DEVELOPING COMPUTERIZED, MOBILE TELEMETRY DATA PROCESSING SYSTEMS

Mike Cunningham
Systems Engineer
Physical Science Laboratory
New Mexico State University
Las Cruces, NM 88003

ABSTRACT

In today's world, the fixed telemetry ground station is giving way to the mobile telemetry ground station. More and more systems are being developed to take advantage of mobility, allowing the ground station to be deployed to the testing area. To accomplish this, the Physical Science Laboratory (PSL) has developed methods to design mobile facilities to house modern, computerized telemetry stations that not only ensure equipment survivability, but also take into account the ergonomic considerations that are vital to operator performance.

INTRODUCTION

This paper addresses the design of mobile shelters that house equipment not specifically intended for mobile environments. Such shelters must provide heating, cooling, power, and lighting; i.e., all the functions of a normal computer room must be contained within the shelter.

SHELTER DESIGN

Equipment that is not designed for the mobile environment must be protected when installed into a mobile shelter. To provide this protection, either the equipment racks or the shelter itself must be shock-mounted for travel. PSL has discovered that the "cleanest" and most simple way to accomplish this is to shock-mount the complete trailer. For dry-freight type vans, "shock-mounting the trailer" is as simple as ordering the trailer with air-ride suspension. Air-ride suspension provides protection not only for the equipment mounted in the racks but also for all other equipment and systems mounted within the shelter; storage cabinets, air conditioners, lighting, and power control equipment survive the mobile environment much better in an air-ride trailer. Of course, an air-ride tractor must be used to properly protect the equipment.

The exterior view of a typical PSL-designed shelter is shown in Figure 1. Tie downs on the external surface of the shelter are used for shipping the shelter by air, rail, or boat. Large storage boxes attached to the underside of the shelter hold spare parts, tools, and other items that do not require a conditioned environment. Steps and entrance platforms store beneath the shelter during travel . Landing gears at the rear of the shelter are used for leveling or stabilizing the shelter. Weatherproof signal interconnection panels are recessed into the shelter wall for external lines that must enter or exit the shelter. Other arrangements for cabling, such as tubes through the bottom of the van, have been included in some shelter designs.

All shelters tend to be custom-designed; hence, there is no “typical” interior floor plan. Figures 2 through 4 illustrate the layout for a mobile, computerized telemetry station designed and constructed by PSL. All the cabinets are custom-designed to make the best use of the space available. Dual air conditioners provide back-up environmental control in the event of the failure of one of the units. Air registers are located over each equipment rack and in the operations area. Dimmer-controlled, fluorescent lighting allows the lighting to be adjusted to the work conditions.

Because small spaces are a necessary evil of the mobile shelter, extra consideration must be given to operator comfort. Colors are selected to reduce fatigue and tension. Sound proofing, within mechanical and economic constraints, is high on the list of ergonomic requirements. PSL accomplishes sound-proofing in its shelters by constructing the interior walls with a commercial-grade, tight-loop carpet installed over a thick plywood backing. This technique significantly reduces noise levels while at the same time giving a glarefree, appealing, long-wearing, low-maintenance finish.

The interiors of PSL-designed shelters can be easily reconfigured because of the use of unistrut channel. Unistrut, a material commonly used in the construction industry, is installed at various heights along the interior walls to mount equipment and cabinets while allowing flexibility in their placement. Because the unistrut is riveted directly to the wall support structure, it provides structural strength to the shelter as well as a convenient and rugged mounting device. When the shelter is being prepared for travel, hooks can be screwed into the unistrut to secure various pieces of equipment that are not mounted into the racks or the cabinets. PSL normally paints the unistrut satin black, thus creating a distinct delineation between two tones of carpet on the walls.

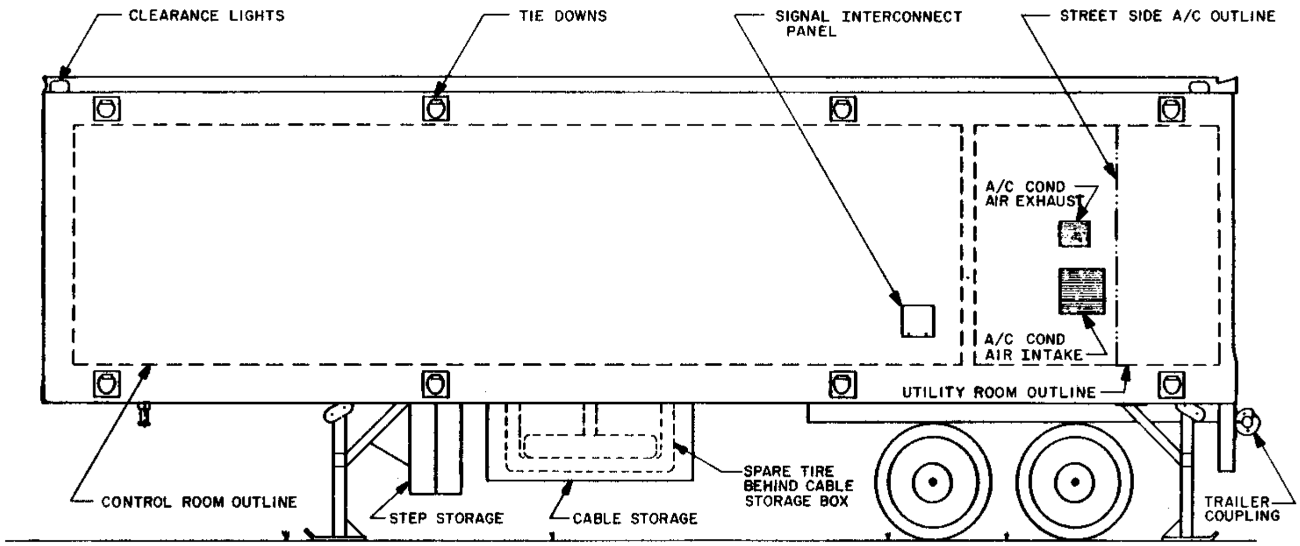

Figure 1 Exterior View

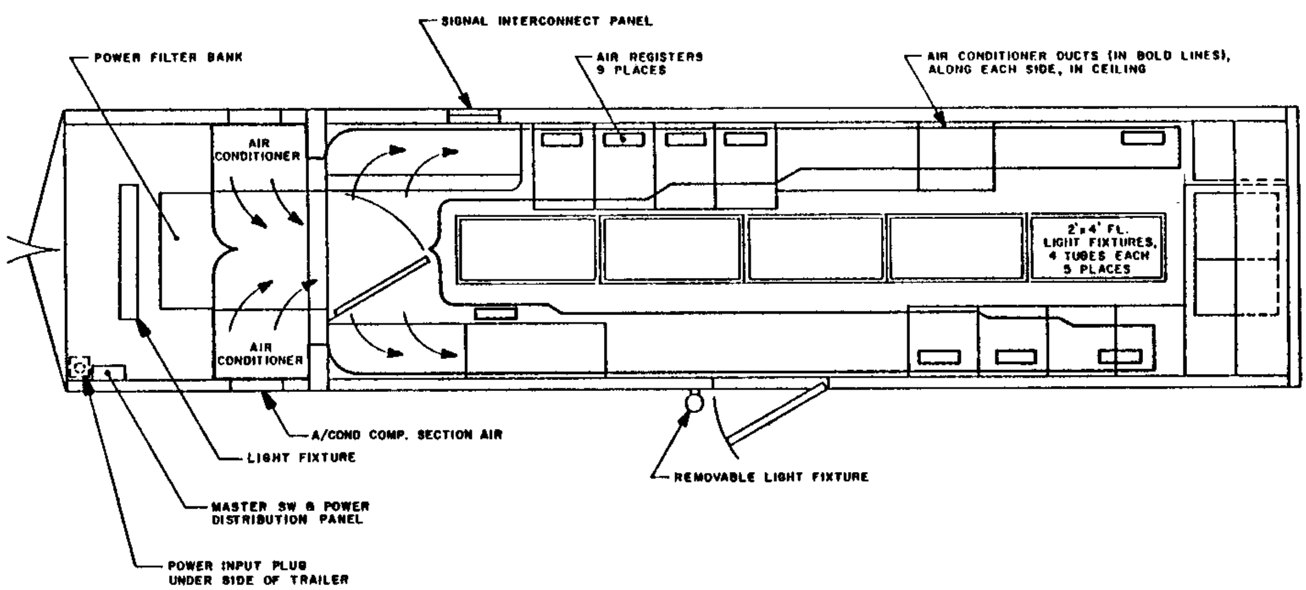

Figure 2 Floor Plan

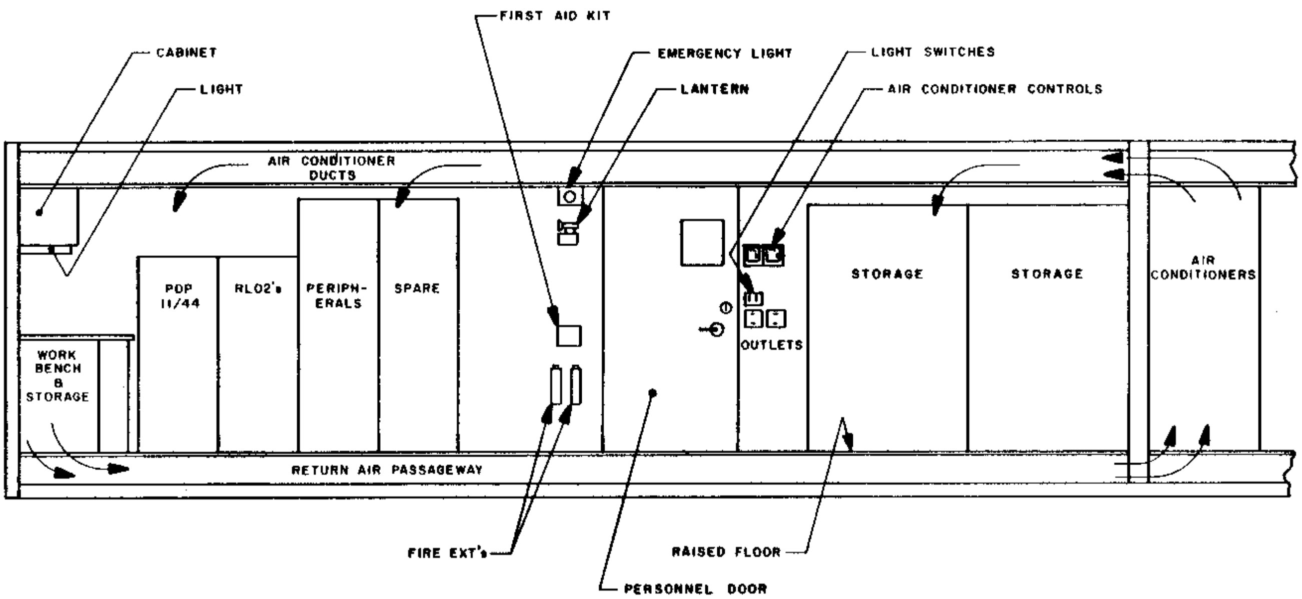

Figure 3 Curbside Interior

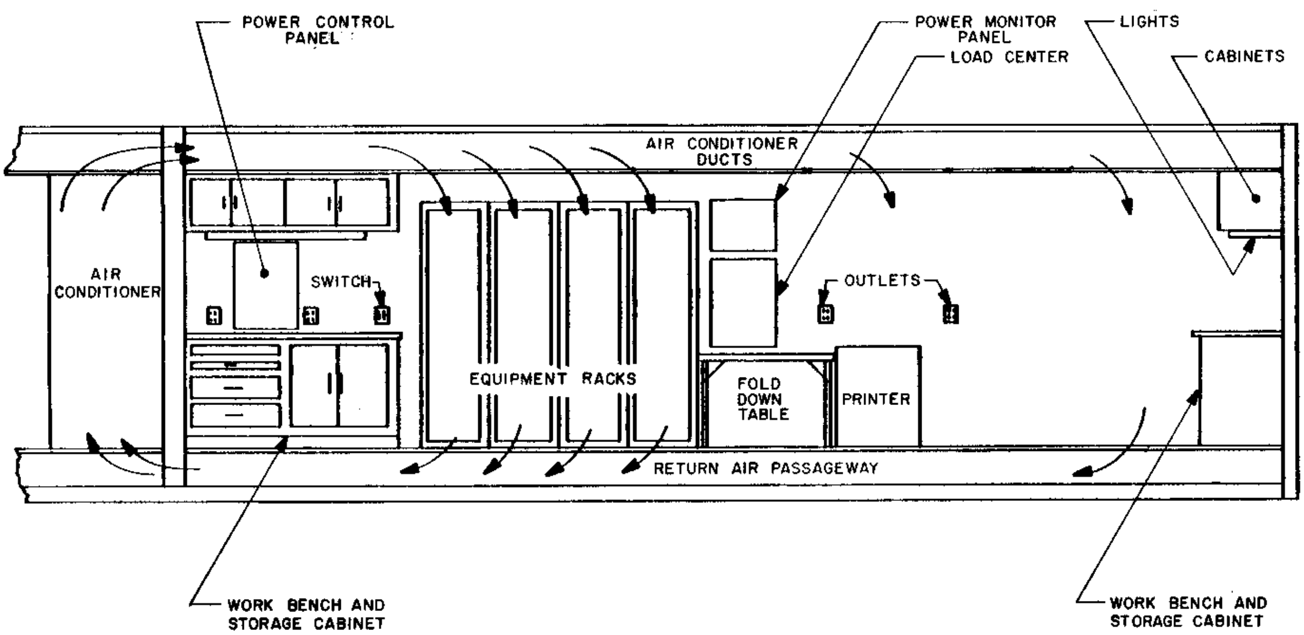

Figure 4 Streetside Interior

The construction of the floor in PSL-designed shelters is similar to that used in computer room floors. Support beams under the floor run the length of the shelter and effectively divide the underfloor area into five areas for electronic and power cables. Two narrow areas near the outside walls are used for power cables. Two larger areas just inside those used for power cables, and under what will normally be the equipment racks, contain signal cables. The signal cables drop into these “cable ways” from the racks above and then run into the center cable way through precut holes in the beams. It is desireable to keep all power cables separate from signal cables; keeping the power cables near the walls effectively does this.

A false floor constructed of thick plywood with tile covering and metal edging is laid over the floor beams that support the equipment. It is usually impossible to use standard tile sizes in all areas of the floor because of support beams for the equipment racks, cabinets, and the layout of the support beams; however, PSL usually manages to cover the center aisle of the floor with standard, two-foot square tiles. The center aisle in a typical PSL-designed shelter provides access to the electronic cable ways.

The Laboratory has discovered that carpeting on the floor of a mobile shelter does not maintain its appearance nearly as well as commercial-grade floor tile. The floor of a mobile shelter with direct access to the outside environment is subject to conditions that tile is better suited for than carpet. Besides being more durable than carpet, tile is also easier to clean than carpet and eliminates static that is usually associated with carpet and hard sole shoes. The tile is protected from static problems with an anti-static wax.

The majority of PSL-designed shelters include a utility room separate from the operations area of the shelter. The utility room is sized according to the space required for the power equipment and the air conditioning system. This applies only to shelters large enough for a separate utility room area. Smaller shelters must have air conditioning equipment mounted externally to the enclosure. Mounting the air conditioning equipment in a utility room removes the equipment from the harsh external environment and reduces maintenance costs and time. The utility room also provides a convenient area for equipment that is not desirable to have in the operations area. Power conditioning equipment, motor generators, or equipment that is too large to be stored beneath the shelter can be placed out of the way in the utility room. Placing such equipment in the utility room isolates any associated equipment noise from the operations area.

POWER SYSTEM

The power system in a PSL-designed mobile shelter is very similar to the wiring in a commercial building. All power wiring is run in metal conduit. All interior shelter circuits run to a power control panel that is conveniently located inside the shelter. Separate circuits are provided for each equipment rack or major piece of equipment, such as computers or tape drives. Each electrical outlet is labeled with a circuit breaker number and voltage and frequency information. Each circuit breaker in the power control panel is numbered. Attached to the inside of the panel door is a description of what each circuit breaker powers. This circuit identification allows operators and maintenance people to shut down equipment at the source for operation or safety reasons. All interior power panels are color-coordinated to match the equipment racks or other trim.

The main input power and distribution panels are installed in the utility room at the rear of the van (Ref. Figure 2). To avoid confusion and to prevent safety hazards, these panels, like the power control panel inside the shelter, are clearly labeled according to their function. The utility room power panels also provide power to the air conditioning, heating, and power conversion equipment. Because these rear panels are surface-mounted with all conduit exposed, any necessary modifications or expansion can be easily accommodated.

Input power to the shelter can come from motor-generators that are integral to the shelter or through power cables that connect to external sources. Power cables, when used, can be stored either in boxes beneath the shelter or on cable reels. One satisfactory arrangement from an operator standpoint, is to use a cable reel with slip rings. Such a configuration alleviates the operators having to unreel the entire cable and plug a connector into the shelter; only the required amount of cable is unreeled when using the slip ring arrangement. This is especially important on shelters that have 200-amp service and require a 100-foot cable that weighs approximately 500 pounds.

ELECTRONIC CABLING

Cabling for electronic equipment in a mobile environment has more than the normal constraints placed upon it. Cables, because they must be placed in tight areas, must be rugged without being cumbersome. The cables must be reliable, yet not cost-prohibitive. Also, vibration is a problem in mobile environments. There is a higher probability of cable failure in a mobile environment than in a fixed installation, regardless of the configuration selected; therefore, when cable failures do occur they must be easy to troubleshoot and to repair quickly.

PSL has responded to these constraints by using various forms of ribbon cable for the digital signal lines. The impedance of the ribbon cable is close to the impedance that most line drivers use in digital circuits. By carefully observing impedances of cables and minimizing transitions to cables of different impedances, a designer can maintain signal quality while at the same time minimizing errors that are caused by reflections at the cable connection points.

In many cases, a piece of equipment will use some form of “twisted pair” cable to get to the rear panel connector, thus making it possible to use a form of ribbon cable that uses individual twisted pairs. This is ideal in those situations where signals and grounds are twisted together.

Ribbon cable has specific advantages. The quick, simple termination that is possible with ribbon cable dramatically reduces construction time and troubleshooting time that can be attributable to technician errors in building the cables. Ribbon cables also are much easier to verify. When ribbon cables are damaged, they can be repaired very quickly in the field. In situations where a system needs to be reconfigured or expanded, cables that use mass termination style connectors on both ends can be rebuilt simply and cheaply.

Although it may seem a small part of the whole, cabling can be the most frustrating of all situations in a large mobile system. Poor cable design can lead to intermittent cable failures that are nearly impossible to locate and correct. If a system is not reliable, its value can be seriously questioned. In areas under the shelter floor, or in any areas where cables might be subject to chafing when the shelter is in motion, the cables are protected by either using a cable with a thick jacket or installing a protective jacket over the cable. This jacket is available in a number of sizes, shapes, thicknesses, and styles (including shielded and unshielded), and can be “zipped” over the cables after they are fabricated and tested.

Typically, the cables under the floor enter and exit the equipment racks through a connector manifold. The manifold provides a convenient place to break into a cable for troubleshooting and allows the cable to be replaced without extensive unlacing and relacing of cables in the rack itself. A connector manifold also allows another very important thing to take place: the equipment bays can be built up, wired, and completely tested while shelter construction is taking place. In a matter of hours, the underfloor cabling can be removed from the build-up site, the equipment racks installed in the shelter, the cabling re-installed, and the system “up and running.”

EQUIPMENT MOUNTING

The majority of the equipment in PSL-designed shelters is slide-mounted into heavy-duty equipment racks. Mobile environments tend to require the heavy-duty racks offered by most manufacturers. Cable refractors are used in the racks to keep the wiring neat and in place. This combination of slide mounts and cable refractors allows the equipment to be pulled out from the equipment rack and opened for adjustments and repairs, without having to remove it from the rack or obtain access to the rear of the rack. If the equipment does have to be removed, the slides make that operation easier, also.

All wiring in equipment racks is tightly laced to the cable refractors to alleviate stress on the rear panel connectors and cables. The transition from cable to connector is a weak point and special care should be taken to protect this junction in mobile installations.

For heavy equipment, extra reinforcement should be installed. This might entail installing extra rails in the racks so that loads will be placed directly on the rails rather than through extenders that may weaken and collapse under severe road conditions. Very heavy items, such as large tape drives, may require extensive bracing, depending on the quality of the equipment rack in which they are mounted. Extra fasteners are often necessary to prevent heavy items from sliding out of the rack during transit. These precautions apply especially to tape drives that are normally held in place with 10-32 screws.

EMI CONSIDERATIONS

Electromagnetic interference (EMI) is a growing concern for many projects, especially those projects that involve any reasonable kind of security. A mobile shelter can be as "Secure" as a fixed installaion, as far as RF leakage is concerned. Essentially, to make a mobile shelter EMI-proof involves plugging all holes where RF can leave or enter the shelter. To what extent this "plugging" needs to be done depends upon what RF frequencies need to be blocked.

For EMI-resistant shelters, PSL rivets in a heavy-gauge metal floor pan and tapes all seams with a commercial EMI tape. If very high frequencies must be blocked, the wall seams are also taped. All power and control lines into and out of the equipment go through RFI filters that prevent the passage of noise into or out of the shelter. Doors are specially designed and use stainless frames to maintain a low-resistance surface. All air conditioning air ducts have RFI filters installed and any windows designed into the shelter use a commercially manufactured filter to prevent RF leaks.

SUMMARY

The integration of a mobile electronics shelter requires a carefully thought-out plan of action to ensure that all facets of the shelter operate properly. The result is a shelter that is satisfying to work in, simple to move, and easy to maintain.

The mobile shelter solves a number of problems associated with disperse test sites. It eliminates the need to ship data back and forth across the country, dramatically reducing turnaround time. This capability obviously reduces testing costs by cutting the amount of "dead" time operators normally would spend waiting for test results.

Mobile computerized telemetry systems will continue to be an effective way to minimize testing costs and maximize equipment use.