennas, and interfaces have already been created. A list of future P^3I and technology changeover points has been investigated for the future. Figure 4 illustrates the platform segment point design for the IC^3 overall concept.

Satellite Mission Overview. The satellite missions of interest to SAF/DSPO involve a space platform hosting mission equipment to serve the earth or atmosphere in all wavelengths of the electromagnetic spectrum or carrying a package which emulates communication or navigation equipment currently deployed for use in tactical battlefield situations.

The space qualified common modules support the mission functions shown in Figure 5. The uplink provides the IC^3 or commands to control the primary mission equipment directly (usually denoted as user tasking). A set of privileged commands is also made available for use in commanding the platform directly. The commands allow for a tactical user to interact with the platform in real time for tasking while maintaining the capability for the space segment operator to independently maintain the health and operational capability of the satellite. The downlink provides the capability for the satellite to maintain direct communications with the tactical user, thus allowing a user to have real time access to data or information from the space segment. These C^3 functions are provided to all service departments and other DoD agencies that have the IC^3 architecture as implemented by the Common Data Link Program.

Platform Communications Element-Space Qualified. The space qualified Platform Communications Element (PCE) is illustrated in Figures 6 and 7. This equipment is hosted by the spacecraft to implement the IC^3 requirements for the CDL program. The space qualified PCE common modules have characteristics as listed in Table 1. These common modules are currently being designed and developed under the direction of the SAF/DSPO for use in a variety of proposed activities. The current development schedules will allow for fully qualified hardware and software to be available for integration into program activities after the second quarter of Government Fiscal Year 1993. The completion of this space qualification activity will achieve a new level of interoperability between space-based resources and command users at the national, strategic and tactical levels.

Conclusion. The SAF/DSPO has defined an interoperable C^3 architecture for use in programs supporting operational needs. This architecture is implemented through hardware and software provided by the Common Data Link Program. This hardware and software has been deployed by the CDL Program for many types of airborne programs and is currently under development for use in similar programs based in space. The development schedule will provide for initial space qualified common module hardware and software to be delivered in the second quarter of Government Fiscal Year 1993. The addition of this space qualified CDL capability to the Government inventory will significantly enhance operational support to command level users.

Figure 1. Airborne CDL Equipment

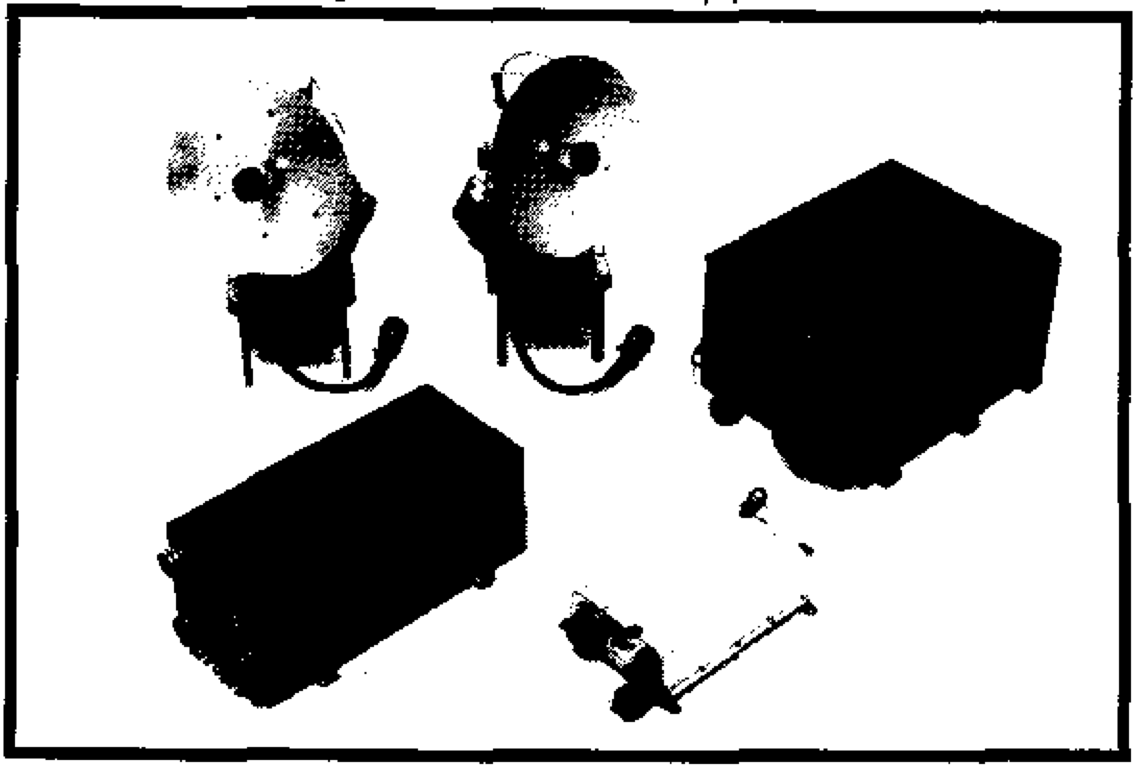

Figure 2. One Example of a Common Module

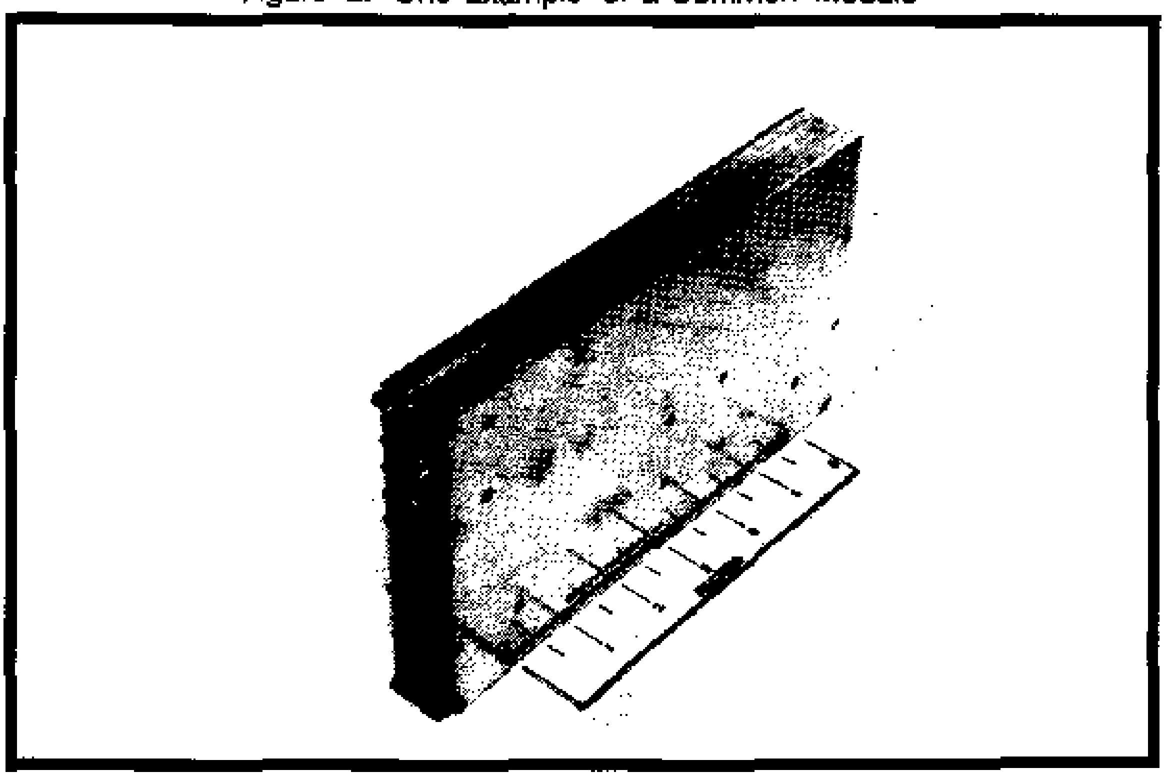

Figure 3. Overall IC³ Concept.

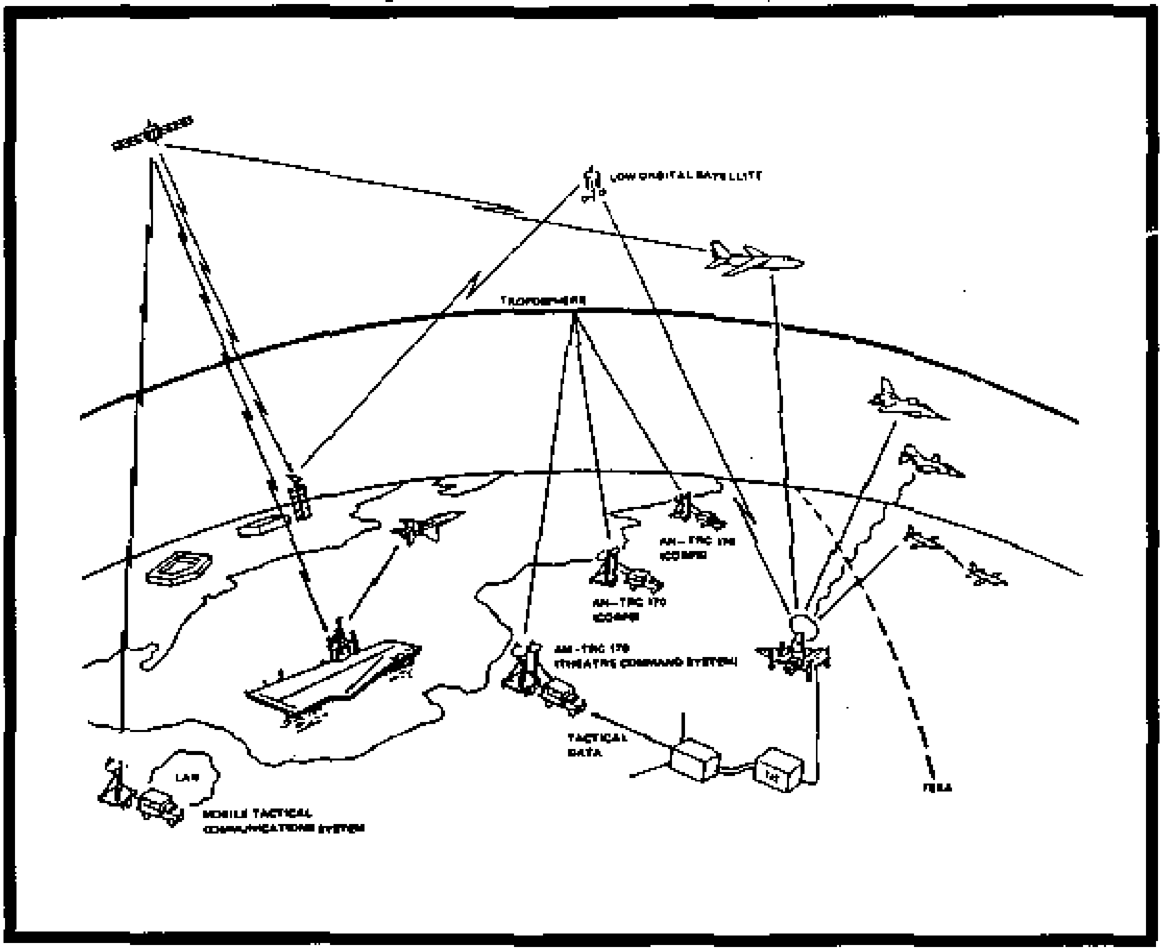

Figure 4. IC³ "Point Design" Platform Architecture

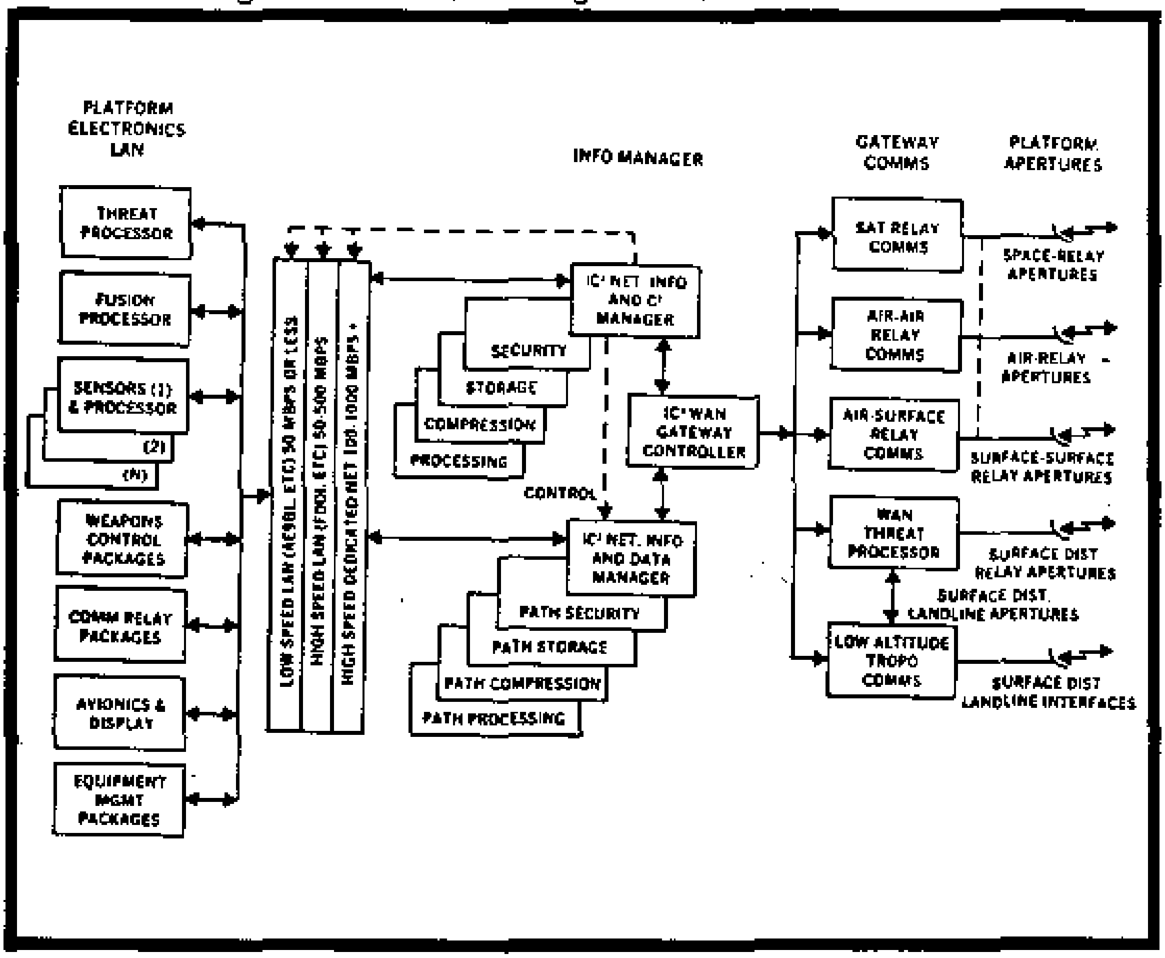

Figure 5. Mission Functions Supported by Common Modules

Command Functions

Standard Electrical, Mechanical, Protocol, Formal Command Interface

Privileged Command Capability for Space Segment Operator

Direct Tasking Command Capability for National, Strategic, or Tactical Command Levels

Independent Command Capability internal to the CDL for the for the IC^3 segment

Control Functions

Standard Electrical, Mechanical, Protocol, Formal Status/Telemetry Interface

Health and Status for Space Segment Operator

Health/Status and Tasking Execution Reports Directly to Command Levels

Independent System Control and Assessment of the IC^3 segment

Communications

Interoperable Line Of Sight Uplink

Interoperable Line Of Sight Downlink

Interoperable Relay Forward Links

Interoperable Relay Return Links

Miscellaneous

Standard Time, Navigation, Location Capability

Standard IC^3 Mission Coordination and Planning

Standard Testing and Prelaunch Support

Standard Mission Threat Assessment and Analysis

Figure 6. Packaging Concept for Space CDL

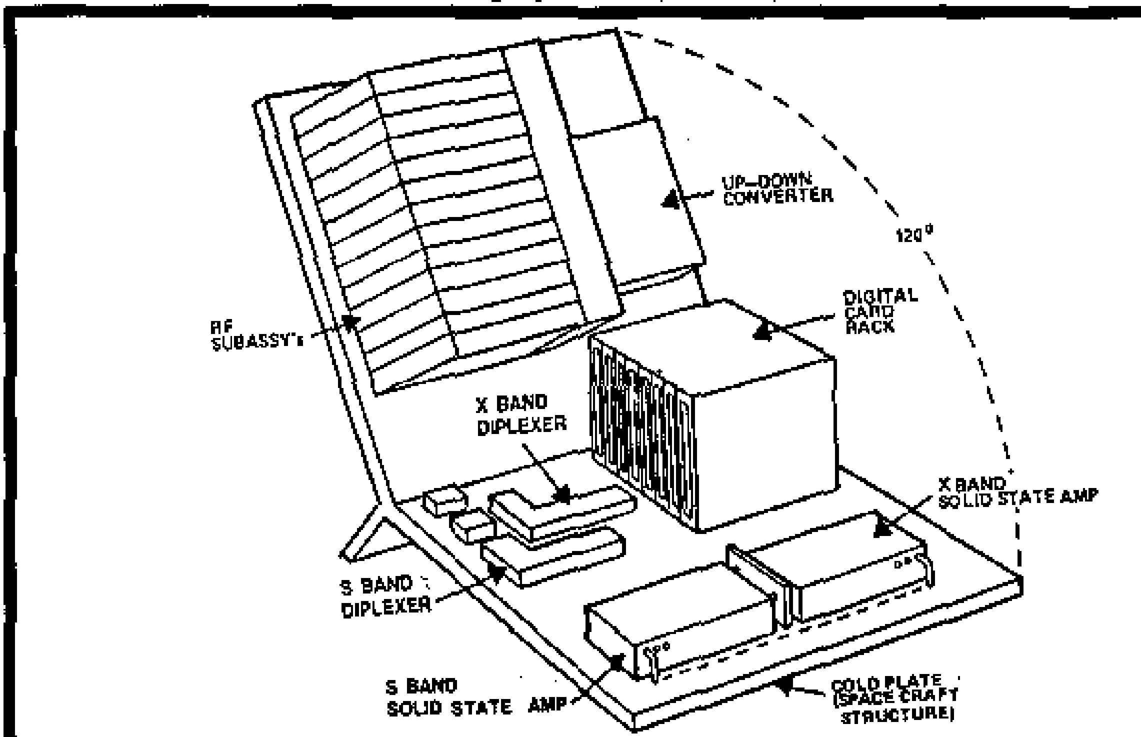

Figure 7. Functional Block Diagram for Space CDL

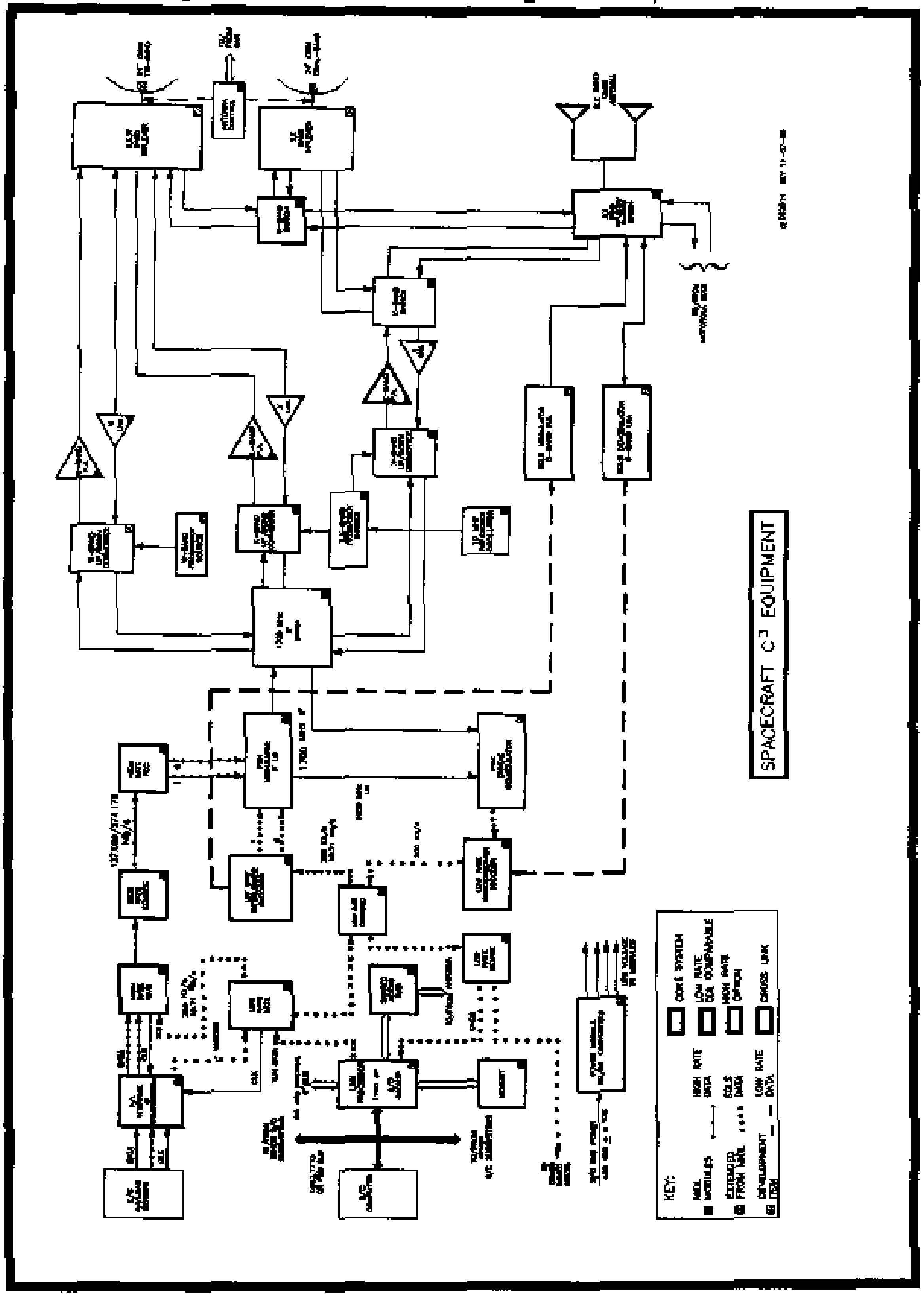

TABLE 1.0. Characteristics of Space CDL

SUBSYSTEM COMPONENT	LENGTH (In)	WIDTH (In)	HEIGHT (in)	WEIGHT (lb)	POWER (W)	TIME ON PER ORBIT	ORBIT AVG PWR (100 min Orbit)
LINK PROCESSOR	4.60	4.80	0.40	0.25	4.20	100.0	4.20
SHARED ACCESS RAM	4.60	4.80	0.40	0.20	4.20	100.0	4.20
MEMORY	4.60	4.80	0.40	0.25	4.20	100.0	4.20
P/L INTERFACE & COMPRESSION	4.60	4.80	0.90	0.80	6.00	26.4	1.58
LOW RATE MUX	4.60	4.80	0.40	0.20	3.97	26.4	1.05
LOW RATE DEMUX	4.60	4.80	0.40	0.20	3.21	100.0	3.21
LOW RATE COMSEC	4.60	4.80	0.80	0.40	4.60	100.0	4.60
LOW RATE INTERLEAVER/ENCODER	4.60	4.80	0.40	0.20	1.14	26.4	0.30
LOW RATE DEINTERLEAVER/DECODER	4.60	4.80	0.40	0.20	4.36	100.0	4.36
RED/PURPLE INTERFACE	4.60	4.80	0.40	0.20	2.00	26.4	0.53
BLACK/PURPLE INTERFACE	4.60	4.80	0.40	0.20	2.00	100.0	2.00
SGLS MODULATOR/S-BAND PA	8.50	4.80	1.50	2.00	18.00	26.4	4.75
SGLS DEMODULATOR/S-BAND LNA	8.50	4.80	1.50	2.00	5.00	100.0	5.00
S,X-BAND DIPLEXER/S-BAND SW	6.00	3.00	2.30	0.50	0.25	100.0	0.25
Subtotal				7.80	63.13		40.23
PSK MODULATOR/IFLO	8.50	4.80	1.00	2.00	16.40	34.8	5.71
PSK DIGITAC DEMODULATOR	8.50	4.80	1.00	2.00	15.00	34.8	5.22
1.7 GHZ IF SWITCH	8.50	4.80	1.00	1.00	2.00	34.8	0.70
X,K-BAND FREQUENCY SOURCE	8.50	5.40	3.00	4.00	20.00	34.8	6.96
10 MHZ REFERENCE OSCILLATOR	2.00	1.90	1.50	1.00	1.20	34.8	0.42
X-BAND UP/DOWN CONVERTER	8.50	5.40	0.90	1.50	18.00	18.0	3.24
X-BAND POWER AMPLIFIER	10.00	3.50	1.90	1.50	50.00	18.0	9.00
X-BAND LNA	2.00	0.66	0.22	0.13	3.00	18.0	0.54
X-BAND SWITCH	1.00	2.00	0.60	0.13	0.25	18.0	0.05
S,X-BAND DIPLEXER	5.00	3.00	2.30	0.70	0.00	44.4	0.00
S-BAND SWITCH	1.00	2.00	0.60	0.13	0.25	100.0	0.25
Subtotal				14.09	126.10		32.09
HIGH RATE MUX	4.60	4.80	0.40	0.25	9.40	18.0	1.69
HIGH RATE COMSEC	4.60	4.80	0.40	0.45	2.32	18.0	0.42
HIGH RATE FEC	4.60	4.80	0.40	0.25	4.36	18.0	0.78
Subtotal				0.95	16.08		2.89
W-BAND UP/DOWNCONVERTER	8.50	5.40	0.45	1.00	10.00	8.4	0.84
W-BAND FREQUENCY SOURCE	8.50	5.40	0.45	1.00	10.00	8.4	0.84
W-BAND POWER AMPLIFIER	10.00	3.50	1.90	2.10	50.00	8.4	4.20
W-BAND LNA	2.00	0.66	0.22	0.13	3.00	8.4	0.25
K-BAND UP/DOWNCONVERTER	8.50	5.40	0.90	1.90	18.00	8.4	1.51
K-BAND POWER AMPLIFIER	10.00	3.50	1.90	2.10	50.00	8.4	4.20
K-BAND LNA	2.00	0.66	0.22	0.13	3.00	8.4	0.25
S,K,W-BAND DIPLEXER	6.00	4.00	3.00	1.50	0.00	25.2	0.00
Subtotal				9.86	144.00		12.09
GRAND TOTAL				32.50	349.31		87.30
ANTENNA REQUIREMENTS							
S,X-BAND OMNI ANTENNA	8.00	7.00	7.00	1.50	0.00	100.0	0.00
S,X-BAND OMNI ANTENNA	8.00	7.00	7.00	1.50	0.00	100.0	0.00
24" DISH DUAL BAND ANTENNA	24.00	24.00	12.00	10.00	20.00	26.4	5.28
24" DISH TRI-BAND ANTENNA	24.00	24.00	12.00	10.00	20.00	25.2	5.04