MODULAR SURVIVABLE SATELLITE SUPPORT

Robert E. Wagner
Ford Aerospace & Communications Corporation
1260 Crossman Avenue
Sunnyvale, CA 94089-9833

ABSTRACT

National defense strategies rely on force enhancement, space defense, space control and space force application functions being provided by survivable space resources. The ground command and control support for these functions must be at least equally survivable. An approach to meeting these ground survivability requirements is presented in this paper.

A highly mobile satellite control system is presented incorporating recent technology advances into a modular design that satisfies a wide variety of user requirements in all levels of conflict. Ground/Air Transportability is enhanced significantly by the incorporation of monolithic phased arrays and miniaturized Tracking, telemetry and command (TT&C) equipment and data processing hardware. Hardness is enhanced by the incorporation of new materials and an advanced structural design that protects against EMP, blast thermal effects and terrorist activities. A preliminary design is described that indicates how modularity supports a spectrum of expected operating scenarios.

INTRODUCTION

National policy directs that space programs provide functional survivability and endurability commensurate with their missions (Presidential Directives 37 & 42 and JCSM 142-83). Figure 1 shows the initial network architecture designed to meet the objectives of this space policy.

For the ground support element, proliferation and mobility, supplemented with hardening and other countermeasures, are the most feasible techniques for enhancing survivability. For this reason, several transportable/mobile ground support systems are already under development or planned for development to provide backup to critical functions. One of the most capable, survivable satellite control systems being built is the Transportable, Mobile Ground Station (T/MGS) that incorporates mobility and EMP protection with other basic survivability measures.

The T/MGS (see Figure 2) being developed by Ford Aerospace under Air Force contract is capable of providing survivable, enduring satellite health and status support through a well defined set of threats.

T/MGS provides:

- Satellite acquisition and tracking
- Telemetry data reception and processing
- Command processing and transmission
- Data storage and routing
- Communications

T/MGS is transportable via C-141 or C-5A aircraft and can be driven over surfaced or gravel roads at normal speeds. It carries its own environmental control unit (ECU) and can be powered by two 60 kw mobile generators.

T/MGS survivabi1ity features are its EMP hardening and its mobility. It can be activated for full operation in less than 4 hours and deactivated to a road transportable configuration in less than 3 hours.

GROUND SUPPORT SURVIVABILITY ISSUES

In general there are many significant issues that need to be addressed during the design of survivable ground support systems. These include:

- What information/capability must survive? What functions need to be provided?
- What is the accepted threat scenario? Operations concept?
- Need for air, land, sea mobility (embedded system)
- Air transportability (when and what type?)
- Dedicated vs. common user/operational incompatibility
- Survivable combination of satellite autonomy and ground station enhancements
- Integrated Logistics Support (ILS)/Life Cycle Cost (LCC) Considerations

There are inherent incompatibilities in addressing these issues. For example, as the number of functions to be provided increases, the system development cost increases. Increased survivability also usually results in increased costs. Often there is no accepted threat scenario and associated operations concept. The desire for optimized dedicated systems results in operational incompatibility and increased logistic support costs.

However, applying technology advances to existing mobile system designs, we can address many of these issues in a balanced manner. New designs can be nuclear hardened as well as highly mobile. New designs (both dedicated and common-user) can be based on a common core unit that allows common Integrated Logistics Support (ILS) and thus reduces Life Cycle Cost (LCC). The following sections indicate an evolutionary system design that starts with the existing T/MGS and addresses the above issues with increasing effectiveness.

INCREMENTAL IMPROVEMENT - PHASE 1

By applying new and existing technology to the existing T/MGS design, room can be made available for additional functional capabilities. Examples of the capabilities that could be added within the same overall configuration to form a modified T/MGS are:

- Remote operation of T/MGS as a telemetry and command bent pipe station. (No operators required on site)
- Automated main beam acquisition of satellites
- Collect and forward wideband telemetry
- Automated update of data bases
- Jam resistant SHF communications
- Meteor Burst Communications
- Advanced communications techniques at HF and VLF
- EHF-Milstar capability
- User-Dedicated telemetry processing system in place of Data System Modernization (DSM)-common user processing system

A modular design concept offers the opportunity to standardize on functional modules without restricting the systems that can be built from these standard modules and without restricting growth of the modules due to new technology application. Figure 3 is an example of how modules that offer common logistics support can be put together in different configurations to satisfy a diverse set of customers.

T/MGS is already modular to the extent that it contains a bent-pipe SGLS tracking station and external communications as its core. To that core is currently added a DSM-based common user processing system, but a user dedicated telemetry processing system could be substituted. Figure 4 indicates the space available for telemetry processing equipment.

Modularity addresses the ILS issue and reduces LCC. It is conservatively estimated that 70% of the recurring and sustaining costs of a typical system involved in the support/ control of military space resources is for common core and associated support equipment. This common core element is composed of the hardware/software that provides satellite TT&C, communications to interfacing functions, and the van, tractor, ECU, generators, etc. associated with providing these functions. (See Figure 5.)

The health and status telemetry processing equipment accounts for about 10% of the total system recurring and support cost. This equipment could be added to the core T/MGS system as an option.

Dedicated, unique mission processing equipment comprises about 20% of the total system recurring and support cost. This equipment could be provided in another facility. Using the same core system for all relevant applications allows for real cost savings during the lifetime of these systems. A serious problem with any mobile system is its logistic support, and for a survivable war-fighting system this is further complicated by the vagaries of crises. The use of common logistics pipelines, support bases and, if necessary, caches as shown in Figure 6, would greatly simplify and reduce costs from that of a multi-system, multi-logistics support architecture.

Thus some of the operational issues are answered by the flexibility of a modular design, a core unit and the capability of remote operations.

INCREMENTAL IMPROVEMENT - PHASE 2

For systems that require a high degree of hardness and/or additional mobility (15 min. set-up or tear-down to/from operational state), other technologies need to be applied to those already resident in the upgraded T/MGS. Modularity is still the key that allows the user to choose the degree of endurance and the extent of functions to be provided. Those modular systems that form the insides of an upgraded T/MGS can be put inside a new van. This basic system is called a Modular Survivable Satellite Support (MS^3) System.

The core MS^3 system consists of a 40-foot hardened van with the same multimedia communications subsystem as in the modified T/MGS, (see Figure 7) . Mobility is provided by a hardened diesel tractor with self contained power and environmental control sources for the core MS^3 system, (see Figure 8) . Sufficient hardening is provided to withstand expected overpressure, thermal blast, and electromagnetic pulse (EMP) levels.

Set-up and tear-down times are reduced significantly thru use of a planar array for SGLS telemetry and a phased array for X-band communications. There is, as a consequence, more space inside the van for optional processing equipment or for living quarters. The equipment is miniaturized and more reliable thru use of VHSIC technology. Power consumption is significantly reduced. Thus the future MS^3 system brings increased survivability thru hardening, reduced set-up/tear-down times and increased performance thru use of VHSIC technology.

CONCLUSION

T/MGS is real and adaptable to a wide spectrum of operation scenarios involving common user or dedicated support applications. However, by applying new & existing technology to this mobile satellite control system, we can produce an evolutionary approach that is increasingly effective in addressing the survivability issues that are being discussed today. Thus, there is no need to commit today to many unique designs that only support one associated program each. Instead, a committment to a modular core unit design that allows the user to choose the degree of endurance and the extent of functions to be provided and allows for new technology growth to be easily incorporated provides the flexibility and low LCC needed to support uncertain future requirements and operating environments.

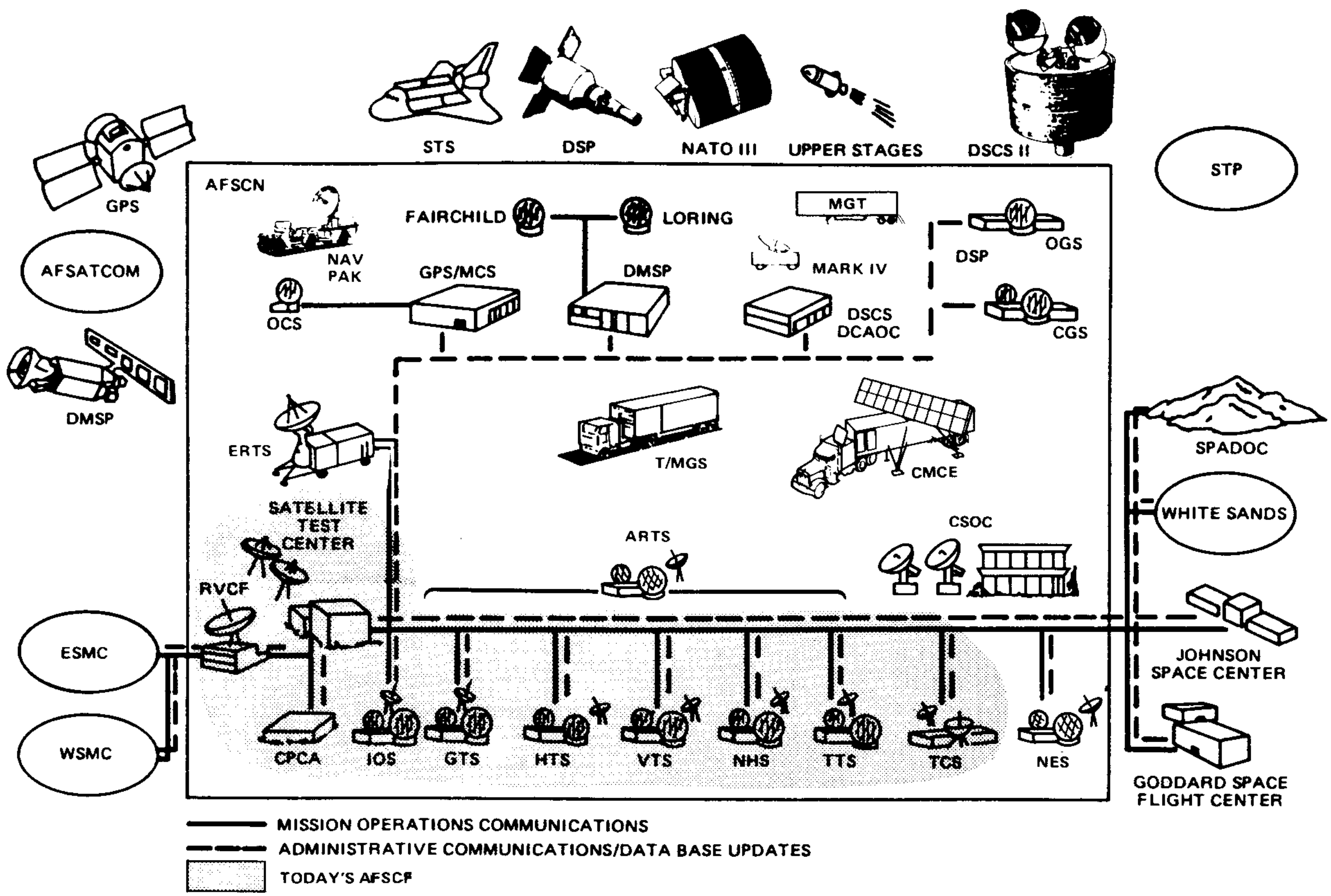

Figure 1. Air Force Space Control Network

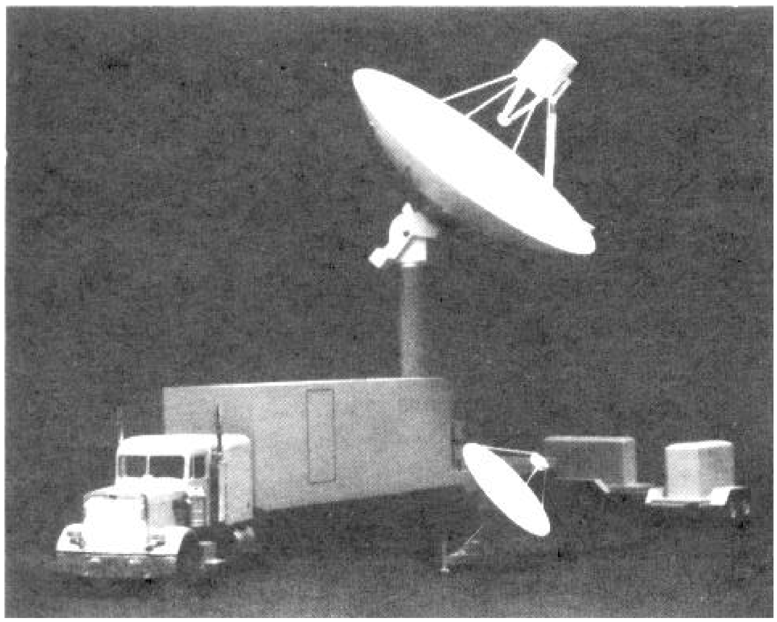

Figure 2. T/MGS Deployed Configuration

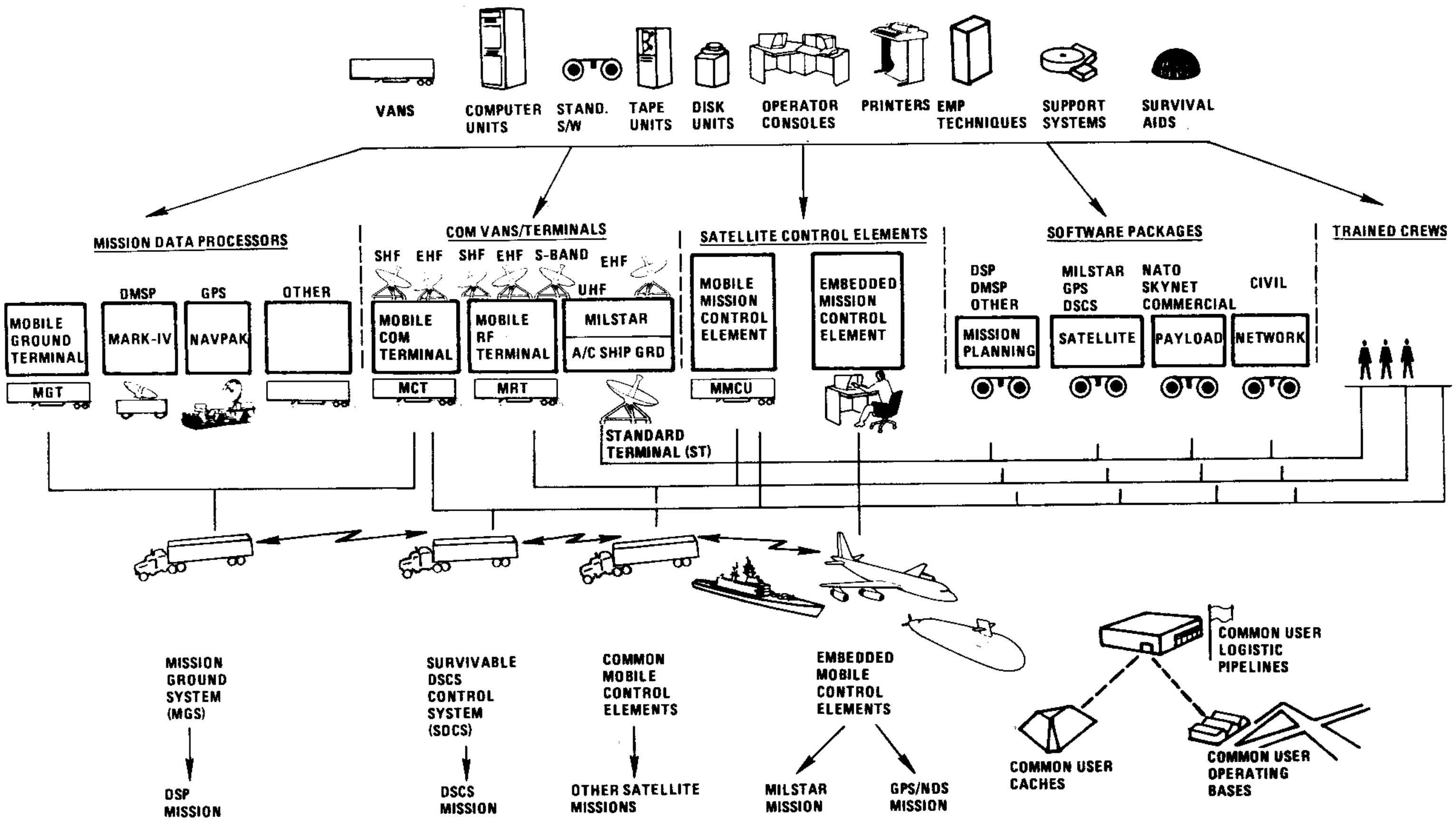

Figure 3. Modules Provide Flexibility

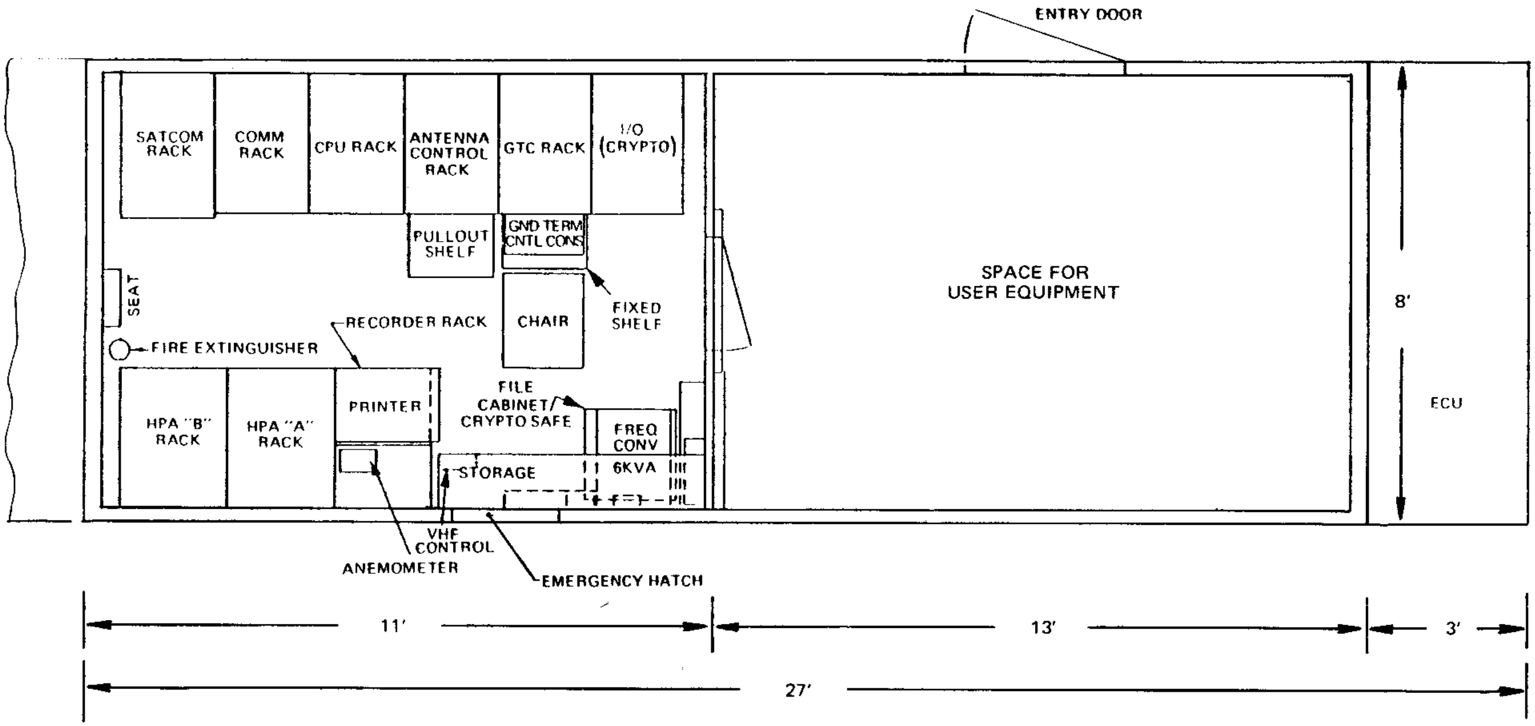

Figure 4. T/MGS Van Layout

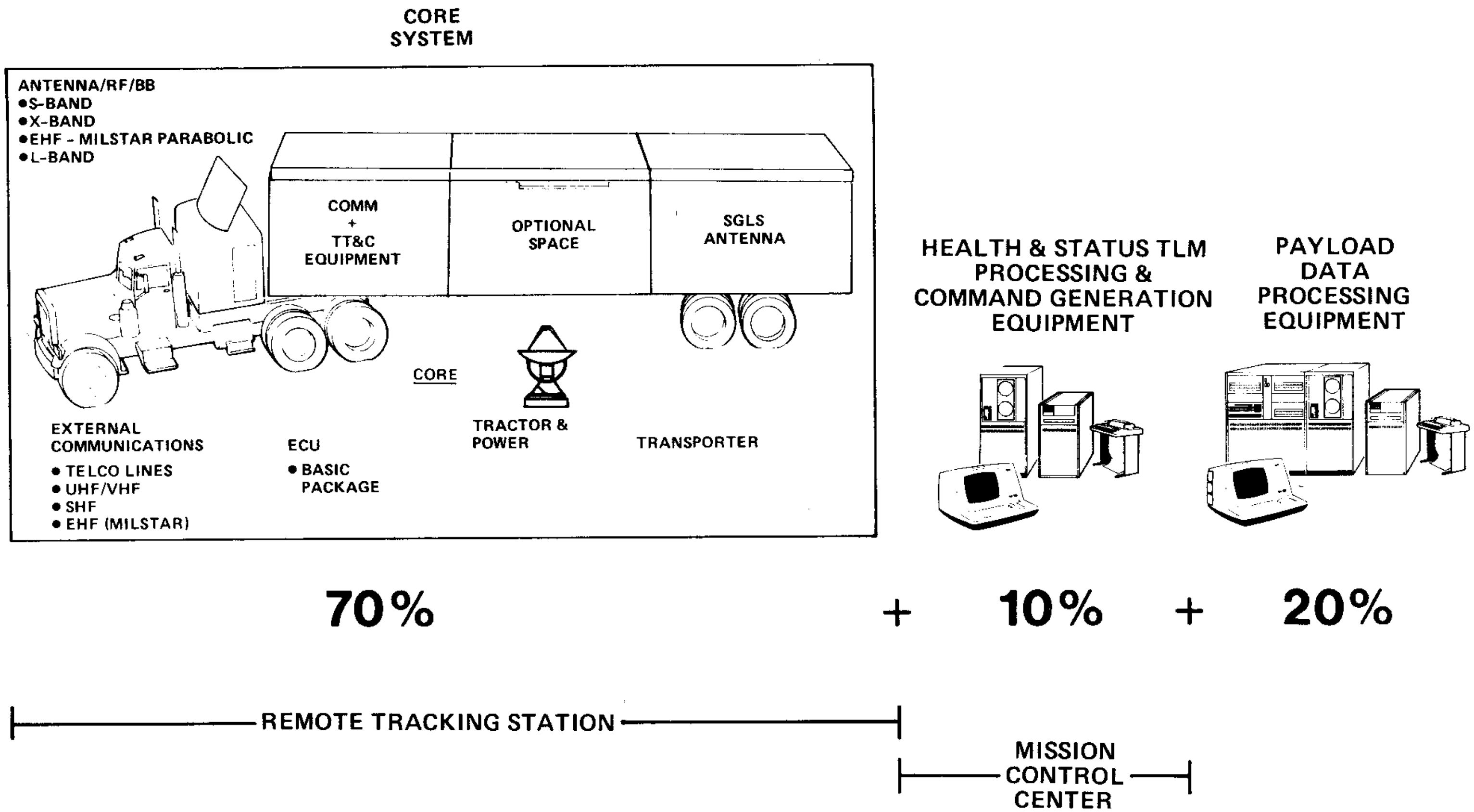

Figure 5. Acquisition and Support Costs

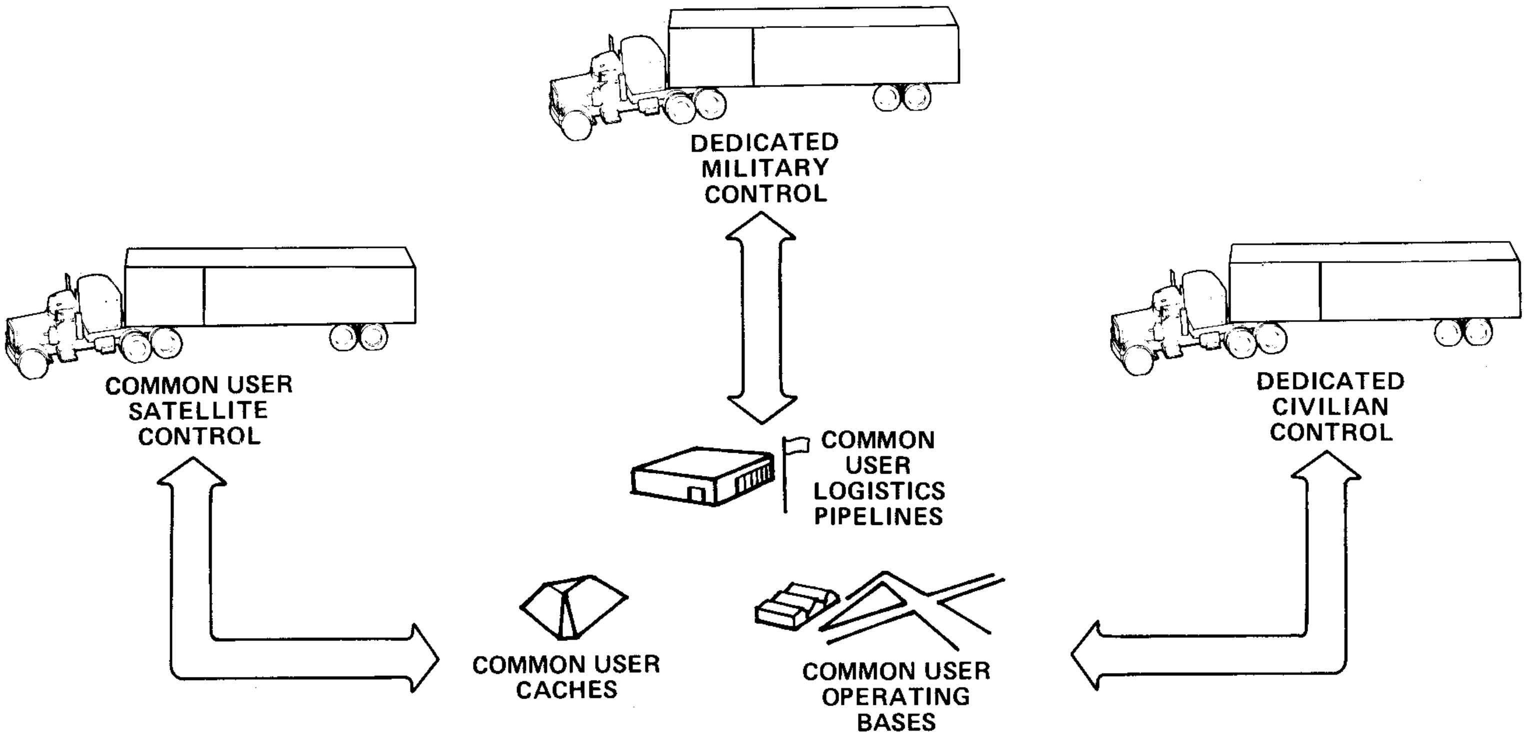

Figure 6. Common Logistics Support

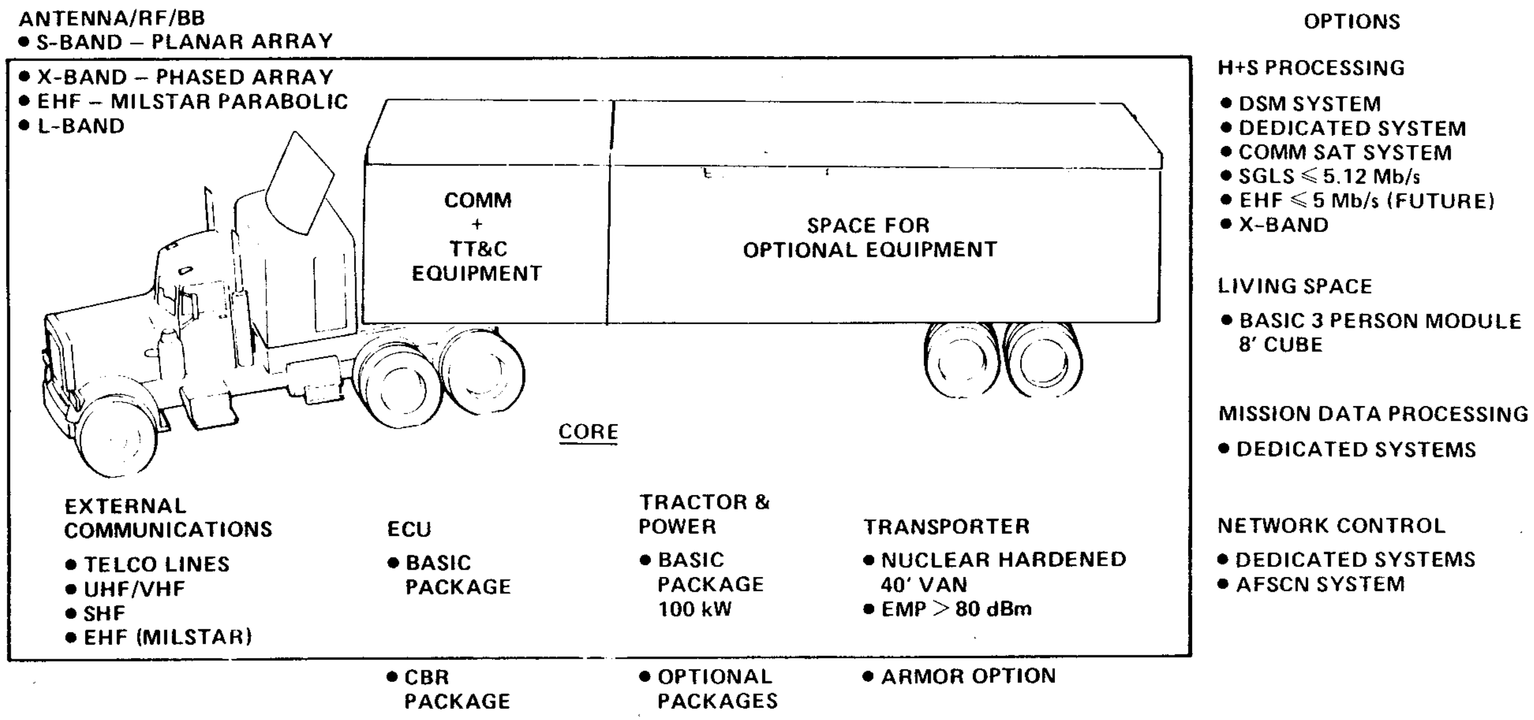

Figure 7. MS^3 Modularity Options

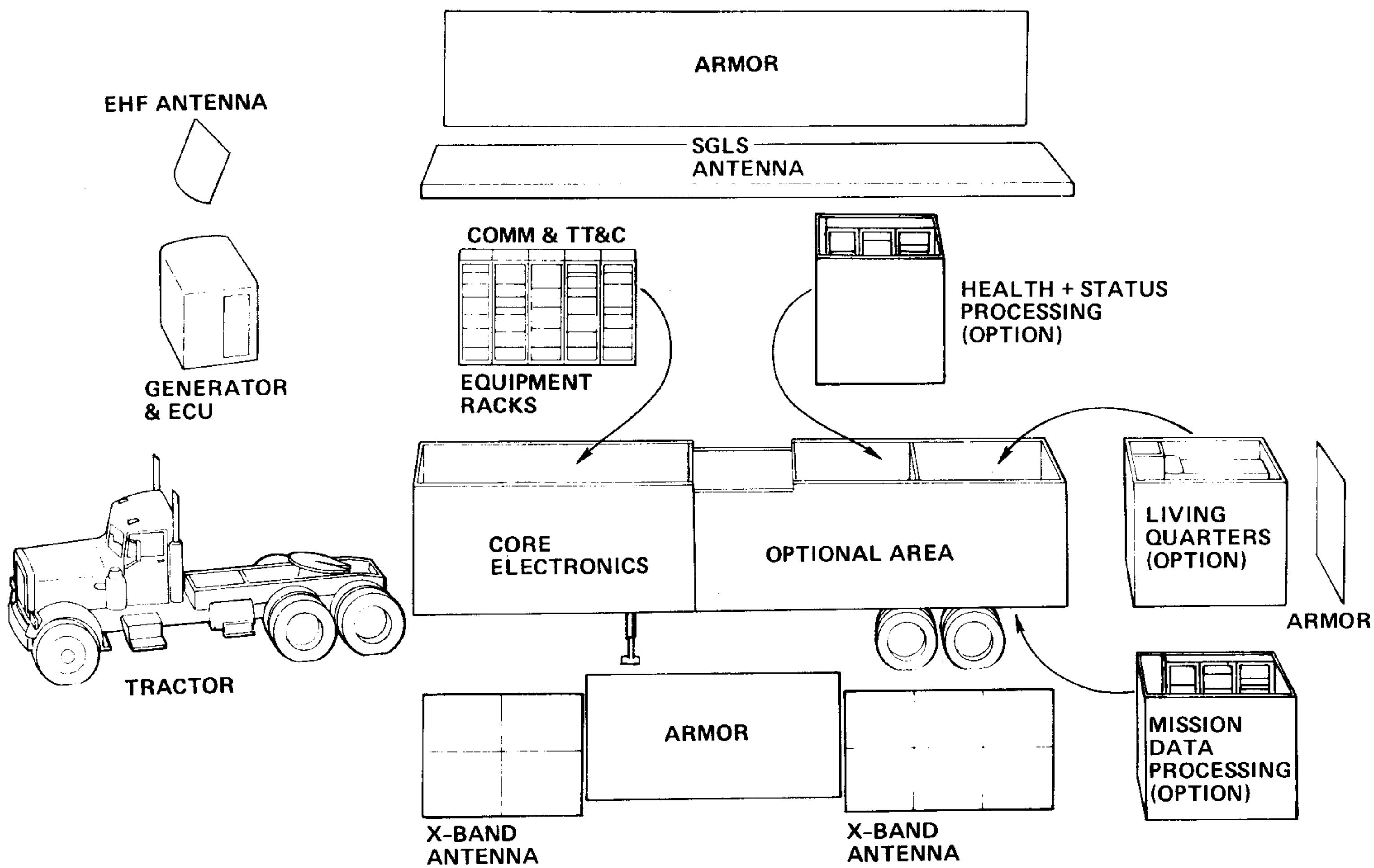

Figure 8. MS³ Modularity