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UNIVERSAL SAFEGUARD CAB (IDLER LOCOMOTIVE CAB)

CONCEPT DEVELOPMENT

Volume II: Demonstrator Alternatives and Implementation

Trans Systems Corporation, Vienna, Virginia

June, 1978

FINAL REPORT

Prepared for

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16. Abstract

Volume II of this report presents analyses of seven different demonstrator configurations, four in the hi-rail dual mode, and three in the rail-bound mode. The examination of the alternatives was carried out in terms of four main criteria: fidelity to the concept of the Universal Safeguard Cab, demonstration credibility, ease of transportation, and cost-effectiveness. The rail-bound Universal Safeguard Cab built on a flat car type of chassis with hostling capability was the final selection. It was determined that the demonstration vehicle should be 60% functional and 40% simulated. The demonstration plan and schedule are laid out; and the institutional problems of the demonstration are assessed.

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PREFACE

Trans Systems Corporation has prepared a two-volume study of Universal Safeguard (Idler Locomotive Cab) concept development. Volume I is a trade-off analysis of alternative locomotive cab concepts, originally conceived in the three-volume Report No. FRA/OR&D-76/275 by Boeing Vertol. Volume II describes the evaluation of demonstrator alternative configurations (four hi-rail dual-mode and three rail-bound), and includes an implementation schedule, design constellations, and operating procedures. Associated subcontractors include the Boeing Vertol Company; Mr. Frank Fisher, P. E., of STV Inc.; and Messrs. G. W. Maxwell, P. E., Everett Weston, P. E., and Frank Kurz, P. E. The project was sponsored by the Federal Railroad Administration (FRA) of the U. S. Department of Transportation.

The objectives of this study have been to foster the latest crew module concepts; to identify the basic alternative demonstration vehicle that meets the criteria of operational practicality, cost effectiveness, and industry acceptability; and to determine how best to demonstrate the chosen alternative through design, layout, and implementation.

The authors appreciate the guidance and support given by the following FRA personnel: Mr. Robert M. Clarke, Program Manager; Mr. Donald Levine, Division Chief of Rail Vehicle Safety Research; and Mr. F. L. Mayronne, the Contract Specialist.

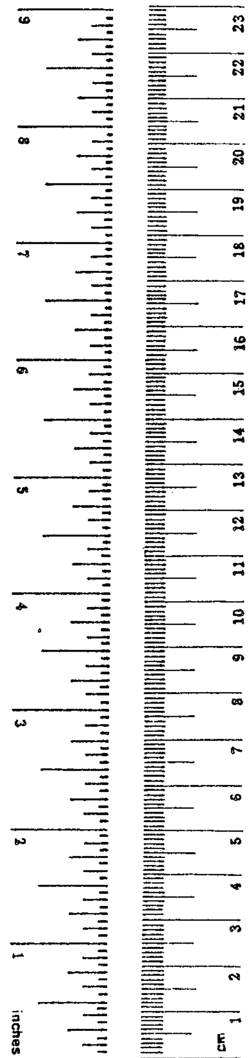
The study would not have been possible without the cooperation of many government officials, railroad operators, and system suppliers in the United States and abroad. The significant contributions of Boeing Vertol personnel, Messrs. William McLean, John Robinson, Edward Widmayer, M. J. Riley, J. M. Byrd, and D. Piccione are acknowledged.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
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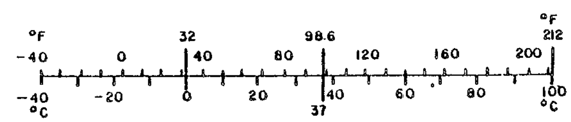
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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EXECUTIVE SUMMARY

This report (Volume II of the study)* covers Phase II of the FRA contract for the Idler Locomotive Cab concept development. It involved analysis of seven possible configurations for Alternative A selected in Phase I. These seven forms are:

- Hi-Rail

  1. A hi-rail vehicle built to highway legal dimensions
  2. A hi-rail vehicle that expands from highway dimensions to railroad dimensions
  3. A hi-rail vehicle built to railroad dimensions
  4. A motor vehicle chassis -based vehicle built to railroad dimensions, carried on a flat-bed trailer

- Rail-Bound

  5. A rail vehicle built on a maintenance-of-way (MOW) based chassis with motive power
  6. A rail vehicle built on a flat-car chassis with hostling capability
  7. A rail vehicle on flat-car type chassis with no motive power

The study in Phase II resulted in the conclusion that hi-rail vehicles (Alternatives 1, 2, 3, and 4) would not be suitable. Alternative 1, although of proper size for highway travel, would not be of sufficient size and weight for safe railroad operation. Alternative 2 would require costly expansion mechanisms that add no benefits to the concept. Alternative 3 vehicles of railroad locomotive size would have great difficulty finding highway routes that are passable and that accept a vehicle of such size. Alternative 4 presents size problems even greater than those of Alternative 3 because of the additional size of the supporting trailer.

Alternative 5 was eliminated because no benefit could be found utilizing a maintenance-of-way chassis rather than a more conventional locomotive or flat-car chassis. Furthermore, a full-power version has been ruled out in the U. S. Cab concept development.

Alternative 6 appears to be preferable to Alternative 7, since the U. S. Cab built on a flat-car-type chassis with hostling capability minimizes the additional costs and arrangements needed to move the demonstrator. The hostling capability with a high-capacity battery-driven motor increases the versatility and credibility of the demonstrator.

* Volume I is entitled Trade-off Analysis of Alternative Locomotive Cab/Demonstrator.

The final work in Phase II of the study showed that the demonstration vehicle should be partly functional and partly simulated. A 100% functional vehicle would require modification to trailing locomotives and certain railroad systems and equipment. For demonstration purposes, it is not practical to implement these modifications. A vehicle that is approximately 60% functional can operate with current locomotives and railroad equipment. Some 40% of the locomotive equipment can be simulated, and thereby result in a highly effective demonstration at a lower cost than a 100% functional vehicle.

RECOMMENDATIONS

The benefits accruing from the U.S. Cab are obvious and many. The immediately visible ones are decisive improvements in crew functionality, comfort, and safety resulting from reduction in the noise, vibration, and fumes of existing locomotive engines. The interrelated improvements in crew working conditions, resulting from streamlined and functional facilities and modern technology, are enhanced by increased railroad productivity. There are also improvements in special run-through train services and versatility in yard operations. The U.S. Cab can give railroads a competitive edge relative to other modes of transportation and can enhance the railroads' ability to reach new markets.

Three specific recommendations are made:

1. Produce a prototype state-of-the-art Universal Safeguard Cab as described in Volume I.

2. Demonstrate the U.S. Cab throughout the United States for testing and evaluation.

3. Update and improve the cab concept programs continuously in pace with changing technology and markets.

CHAPTER I

INTRODUCTION

This report covers work involved in the selection of the best alternative configuration mode for a demonstrator vehicle of the Universal Safeguard Cab. It can be constructed as a demonstrator in several different ways. The objective of this task was to determine the best demonstration method in terms of four considerations:

- The means that best demonstrates the concept of the Universal Safeguard Cab
- The means that is likely to be the most credible demonstration
- The means that provides greatest ease of transportation
- The means that can provide the greatest demonstration efficiency at the least cost.

The first criterion has to do with the acceptance and fidelity of the demonstration vehicle as a valid representation of a future production vehicle. The vehicle must be representative of the concepts of the Universal Safeguard Cab. This means that the demonstrator should, first of all, look like the real thing. It should be identical in as many details as possible. The greater the similarity of the demonstration and operational vehicles, the greater the fidelity to the new concept. All expected railroad equipment must be present, as otherwise questions arise about its absence. For a demonstration to be effective, it must focus on relevant equipment, functions, and processes. On the other hand, all non-related systems (such as systems involved in highway transport - steering wheel, lights, brakes, etc.) must be completely hidden, since they do not exist on the real vehicle. The more the demonstration involves non-relevant items, questions, and equipment, the less effective it is.

The second criterion involves demonstration credibility. The project team examined seven alternatives. Four were hi-rail vehicles able to travel equally well on highways or on railroads. The advantage of the hi-rail vehicle was in flexibility - being able to choose the most advantageous means of transport. The rail-bound vehicle, described in three configurations, is totally a railroad vehicle, operating only on rails, and moving throughout the country on rails. This is not an important disadvantage, since most or all demonstration sites are railroad sites.

The alternative configurations were examined in terms of ease of transportation. This refers to how easy or difficult it is to move the vehicle in terms of limitations, special permits, and routing requirements. Large vehicles cannot move under most overpasses if the vehicle is higher than 13'6"; this physical limitation in general takes precedence over the question of load permits.

One of the major limiting factors in the size of the vehicle is its dimensions. Railroad and highway vehicles generally have considerably different size dimension, since railroad vehicles tend to be of much greater size and weight than highway vehicles. Since this difference is substantial, railroad vehicles usually exceed highway limitations in terms of height, weight, width, and length. These dimensions were studied in order to determine the maximum dimensions that the vehicle could assume. Alternative procedures such as the use of special permits and expansion devices were also considered.

Basic costing factors relative to efficiency were very important considerations in determining the best demonstrator vehicle. The first element to evaluate was the demonstration vehicle construction cost. It should be noted that the costs presented represent costs for the demonstration vehicle only. Costs for a fully developed and operational Universal Safeguard Cab will be different; they will be considerably higher than those for the demonstrator, and they may not be related to it, system by system. For example, the cost for hostling power in the demonstrator will not be the same as the cost of hostling power in a completely operational unit, because the operational hostling engine may be different from the engine in the demonstrator.

Beyond the basic vehicle construction costs, additional and special costs for the different alternatives were also calculated. These special costs result from additional equipment, engineering, and systems required to make the Universal Safeguard Cab a roadworthy vehicle. Generally, no additional costs are incurred in the development, construction, and implementation of the rail-bound alternatives.

A major impact on the demonstration program is the cost of vehicle transport during the demonstration phase. Different vehicle configurations generate different transportation methods, which involve different costs. Transportation costs are critical to the demonstration program and must be weighed against the cost of the vehicle alone. The important cost is the total cost, which includes both vehicle construction and engineering costs, and the transportation costs. An example of variability is that a more expensive vehicle may be considerably less espensive to transport than a less expensive but heavier vehicle. The cheapest vehicle, if it is the most costly to transport, may not be the most cost-effective demonstration vehicle.

This report on alternative configurations for the Universal Safeguard Cab demonstration vehicle proceeds first in Chapter 2 with a description of the alternatives. Seven configurations are evaluated in terms of credibility as a vehicle, dimensions, positioning of equipment, legal and practical size limits, service and maintenance requirements, effectiveness as an operational system, transportation problems, human factors considerations, expense, and safety.

In Chapter 3, the discussion then focuses on specific factors that must be considered in evaluating the different configurations. These include mobility, size (including legal dimensions in the different U.S. jurisdictions), special handling, parking, maintenance, engineering, and demonstration credibility.

Chapter 4 concentrates on costs of the demonstration vehicle. Costs considered include both those for the vehicle itself and those for transportation and set-up. Costs are specified for elements needed whatever the specific alternative chosen and for the seven individual alternatives. A matrix (Table 4-2) at the end of Chapter 4 shows cost variables for the seven configurations.

Chapter 5 considers design criteria, including visual and tactual control identification, positioning of more and less important controls relative to the engineer's reach, color coding as cues to functions, the shaping of controls to be most easily usable, and other such design criteria.

Chapter 6 describes the demonstrator equipment, the degrees of functionality of each piece, and then the functional and institutional aspects, including the stages of familiarization and operation. Then it goes on to discuss the operating procedures, including pre-run preparation, running procedures, post-run procedures, emergency provisions, and operating scenarios.

Chapter 7 sets forth the demonstration plan and schedule for showing the demonstration vehicle in six types of operations: moving, nighttime, bad weather, grade, track geometry assessment, and short term. Detailed information is given on demonstrator itinerary and costs over the selected route. The general procedures for the demonstration at each site are given, and then the major milestones of the demonstration are set forth in a timing chart (Figure 7-2).

CHAPTER 2

DESCRIPTION OF THE ALTERNATIVES

AND SUMMARY OF FINDINGS

There are two basic possibilities for the Universal Safeguard Cab: (1) a vehicle that can travel over both highway and rails (hi-rail), and (2) a vehicle that is confined to railroad use.

Typical configurations considered are:

- Dual Mode - Highway and Rail

  (1) Vehicle totally compatible with highway dimensions and no movable/expandable cab

  (2) Vehicle with movable/expandable panels to bring it to R. R. maximum dimensions from highway maximum dimensions - still roadworthy

  (3) Highway vehicle - built to R. R. dimensions - moving on highway via special permit

  (4) Motor vehicle chassis based vehicle built to R. R. dimensions but moving on highway on flatbed trailer, under special permit

- Rail-Bound Vehicle

  (5) Dummy Universal Safeguard Cab built on MOW-based chassis with motive power

  (6) Universal Safeguard Cab built on flat-car type rail car chassis but with hostling capability

  (7) Universal Safeguard Cab built on flat-car type chassis with no motive power

Of these two possibilities, our analyses indicate that the better alternative appears to be the rail-bound vehicle. Although a hi-rail vehicle would allow more flexibility, its advantages are diminished in view of three important limitations:

- Safety problems caused by having to meet dimension limitations
- Costs involved in including dual equipment
- Permit problems and costs caused by using such a vehicle on the highways.

2.1 Hi-Rail Alternatives

In general, there are two main limitations on any highway-railroad cab.

- Weight

Railroad locomotives are designed to be heavy for a number of reasons. In order to meet the weight limitations for highways, cabs would have to be designed to be lighter. This weight sacrifice would cause problems in using the vehicle in the track mode. The weight sacrifice is necessary not only in terms of the legal allowable limits on roads, but also because of physical limitations; for instance, bridges and other structures must be capable of supporting the vehicle.

- Height

Height is also a problem. Designing the cab so that it could move under overpasses would be difficult, since typical locomotives are 15-16 feet high.

2.1.1 Three Self-Propelled Dual-Mode Configurations

Configuration (1) - Without Movable/Expandable Cab, Totally Compatible with Highway Dimensions (Figure 2-1)

From an examination of the legal limits of highway dimensions, it would be anticipated that the maximum dimensions permissible for a highway vehicle would be 8' wide, 13'6" high, 40' long, and under approximately 44,000 pounds. These dimensions would permit free and easy access within states and, thus, would permit the most effective routing of the demonstration phase.

These dimensions do not, however, properly approximate the size of the U.S. Cab demonstration vehicle. The 96" maximum width, for example, is 26" to 32" narrower than the anticipated size of the locomotive. This would require extensive re-design of the cab, and would not be representative of the true size of the Safeguard Cab.

Similarly, the 13'6" height limitation is 12" to 26" lower than the height dimension currently projected for the demonstration vehicle. The height of 13'6" for the demonstration vehicle would cause two main problems: decreased visibility, and decreased demonstrator fidelity.

Length and weight limitations are less critical at this time. Although 35' is somewhat short, it is usable for demonstration purposes. The highway weight

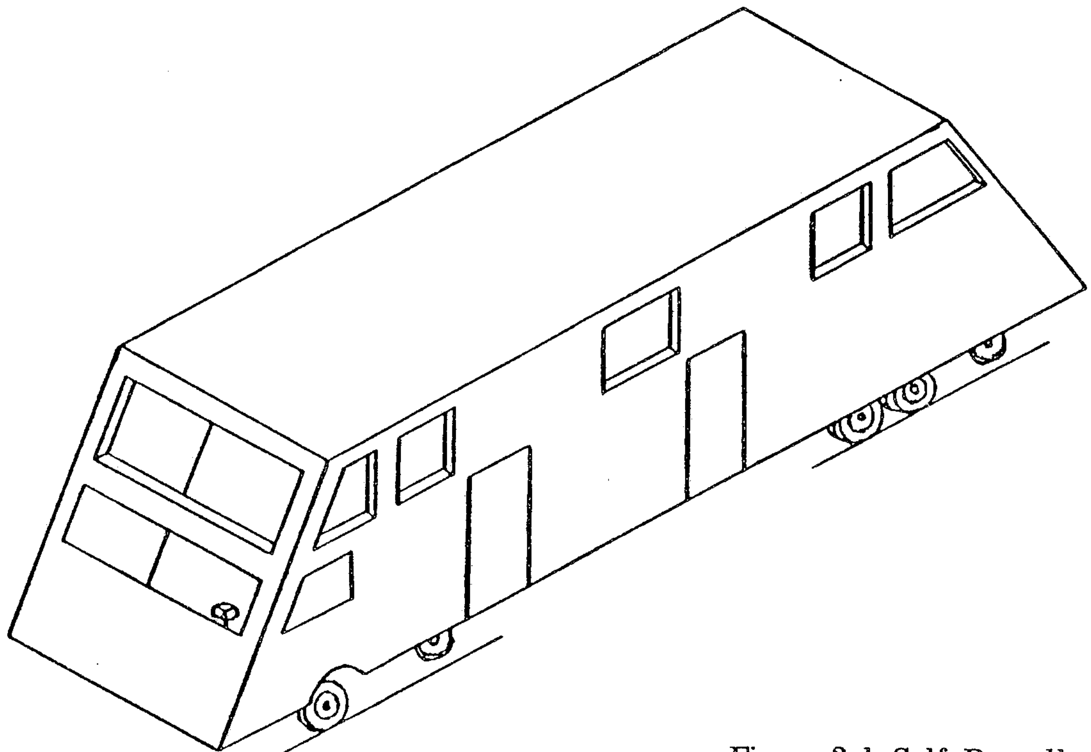


Figure 2-1. Self-Propelled Dual-Mode (Hi-Railer) U. S. Cab Demonstrator Configurations

(1) Totally compatible with highway dimensions and no movable/expandable cab.
(2) Movable/expandable panels to R. R. maximum dimensions from highway maximum dimensions-still roadworthy.
(3) Built to R. R. dimensions and moving on highway via special permit.

limitations are considerably less than typical railroad lead unit weights; however, it is anticipated that the demonstrator will weigh considerably less than the real version.

The height and width limits generally preclude the development of the demonstrator as a vehicle within highway limitations.

The main problem with designing this type of vehicle is that its effectiveness as a locomotive - particularly, a safe locomotive - is diminished.

Configuration (2) - With Movable/Expandable Panels (Figure 2-1)

This vehicle has been suggested as a solution to the problem of meeting the dimension problems of both railroads and highways. The expansion/collapse feature would have to be designed in such a way that equipment would not be disturbed. On the road, the demonstrator can be within the legal highway dimensions; upon reaching the demonstration site, the vehicle can be expanded to railroad size.

An important requirement is that internal vehicle equipment be positioned in a manner that would allow movement without disturbance of the equipment. Expansion along the height dimension is possible, particularly if expansion involves the raising of the floor. This would not disturb the positioning and location of equipment, consoles, seats, windows, etc. A hydraulic or pneumatic mechanism would raise and lower the floor.

Expansion along the width dimension appears to be a greater problem, and at this point appears to be prohibitive.

It would appear that the concept of an expandable vehicle contains many engineering problems that may be costly to solve and implement but that will not improve the demonstration effectiveness of the vehicle.

Configuration (3) - With Railroad Dimensions, But Operable on Highways with Special Permits (Figure 2-1)

Consideration has been given to constructing a vehicle of railroad dimensions that could move on the highways with special permits, as is done with house trailers, for example.

Constructing this type of vehicle would cause major problems for the demonstration program. The biggest problem is height; many roads could not accommodate a rail-sized vehicle, because of the limitations on height of overpasses. Clearance of 14' is typical for roads, but this type of demonstrator may measure somewhere between 14'6" and 15'8". This size would rule out operating the vehicle on most roads, with the exception of some (specially designated ones) whose overpasses have 16' of clearance. This appears to indicate severe problems in routing on interstate highways, state roads, and especially on local roads.

A 10' width is feasible, especially on interstate highways with 12' lanes. The vehicle would have to move at restricted speed and would have to be identified as a wide load. The major problems would occur off interstate highways where some 60% of state primary roads are less than 12' wide. The percentage varies from state to state, and the size of the lane would have an impact on the demonstration site. Many potential sites would necessarily be limited because of impassable roads.

Construction of a highway vehicle to railroad dimensions appears to create severe problems in mobility, and severe restrictions as to potential demonstration sites.

2.1.2 Towed Dual-Mode Demonstrator for Three Configurations (Figure 2-2)

This alternative is possible in three configurations. The first basic configuration is a towed vehicle without movable/expandable panels that is totally compatible with highway legal dimensions. The second configuration is a roadworthy towed vehicle with movable/expandable panels to increase its dimensions from highway to railroad dimensions. The third configuration involves a towed vehicle constructed to railroad dimensions, but moving under a special permit. The three configurations are discussed below.

Configuration (1) - Compatible with Highway Dimensions and No Movable/Expandable Cab (Figure 2-2)

Configuration (1), the highway-sized vehicle, would be no greater than 8' wide, 13'6" high, and 55' in length to permit access to all states but one. There is no access problem with a towed vehicle of these dimensions on the highway. Generally, access is assured in most states; bridges, tunnels, and underpasses can usually be traversed. The problem arises when the vehicle mounts the rails. As a short vehicle with a height of only 13'6", it is approximately 12" to 24" lower than a normal railroad vehicle. As such, it presents crashworthiness problems. It diminishes the safety advantages that were gained with placement of the crew in as high a position as possible. Another railroad problem is decreased visibility. This size vehicle does not seem appropriate for railroad use, and actually represents a degradation of human factors considerations as compared to currently used locomotive equipment. On the basis of decreased safety and crashworthiness, this configuration is not seen as a viable alternative for further consideration.

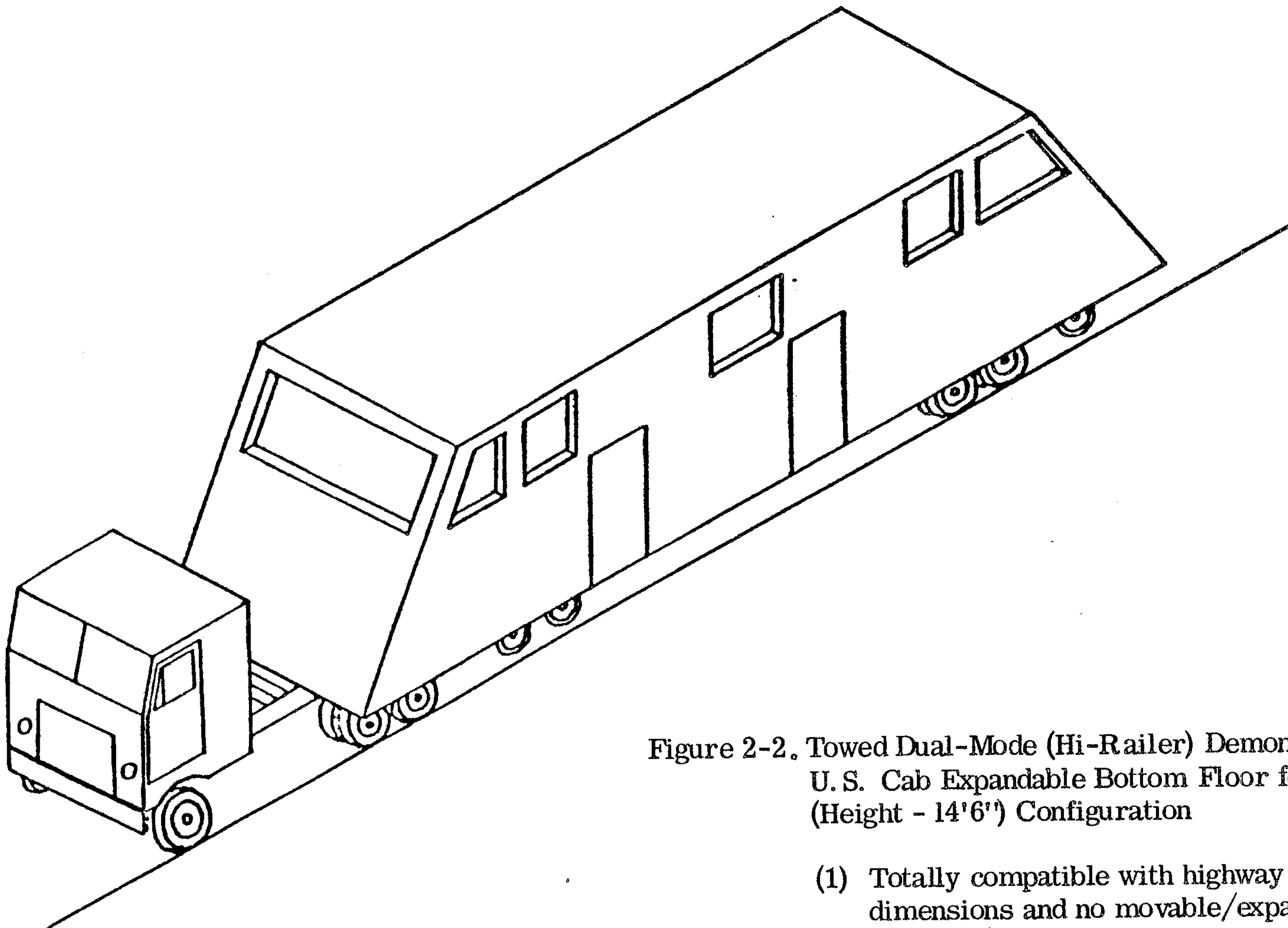


Figure 2-2. Towed Dual-Mode (Hi-Railer) Demonstrator - U.S. Cab Expandable Bottom Floor for Rail-bound (Height - 14'6'') Configuration

(1) Totally compatible with highway dimensions and no movable/expandable cab.
(2) Movable/expandable panels to R.R. dimensions from highway dimensions - still roadworthy.
(3) Built to R.R. dimensions and moving on highway via special permit.

Configuration (2) - Movable/Expandable Panels to Railroad Dimensions from Highway Dimensions - Still Roadworthy (Figure 2-2)

Configuration (2), which is a towed vehicle with movable/expandable panels, is a viable configuration. Movement without difficulty is possible on most highways and interstate highways, and the vehicle does not have any trouble at bridges, tunnels, and underpasses. At the demonstration site, the vehicle can be expanded to railroad size. Railroad size would make this configuration acceptable from a visibility and crew height/safety standpoint. The limitation is that the production model may not be feasible from a crashworthiness standpoint. It is not feasible to develop structures that are both movable/expandable and crashworthy, since the basic premise of a crashworthy structure is that a strong cage-like network of steel is constructed to protect the occupants during a collision. The movable/expandable panel concept would destroy the integrated, crashworthy structure.

In addition, this configuration would involve additional expense for the design, engineering, and construction of the expandable panels. The cost of each unit would also have to include the additional costs for the equipment necessary to raise and lower the panels. There would be additional costs to ensure that the rearrangement of displays, panels, controls, and other equipment is still satisfactory from the human factors point of view.

Configuration (3) - Built to Railroad Dimensions and Moving on Highway via Special Permit

Configuration (3), which is a towed vehicle built to railroad dimensions, but traveling on the highway system under special permit, is not considered to be a viable alternative. Although oversized vehicles can be moved on roads, highways, and the interstate highway network, height is a major limitation. A demonstration vehicle built to railroad standards simply will not clear most underpasses, tunnels, and bridges. Therefore, at best, routing of the vehicle will be extremely circuitous, time-consuming, and costly. It is estimated that the normal transportation cost will be increased by a factor of 2 to 4. In addition, a number of excellent demonstration sites may be inaccessible by highway transportation.

As with other forms of hi-rail concepts for the Universal Safeguard Cab demonstrator vehicle, the hi-rail concepts involve more disadvantages than advantages, and do not generally result either in initial cost savings or in cost-benefit advantages.

2.1.3 Configuration (4) - Demonstrator Built to Railroad Specifications that Can Be Hauled Over Highways on Flat-Bed Trailer (Figure 2-3)

Although this combination is simpler than the first three hi-rail modes considered in terms of engineering, the dimension problem is greater. When

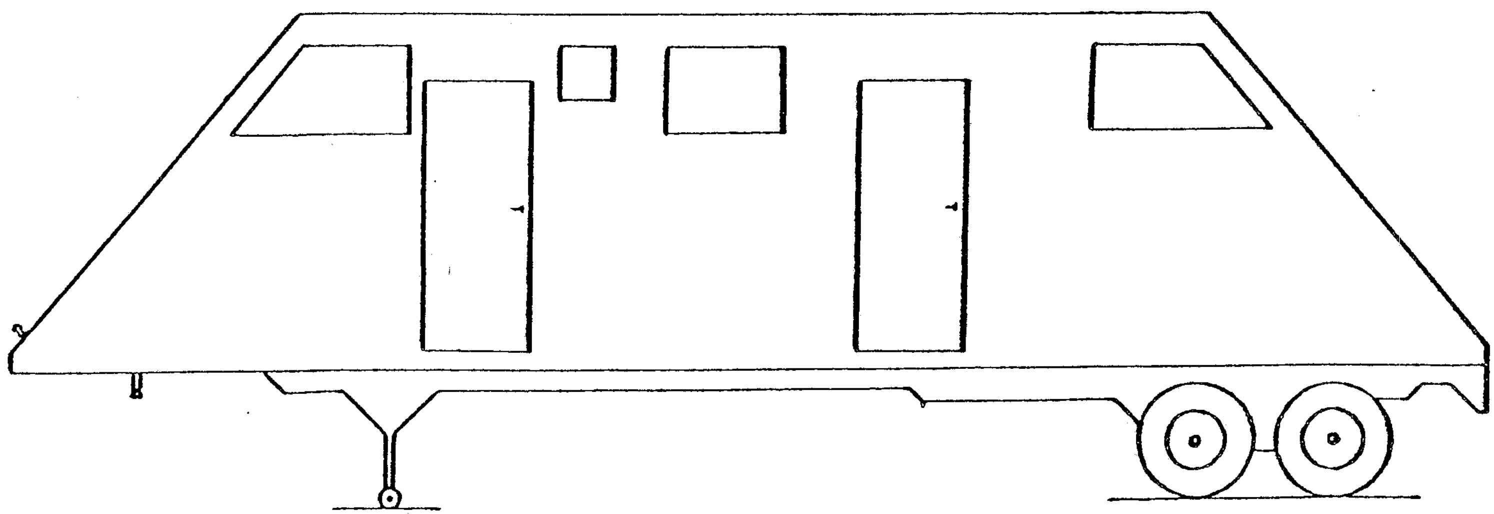


Figure 2-3. U.S. Cab Demonstrator Hauled on Flat Bed Trailer or Flat Rail Car - One Configuration on Dual Mode of Transport

Configuration (4) - Chassis based vehicle built to railroad dimensions but moving on highway via flat bed tractor-trailer under special permit.

the cab is carried on the highway, there is not only the locomotive height to contend with, but also the height of the trailer carrying it. There may be a possibility of developing a special trailer for the project.

Another consideration is that the demonstrator could be constructed in two pieces that could then be transported on two trailers. This has the advantage of allowing the vehicle to be transported in two pieces, each of which is legal on the highway and can be moved about anywhere. The major disadvantage with this approach is the need for a substantial crane at the demonstration site in order to put the demonstration vehicle together.

It would appear that there is no advantage to be gained by transporting the demonstration vehicle on a tractor or as a modified trailer.

2. 2 Rail-Bound Alternatives

Using a purely railroad vehicle for the demonstrator eliminates engineering problems associated with the hybrid cab. Dimensions no longer present a problem, because standard rail dimensions are used. Only normal railroad maintenance is necessary, not the double maintenance requirements of highway and railroad use. Parking and security problems are not anticipated with the rail mode. Yards and/or sidings can be used. The demonstrator is designed so that it can be left secured, without the need for security personnel.

Three rail-bound configurations are under consideration.

Configuration (5) - With Motive Power, Constructed on a Flat Car (Figure 2-4)

For this demonstration alternative, the engine is installed in the vehicle. The anticipated power capability for the demonstrator is minimal, about 400 hp. to 600 hp. Operating systems, such as brakes, controls, displays, etc. , are operational, and hostling capability is provided. Both this version and the other one with motive power offer credibility advantage.

Configuration (6) - On a Maintenance of Way (MOW) Chassis with Motive Power (Figure 2-4)

This alternative offers the advantage of a variety of chassis sizes for the demonstrator; chassis of all sizes are in existence. This vehicle operates under its own power. Credibility for this type of demonstration vehicle is high, for it is much like a "real" rail vehicle. Railroad personnel may well be more receptive to the design factors of the demonstrator if they are not distracted by structural differences from the real vehicle.

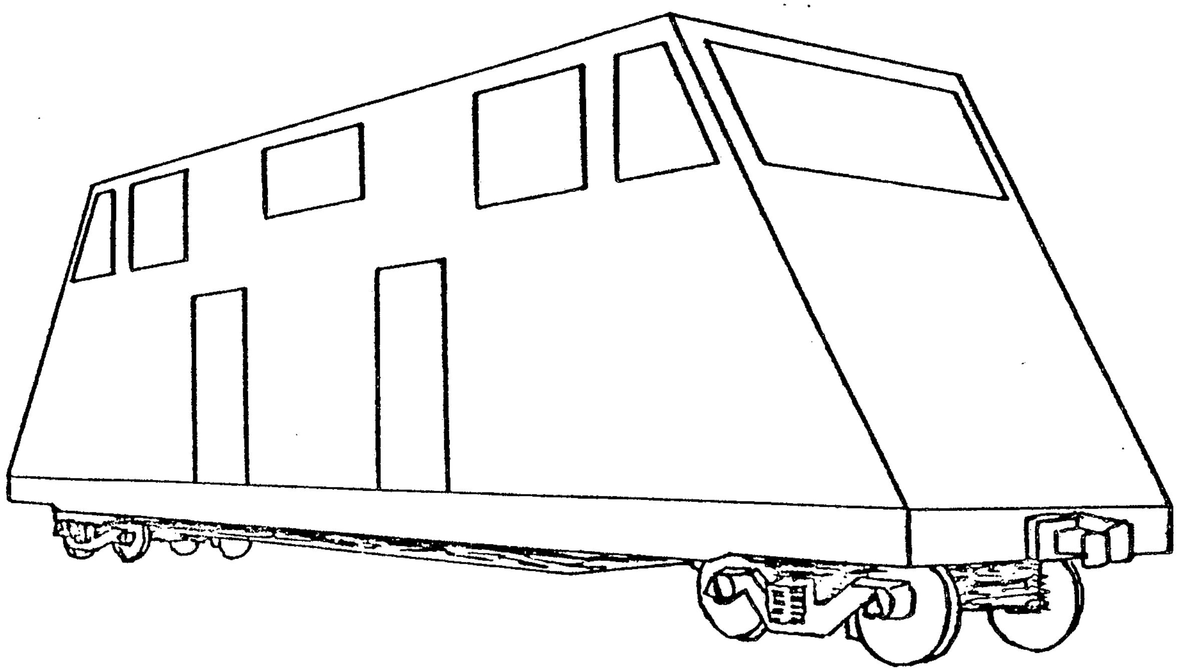


Figure 2-4. Rail-Bound U.S. Cab Demonstrator

Configurations

(5) MOW-based chassis with motive power
(6) Flat rail car chassis with power - hostling
(7) Built on flat car chassis without power

Configuration (7) - No Motive Power, Constructed on a Flat Car (Figure 2-4)

As with the above chassis alternative, various sizes of flat cars can be obtained. This type of demonstrator has a distinct cost advantage. This option appears to afford the simplest construction on a flat car, although the truck may have to be replaced. Flat cars are readily available in various sizes and configurations. The two motive-power alternatives are probably more credible to railroad personnel, because they are more like real railroad vehicles.

Of the railbound alternatives, either of the self-propelled versions appears more desirable in terms of convincing railroad personnel that the cab is a viable alternative.

In general, the rail-bound vehicle seems to be superior to the hi-railer as a demonstrator, for several reasons:

1. It avoids the problems and limitations of safety trade-offs.

2. It established credibility, in that it is a "real" and familiar rail vehicle.

3. It averts engineering problems.

4. It keeps service at a minimum.

5. It avoids the multiplicity of regulations associated with transporting a vehicle on both highways and railroads.

CHAPTER 3

COMPARATIVE ANALYSIS

OF DEMONSTRATION ALTERNATIVES

The focus in Chapter 3 is on both the capabilities and the limitations of the demonstration vehicle that must be considered in evaluating the proposed rail-bound and hi-rail configurations. These overall factors, ranging from mobility and size to engineering and demonstration credibility, are analyzed below. Appropriate data are included here for both rail-bound and hi-rail configurations. Additional data on hi-rail vehicles are included in Appendix A.

3.1 Mobility

Mobility - the capability to move or be moved, adaptability, versatility - varies on the basis of a vehicle's configuration.

The rail-bound vehicle is limited to rail systems, whether on tracks or in yards or sidings. It does have use of all the facilities and personnel of these systems.

In the case of rail flat car freight, the vehicle enjoys the advantages of rail operations, including an exclusive crew and a locomotive whose only assignment is pulling the demonstration car.

Truck-trailers and multiple truck-trailers are considered to have average mobility. This means that they have all the mobility of truck/highway operations, but none of the rail capability. The demonstration vehicle will, of course, be able to operate on rails; however, the primary means of transport between demonstration sites could be by highways.

The hi-railer configuration is considered to have excellent mobility in that it can move equally well in both highway and railroad modes. Conceptually, considering only mobility, the hi-railer is a completely dual-capability vehicle. It can travel the highway system freely; this includes major U. S. interstates and highways. Rail mobility includes all track throughout the United States. Specifically, the vehicle can travel main lines and is capable of utilizing lower grade sidings and yard tracks for actual demonstrations.

3.2 Size

1. General

Rail-bound size and weight limitations present no problem for the demonstration vehicle because the size and weight of the demonstrator will not have to exceed any rail-bound limitations and will approximate the current size of locomotives at a maximum and will be considerably less in terms of weight.

In the truck-trailer mode, size limitations are critical in that the size and weight of the tractor and trailer must be included in the total limitations. If a multiple truck-trailer mode is used, the critical nature of size and weight limitations is reduced, since the demonstrator vehicle can be transported in sections, which can be assembled at the demonstration site.

The hi-railer has major limitations in terms of the size of the vehicle. Since these limitations are discussed in detail elsewhere in this report, they are simply summarized here. Height limitations are critical. In most states, 13'6" is the maximum height for highway vehicles to be able to clear bridges and overpasses. 13'6" is somewhat less (12" to 24") than the estimated size of the demonstration vehicle. Width, length, and weight present some problems on the highway; in particular, width requires special permits, routing, and clearances if it is above the width permitted. These problems must be considered as disadvantages, even if they are made to be manageable.

2. Legal Dimensions of Vehicle

- Railroad Limitations - For the rail-bound configuration, the demonstration vehicle can be as large as current motive power units in terms of height, width, length, and weight.

Table 3-1 shows the typical dimensions of locomotives.

The rail-freight mode may present some problems in terms of limitations in that traveling as rail freight requires that the demonstrator be carried on another rail car. Most likely the car would be a flat car; however, depending on the size of the demonstrator vehicle, an oversized or specially constructed flat car may be required. In either case, problems concerning rail car limitations may cause difficulties. Although the demonstrator itself can meet the limitations, a demonstrator riding on a rail car may exceed limitations.

- Highway Limitations - There are specific legal dimensions imposed by states on vehicles utilizing highways, covering width, height, length, and weight. See Table 3-2. There are, however, numerous exceptions. For example, dimensions may be exceeded with special permits, and the vehicle may be subjected to a variety of considerations such as special escorts, particular routes, and specific operating conditions varying from state to state.

The data summarized in Table 3-2 generally permit unrestricted travel so long as the dimensions are not exceeded.

Table 3-1. Railroad Locomotive Dimensions

Locomotive	Height	Width	Length
F-40C	14'8 3/4"	10'8 5/8"	68'10"
SDP40F	15'8 11/16"	10'8 5/8"	72'4"
SD45	14'8 3/4"	10'3"	68'10"
SD40	14'8 3/4"	10'3"	68'10"
SD38	14'8 3/4"	10'3"	68'10"
GP40	14'6"	10'3"	59'2"
MLW-M-640	15'9 5/8"	10'4 3/8"	69'10 1/2"
U36C			67'3"
U33	15'4 1/2"	10'3 1/4"	67'3"
U30	15'8 1/2"	10'3 1/4"	67'3"
U23C	15'4 1/2"	10'3 1/4"	67'3"
U18	15'4 1/4"	10'2 1/4"	54'8"

Weight - variable - demonstration vehicle ≤ current units

Maximum Size for RR Car (Width is function of the distance between track centers.)

Width 10' 8 5/8"
Width decreases to 8'6"

Height 17'0"

RR Tunnel Clearances (American Railway Engineering Association)

Single Track Width - 16' (8' at mid-height from center, 5'6" at bottom or top)

Height - 22"

Double Track Width - 16' (8' at mid-height from center, 5'6" at bottom or top)

Height - 22'

Table 3-2. Highway Legal Dimensions

Width	96" - 102" (96" in most states - 41 states)
Height	13'6" in all states except: 14'0" - Idaho, Nevada, Utah, Washington 12'6" - West Virginia, District of Columbia
Length	• As a self-propelled 3-axle vehicle 35' to 55'. Most states - 40'. In 16 states, 35' to 40'. • As a tractor-trailer unit 35' to 75'. Most states - 55'. One state less than 55' - West Virginia, 35'.
Weight	• As a self-propelled vehicle, 40,000 lbs to 52,000 lbs. 39 states, 40,000 to 44,000 lbs. • As a 4-axle tractor trailer, 55,000 lbs to 74,000 lbs. 36 states permit 62,000 or more.

3.3 Special Handling

It is not foreseen that the demonstrator will require a great deal of special handling. It is assumed that it will receive a normal amount of reasonable handling in the hi-rail and truck-trailer modes, meaning only that the demonstrator will not be dropped, rolled, or impacted, as in a collision. Otherwise, the vehicle can be treated in the same manner as any other tractor-trailer shipment.

As rail flat car or as rail freight, it is recommended that the shipment be treated as normal rail freight except in classification yards, where it is recommended that the demonstrator or the demonstrator rail freight vehicle be placarded as "Do Not Hump." It is not expected that humping would be deleterious to the rail vehicle, but it may be harmful to the demonstrator, since it is anticipated that the demonstrator will be of a more lightweight construction.

3.4 Parking

It is not anticipated that any serious problems will be generated relative to parking.

Generally, the pure rail alternatives are not seen as leading to particular problems of storage. The demonstrator can be parked on any siding or in any yard. It will be totally securable, so that constant surveillance is not necessary.

The truck-trailer mode allows for street parking for the carrying vehicle-tractor and/or trailer with the demonstrator. It also permits the demonstrator alone to be parked at a separate location on rails. It may be that the truck trailer would be useful only as the means of transport, whereas storage would be accomplished totally on rail. This mode also permits flexibility; however, a disadvantage is the need for a standby driver to move the vehicle as necessary.

The hi-rail mode will permit parking and storage easily on rail surfaces, rail sidings, and yards; this mode also permits parking and storage on streets, parking lots, and probably fields. Thus, this mode seems to have the advantage in terms of the greatest flexibility of suitable parking space.

3.5 Maintenance

In either the rail flat car mode or the rail freight mode, the demonstrator is subject only to normal railroad maintenance and inspection requirements. These modes are considered to have the advantage over other modes because only one set of maintenance and inspection requirements applies.

In the truck-trailer or multiple truck-trailer operation, the transport vehicle requires normal highway maintenance and is subject to highway inspection requirements. The demonstrator itself is subject to railroad maintenance and inspection requirements.

The hi-railer mode vehicle requires both normal railroad vehicle maintenance and inspection requirements and normal highway vehicle maintenance and inspection.

3.6 Engineering

The rail flat-car approach has the advantage, since additional engineering is not required. The vehicle is a complete railroad vehicle: engineered, designed, and constructed solely for the railbound environment. Additional engineering considerations relative to highway operations, expansion, and loading/unloading are totally unnecessary.

In the truck-trailer mode, in which the demonstrator is transported in pieces, there is the requirement for equipment that not only lifts the demonstrator but also is able to fit the demonstrator sections together. In addition, there is a requirement for a certain level of knowledge and skill to assemble the sections. This approach requires the demonstrator to be engineered in sections and the means and equipment for fastening the sections together.

In the truck-trailer mode and the rail-freight mode, special crane equipment is necessary for removing the vehicle from the carrier and placing it on a track. This involves special equipment and man-hour utilization, and may require special scheduling in order to have the equipment and personnel available at the right time and in the right place. Exactly the same difficulties occur for reverse operations, when the demonstrator has to be removed from the track and secured to the carrier vehicle.

The hi-rail vehicle requires a substantial amount of additional engineering. Since the hi-railer has to meet the requirements of both highway and railroad vehicles, both vehicle and railroad engineering are required. The hi-railer requires both vehicle and railroad control systems. For example, it requires both highway braking systems and railroad air brakes.

To be compatible for both modes of operation, the vehicle will have to have headlights suitable for highway use, and a second headlight unit sutiable for rail use. To be within acceptable limitations for both highway and rail usage, the hi-railer must be expandable. Thus, additional engineering and systems are required to design and implement the required expansion.

In some ways, the advantages of hi-rail operations are minimized and limited by the necessity for duplication of many of the basic functions of the vehicle, including propulsion, control, maintenance, and the need for expansion mechanisms.

3.7 Demonstration Credibility

It is highly likely that there will be major differences in terms of the credibility that the demonstrator will have for railroad personnel.

The demonstration vehicle built as a complete railroad vehicle with railroad couplings, air brakes etc., and as a rail-traveling vehicle, will be seen as a much more credible vehicle than other configurations. It will appear to railroad personnel as a real "railroad" vehicle.

With the truck-trailer or rail-freight mode, in which a vehicle arrives on a carrier, the demonstrator may not be viewed as a serious railroad vehicle. It is likely to receive comments concerning its need to travel on the highway rather than on rail, as rail vehicles do.

It is likely that a hi-rail vehicle will not appear as a credible railroad "locomotive." It will probably be seen as an interesting idea or as an interesting application, but a vehicle with a doubtful degree of usability. It probably would not be viewed as a serious "railroad state-of-the-art vehicle."

Table 3-3 shows a summary of the comparative problem areas of the demonstrator alternatives in matrix form.

- Conclusions

On the basis of the problem areas considered in this analysis, a rail-bound vehicle is the most problem-free mode for the demonstration vehicle. It requires the least additional engineering, only normal railroad maintenance, no special equipment for loading or unloading, no special expansion engineering and equipment, and appears to be the most credible mode for the demonstration vehicle.

Table 3-3. Comparative Problem Area Matrix

Problem Area	Hi-Railer	Truck-Trailer	Truck-Trailers	Rail Flat Car	Rail Freight
Getting There					
Mobility	Excellent	Average	Average	Average	Average
Size	Major Size Limitations	Size Limitations	Fewer Size Limitations	No Limit	Limited
Special Handling	No Impact	No Impact	No Impact	Do Not Hump	Do Not Hump
Storage					
Street Parking	No Problem on Streets	Need for Truck Driver on Stand-by	Need for Truck Driver on Stand-by	No Problem	No Problem
Railroad Siding	No Problem on Rails				
Maintenance					
Highway and Railroad Maintenance	Requires Highway and Rail Maintenance	Requires Highway and Rail Maintenance	Requires Highway and Rail Maintenance	Requires only Normal Rail Maintenance	Requires only Normal Rail Maintenance
Construction					
Add'tl. Engineering Add'tl. Coupling Equipment	Will Require Additional Engineering & Systems	Will Require Special Equipment To Set Up and Operate	Will Require Special Equipment To Set Up and Operate	No Additional Equipment	Needs Special Equipment for Loading and Unloading
Demonstration					
Weight	Not Enough Weight	Not Enough Weight	Not Enough Weight	Completely Simulates Locomotive-Type Vehicle	Not Like a "Real" Locomotive
Credibility	Doubtful				

CHAPTER 4

COST EVALUATION OF DEMONSTRATOR

This section is divided into three major subsections. The first is concerned primarily with development of demonstrator costs for the various alternatives. The second subsection is devoted to an analysis of transportation cost calculations, and the third section contains the summary cost analysis and recommendations concerning the selection of a cost-effective demonstrator.

4.1 Demonstrator Vehicle Costs

These are the major costs involved in the design and construction of the demonstrator vehicle. These costs do not include operational expenses, maintenance costs, or transportation expenses, but are purely the costs of developing and constructing the demonstratión vehicle.

4.1.1 Engine and Engine Accessory Costs

These costs include total costs for:

• The diesel power plant	$51,000
• Motor generator	15,000
• Battery systems and equipment	6,100
Total	$72,100

This represents the power equipment to provide the idler cab with hostling capability. Regardless of the level of functionality of the demonstrator, complete hostling capability is required. Therefore, the cost is not variable, except for the special case of Alternative VII, which does not include any hostling capability.

4.1.2 Superstructure Costs

There are two basic approaches to the construction of the demonstrator superstructure. A wood or a steel construction can be utilized. Wood is often used as a cheaper substitute for metal in certain applications; however, in this case wood construction appears to be only slightly less expensive than steel construction.

An analysis of the costs for wood construction of the demonstrator superstructure indicated a cost of $19,256.22. This is almost equal to the estimated steel construction superstructure cost of $19,400. Since there are basic problems with a wooden structure in terms of safety and crashworthiness, and since the cost differential is relatively insignificant, the demonstrator will be constructed with a steel superstructure.

These costs are constant and do not vary as a function of the alternative selected; nor do they vary in terms of the degree of functionality.

4.1.3 Underframe, Trucks, and Air Brake Equipment

The underframe construction cost is estimated to be $40,000, the locomotive trucks are $64,250 and the air brake equipment is $16,100. The total cost for this equipment is $120,350. As with previous costs, these costs are constant.

4.1.4 Cab Costs Including Microcomputer

These costs include basic cab costs of $39,200; $117,000 for two complete Boeing consoles, $52,000 for switches, warning lights, etc., and $40,000 for the helper consist panel. The microcomputer cost is estimated at $4,000. The total cost for these items is $252,200. This cost represents 100% functionality. Unlike previous items mentioned, these costs are, in part, variable depending on the degree of functionality. Table 4-1 shows the decrease in cost with the decrease in functionality.

The largest decrease in cost occurs in the differential costs presented for the Boeing console. At 100% functionality, the idler cab contains two completely functional Boeing designed cabs costing $117,000. At 80% functionality, the idler cab contains only one cab, and that cab is approximately 80% functional. Thus, the entire cost of one cab is saved ($58,500), plus 20% of the cost of a single cab ($11,700). Therefore, in reducing functionality from 100% which costs $117,000, 80% functionality can be attained for $46,800. Proportionately, 60% functionality costs $35,100 and 40% functionality can be realized for $23,400.

Similiarly, cab construction costs drop from $39,200 at 100% functionality to $15,680 at 80%, $11,760 at 60%, and $7,840 at 40% functionality. Costs for switches, warning lights, etc. drop from $52,000 at 100% functionality to $20,800 at 80% functionality, to $15,600 at 60% functionality, and to $10,400 at 40% functionality.

The Helper Consist panel is functional only under 100% vehicle functionality. At all lesser levels of functionality, the cost drops to zero. It is not felt that remote consist control is necessary for the demonstrator vehicle as the demonstration is currently planned.

Contrary to these other systems, the microcomputer cost is constant at $4,000 for all levels of functionality. This is because the microcomputer needs to be 100% functional at all levels of cab functionality. At 100% functionality the microprocessor will drive operational equipment. At less than 100% functionality of the vehicle, the microcomputer will operate simulated systems.

4.1.5 High and Low Voltage Wiring

The costs associated with wiring decrease proportionately as the functionality of other systems decreases. Thus, the 100% functionality cost of $11,400 drops to $9,120 at 80%, $6,840 at 60%, and $4,560 at 40% functionality.

Table 4-1. Costs per Level of Functionality * Installation

	40%	60%	80%	100%
Diesel Power Plant	51,000	51,000	51,000	51,000
Motor Generator	15,000	15,000	15,000	15,000
Battery	6,100	6,100	6,100	6,100
Hi-lo Volt Wiring	4,560	6,840	9,120	11,400
Cab	7,840	11,760	15,680	39,200
HVAC	14,800	14,800	14,800	14,800
Air Brake - remote	10,000	10,000	10,000	10,000
Air Brake - motor	6,100	6,100	6,100	6,100
Superstructure	19,400	19,400	19,400	19,400
Underframe	40,000	40,000	40,000	40,000
Train Radio	-	-	-	60,000
Cab Refuge	11,900	11,900	11,900	11,900
Microcomputer	4,000	4,000	4,000	4,000
Track Geometry	2,000	10,000	40,000	87,000
Trucks	64,250	64,250	64,250	64,250
Boeing Console	23,400	35,100	46,800	117,000
Switches, Etc.	10,400	15,600	20,800	52,000
Helper Consist Panel	-	-	-	40,000
TOTALS	$290,750	$321,850	$374,950	$649,150

*Costs are based on variable and invariable subsystem costs. For example, HVAC, brakes, and microcomputer systems are operational. Other systems can be a combination of operational systems and mock-ups.

4.1.6 Heating, Ventilation, and Air Conditioning

Regardless of the level of functionality of the vehicle, a completely functional HVAC system will be provided. The cost for this is a constant $14,800.

4.1.7 Train Radio

The consist control capability is provided only under a condition of 100% functionality. The cost is $60,000. At all lesser degrees of functionality, a train radio capability is not provided; thus the cost is nil.

4.1.8 Cab Refuge

The cost for the cab refuge space is constant. In the interest of safety, the cab refuge space is provided regardless of the level of vehicle functionality. The cost for this is $11,800.

4.1.9 Track Geometry Measuring Equipment

An essential feature of the idler cab is the capability for assessing track problems with the track geometry measuring equipment. In the 100% functionality condition, a completely operational track geometry unit will be installed. This equipment will actually be capable of measuring the condition of the track during the demonstration. Under conditions of lesser functionality, the track geometry equipment will be less and less functional and more of a simulated concept. It is felt that at a minimum a completely simulated track geometry system is appropriate. For a completely functional track geometry system, the cost is $87,000. Lesser degrees of functionality and corresponding greater degrees of simulation cost $40,000 at the 80% functionality level, and $10,000 at 60%. The cost of $2,000 represents a simple mock-up at the 40% level.

4.2 Transportation and Related Costs

4.2.1 Highway Control

Additional equipment is necessary under the idler cab self-propelled bi-modal configurations (Configurations I, II, and III).

The estimated cost is $36,000, which is based on the cost of truck systems which would be installed. These systems include:

1. steering controls
2. highway brakes
3. highway propulsion
4. engine controls and displays
5. head lights, tail lights, signal lights
6. highway control station

4.2.2 Expansion Mechanism Costs

This is an additional cost which applies to Configuration II only. The expansion mechanism permits the vehicle to change its overall height dimensions in order to have greater highway flexibility. This cost is estimated to be $30,000 for the following expansion equipments:

1. engineering expense for equipment arrangement
2. hydraulic pumps, reservoirs, and piping
3. controls including mechanical and electrical equipment
4. power source and connections
5. mechanical screws and linkages

4.2.3 Transportation Expenses

Transportation costs for Configurations I, II, and III are composed of three primary costs:

1. The cost of the driver
2. Gasoline and oil
3. Tolls, road fees

The cost of a driver is based on an acceptable pay rate of $8.00/hr. at 100% markup = $33,280. The rate includes the driver's time for one year, since much of his time will be spent in transit and on a standby basis.

Gasoline is calculated on the basis of 70¢ per gallon and 5 miles per gallon. Thus, the transport cost is 14¢ per mile. Oil is calculated at $1.00 per quart and one quart per 1,000 miles. Total gasoline and oil costs are estimated to be $1,410 for 10,000 miles.

Tolls, road fees, etc. are calculated on an estimate of $5.00 per 100 miles, which equals $500.

Configuration IV costs include:

1. The need for a tractor and trailer or trailers
2. A driver for the tractor

Both of these costs are subsumed under the standard charges and fees of a trucking company. Estimates indicate a transportation cost of $30,000 per 10,000 miles of transport for a single tractor trailer and $60,000 per 10,000 miles with two tractor trailers. (See Appendix B for details.)

Transportation costs for Configurations V, VI, and VII are calculated on the basis of the tariffs for eight-wheel caboose-type vehicles. There is currently no tariff for the idler cab vehicle since it is not a locomotive; thus, the eight-wheel caboose concept most closely relates to the idler cab structure and configuration. This cost has been estimated at $7,270.52. A detailed breakdown of this cost appears in Table 7-1.

4.2.4 Special Set-up Costs

Configurations IV and VII will incur certain additional costs associated with the set-up of the equipment at the demonstration sites.

Configuration IV will require the rental of a flat car for demonstration purposes. This cost is estimated at $50.00 per day for 60 demonstration days for a total cost of $3,000.

Configuration IV will also incur an additional set-up cost at each demonstration site for the crane equipment and labor to move the demonstration vehicle from the trailer to the flat car. This cost is estimated at $3,000.

Configuration VII, because it contains no power of its own, must be supplied at each demonstration site with special handling and movement equipment; this special handling will most likely be provided by a locomotive. This special cost is estimated at $2,300.

4.2.5 Insurance Costs

An estimate of $100,000 is provided to cover the cost of insurance for the vehicle, including liability insurance.

4.3 Cost-Benefit Analysis and Recommendations

Table 4-2 shows the total costs for each configuration in the demonstration program.

Based upon our previous studies involving the feasibility of hi-rail versus rail-bound vehicles, we have concluded that the rail-bound vehicle is more feasible and practical than a hi-rail vehicle.

Examining the costs of rail-bound vehicles indicates that Alternative VII, the Universal Safeguard Cab built on a flat car type chassis with no motive power, is the least costly.

Alternatives V and VI are more costly because of motive power. However, the demonstration phase would be awkward and less credible without power. A

Table 4-2. Preliminary Demonstration Cost Matrix Based on 60% Level Functionality

Cost Variable	Configuration						
	Self-propelled Hi-railer				Rail-bound Vehicle		
	I	II	III	IV	V	VI	VII
Preliminary Basic Vehicle Cost (with 60% Mockup)	$321,900	$321,900	$321,900	$321,900	$321,900	$321,900	$321,900
Dual Control Costs	$36,000	$36,000	$36,000				
Expansion Mechanism Costs		$30,000					
Transportation Costs (6 months duration)*	$35,200	$35,200	$35,200	$30,000 to $60,000	$7,300	$7,300	$7,300
Set-up Costs				$6,000			$2,300
Annual Insurance**	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
Preliminary Demonstration Costs	$493,100	$523,100	$493,100	$458,000 to $487,900	$429,200	$429,200	$359,400

* "Operation in Service" consideration by Southern RR System could reduce transportation costs.

** Rail-bound cab demonstration general risk insurance cost is estimated at $100,000 per annum, considering the earlier case of "Liberty Train" demonstration.

powered version with hostling capability, although more costly, would provide a more effective demonstration.

Therefore, Alternative VI, the U.S. Cab built on a flat-car-type chassis with hostling power added, appears to be the most desirable alternative from a feasibility and practicality standpoint.

Table 4-3 summarizes information on the transport costs for the demonstration vehicle.

Table 4-3. Summary of Transport Cost Inquiries

Assumed: Weight - 25,000/30,000 lbs. size - 14.5' (H) X 13' (L) X 9' (W)
Route - from Washington, D.C. (Alexandria, Va.) to major cities.

	Name of Companies	Quotations
A. Rail-bound Cost	Southern Pacific	Referred to Southern Railway
	Conrail	Referred to Southern Railway
	Union Pacific	Referred to Southern Railway
	Amtrak	For passenger-type car - $1.35/mile
	Burlington Northern (Mr. Jim Gains)	For distance from Washington, D.C., to San Francisco, $3,772 for 40,000 lbs. $9.43 per 100 lbs. at minimum weight of 30,000 lbs.
	Southern Railway	Detailed tariff obtained.
B. Truck-trailer on Highway	Yellow Freight	$8.76/100 lbs. for the distance from Washington - San Francisco
	Tri-State Motor	$1.06/mi. for total weight of 25,000 lbs.
C. General Liability Insurance (RR)	Midland Insurance Co. (Mr. R. Libers)	All railroad risks involving siding, switching, derailments, collision, injury at demo site, etc. - $80,000/$110,000 per annum considering the case of Liberty Train demonstration (Minimum of $2 million coverage with $25,000/$50,000 deductible).

CHAPTER 5

DESIGN CRITERIA

5.1 General Design Considerations

This section covers human factors and general design criteria that are related to the overall design of control and display panels for the normally seated operator, and with anticipated vision over the top of the panel.

Visual and tactual differentiation of controls helps ensure that the operator correctly uses the controls. For instance, the train brake and the independent brake should be both visually and tactually identifiable; in other words, they should feel different so as to prevent confusion between two similar controls when operated.

As a general rule, controls should be positioned for the optimum efficiency of control utilization.

In general, large surfaces such as panels, walls, floors, and ceilings should have dull rather than glossy finishes. Colors should be light on large surfaces. Highly saturated colors are recommended for the cab. Certain other color combinations should be avoided. Avoid mixing blues and greens, blues and yellows, and reds and greens.

It is desirable to color code controls so that color can serve as a cue for function. Thus, it is desirable to code all functions that relate to stopping train brake, independent brake, emergency stop, stop all engines, etc., in red to facilitate discrimination and to help minimize inadvertent operation.

Color coding allows for the discrimination of controls in an absolute sense, in that reference to other colors is not necessary, provided that a maximum of only eight colors (red, orange, yellow, green, blue, violet, black, and white) are used.

Color coding of controls is completely compatible with other forms of coding and may be used as a supplementary form of coding. For color coding to be effective, there must be a sufficient quantity of ambient illumination (white light).

Red should be used for "stop" controls, while green can be used for "go"-type controls. The throttle and associated condition indicators should appear green during power operations and red during dynamic braking operations.

5.2 Panel Analysis and Design

The main control panel is located directly in front of the engineer on the cab control console. All primary controls needed to operate the forward engine consist are located on this panel. Unlike currently utilized control stands which are located to the side of the engineer, in this design the engineer can reach all controls with either hand without crossing over his chest. The positioning of this control panel forward represents an improvement in comfort and utility to the degree found in the newer European and Japanese locomotives.

In addition, the forward location of the controls means less head turning and a lesser degree of fatigue for the Universal Safeguard engineer. Similarly, since the head does not have to be turned to see controls, mistaken control applications will be minimized. Figure 5-1 shows the main control panel with all controls, including levers, pushbuttons, toggle switches, on-off switch, and a thumbwheel with indicator.

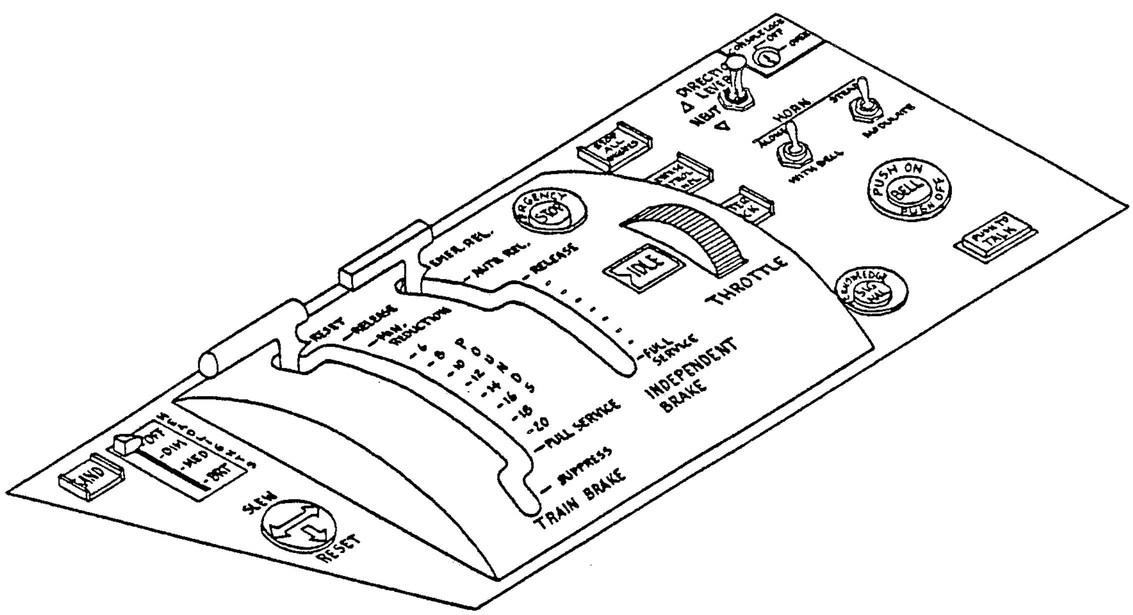


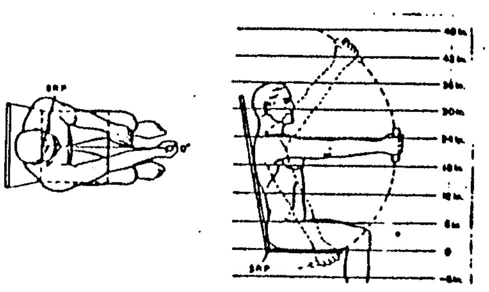
Figure 5-1. Main Control Panel

The panel is located approximately 28" from the floor and is inclined at an angle of 30^{o} so as to facilitate vision and reach. The main control panel is 11" deep, 21" wide at the front, and 25" wide at the back. It is located entirely in the accepted optimal zone for the placement of controls. Figure 5-2 shows arm reach zones for use in designing controls for best placement, from the most important ones such as emergency controls and other primary controls to less important controls.

Figure 5-2. Functional Arm Reach from Body Midplane

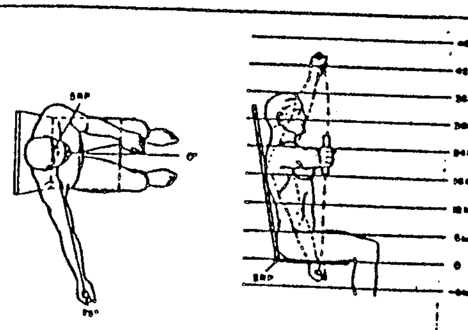
Functional Arm Reach (Sitting) 0 deg from the Midplane of the Body

Height above SRP (in.)	Percentiles (in.)		
	5th	50th	95th
6	17.0	19.5	22.7
12	19.4	22.5	25.1
18	21.3	24.0	26.6
24	21.6	24.5	26.3
30	20.1	23.6	25.9
36	17.4	21.0	24.5
42	12.7	17.0	20.8
48		11.0	15.4



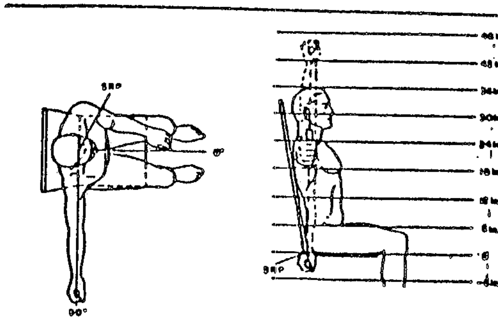
Functional Arm Reach (Sitting) 75 deg from the Midplane

Height above SRP (in.)	Percentiles (in.)		
	5th	50th	95th
-6			12.0
0	17.4	21.0	24.5
6	23.9	26.5	29.6
12	27.6	29.5	32.1
18	29.3	31.1	34.1
24	28.9	31.5	34.0
30	28.3	30.6	33.5
36	25.1	28.0	31.1
42	20.3	24.5	27.3
48		16.8	21.7



Functional Arm Reach (Sitting) 90 deg from the Midplane

Height above SRP (in.)	Percentiles (in.)		
	5th	50th	95th
-6			11.9
0	18.5	21.0	24.8
6	25.6	27.0	30.3
12	28.0	30.0	33.2
18	30.0	32.0	34.6
24	30.0	32.5	35.0
30	29.3	31.6	34.4
36	25.9	29.0	32.0
42	21.1	25.5	29.0
48		18.0	21.9



The dimensions are based on what is commonly referred to as the Seat Reference Point, or SRP for short. The seat reference point is a geometric point located at the rear center of the seat at the point where the backrest joins the seat. This point is commonly used so that all human engineering data concerning reach are standardized with the same biomechanical reference point. All dimensions are calculated in planes above the seat reference point and in planes to the left and right of the SRP.

A vertically adjustable seat changes the SRP. Such adjustment permits the individual to change his orientation. Seat adjustments normally change the SRP by a couple of inches.

Functional arm reach is the maximum allowable distance from a vertical line through the SRP to the control. The figures and data that are presented here are conservative; that is, certain allowances have been made and assumptions maintained. For design purposes, the reach distance is calculated on the basis of a non-adjustable seat or a seat in the full forward position; and the calculations are based on the 5th percentile man (small). This is to ensure adequate reach by the smaller engineers.

To further ensure adequate reach, it is assumed that the most distant controls are to be grasped rather than touched. Since the main control panel is located at approximately 12" to 15" above the SRP, the dimension for the 12" level is therefore appropriate for design purposes. Therefore, 21.5" is the maximum allowable distance from the SRP to the furthest control on the main control panel.

A general recommendation for primary control panels is that the controls be distributed equally so that one arm is not overloaded. Current American locomotives with standard control stands violate this rule by overloading the left arm of the engineer; operation of the controls with the right arm while facing forward is at best inconvenient, and at worst both awkward and uncomfortable. The panel design presented in Figure 5-1 allows all primary controls to be operated with either arm. In two-handed operations, both arms reach forward rather than requiring the right hand to cross over the engineer's body.

It is conceivable that since the Universal Safeguard Cab is based on a thorough application of human engineering it will be a single acceptable design for all locomotives. The Universal Safeguard Cab will be standardized for use by all railroads, while of course permitting small design modifications to meet differing railroad requirements and operating practices. In addition, the Universal Safeguard Cab will improve standardization by its capacity to control all locomotives with different cab designs. The one standardized cab of the U.S. Cab will operate any combination of locomotives and, of course, any manufacturer's "B" unit.

It is important to point out that the concept of standardization of locomotives is not a new idea. Standardization in Europe was significantly advanced with the issuance of recommendations by the International Union of Railways beginning in 1958 (Jankovich, 1972). These recommendations covered all international rolling stock, and certain recommendations specifically applied to primary controls. One report indicated that the controls of electric locomotives in France have been completely standardized (Engineer, 1965).

The illumination level for the main control panel should be variable. The engineer should be able to adjust the illumination to suit his particular needs and his level of dark adaptation.

5.3 Control Analysis and Design

The main control panel contains the primary controls used by the engineer in operating the locomotive consist. These controls include:

- Train brake
- Independent brake
- Emergency stop
- Throttle
- Stop all engines
- Reverse control panel (optional)
- Sand switch
- Headlight slew
- Interlock
- Direction switch
- Horn switches
- Bell switch
- Signal acknowledge
- Push to talk
- Headlight control

Braking and throttle controls are obvious primary controls. The other controls are located on the panel because of their frequency of use. Controls are generally grouped by function, which is a standard human engineering/biomechanical principle for efficient and safe control operation.

a. The Train Brake (Automatic Brake Valve)

The train brake is a T handle control mounted in and on the main control panel. See Figure 5-3. This control is used to control the air brakes on the entire train.

The train brake handle contains a number of specific settings for various uses.

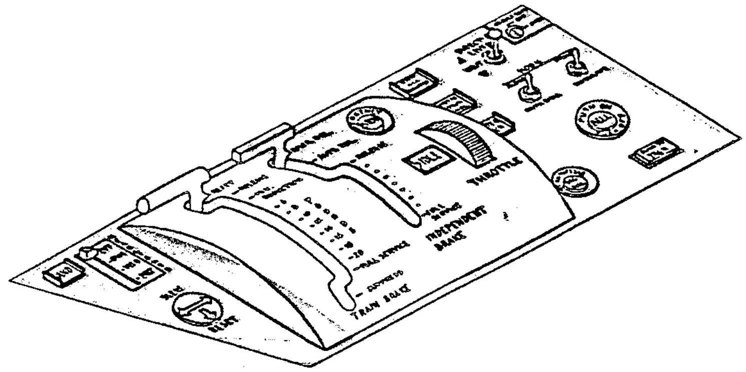


Figure 5-3. Train Brake

The operation and effect of the train brake are identical to the braking system operation on current domestic locomotives. Although the brake has been mounted on the main control panel, the impact to the train is exactly what the engineer expects and is used to. As with other equipment on the Universal Safeguard Cab, the engineer requires only familiarization rather than extensive retraining.

The T handle of the train brake has been designed to human engineering standards appropriate to the dimensions of T handles. See Figure 5-4. The grasping position of the handle is 4.5" long so as to allow for sufficient space for the entire hand to grasp the handle. The grasping portion of the handle is raised above the surface of the panel in order to allow sufficient clearance for the fingers. In addition, sufficient space has been allotted to permit an effective grip, even if the engineer is wearing gloves. Gripping efficiency is greatest if the fingers can curl around

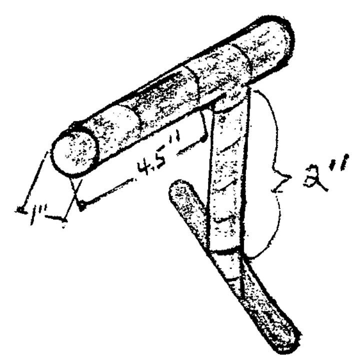


Figure 5-4. Train Brake Dimensions

the handle to any angle of 120^{o} or better. The handle is one inch thick, which provides a sufficient surface for the grasp.

The surface of the control handle is knurled so as to provide a non-slip surface, especially if grasped with an oily, dirty, or greasy hand.

The handle is shape coded - round. Shape coding permits both the tactual and visual identification of controls without reference to tables, after the engineer has had a sufficient degree of familiarity with the Universal Safeguard Cab control panels. The main advantage of shape coding is that the control can be easily identified without vision. This is not to say that the engineer should normally not view the control, but simply that if the engineer's attention is diverted at the moment he is reaching for the control, the probability of operating the wrong control is minimized.

The train brake is color coded - red, as are all brake system controls. Again, this coding, like shape coding, is to increase the efficiency and accuracy of the engineer, especially in emergency situations.

b. The Independent Brake

The independent brake, like the train brake, is a T handle mounted on the main control panel. See Figure 5-5. Its function is to allow the operation of only the brakes on the forward engine consist, and the brakes on the Universal Safeguard Cab when it is connected to a locomotive.

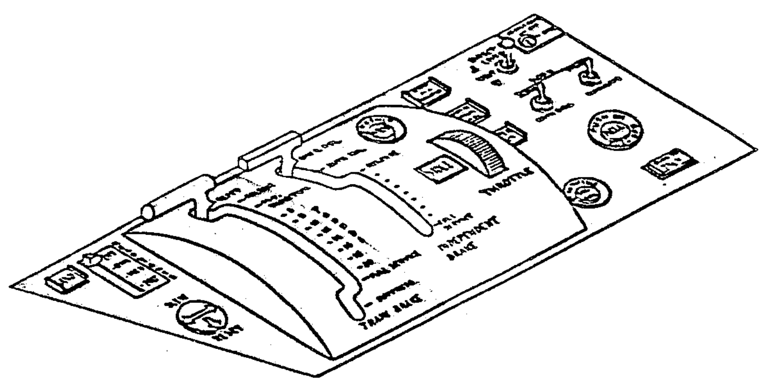


Figure 5-5. The Independent Brake

The independent brake is a 4-position control. It contains an EMERGENCY RELEASE position which is a spring-loaded position used to bail off the locomotive brakes in the case of an emergency brake application. Since this is a spring-loaded position, the handle must be deliberately held in this position while the engineer monitors brake cylinder. The AUTOMATIC RELEASE position releases the locomotive brakes and prevents the locomotive brakes from being energized regardless of the train brake application and is used when the engineer desires a train brake application without a locomotive brake application. The RELEASE position transfers control of the locomotive brake to the train brake. The FULL SERVICE position applies the locomotive brakes fully.

The independent brake conforms to the same basic design as that of the train brake. The handle is 4.5" long, 2" above the surface of the panel, and 1" square to allow for a firm grip of the control.

Note that the independent brake handle is square rather than rounded. The independent brake is shape coded - square - so that it can be visually and tactually identified by the engineer immediately upon grasping the handle. This is a safety consideration which will help prevent inadvertent operation of the wrong control handle.

In addition, like the train brake, the independent brake is color coded - red - for instantaneous braking system visual identification.

c. Emergency Stop

This is a large recessed button used to initiate an emergency brake application. See Figure 5-6. The emergency stop button is recessed in order to minimize

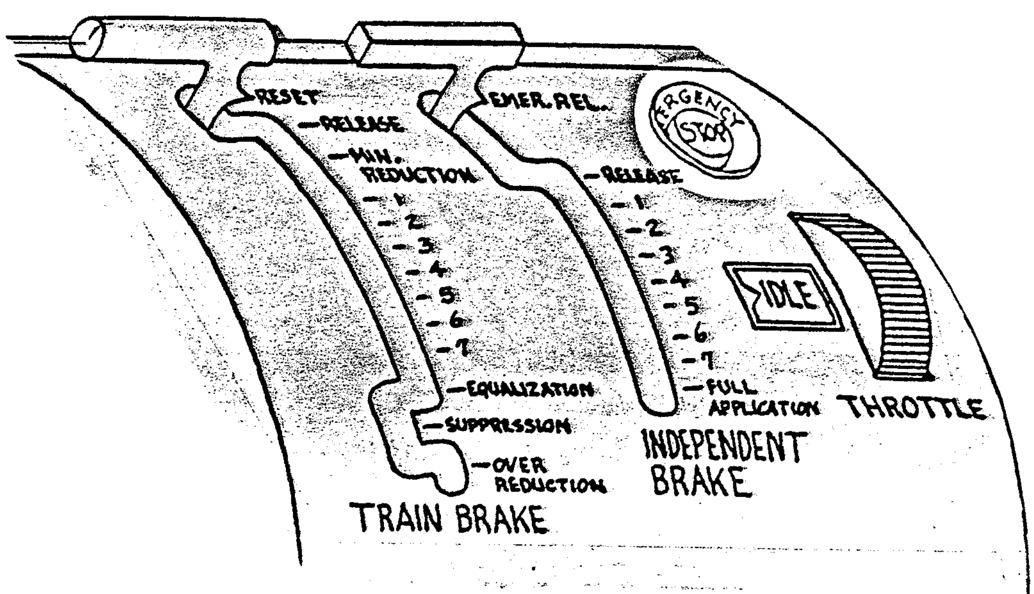


Figure 5-6. Emergency Stop

the possibility of an inadvertent activation. The push button control is used for a momentary contact which engages the emergency braking locking circuitry. Once this button is energized, it cannot be overridden. The push button itself is concave to fit the finger and has a surface which provides a high degree of friction. A positive indication of button activation is provided by a snap feel and a light indication. When the emergency braking locking circuit is energized, the button is brightly illuminated. The snap feel consists of an elastic resistance of 20.0 oz, which suddenly drops to indicate that the control has been activated. The displacement, that is, the distance the button moves from the normal resting position to the point at which it activates the locking circuit, is 0.5".

The push button is 0.75" in diameter, and the recessed surface is 2" in diameter. Both the recessed surface and the push button are color coded - red - to indicate a braking system.

d. Stop All Engines

The STOP ALL ENGINES control is a push button type of control which is used as an emergency switch to immediately stop all engines in the locomotive consist. See Figure 5-7.

Inadvertent activation of the switch is in part prevented by guards for the switch. The guards extend upward for 0.25" and serve to prevent the fingers from sliding onto the control, yet do not impact reaction time as do switch covers and plates.

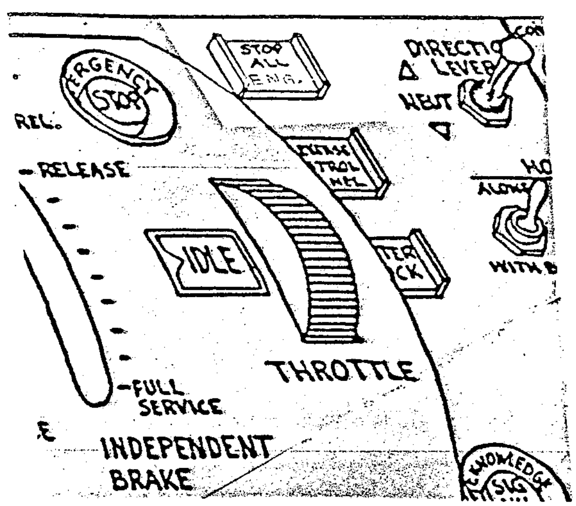


Figure 5-7. Stop All Engines

The Stop All Engines switch is one square inch with a non-skid surface. As with other push button type controls for the main control panel, the displacement is 0.25", with a resistance level of 20.0 oz and a snap feel, and illumination when the circuitry has been engaged. Because this control is also a "stopping" control, it also is color coded - red.

e. Throttle and Throttle Indicator

The throttle control is a recessed thumbwheel on the main control panel. See Figure 5-8. It is accompanied by an indicator that provides information relative to the setting of the throttle. The settings include idle and power settings from 1-8, with 8 indicating maximum power.

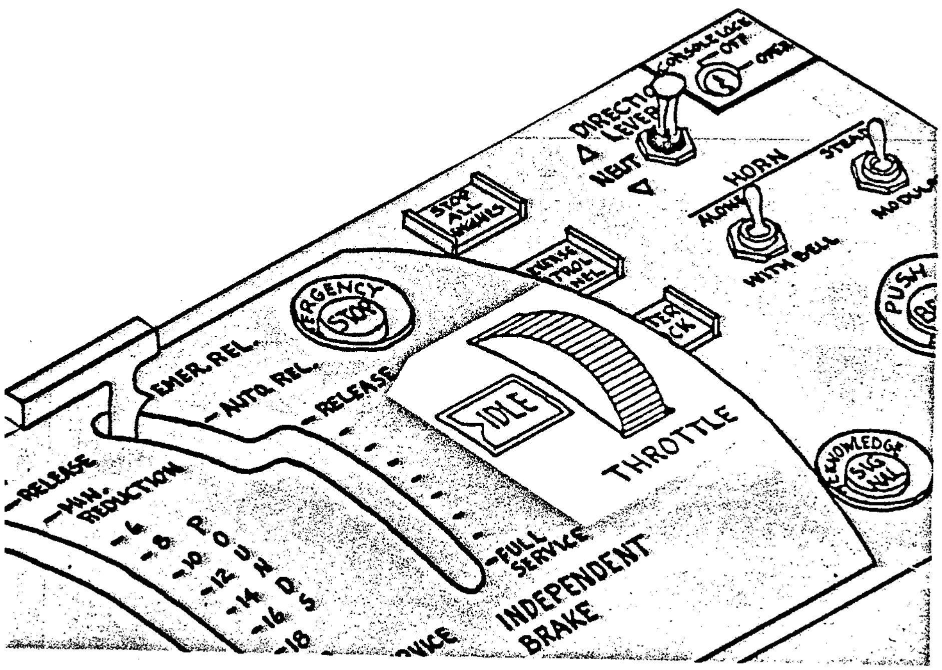


Figure 5-8. Throttle and Throttle Indicator

A movement of the thumbwheel forward increases the throttle setting and engine power, and, consequently, a rotation of the thumbwheel toward the engineer results in a reduction of the throttle setting and engine power.

Thumbwheels can be fluted, or machined with rectangular or triangular knurls. See Figure 5-9. The throttle control for the Universal Safeguard Cab will be provided with rectangular knurls with the ribbing closer and closer toward

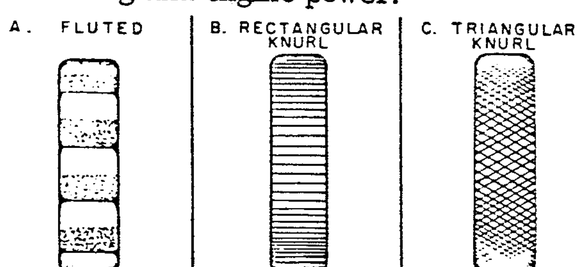


Figure 5-9. Thumbwheel Surfaces

the maximum power setting of 8. This type of knurling provides not only a non-skid surface, but also is a tactual coding method which helps the engineer identify the power setting at least in a general way.

In order to ensure maximum usability of the thumbwheel, even with a gloved hand, the thumbwheel will protrude 0.5" from the surface of the panel. See Figure 5-10. The thumbwheel is 7/8" wide and 4" long.

The throttle indicator is 0.75" by 0.75", and internally illuminated at all times. The word Idle and the numbers 1 through 8 are black on a green background.

The throttle thumbwheel and the throttle indicator are continuous controls. That is, the throttle can be set at any point including settings between indicated power ratings; thus, for example, the throttle can be set halfway or a quarter of the way between power settings 4 and 5. In all cases, however, enough of either number is visible and identifiable so that the engineer is aware of where he is in the power range at all times.

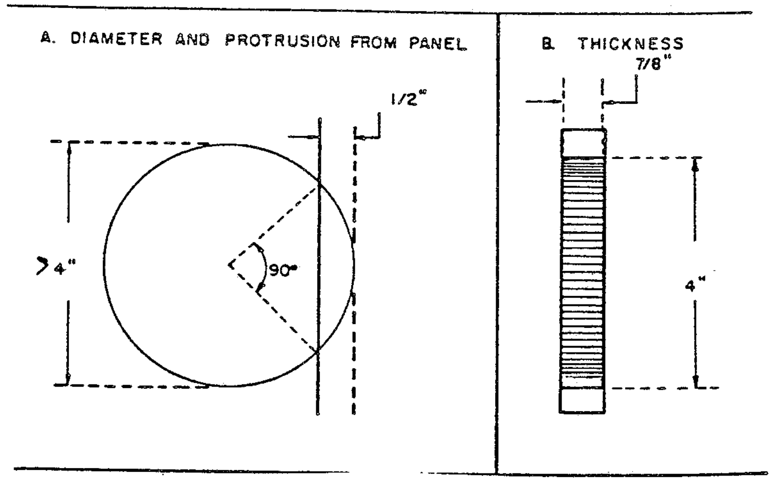


Figure 5-10. Thumbwheel Dimensions

The throttle thumbwheel is not color coded, but rather is metallic silver or gray, as all other non-color coded controls are.

f. Dynamic Braking (Interlock)

The dynamic brake control is a pushbutton type switch located close to the throttle thumbwheel. See Figure 5-11.

To activate the dynamic braking system, the DYNAMIC BRAKE pushbutton is pressed while the throttle is in the idle position. As are most other pushbuttons on the panel, the dynamic brake pushbutton is a snap feel button that illuminates when the system is engaged. The system can only be engaged when the throttle is in the idle position; therefore, pressing of the button when the throttle is in any other setting than idle will have no effect on the system.

Once the system has been activated, moving the throttle thumbwheel forward increases the dynamic braking through throttle positions 1 to 8, where 8 represents the maximum application of dynamic braking.

The dynamic brake pushbutton is 0. 75" by 0. 75", with an internal resistance factor of 20. 0 oz. As with other main control panel pushbuttons, its displacement is 0. 25". The pushbutton is guarded to help prevent accidental activation, although the internal circuitry additionally helps prevent this.

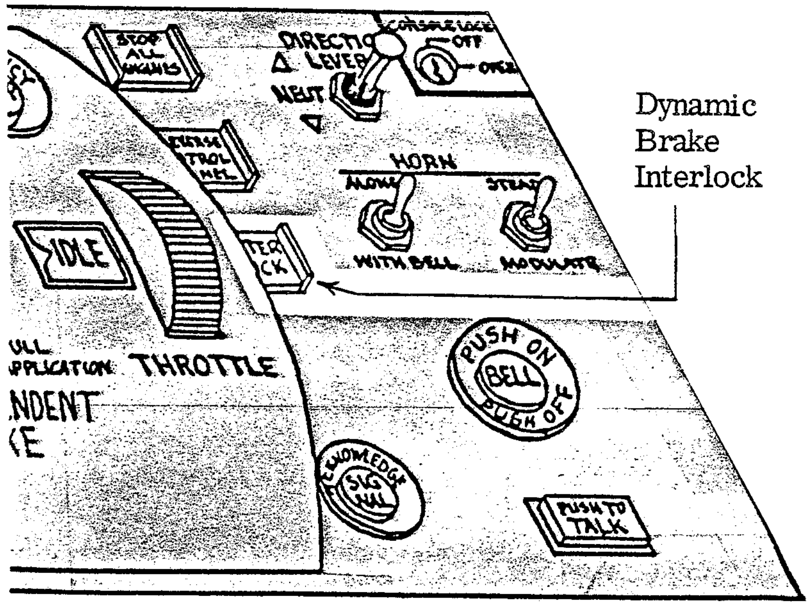


Figure 5-11. Dynamic Brake

g. The Direction Lever

The direction lever is a three-position locking toggle switch which is used to set the direction of the train. The positions are forward, neutral, and reverse. See Figure 5-12.

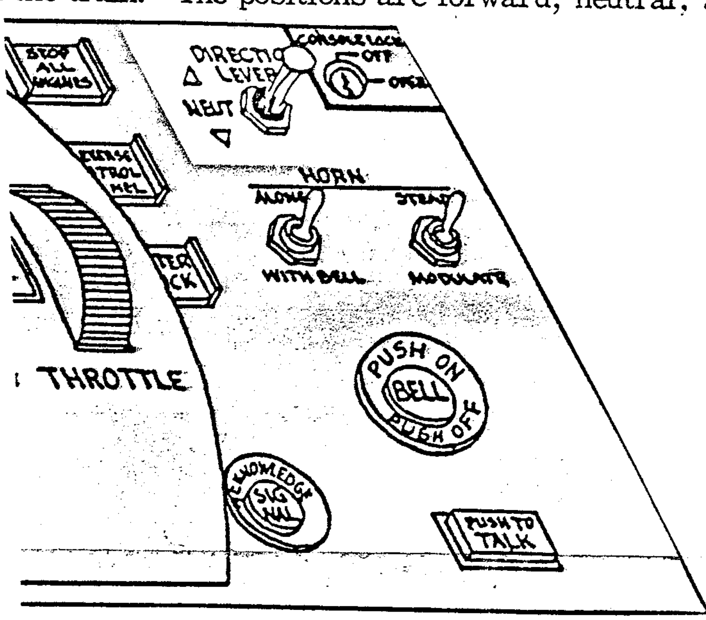


Figure 5-12. Direction Lever

Two small indicator arrows are also provided with the switch to provide a positive indication of the position of the switch. These indicators are energized when the appropriate switch circuit has been energized. The forward position of the switch indicates forward motion, the neutral straight-up position indicates neutral, and the rearward position indicates rearward motion of the cab.

Although this switch is a locking switch, that is, it is locked in position until pulled out from the panel, it still operates as a snap-action switch in order to ensure positive point contact and to prevent stopping between positions.

The length of the arm is one inch with the top at least 0.25". The arm has a non-skid-type surface to facilitate pulling the switch out during operation of the switch.

h. Horn and Bell Controls

The horn and bell controls consist of two toggle switches and a pushbutton on the panel, and a foot pedal located on the footrest under the engineer's console. See Figure 5-13. The foot pedal is activated by the left foot.

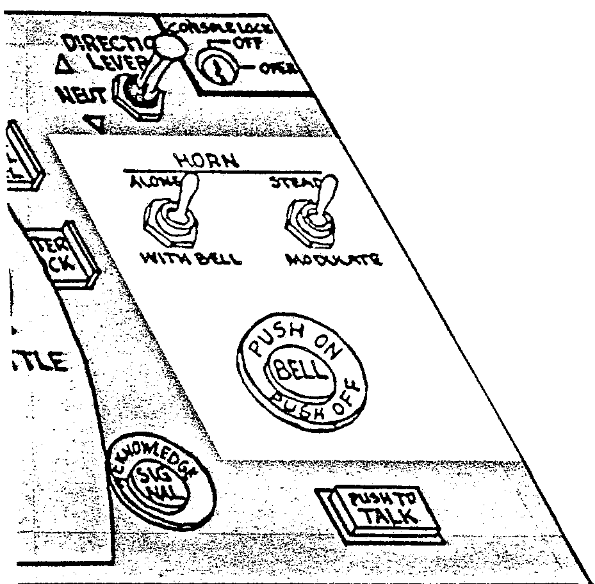


Figure 5-13. Horn and Bell Controls

The two toggle switches are snap-action two-position switches that provide a horn alone vs. a horn with bell option, and a steady horn vs. a modulated horn option. These are set by the engineer prior to the actual activation of the horn by the foot pedal. However, the switches can be operated while the foot pedal is depressed to permit a change of option during the horn operation.

The toggle switches are identical in dimensions. See Figure 5-14. The displacement (A) can be anything from 30° to 120°. The length of the arm is one inch, and the width of the tip (D) is 0.25". These dimensions permit the effective utilization of these switches by the engineer. The distance between the switches is a maximum of 2" to prevent accidental operation of the wrong switch.

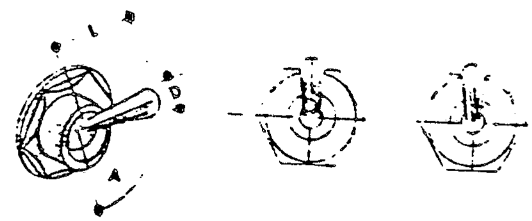


Figure 5-14. Typical Switch Dimensions

The bell pushbutton is a press-on, press-off switch in which the switch is illuminated while the bell circuitry is energized. The bell is 0.75" in diameter, it has a displacement of 0.25", and it has a snap feel in which resistance gradually builds up to approximately 20 oz. before suddenly dropping off to indicate that the switch has been activated.

The foot-operated horn pushbutton has been provided in order to minimize the burden on the engineer's hands and arms. See Figure 5-15. Foot-operated controls are susceptible to accidental activation; however, in this case, this is not considered a serious problem since the control is not considered a critical function.

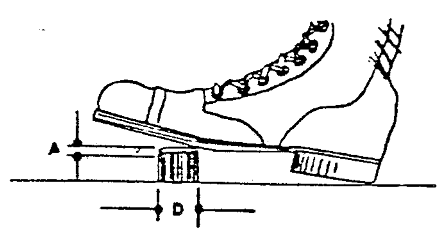


Figure 5-15. Foot-Operated Pushbutton Dimensions

This pushbutton will be 1" in diameter, and is designed to be operated with the sole of the foot. It has a resistance level of 10 pounds to allow the engineer to inadvertently set his foot on the button without operating it. The resistance is light, however, so that little force is required to operate the button. This control is considered to be a frequently used control. One study of freight operations on the Frisco showed that the horn was operated an average of 40 times per hour (Aureleus, 1971). This control can become fatiguing unless the effort is kept minimal, as it is in this design. The displacement (A) is 1". This is to allow for comfortable operation with heavy work shoes which many engineers wear.

i. Headlight Controls

There are two headlight controls. There is the illumination control and a slew switch, both of which are located on the left side of the panel. See Figure 5-16.

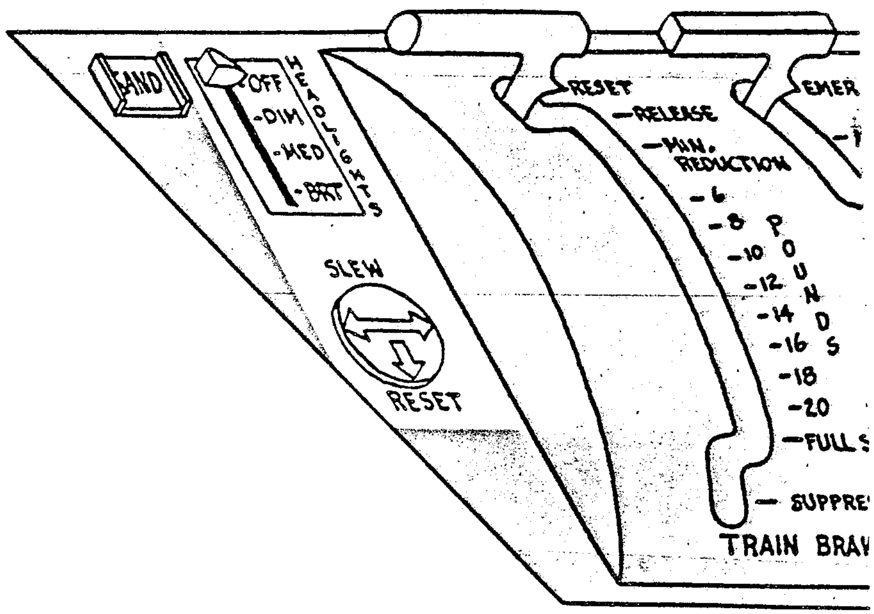


Figure 5-16. Headlight Controls

The illumination control provides a range of intensity levels for the headlights. This lever provides dim, medium, and bright headlight settings. Each position is notched and is a spring-loaded detent so that the switch cannot be inadvertently placed between positions.

The slew control is a two-position pushbutton. Pressing the right side of the button causes one of the headlights to slew to the right; pressing the left side of the button causes one of the headlights to slew to the left. Releasing the switch returns the headlight to the forward position.

The positions of the headlight switch are illuminated when the lever is in the detent position that indicates the position of the switch.

CHAPTER 6

EQUIPMENT, FUNCTIONAL AND INSTITUTIONAL ASPECTS, AND OPERATING PROCEDURES

6.1 Demonstrator Cab Equipment Description

During the demonstrations, each piece of equipment on the Idler Cab will be shown for the benefit of the attendees. See Table 6-1, which shows the items that are functional and those that are non-functional. Some equipment will be operated for the attendees on a simulated basis for two reasons:

- In order to hold down the cost of the demonstration vehicles, only a percentage of the equipment will be completely operational.
- Since several of the systems involve accident and error prevention, a real demonstration would require placing the vehicle, the crew, and the attendees in dangerous situations. It is highly undesirable to place people in such situations simply for a demonstration.

The simulated systems include the fault-detection system that reports problems occurring in trailing locomotives. This system will be demonstrated by flipping a toggle switch that will cause the warning lights and the voice warning system to give a simulated malfunction indication. This indication will be observed by the attendees. Similarly, the track geometry measuring equipment must be simulated; otherwise, the demonstration program would need operational sensors. Since this would not be desirable, and since the attendees should see how the track geometry equipment works and how it signals the engineer, simulation is necessary. Similarly, the voice warning system has to be simulated. Without simulation, the attendees would see this system in operation only if there were an emergency or a real malfunction. The vigilance system will probably be simulated, since this system, to be fully operational, depends on the complete programming of the train-handling system, which would be unnecessarily expensive for the demonstration.

Some systems may be constructed only as non-functioning mock-ups. The train location and collision-avoidance systems will probably be simple mock-ups. These systems, as well as the operating and simulated systems, will be shown in the cab.

6.2 Functional Aspects of Demonstration

The demonstration at each location consists of two phases: familiarization and operation.

Table 6-1. Functionality of Display/Control Elements for Demonstrator

Item	Functional or Simulated	Non-Functional and Mock-up
1. Manual Sand		X
2. Train Brake	X	
3. Auto Brake	X	
4. Stop All Engines	X	
5. Interlock		X
6. Reverse Control Panel Switch	X	
7. Throttle	X	
8. Dynamic Brake		X
9. Direction Lever	X	
10. Emergency Stop	X	
11. Bell	X	
12. Console Lock		X
13. Brake Pipe Air Flow	X	
14. Main Reservoir	X	
15. Equalizing Reservoir Pressure	X	
16. Brake Cylinder Pressure	X	
17. Brake Condition Annunciator		X
18. Speedometer	X	
19. Cab Signal		X
20. Power Drawbar Force		X
21. Timer		X
22. Consist Alarm		X
23. Radio		X
24. Train Handling Display	X	
25. Caution/Warning Advisory		X
(20 indicators)		X
26. Dynamic Brake Cutout		X
27. Generator Field	X	
28. Engine Run	X	
29. Fuel Pump	X	
30. Ground Relay Reset	X	
31. Cab Temperature Control	X	
32. Air Conditioner	X	
33. Cab Heat Control	X	
34. Classification Lights	X	
35. Traction Motor Cutout		X
36. Engine Condition	X	
37. MU-2 Valve		X
38. Windshield Defogger		X
39. Windshield Wiper-Washer	X	

Table 6-1. Functionality of Display/Control Elements for Demonstrator (Con't.)

	Item	Functional or Simulated	Non-Functional and Mock-up
40.	Cab Dome Lights	X	
41.	Number Lights	X	
42.	Step Lights	X	
43.	Platform Lights	X	
44.	Spare	X	
45.	Instrument Lights	X	
46.	Panel Lights	X	
47.	Headlight Control	X	
48.	Headlight MU Setup		X
49.	Headlight Slew		X
50.	Wheel Slip		X
51.	Power Cutoff		X
52.	No Continuity		X
53.	Lead Radio		X
54.	Remote Radio		X
55.	Helper Emergency Brake	X	
56.	Lamp Test	X	
57.	Train Brake-Feed Valve	X	
58.	Independent Brake	X	
59.	Alarm	X	
60.	Ground Relay	X	
61.	Drawbar Force		X
62.	Interlock		X
63.	Throttle	X	
64.	Override		X
65.	Sand		X
66.	Reducing Valve		X
67.	System Test		X
68.	MU/IND Control		X
69.	Panel Power	X	
70.	Panel	X	
71.	Speedometer		X
72.	Cab Signal		X
73.	Lighting Switch		X
74.	HVAC Switch		X

Table 6-1. Functionality of Display/Control Elements for Demonstrator (Con't)

Item	Functional or Simulated	Non-Functional and Mock-up
75. Emergency Brake Valve	X	
76. Communication Handset		X
77. Console Construction	X	

Criteria: Effectiveness of real cab concept demonstration (such as brake control), visual effects, and minimization of costs.

1. Familiarization

The familiarization phase, including a one-hour slide presentation explaining the concept of the Idler Cab, is designed to completely familiarize attendees with the concepts, systems, and benefits of the cab. The familiarization objectives include explanations of:

- The purpose of the cab
- Design for accident reduction
- Crashworthiness
- Human-engineered basic controls
- Advanced systems, including:
  - Collision avoidance
  - Rear-end brake pressure
  - Fuel economy
  - Voice warning
  - Automatic pilot
  - Train location
  - Crew identification
- Vigilance system
- Malfunction and maintenance systems
- Signal-recognition system
- Communications system
- Track geometry measurement system

The rationale behind the design of these systems and how they will be incorporated into the cab will also be explained. The anticipated savings in fatalities, injuries, accidents, and costs accruing from these systems will be emphasized. To eliminate misconceptions before the actual demonstration, all attendees will be thoroughly briefed as to what to expect from the cab before seeing the vehicle. This will reduce time that might otherwise be wasted in the cab attempting to correct misconceptions instead of concentrating on showing the systems and equipment of the cab.

The demonstration at each individual site will include the explanation of all functional and simulated systems and operation of those that can be operated. The basic controls will be handled by the railroad's own engineer. Since the Idler Cab contains the same basic operating controls as conventional cabs, the engineer will be able to handle them under close supervision.

2. Operation

The demonstration will be conducted in an active manner in that the vehicle and as many of its systems as possible will be operational. Very few systems or equipments will be demonstrated as pure paper mock-ups.

With respect to moving operations during the demonstration phase, it is important to realize two things:

- The MU control equipment is functional and workable with currently used locomotives; thus, the demonstrator will be compatible with any locomotive provided by the railroads at the demonstration sites.

- The MU control system will be different in the demonstrator from that in a completely operational Idler Cab, primarily in that the operational cab will have an expanded MU system. It is anticipated that modifications to trailing units that are necessary for the complete functionality of the cab will be made in stages that build on the current MU system. In other words, a completely functional cab will be able to control any locomotive in a basic operating mode. When trailing units are modified with the additional MU system components and circuitry, all of the capabilities of the Idler Cab will become functional.

For purposes of the demonstration, the Idler Cab will have an operational MU system so that it can control current locomotives. It should be noted, however, that the systems that require modification will be simulated, since it is not likely or possible at this point to modify locomotives in current use just for the purposes of this demonstration.

The demonstrator will be fully capable of operation either during the day or at night. Even so, the demonstration is best conducted during the daytime, primarily to ensure the safety of the attendees, especially those who are not familiar with walking through yards and mounting and dismounting engines.

It is fully anticipated that the demonstration will occur regardless of the weather. Bad weather can actually enhance the credibility of the vehicle in that it can show its ability to operate despite difficult conditions.

Similarly, it would be most desirable for the demonstration to include areas of track in which there are grade crossings. Parts of the computer-monitored controlling systems involve the automatic application of bell and whistle signals. If the route for each demonstration run covers grade crossings, this system can operate with a great deal of realism. This leads to an improved sense of credibility and further strengthens the concept that the cab is not only feasible, but also practical and effective.

In general, the Idler Cab should be as operationally feasible as possible within cost limits and should not require modification of locomotive units of the railroads that are used in the demonstration program. Thus, it is advised that the demonstration program be conducted within the current capabilities of rail locomotives regardless of their state-of-the-art. Everything else should be simulated.

The time allowed to each individual demonstration must remain flexible, because it will be left to the individual railroad to determine the actual routing of the demonstration run. Since this routing may very well be the first leg of a regularly scheduled train, it will vary from railroad to railroad; it is considered desirable to leave these choices to the host railroads.

6.3 Institutional Aspects

There are two categories of institutional problems that must be dealt with. The first category involves the demonstration program itself, and the second involves problems that will occur during the introduction of the Idler Cab into the fleet. The problems associated with the use of the cab in the demonstration program are the only ones discussed in this volume; the others are discussed in Volume I.

There are several conditions associated with the use of the Idler Cab in the demonstration phase. These include:

- Scheduling of the demonstration
- Scheduling of the attendees
- Transport of the vehicle
- Routing of the demonstrator
- Use of a railroad engineer
- Interface with current vehicles
- Insurance requirements.

The scheduling of the demonstrator involves all those activities associated with getting the demonstrator to the right location at the right time. This problem will be worked out with all railroads beforehand, and the exact schedule will be determined on the basis of convenience to these railroads.

The scheduling of the attendees also must be worked out with the individual railroads. The most important aspect of the demonstration is to allow its viewing by constructively critical railroad personnel. Therefore, it is most important that the demonstration be scheduled at a time when these people are available and are willing to attend.

A major problem in the demonstration phase will be the transport of the vehicle from one demonstration site to the next. This involves careful scheduling in advance to move the demonstrator in the most cost-effective manner while still ensuring that the demonstrator arrives at each location in a timely and appropriate manner that allows last-minute adjustments and cleaning as necessary. It must also be anticipated that a certain amount of very minor maintenance will have to be accomplished during the course of the demonstration. Examples include replacing light bulbs and calibrating instruments.

The routing of the demonstration vehicle is another problem that will be solved in conjunction with the railroads. The individual railroads are in the best position to select good routes and to determine to what extent the demonstrator can be used in conjunction with regularly scheduled trains. Only the railroads can make such decisions, although guidelines and operational suggestions will be prepared. Most of this work can be accomplished by telephone prior to the arrival of the demonstration vehicle at the site. It is important that the railroads have an opportunity to participate in this phase of the demonstration, since they know their railroads best, and since they will be more interested if the railroads are given an opportunity to participate. The duration of the demonstration period will be variable. Some railroads may opt for a short period, such as one to two hours, while others may prefer a longer time, such as two to four hours and possibly longer. Also, at some of the larger railroads, more than one trial trip may be necessary in order that all the desired attendees can view the vehicle in action. Some demonstration trips may become dual trips in which one group rides it on the way out, while another group rides it on the way in. This method permits twice the number of attendees to ride the vehicle per trip. This process requires greater attention to scheduling, since groups of attendees have to be at certain pick-up locations at set times, and special arrangements have to be made to return the first group of attendees from the drop-off point to the starting point so that they will be able to attend the special debriefing session afterwards.

The debriefing session is held for further discussion, clearing up any final questions, and to emphasize the beneficial aspects of the cab. At this point, attendees will be asked to fill out detailed questionnaires as to their comments, feelings, thoughts, and suggestions relative to the cab. This material will later be used in the evaluation of the cab.

The use of a railroad train is critical during the demonstration phase, since it is anticipated that the only effective demonstration will be the control by the cab of one or more regular locomotives and a train with any number of cars. The railroads will have the responsibility of providing the train and engines. In addition, cooperation will be solicited from railroad yard and mechanical personnel to handle the cab in the yard, to properly couple the cab and to perform the train brake test prior to departure with the regularly scheduled crew and the attendees. Such cooperation must of course be obtained before the arrival of the car at the demonstration site; such cooperation is anticipated since the program fits into the railroad's operating procedures and does not require special or unusual work or activities.

The use of a regular railroad crew to operate the cab is a most desirable and credible means of demonstrating the cab. The railroad may, however, want to select the specific crew for this run. In addition, it is important to note that union clearance will probably have to be completed and received before arrival at the demonstration site; however, union cooperation is expected and anticipated since the unions most likely will desire to participate and be represented in the demonstration.

There are design problems in the interface between the cab and currently used locomotives. These design problems will be resolved completely only by the modification of currently used locomotives. Since it is neither expected nor desirable to modify currently used units solely for the purpose of the demonstration, the systems of the cab may therefore be in a mock-up or simulation mode, rather than being fully operational. Many of the cab systems and equipment can be simulated very effectively and will provide a clear demonstration of their purpose and means of operation. This means that what the attendees see will be exactly what they would see if the interface requirements were met, and if the right external contingencies were occurring. For example, during the demonstration of the track geometry track geometry measuring equipment, which is simulated equipment, the attendees will see the warning light illuminating and a magnetic tape recording being made.

Another problem area in the demonstration phase is the need for insurance coverage. This problem will have to be worked out both with the railroads and with appropriate insurance carriers. Insurance will be necessary to protect both the demonstrator vehicle and the railroads from damage and liability loss occurring during the course of the demonstration program.

6.4 Operating Procedures

6.4.1 Pre-Run Preparation

1. Fuse and switch panel (located in lavatory compartment). Place consist set-up switches in appropriate positions as required by power units coupled.

2. Upper front control panel. Place engine set-up and lighting switches in appropriate positions as required by equipment.

3. Check main control panel to see that:

   a. Throttle is in IDLE.

   b. Direction lever is in NEUTRAL.

   c. Console lock is turned to OPERATE, pushed in and key removed.

   d. Train brake is in suppression.

   e. Independent brake is in full application.

   f. Stop all engines is not illuminated.

4. Energize power plant by turning fuel pump ON and turning engine condition condition switch to START ISOLATE.

5. Check main reservoir pressure - pointer must be in green band before proceeding.

6. Train brake test

   a. Check main reservoir pressure - pointer in green band.

   b. Unlock console by inserting key and turning to operate position.

   c. Check hand brake indicator light - green "HAND BRAKE ON" light must be dark indicating hand brake is not applied.

   d. Train brake placed in release position.

   e. Independent brake placed in release position.

   f. Check brake cylinder pressure - must be 0.

   g. After placing independent brake in full application, the brake cylinder pressure gage should show increase in pressure to maximum pressure as specified by operating authority.

   h. Train brake tests are performed as specified by government authority. Use should be made of "Brake Pipe Venting" indicator, air flow gage, timer, and train handling display to take full advantage of these facilities.

7. Sanding Test

   a. Depress manual sand button - button should illuminate and latch in the down position.

   b. Ground observer should check to see that sand is being properly applied.

   c. Depress manual sand button - button should be popped out and not illuminated. Sanding action should stop.

6.4.2 Running Procedures

1. Pre-start Checkout

   a. Throttle - move to idle.

   b. Direction lever - move to neutral.

c. Brakes - set as required.

d. Generator field switch - in ON position.

e. Engine run switch - in ON position.

f. Ground relay reset - be sure that button is not lighted.

g. Cab temperature control - set as needed.

h. Class lights - set to appropriate color.

i. Traction motor cutout - set to appropriate position.

j. Cutout valve - set to FRT or PASS.

k. Windshield defog/deice - set as needed.

l. Windshield wiper/washer - set controls as needed.

m. Cab dome lights - set as needed.

n. Number lights (rear and front) - ON.

o. Instrument and panel lights - set as needed.

p. Headlight control - set to position required by governing authority.

q. Headlight slew test - push switch to right to move headlight to right, push to left to move headlight to left, push "RESET" to center the movable headlight.

r. Check caution/warning/advisory panel - ensure that all indicator lights are not lighted. If indicator is lighted, correct fault before proceeding, except lube pump which will stay on for 30 minutes.

s. Check train handling display to be sure that all display modes are operating.

t. Perform communications check on radio.

u. Perform cab signal check.

2. Starting Train

a. Release train brakes allowing sufficient time for all brakes in train to release. Train handling display may be used to verify when brake pipe pressure has stabilized.

b. Check main reservoir pressure - pointer must be in green band.

c. Move direction lever in desired direction.

d. Release independent brake.

e. Move throttle wheel forward to move train.

f. Read power/drawbar force meter.

g. Roll throttle forward to achieve desired acceleration without allowing either "FORCE" or "POWER" needles on power/drawbar force meter to cross into red zone. Throttle settings are numbered 1 through 8 on a green background.

3. Accelerating Train

a. Throttle wheel is a variable control allowing operator to place throttle between numbered settings to achieve desired tractive effort. However, advancing the throttle more than one numbered setting at a time is not desirable to prevent wheel slipping.

b. Desired acceleration can be achieved by noting rate that speed increases and holding "FORCE" pointer on power/drawbar force meter steady by gradually advancing throttle when force pointer moves back toward center of dial.

c. "FORCE" pointer and "POWER" pointer on power/drawbar force meter must be carefully monitored to ensure that neither pointer crosses into the red zone. If either pointer crosses into the red zone, throttle may be reduced to avoid this condition.

d. Draft/buff indication on train handling display must be monitored to ensure that drawbar force is not exceeded throughout length of train. If curve climbs too rapidly toward a maximum level, or exceeds the maximum level, corrective action must be taken to prevent excessive forces from building up.

4. Train braking - speed may be decreased by using any one, or combination, of the following methods:

a. Roll throttle wheel back to sufficiently decrease tractive effort and reduce speed. Train handling display may be used to review grade and curvature characteristics. Rate of change of speed should be noted so that new target speed will be met without excessive throttle movements.

b. Dynamic brakes are activated by assuring throttle is in idle, depressing interlock button and rolling throttle wheel back to "SET UP" position. After pausing in "SET UP" for a period specified by the governing authority, the throttle wheel may be rolled back into dynamic brake to slow the train. The dynamic brake positions are numbered 1 through 8 on a blue background. When throttle is placed in dynamic braking power/drawbar force pointers will move into blue dynamic brake band. Neither pointer should be allowed to move into the red zone. Train handling display may be used to monitor drawbar force throughout the length of train to ensure that maximum forces are not exceeded. If graph of draft/buff force drops below neutral line too rapidly or exceeds maximum buff limit at bottom of display, throttle wheel may be rolled forward a sufficient amount to reduce danger of exceeding drawbar force limit.

c. Train brakes operate in a manner similar to 26L brake equipment. Pulling the train brake handle back in the service range decreases equalizer reservoir and brake pipe pressure. Brake system values are indicated on the vertical tape instrument on the main display panel. Emergency brake function is on right side of panel.

d. Independent brakes are operated in the same manner as 26L brakes in the service range. See Section 4 for explanation of release and emergency release positions.

e. Emergency brakes may be used in either of two ways. Push button labeled "EMERGENCY STOP" will activate emergency brakes when depressed. Red handle at brakeman's console will activate emergency brakes when pulled. Red "EMERGENCY BRAKE ON" indicator light will illuminate when emergency brakes are applied.

During emergency brake application (either intentional or unintentional), locomotive brake application may not be desired. To counteract locomotive brake application during emergency braking, place independent brake handle in "EMERGENCY RELEASE" position. This position is spring-loaded and handle must be held in this position until brake cylinder gage displays "0." Locomotive brakes may be reapplied as specified by governing authority.

Emergency brakes may be released by placing the emergency brake control that was used into normal "OFF" position. When train has stopped, brake pipe has stopped venting, as indicated by the green "BRAKE PIPE VENTING" indicator light no longer being lighted, and train handling display shows no pressure in brake handle in "RESET" position. When brake pipe pressure has been restored, place train brake handle in "RELEASE" and resume mission.

5. Operating Train in Reverse

a. Train must be at a complete stop.

b. Throttle must be in "IDLE."

c. Pull direction lever toggle switch out from panel and place into appropriate position. Switch handle should point in direction locomotive must move.

d. Release brakes and apply tractive effort by rolling throttle wheel forward as required.

6. Changing control position from main control panel to optional reverse control panel

a. Main control panel setup

(1) Direction lever - "NEUTRAL."

(2) Throttle wheel - "IDLE."

(3) Train brake - "RELEASE" or specified by governing authority.

(4) Independent brake - "Full application" or as specified by governing authority.

(5) Bell - OFF.

(6) Emergency stop - OFF.

(7) Sand - OFF.

(8) Console lock - OPERATE.

(9) Remote control panel switch - ON.

b. Reverse control position setup

(1) Throttle - "IDLE."

(2) Train brake - "RELEASE" or as specified by governing authority.

(3) Independent brake - "Full Application" or as specified by governing authority.

(4) Emergency stop - OFF.

(5) Direction lever - 'NEUTRAL."

(6) Panel power - ON.

c. Operation - controls on this panel operate in the same manner as controls on the main control panel with the exception of the throttle. This control is a slide that increases or decreases power. No dynamic braking is available.

6.4.3 Post-Run Procedures

1. Note all malfunctions, failures, performance parameters, on appropriate form.

2. Throttle - 'IDLE."

3. Direction lever - 'NEUTRAL."

4. Train brake - 'SUPPRESSION."

5. Independent brake - full application.

6. Generator field switch - OFF.

7. Console lock-key removed and button depressed.

8. If engine is to be shut down, move engine condition switch to STOP position. Engine will immediately shut down.

6.4.4 Emergency Provisions

6.4.4.1 Ingress/Egress

Normal and emergency escape/rescue is through the two doors on the sides of the cab. Additional emergency escape/rescue points are:

Side Windows - Windows slide open toward rear.

Front Windshields - Windshields may be removed by pulling a small handle located on the rubber stripping around the glass. When handle is pulled, the rubber stripping is exposed and can be pulled away to remove the window. Instructions for use are printed on inside and outside of cab.

Roof Hatch - In case of roll-over, hatch will be accessible for escape/rescue. Hatch is opened by unlocking and rotating two securing levers and pulling hatch in.

NOTE

THE ENTIRE TRAIN AND ENGINE CREW SHOULD BE FAMILIAR WITH AND KNOW THE LOCATION OF FIRE EXTINGUISHERS AND FIRST-AID KITS. IF IN DOUBT AS TO PROCEDURES TO BE USED IN CASE OF FIRE ON LOCOMOTIVES, CHECK WITH ROAD FOREMAN, SAFETY DEPARTMENT, SUPERVISOR OF LOCOMOTIVES, MASTER MECHANIC, OR FIRE CHIEF.

6.4.4.2 Fire

1. Fire extinguisher is provided in cab next to brakeman's seat.

2. Guarded push button on main control panel will stop all engines in locomotive consist in case of fire, smoke, or other emergency.

3. Engine condition switch on overhead panel will stop engine on locomotive in case of emergency.

4. Fuel pump cutoff switch on overhead panel will stop fuel flow to engine in case of fire.

6.4.4.3 First Aid

A first-aid kit is available in the recessed cabinet in the toilet compartment.

6.4.5 Operating Scenarios (Example)

The operation begins with the engineer reporting to his train to begin preparation for his run. He will be operating a rather long train made up initially of 100 cars of mixed freight. His motive power will consist of three high horsepower units in the lead consist with two helper units approximately halfway back in his train, all controlled by the Universal Safeguard Cab. The remote units are radio control units which he will operate in the independent mode. The run will begin at Big Bend and terminate at Snedley. There will be another stop at Lafayette Shop to wait for a passing train, at which time they will eat. The operation begins just after sunset on a hot evening in August.

Before the engineer accepts locomotive power he performs a walk-around inspection which will include checks to ensure that the trailing units are set up properly. This will be followed by an inspection of the Universal Safeguard Cab, and a pre-run set-up procedure that will include performance of brake tests and communication checks. When he is satisfied that everything is operational and within required acceptable limits and that his consist is ready to go, he will request clearance to move his consist to the ready track. Once this clearance is given by the dispatcher, the engineer pulls the consist out onto the ready track and backs up to couple with his train. He then waits for the signal from his brakeman that the train is coupled and trainlined properly. He then performs pre-run train brake tests and sets up his helper consist control panel, performing checks on the control response of his remote radio-controlled units.

Once the engineer is satisfied that his train is ready he will again obtain a clearance from the dispatcher to move his train out onto the main track.

On this run the engineer knows that he has to pull a grade for most of the first 7 miles so he will attempt to throttle up as fast as permissible without exceeding power/drawbar force limitations. In order to alleviate problems with controlling the slack action of his train, he will start by rolling the throttle "on" on the remote units. A notch or two ahead of the lead units, he carefully monitors the slack/buff display - on the train handling aid CRT - and the draw bar force gauges for both the remote and lead consists, avoiding any excessive buildup of buff forces between the remote consist and the lead consist.

As he pulls out of the station he is confronted by the first of many road crossings for which he sounds both the bell and the whistle until safely past the crossing.

As the train crests the top of the first grade about 3 1/2 miles from the small town of St. John, the engineer begins to throttle back on the lead consist smoothly into dynamic braking. He maintains throttle on at the remote consist to push the train over the top - thereby keeping the slack bunched between the two locomotive consists. As the helpers crest the hill, he begins to throttle back on them also, eventually going into dynamic braking on the remote units as well as the lead. The engineer knows that he must slow to 25 mph one mile before reaching the town of Lowell. (This is due to a slow order in effect for a bad section of track near Lowell - he knows this from his train orders which he read before departing Big Bend). He therefore attempts to bunch his whole train smoothly after cresting the hill, so that he will be able to slow his train while on the descending grade approaching Lowell, without undesirable slack action. This he accomplishes with no problems utilizing the information provided by the train/track profile and draft/buff displays on the train handling aid.

Having passed Lowell there are no train orders in effect and the engineer has relatively little to do. Aside from normal train handling - over mostly flat, slightly undulating terrain - he must sound the horn and bell at every road crossing, of which there are many, and almost all are unguarded. He does have to maintain an alert watch for vehicles or pedestrians on the track, knowing that such occurrences are frequent.

Upon reaching Monon the schedule calls for 40 cars to be set out from the rear end of the train and 50 cars to be picked up. The engineer slows the train to 5 mph before reaching the yard limit marker, proceeding into the yard as clearance is given by the dispatcher. Then, in compliance with the dispatcher's directions and the ground crew's signals, the engineer proceeds to back the train onto the side track to set-out the cars and again to pick up the new cars on an adjacent side track. Once this is done, the engineer performs another brake test before he is ready to take the train back out onto the main track. He then is instructed by the dispatcher that he will have to hold on the siding for 15 minutes to wait for a passing train which is running behind schedule. As the train approaches, the engineer dims his headlights, then slews one headlight to inspect the other train as it passes by.

After the train has passed and the engineer receives his clearance onto the main track, he starts his train, again keeping the slack bunched between the lead and remote consists. A heavy downpour of rain which began while they were waiting for the other train to pass, has left the track wet and slippery. To get his train moving without wheelslip the engineer applies sand to the remote units and to the lead trucks, by depressing the respective buttons. As the caboose begins to roll, he again depresses the sand buttons to stop sanding.

The next leg from Monon to Lafayette is again mostly flat and slightly undulating with few curves and a descending grade from Ash Grove to Lafayette Shop. Again upon cresting the hill at Ash Grove, the engineer begins to take up the slack in the rear half of his train in order to slow to 5 mph before reaching the yard limit at Lafayette.

About 2 miles before reaching the Lafayette yard limit a truck is encountered stalled on the tracks at a crossing which lies just beyond a blind curve. The engineer realizes that he will not be able to stop with a normal brake application, so he quickly depresses the emergency stop button, rolling the throttle to idle. He is, however, concerned about developing flat spots on the locomotive wheels and, therefore, allows only 20 p. s. i. brake cylinder pressure to develop by moving the independent brake control into the emergency release position, to bail-off any further build-up of pressure. This brings the train to a stop short of the stalled vehicle, which is eventually restarted and driven off.

The engineer now moves his train brake handle to the reset position and allows his train to recharge. He also contacts the dispatcher and informs him of the delay. When the train is fully charged and the brakeman has inspected the train for possible damage and for proper release of the train brakes, the engineer again starts the train and proceeds on to Lafayette.

Upon arrival at Lafayette Shop clearance is received from the dispatcher to go directly into the siding to wait for another train passing in the opposite direction. During this delay the crew will leave the train to get a hot meal. The engineer therefore parks the train, setting the brakes and controls as required by railroad regulations, finally locking the console before departing the train.

Upon returning to the train, the crew performs a pre-run inspection and the engineer performs his pre run procedure to set up the train again, to continue the run. Once this is completed and clearance is received from the dispatcher, the engineer starts the train, pulling out onto the ready track, and continues his run on to Michigan City.

The terrain en route to Michigan City is mostly steep grades with many curves. The engineer's skill is tested as smooth train handling becomes a difficult challenge. However, with the aid of his train/track profile display and the slack/buff display on the CRT, as well as the drawbar force indicators, he is able to plan ahead and see how his train is reacting to his control actions. He is also able to determine adverse slack action beginning to develop and take remedial action before serious situations can arise. Thus the run to Michigan City passes without incident.

Upon arrival at Michigan City clearance is received from the dispatcher to pass through without delays; thus our train continues on to Murdock. However, the stretch between Murdock and Bedford is a very steep grade. The engineer knows from experience that he won't be able to pull the grade with such a long train. He therefore must double the hill.

To do this he first backs into the wye at Murdock and sets out the cars at the rear end of his train. He then pulls the grade with the remaining cars and parks them at Bedford Junction. Then he backs his locomotive consist back down to Murdock, utilizing the reverse control panel, to pick up the rest of his train. Once the train is made up and the necessary checks and brake tests are satisfactorily completed, the engineer will pull the train out of Bedford Junction and proceed on to Snedley.

Upon arrival at Snedley the train is switched onto side track where the engineer will terminate his run and set the train up to be parked. He performs post-run checks and procedures, locks the console and leaves the train.

6.5 Demonstration Procedures

The Universal Safeguard Cab demonstrator vehicle will stand alone on the siding, ready for a demonstration run of several miles. The purpose of the demonstration run is to familiarize those present with the vehicle and its eventual capabilities in the real world environment, even though not all of its state-of-the-art technological advances have been fully implemented yet in this prototype vehicle due to economic and time constraints.

The individual presenting the Universal Safeguard Cab demonstrator to viewing personnel will perform the following procedures:

Start-Up Routine

1. Study vehicle and documentation thoroughly to become familiar with operating methods and safety precautions.

2. Inspect vehicle for cleanliness, proper operation of all systems and presence of adequate fuel, lubricant, etc.

3. Set lighting and air-conditioning levels as necessary for time of demonstration.

4. Arrange for clearance of locomotive and cars to be used in demonstration.

5. Arrange demonstration route details based on time and track clearances available.

Demonstration Routine

1. Meet viewing personnel at terminal building and escort to demonstrator location.

2. Execute walk-around inspection of vehicle with visitors, explaining exterior features and undercarriage and introducing over-all purpose and design of U. S. Cab.

3. Assist visiting party in boarding vehicle and conduct walk-through tour, explaining general lay-out, track geometry instrumentation, and crash-protection features.

4. Introduce visitors to general configuration of cab area and control console, with emphasis on exterior visibility and comparison of console functions, to presently used locomotive control stand.

Hostling Demonstration

1. Secure passengers for vehicle movement and operate demonstrator in yard to couple with assigned locomotive and cars.

2. Demonstrate forward and reverse hostling, ride quality, sound-proofing, use of sliding windows, horn & bell controls, rear-view mirrors, etc. Explain bi-directional capability of fully implemented U. S. Cab.

3. Explain, during period of in-yard assembly, the development status of mock-up systems and their potential capabilities.

4. Demonstrate loading of computer with stored data on consist makeup and route profile, explaining how computer system will utilize data in train handling during trip.

5. Explain and demonstrate interface arrangements between U. S. Cab demonstrator and trailing locomotive during coupling and brake tests.

6. Prepare track geometry instrumentation for route demonstration.

Control Demonstration

1. Clear for main track and demonstrate acceleration, cab signal operation, brake system gauges, etc.

2. Demonstrate computer display of track profile and train handling parameters.

3. Demonstrate track geometry instrumentation in operation.

4. Demonstrate radio communication in route.

5. Invite questions from visiting personnel at frequent intervals.

6. Return to starting point and spot locomotive and cars in assigned positions.

Conclusion Routine

1. Thank visitors and present evaluation and suggestion forms to be completed by them.

2. Invite further questions and discussion.

3. Secure U. S. Cab demonstrator and escort visitors back to terminal building.

4. Complete demonstration report form for visit, describing notable events of the trip, who was present, and other appropriate data.

5. Arrange for transportation of demonstrator to next demonstration site.

CHAPTER 7

DEMONSTRATION PLAN AND SCHEDULE

In order to show the functionality of the demonstration vehicle, a fairly clear plan of the demonstration is needed.

7.1 Approaches

Major decisions involve basic demonstration approaches. These include:

1. Moving operations
2. Nighttime operations
3. Bad weather operations
4. Grade operations
5. Track geometry assessment
6. Short-term operations

7.1.1 Moving Operations

A basic distinction can be made between a demonstration which is purely a static mockup and one in which the demonstrator vehicle moves. The basic movement can be accomplished in two ways:

1. The demonstrator can be pushed by the trailing locomotive on signal.

2. The demonstrator can control the operation of the following locomotive.

In the first case, the trailing locomotive will require a crew, as will the Universal Safeguard demonstrator. In the second case, a crew will be required only in the demonstrator, as the action of the locomotive will be controlled by the demonstrator. This, of course, requires an operational control and braking system. However, for demonstration purposes, a non-moving vehicle will be seen by observers as dubious; the impression created by a moving vehicle is better.

A vehicle which can control the movement will be seen immediately as a vehicle which works. This is the opinion shared by all Trans Systems team members and consultants. This immediate impression translates into the impression that all systems will work, even in mockups.

7.1.2 Nighttime Operations

Another major decision involves the time of the demonstration. If the demonstration is conducted only during daylight operations, certain systems need not be operational. These systems include:

- ▲ headlights, including the slew system
- ▲ warning lights
- ▲ dome lights
- ▲ exit lights

Restricting the demonstration to daylight operations will not affect the quality of the demonstration. In fact, this may be superior in terms of permitting ease in inspection of the external structure and equipment. A piece of equipment that will, no doubt, be of particular interest will be the external track geometry sensing equipment.

7.1.3 Bad Weather Operations

One possibility for a demonstration time is during bad weather. Bad weather operations would show the operation of the Universal Safeguard demonstrator under adverse conditions. Therefore, bad weather operations will be demonstrated only on a limited scale because of the following:

1. Safety considerations. Bad weather entails some additional operating risks. Guests would thereby be exposed to additional risk.

2. There would be difficulty in inspecting the exterior of the vehicle, and in adequately assessing visibility, since visibility will be restricted during rain and snow.

3. In order to be equipped for bad weather operations, functional equipment including lights, windshield wipers, and defrosters would have to be installed.

7.1.4 Grade Operations

Although operating on a grade may or may not occur depending on where the demonstrations take place, operation specifically on a grade is not necessary for an effective demonstration. Any available track, such as a test track or training track, is considered acceptable.

There may be a problem with a severe grade in that, should the locomotive provided have any difficulty, that difficulty will be seen as a fault of the Universal Safeguard demonstrator rather than a fault of the provided locomotive.

Finally, grade operations, especially for severe grades, will require the installation of functional, dynamic braking controls in the demonstrator which would otherwise be unnecessary.

7.1.5 Track Geometry Assessment

This demonstrator aspect is considered essential. The track geometry measuring equipment should be operational in the sense of demonstrating something. This demonstration can be a real track evaluation or a programmed fault indication.

An actual fully-operational measuring device is desirable in that it is the most credible. The disadvantage is that if there happens to be no fault on the test route, nothing will be seen. If a fault can be simulated, the track geometry measuring equipment will operate and will record the problem. Something will be shown happening, and this will enhance the believability of the demonstration.

7.1.6 Short-term Operations

If the demonstration period is kept short - for example, to an hour or less at each site and/or for each group - then habitability facilities such as the restroom, water cooler, and refrigerator need not be functional items. But if the demonstration takes longer, these items should be functional.

At this time, it is recommended that the demonstration be limited to an operational time of one hour. Additional static time can be made available before and after the operational demonstration.

7.2 Demonstrator Itinerary and Costs

The demonstration program is seen as a mini-sample of what the Universal Safeguard Cab can do. Therefore, the demonstration phase is an activity primarily designed to show that the Universal Safeguard Cab actually works in an operational setting. Thus, what is critical to a successful demonstration is the incorporation of all functional systems. This would create the impression that the Universal Safeguard Cab actually works, and that it works better than currently operational locomotive cabs. To create a successful demonstration vehicle, certain basic systems must be operational. For example, the basic control systems must be operational so that the demonstrator can actually pull a train. If it cannot actually control a train, it will not be seen as a control vehicle, and a major portion of the demonstration will have to be devoted to a convincing verbal discussion that the demonstrator "could control the train if the right systems were hooked up." This is, at best, a weak form of demonstration, whereas the moment the vehicle moves as the controlling vehicle of the train, the point is made. No discussion "trying to prove" that the Idler Cab actually works is necessary. Only words emphasizing the controlling ability of the cab are necessary to emphasize the ability of the Universal Safeguard Cab to control the train. This only adds to the value of the effective demonstration.

Thus, it would appear that the demonstration program should allow:

1. Control and braking by the demonstrator
2. Basic communications
3. HVAC
4. Some form of track geometry measurement.

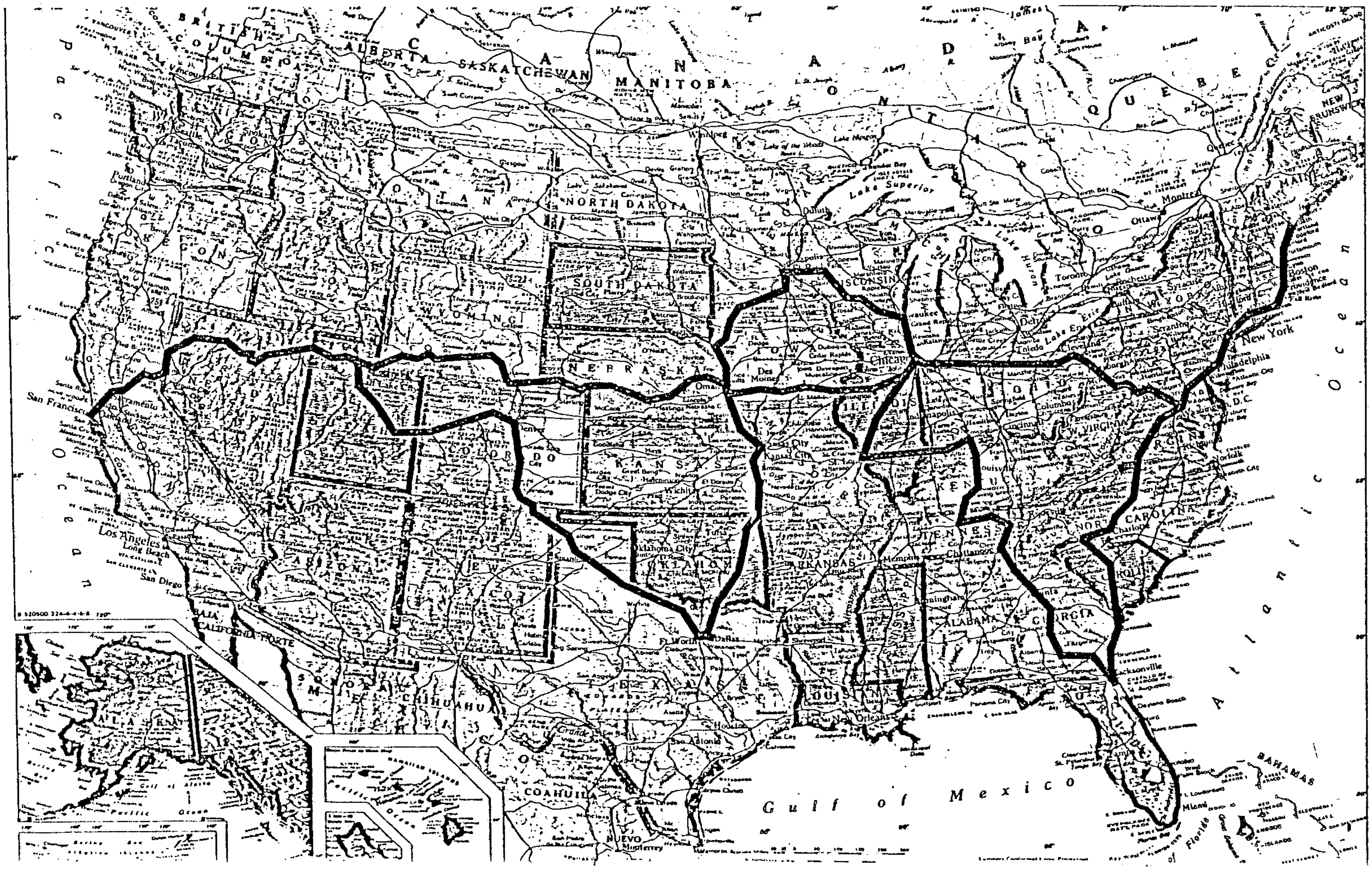
Further, it is envisioned that the operational form of the demonstration will take place on a test and training track, rather than on main line routes.

For the demonstration sites, Table 7-1 shows the proposed itinerary and Figure 7-1 shows the map route. The sites were chosen to provide the most cost-effective means of demonstrating the U.S. Cab to the greatest number of Class I railroads on one round-trip demonstration program. The involvement of specific railroads in the demonstration is shown in Table 7-2.

Table 7-1. Demonstration Sites and Rail-Bound Transportation Costs

Itinerary	Distance		Transport Costs	
	Miles	Cum. Miles	Cost	Cum. Cost
Washington, D.C. to Portland, Me. (Alexandria, Va.) (Bangor, Me.)	455	455	$ 339.43	$ 339.43
Portland, Me. to Boston, Mass.	110	565	82.06	421.49
Boston, Mass., to Philadelphia, Pa.	310	875	231.26	652.75
Philadelphia, Pa., to Baltimore, Md.	100	975	76.37	729.12
Baltimore, Md., to Roanoke, Va.	325	1,300	242.45	971.57
Roanoke, Va., to Jacksonville, Fla. (St. Augustine)	600	1,900	447.60	1,419.17
Jacksonville, Fla., to Atlanta, Ga.	330	2,230	216.81	1,635.98
Atlanta, Ga., to Louisville, Ky.	320	2,550	210.24	1,846.22
Louisville, Ky., to St. Louis, Mo.	270	2,820	198.45	2,044.67
St. Louis, Mo., to Chicago, Ill.	300	3,120	220.50	2,265.17
Chicago, Ill., to St. Paul, Minn.	430	3,550	344.86	2,610.03
St. Paul, Minn., to Minneapolis, Minn.	20	3,570	76.37*	2,686.40
Minneapolis, Minn., to Omaha, Neb.	360	3,930	288.72	2,975.12
Omaha, Neb., to Dallas, Tex.	675	4,605	541.35	3,516.47
Dallas, Tex., to Denver, Col.	700	5,305	561.35	4,077.82
Denver, Col., to San Francisco, Cal.	1,250	6,555	1,002.50	5,080.32
San Francisco, Cal., to Wash., D.C.	2,800	9,355	2,190.20	7,270.52
* Minimum Charge			Total Transportation Cost	$7,270.52

Note: Transport costs are based on rail cab/caboose car - 8 wheels classification:
Cost Per Car Per Mile Rate: South - $0.657, East - $0.746,
West (1) - $0.746, West (2) - $0.802.
Cities are selected on the basis of Class 1 Railroad Class A Mainlines.



▬ Demonstration Route

Figure 7-1. Routing of Demonstration Sites

Table 7-2. Class I Railroad Demonstration Involvement

Bangor, Maine	Bangor and Aroostook R.R.
Portland, Maine	Maine Central
Boston, Massachusetts	Boston and Maine
Philadelphia, Pennsylvania	Conrail
Baltimore, Maryland	Chessie System
Roanoke, Virginia	Norfolk & Western
Jacksonville, Florida	Seaboard Coast Line
St. Augustine, Florida	Florida East Coast
Atlanta, Georgia	Southern Railway System
Louisville, Kentucky	Louisville and Nashville
St. Louis, Missouri	Missouri Pacific St. Louis - San Francisco R.R. Company
Chicago, Illinois	Santa Fe Chicago North Western Chicago Rock Island Chicago-Milwaukee St. Paul & Pacific R.R. Illinois Central
St. Paul, Minnesota	Burlington Northern
Minneapolis, Minnesota	Soo Line
Omaha, Nebraska	Union Pacific
Dallas, Texas	Missouri Kansas & Texas R.R. Company
Denver, Colorado	Denver Rio Grande
San Francisco, California	Southern Pacific

7.3 Major Milestone Timing Chart

The overall work plan for the demonstration phase is illustrated in Figure 7-2.

Task I, "Build Demonstrator," includes the engineering and fabrication to the previously specified level of functionality of the cab structure and equipment and the mock-up and simulated equipments. The eight months' time allows not only for the basic construction, but also for checking and debugging of the cab structure, equipments, controls, and simulators. The project management will assure that the design is progressing exactly according to design specifications and will work out any last-minute modifications and improvements.

Task II involves two major subtasks, "Complete Arrangements" and "Certify Cab." The first subtask includes the scheduling and arranging of demonstration sites, personnel, supporting equipment, and insurance requirements, as well as the basic process of arranging for the transport of the U. S. Cab from one demonstration site to the next. This is primarily a management/scheduling problem.

The second subtask involves the roadworthy certification of the cab, to ensure that all equipments for road operations meet standards and requirements of individual railroads. This activity requires close work with governmental agencies, AAR, and the individual railroads.

Task III, "Demonstrate U. S. Cab Nationwide," is the actual nationwide demonstration of the U. S. Cab. This involves the movement of the cab from point to point, and a complete exposition of the advantages and capabilities of the cab. It is anticipated that each demonstration will begin with a short slide presentation explaining the advantages, capabilities, uses, and benefits of the cab to the individual railroad. After the familiarization presentation and discussion, the attendees will be brought to the U. S. Cab for a ride covering a route specified by the railroad. The cab will be operated by engineers or road foremen of the host railroad. During the ride, the operational and simulated equipments will be exhibited.

Task IV, "Inventory Comments," will involve a debriefing session and discussion in which critiques will be inventoried and comments studied to improve both the cab and the demonstration program. Critique sheets will be distributed to all attendees at the demonstrations.

Task V, "Evaluate the Demonstrator," will follow the complete nationwide demonstration. A detailed evaluation of the Universal Safeguard Cab will be performed using comments, data, and information developed during the previous tasks. It will include detailed evaluations of structure, equipments, designs, functions, uses, and applications. Of importance also will be suggested modifications and improvements, and recommendations concerning the need for additional systems, equipments, and capabilities.

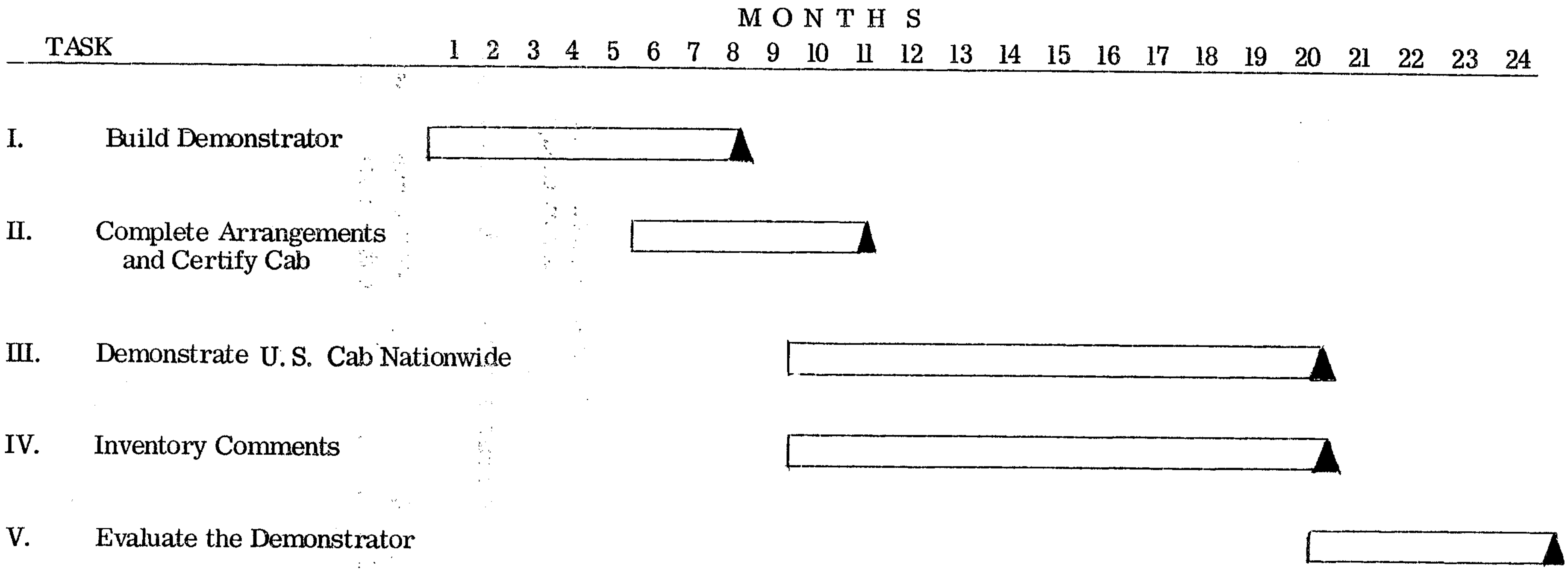


Figure 7-2. Milestone Chart for Demonstration Phase

APPENDIX A

HI-RAIL DISCUSSION

A-1 Assumed Hi-Rail Vehicle

The following findings emerge from an analysis of the dual-mode of demonstrator. They are presented here for those who are interested in more detailed information about the hi-railer than was considered necessary for evaluating the seven configuration alternatives in the main body of the report.

Listed below are details of approximately as large a hi-rail vehicle as can be accomodated on the track.

The vehicle below is similar to either a GMC model V4000 or a Ford F-800 series chassis.

Overall length - 345" or 28'-9"
Wheel base - 212" or 17'-8"
Height over cab - 89" or 7'-5"
Overall width - 90" or 7'-6" (over rear double tires)
Chassis weight with cab only - 6,100 lbs.
Capacity of front axle - 7,000 lbs.
Capacity of rear axle -16,000 lbs.

Gross van weight -23,000 lbs. -- (about 16,900 lbs. for mock-up)

The estimated complete cost of chassis only with hydraulic-operated Hi-Rail guiding wheels is $30,700.00.

The comparison of GMC model V4000 or Ford F-800 series chassis is used for deriving two vehicle types. Some of the flexibility in dimension is represented by common types of vehicles available.

APPENDIX B
HIGHWAY-BOUND DEMONSTRATOR TRANSPORTATION COSTS

45' L x 10' W x 10' H -- 25,000 Pounds
To Move on Tri-State 260 Series Extendible Trailer
(Quotation from Tri-State Motor Transit Co., Oct. 5, 1977)

From	To	Highway Miles	Truck-Trailer Cost
Washington, D.C.	Bangor, Me.	663	$1,343.41
Bangor, Me.	Portland, Me.	134	540.80
Portland, Me.	Boston, Mass.	106	694.80
Boston, Mass.	Philadelphia, Pa.	296	825.72
Philadelphia, Pa.	Baltimore, Md.	96	702.80
Baltimore, Md.	Roanoke, Va.	262	767.60
Roanoke, Va.	Jacksonville, Fla.	565	1,031.15
Jacksonville, Fla.	St. Augustine, Fla.	39	476.20
St. Augustine, Fla.	Atlanta, Ga.	345	656.25
Atlanta, Ga.	Louisville, Ky.	382	741.74
Louisville, Ky.	St. Louis, Mo.	263	787.60
St. Louis, Mo.	Chicago, Ill.	289	783.20
Chicago, Ill.	St. Paul, Minn.	395	964.45
St. Paul, Minn.	Minneapolis, Minn.	10	489.20
Minneapolis, Minn.	Omaha, Neb.	357	724.39
Omaha, Neb.	Dallas, Tex.	644	1,133.68
Dallas, Tex.	Denver, Colo.	781	1,315.07
Denver, Colo.	San Francisco, Calif.	1,235	1,540.50
San Francisco, Calif.	Washington, D.C.	2,799	4,726.53

Estimated Total Line Haul Charges. $20,245.09

Detention of Tractor and Trailer at Each Destination Per Day . . . $152.00