THE IRON HIGHWAY AND ITS EFFECTS ON INTERMODAL TERMINAL DESIGN AND OPERATIONS*

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Iron Highway™ is a proprietory technology of CSX. This paper represents the perspective of the authors rather than CSX.

ABSTRACT

The purpose of this paper is to describe the unique intermodal terminals that will support the Iron Highway, a new, radically different intermodal technology designed to make rail-intermodal price and service competitive in markets currently unserviceable. Several types of terminals and their markets will be examined, including sites in major metropolitan, seasonal agricultural, and dedicated industrial areas.

The Iron Highway combines an innovative railroad technology with a traditional intermodal operation—circus loading. The basic unit of the Iron Highway is a 1200 ft (366 m) long, self-propelled, bidirectional element consisting of a self-propelled, continuous flat deck with a split-ramp loader at its center and control cabs at either end. Trains of up to five elements may be made. Standard highway trailers ranging in length from 28 ft (8.5 m) to 57 ft (17.4 m) can be quickly loaded onto the deck by a single operator using a hostler tractor. Typically an element would carry 20 trailers.

Terminal requirements for the Iron Highway are minimal. Terminals can be built anywhere along a rail line that has sufficient room for a siding and convenient highway access. No mechanized lift equipment is needed. Terminals can be established where they most conveniently serve the customer, thus minimizing truck-haul and lowering drayage costs. The simplicity, flexibility, and lower cost of Iron Highway terminals will create new opportunities for railroads in the intercity freight market.

IRON HIGHWAY: A NEW RAIL-INTERMODAL TECHNOLOGY

The Iron Highway Concept

At a public meeting in 1985, the Association of American Railroads (AAR) introduced the High Productivity Integral Train (HPIT) program and invited proposals for the development of integral train technology and design concepts for both a bulk and an intermodal train. To assist and guide train-design proposers, AAR published a market-size estimate and goals for designers to meet or exceed. Each design was to reduce line-haul costs by 50 percent. AAR provided a panel of experts, from its member railroads, to evaluate the proposals.

The New York Air Brake Co. (NYAB), a designer of electro-pneumatic brake and control systems, offered a number of device variants and systems to proposers. NYAB also provided overall concepts intended to assist potential customers. To ground these ideas in reality, rather than take an invent-it-and-they-will-come view of the problem, NYAB availed itself of market information on both types of service. The company soon concluded that a 50 percent reduction in line-haul costs, solely through change in train technology, was probably not possible. However, in conducting the research that led to this conclusion, a viable option arose. Since about 40 percent of the price paid by customers goes toward line-haul cost (the remainder goes toward drayage and terminal costs), a 50 percent reduction in the overall cost of the operation would be beneficial. This reduction might be achievable if technology could overcome certain barriers to intermodal operations.

NYAB recognized that input cost seemed to exclusively affect the pricing of a good or service, and it recognized that the customer is, in fact, a purchaser of a good or service and a purchaser of performance and quality. Thus, if design-improvement goals were to be modified to include increased performance, such a new technology would be very important, influencing the growth of market size and profitability. With this background, NYAB outlined a concept dubbed the "Iron Highway."

The Iron Highway concept sought to overcome perceived barriers to intermodal growth and to improve service timing and reliability to the point where the Iron Highway could be observed by trucking companies (the target market) as a low-cost performance equivalent to the concrete highway. It was this interchangeability, incidentally, that gave the system its name.

To compete for trucking business, the new technology had to perform in seven vital ways:

1. Use other peoples' boxes (any size, length, and type);
2. Reduce capital cost per unit of production;
3. Reduce or eliminate drayage;
4. Offer trucking companies an opportunity to reduce their costs;
5. Offer schedules that trucking companies could accept;
6. Offer truckers reduced cargo loss and damage; and
7. Reduce wheel, rail, and equipment maintenance.

Each of these seven performance requirements dictated some aspect of the final design concepts, which correspond to the above technology requisites:

1. Implement roll-on-roll-off loading and a continuous deck;
2. Reduce costs in comparison with the costs of conventional cars and locomotive;
3. Achieve faster turnaround time and or increase performance reliability;
4. Load and unload at points convenient to the customer, without requiring high year-round volumes, as needed by existing technologies;
5. Understand and address all sources of service and maintenance delays in existing systems;
6. Attend to slack action, impact, and ride quality; and
7. Focus on wheel and rail interaction, and carefully analyze potential failure modes, affects, and corrective actions.

The design produced is an outcome of this examination. In the words of the AAR expert analysis team, "While different from conventional equipment in virtually every aspect of its design, there is no fundamental reason why it should not be successful."

The Iron Highway Design

The Iron Highway design combines an innovative and unique railroad technology with traditional rail-intermodal terminal operation—circus loading. The primary unit of the Iron Highway is a self-propelled bidirectional element that consists of a continuous flat deck with a split-ramp loader at its center and control cabs at either end (Figs. 1 and 2). Each control cab is equipped with transit-type couplers which permit, from the head-end cab, the rapid make up of trains capable of multiple unit (MU) operation. As many as five of the 1200 ft (366 m) elements can be coupled together to make trains up to 6,000 ft (1,829 m) long.

The deck itself is composed of small articulated platforms, with a single pair of wheels supporting each articulation. Motive power from the diesel propulsion engines in each cab is transmitted to the first five axles on each end of the element. A trainlined computer system simultaneously logs maintenance data, commands propulsion, brakes, and couplers, as well as controls the operation of the element.

The loader (Fig. 3) is, in reality, two ramps, each of which is connected to an adjacent half-element by an articulated joint (Fig. 3). When the loader is separated, the apron of each ramp is supported, a slight distance above the rails, by small wheels, enabling trailers to be driven easily onto the deck. When pushed together using the motive power of one of the half-elements, the ramps interleave, one on top of the other. After the ramps are mated, special couplings automatically connect all air and electrical circuits and hold them together.

Standard highway trailers that range in length from 28 ft (8.5 m) to 57 ft (17.4 m) can be quickly loaded onto the deck by a single operator using a specially equipped hostling tractor—without the use of ground personnel. The operator can select a pull-up hitch to accommodate each trailer's length. Hitch spacing will be optimized for 28 and 57 ft trailers, independent of platform length, and can be easily changed. A typical element will carry approximately 20 trailers.

Development of the Iron Highway

As a direct result of the AAR program, CSX Intermodal gave NYAB the opportunity to develop the Iron Highway technology in a joint development program. This program, initiated in 1990, envisioned a three-phase effort to prove the concept by developing a practical train which would fulfill the promise shown in the preliminary AAR evaluation.

Phase one of the program used a three-platform partial train to prove the radical suspension and articulation concepts on the AAR's test track at Pueblo,

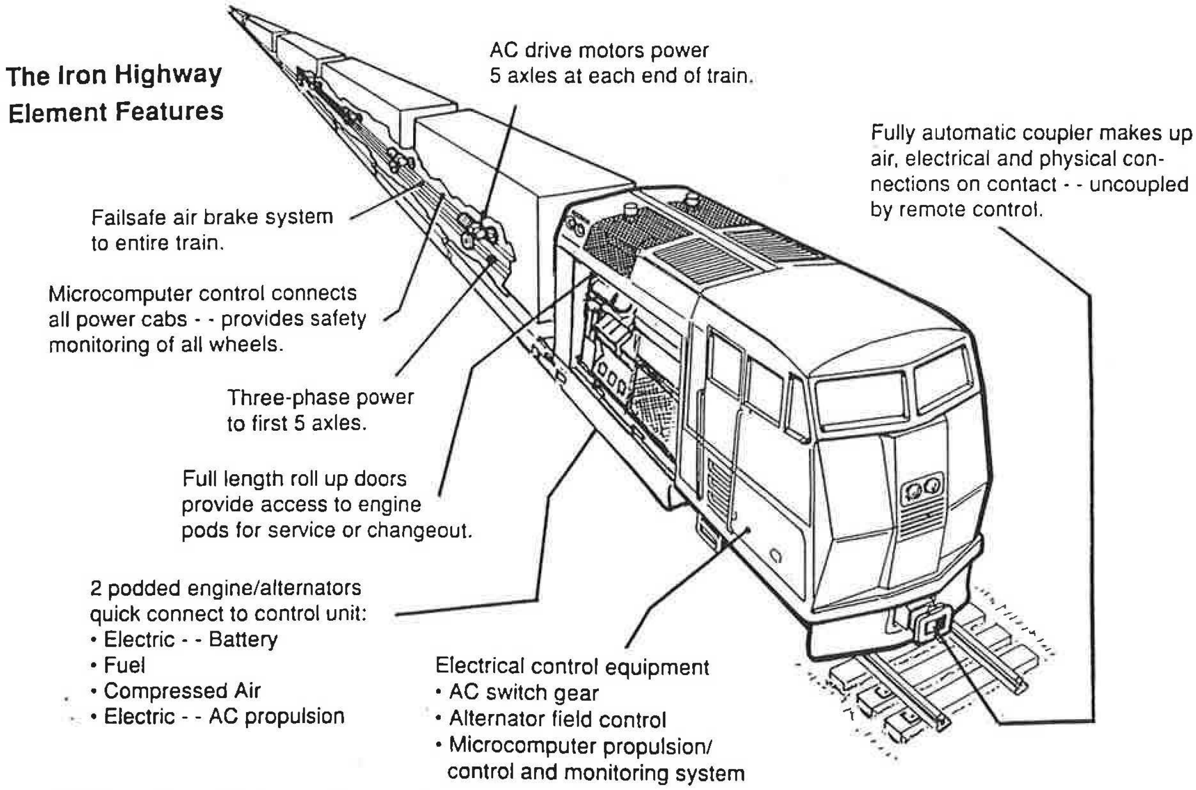

FIGURE 1 Iron Highway element features.

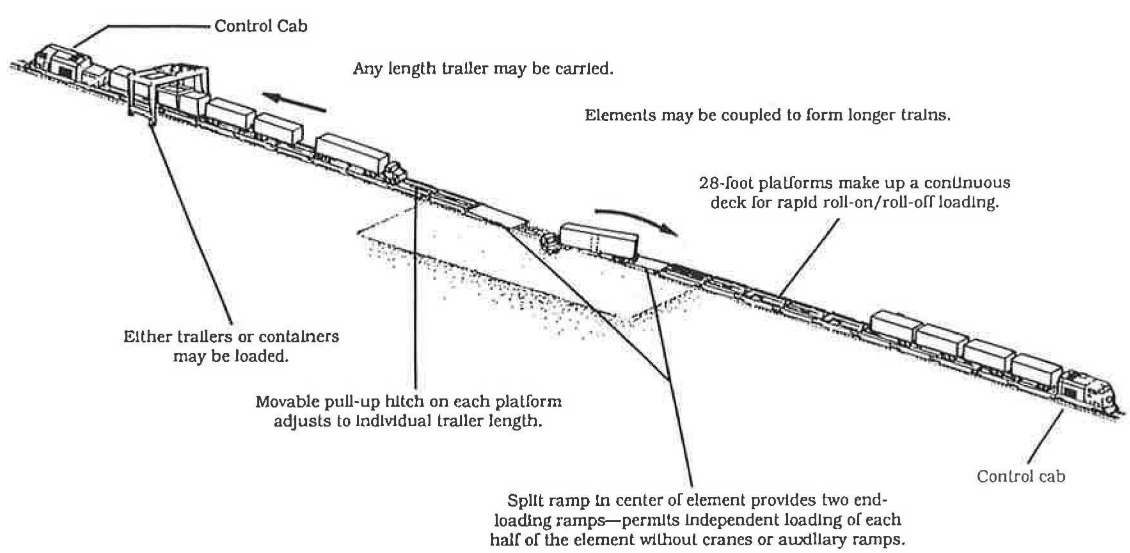

FIGURE 2 Terminal loading system.

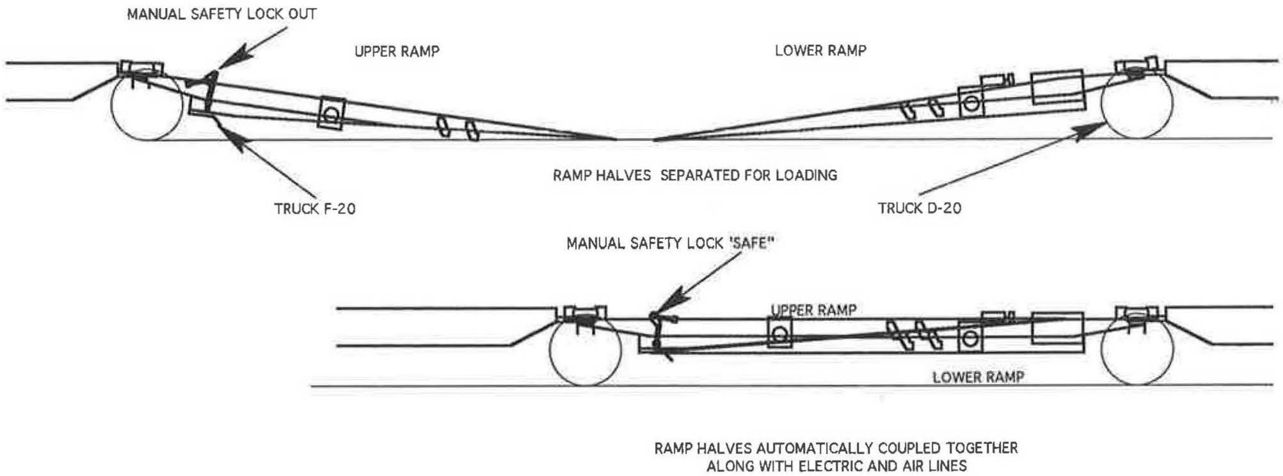

FIGURE 3 Split ramp operation.

Colorado. At the same time, tests of a proposed loading and tiedown system were performed at NYAB's plant in Watertown, New York. By the conclusion of phase one, there were no doubts about the capability of the suspension system, as it had demonstrated superior ride quality and excellent trackability during extremely difficult stretches of AAR's test track. Need for further improvement in the trailer loading system was noted and addressed.

Phase two included the production of a fully-powered partial train element that would allow testing of the improved loading, propulsion, braking, and power transmission systems. Propulsion-system development carried out in this phase included the computer-based MU control system hardware and software. Squeeze tests and further ride testing were also conducted. The loading system was considerably refined. As a serious design flaw in the final drive-differential gearboxes prevented full-power and speed testing of the propulsion system, these issue have been remedied and appropriate design testing implemented.

CSX Intermodal purchased NYAB's interest in the Iron Highway and, to accelerate the concept to market, embarked on an additional phase of development work, known as "phase $2^1/_2$." In this phase, four trains will be built that are to be propelled by a pair of semipermanently-coupled locomotives. This combination will permit evaluation of all operational aspects of the system while phase-three testing and development of the propulsion system continue.

Iron Highway Loading and Unloading Operations

Tests with actual equipment have demonstrated that the average time required to move a trailer from the end of the ramp, position the trailer on the deck, tie it down, and move the hostler off the deck is consistently less than five minutes. These tests have also shown that the average time required to drive a hostler tractor from the end of the ramp onto the deck, retrieve a tied-down trailer, and pull the trailer off the deck to the ground is under three minutes.

Since only one hostler can work on the deck of a half-element at a time, the minimum theoretical loading time for one element with 20 trailers is 50 minutes (assuming two hostlers, each working a half-element at the same time). Likewise, the minimum unload time of a 20-trailer element is 30 min. In actual situations, loading and unloading times will vary, depending on the number of hostlers actually employed, the distance from the lip of the ramp to the parking space, and other local variables. These simple test results, verified a number of times during phase-two test work, permit the design of loading and terminal operations and give creditability to the projections to be described further on.

THE INTERCITY FREIGHT MARKET—IRON HIGHWAY MEETS THE CHALLENGE

Trucks Dominate the Short-Haul Market

In 1992 motor carriers hauled 2.8 billion tons (2.5 billion Mg) of domestic intercity freight—43 percent of the total tonnage moved by all modes. (*1*) To move this volume, the trucking industry primarily employed combination unit trucks (i.e., truck configurations that combine separate power units with semitrailers), using a fleet of nearly 1.3 million truck tractors and over 3.8 million commercial trailers. (*1*) Significantly, the average length of haul for these intercity trucks was 410 mi (660 km), while in the same year railroads hauled 1.4 billion tons (1.3 billion Mg) of freight for an average haul length of 763 mi (1,228 km). (*2, 3*)

What the former tonnage statistics do not tell is that trucks, compared with railroads, are much more likely to haul high-value goods, than lower-paying bulk commodities. Intercity trucks earn, on average, 22.4 cents/ton-mi, a rate that is more than eight times what rail earned at 2.58 cents/ton-mi in 1992. (*2*)

Unquestionably, U.S. railroads, which carried over 7.1 million containers and trailers on double-stacks, spine cars, and flatcars last year, have become very successful in the long-haul intercity market. (*3*) However, in the immense and lucrative short-haul intercity market, trucking is virtually unchallenged by the railroads. With exception of a few unique corridors, railroads have had only limited success in selling intermodal services of 500 mi (800 km) or less. In fact, the typical haul length (rail portion) for an intermodal trailer with marine containers ranges from 1,300 mi (2 090 km) and 1,900 mi (3 060 km) to 1,700 mi (2 700 km) (Smith, D., Mercer Management, *unpublished data*).

Railroads using current intermodal technologies have difficulty competing in the short-haul intercity market for two age-old reasons—time and money. As the length of the rail portion of the move decreased, terminal handling time, which is not a function of the length of the rail haul, assumes a greater share of the overall transit time. Likewise, as the length of the rail portion of the move decreases, terminal handling and drayage costs, which are also not a function of the distance that the trailer or container travels on the rails, take on an increasingly larger share of the overall transportation costs. There is a point at which it becomes faster and cheaper (and easier) to haul goods all the way by truck rather than by intermodal services, and, depending on the corridor, this point usually occurs somewhere between 700 and 1,100 mi (1 120 to 1 760 km).

Other Limitations of Conventional Rail Intermodal Services

Rail intermodal services have other disadvantages in competition with trucks in the intercity market. To maximize the railroad's inherent economies of scale, U.S. railroads have concentrated on creating large intermodal hubs in more populous metropolitan centers, and U.S railroads have either reduced the service to intermodal ramps in less populated areas or eliminated the ramps at these locations altogether. Consequently, many regions of the country are not well served by intermodal services. Because the per mile cost of drayage is greater than the per mile cost of long-haul trucking, the overall cost of an intermodal move to a remote location served through a major intermodal hub can be higher than an all-truck move, even when the move is long-haul.

Furthermore, since virtually all of the approximately 200 U.S. intermodal facilities are fully mechanized (DeBoer, D., Greenbrier Intermodal, *unpublished data*) and few railcars are configured for circus loading, railroads are limited to lifting trailers and containers on and off railcars. A trailer not meeting AAR structural standards that is lifted is at some risk of damage to the trailer and its contents, and this risk increases with each successive lift. Presently, the railroads own or control approximately 100,000 Z-type (i.e., piggyback) vans which meet AAR structural standards (Cole, D., TTX *unpublished data*). This number is quite small compared to the number of over-the-road trailers indicated earlier. Consequently, when competing against the abundant supply of standard trailers operated by truckers, providers of intermodal services which rely on rail-controlled trailers are at somewhat of an equipment disadvantage.

As for containers, even though the size of the domestic container fleet, estimated at 75,000 to 80,000 (DeBoer, D., Greenbrier Intermodal, *unpublished data*), is growing and marine containers are usually in plentiful supply, these containers require chassis. And chassis and chassis management together increase the level of complexity and add an additional cost to intermodal services; two problems intercity truckers do not face.

Iron Highway Meets the Challenge

Clearly, there are segments of the intercity market that represent an enormous opportunity for railroads. With the Iron Highway, railroads now have an excellent time- and cost-saving intermodal technology for competing more successfully in the short-haul intercity market and in other markets currently insufficiently served, or not served at all, by intermodal. The Iron Highway's inherent lower labor costs, flexibility, and rapid loading/unloading performance are of particular benefit to terminal operations. These beneficial operating features are especially evident in these areas: the assembly of trains; inspection of mechanical systems; fast one-person loading and unloading; and the sole use of one minimum-sized fixed plant.

These modest terminal needs of the Iron Highway contribute significantly to its competitive edge. Because of this important feature, Iron Highway terminals, unlike "conventional" rail-intermodal terminals, do not need to be sited at a small number of hubs, where a great number of trailers and containers are concentrated from a large-dray radius.

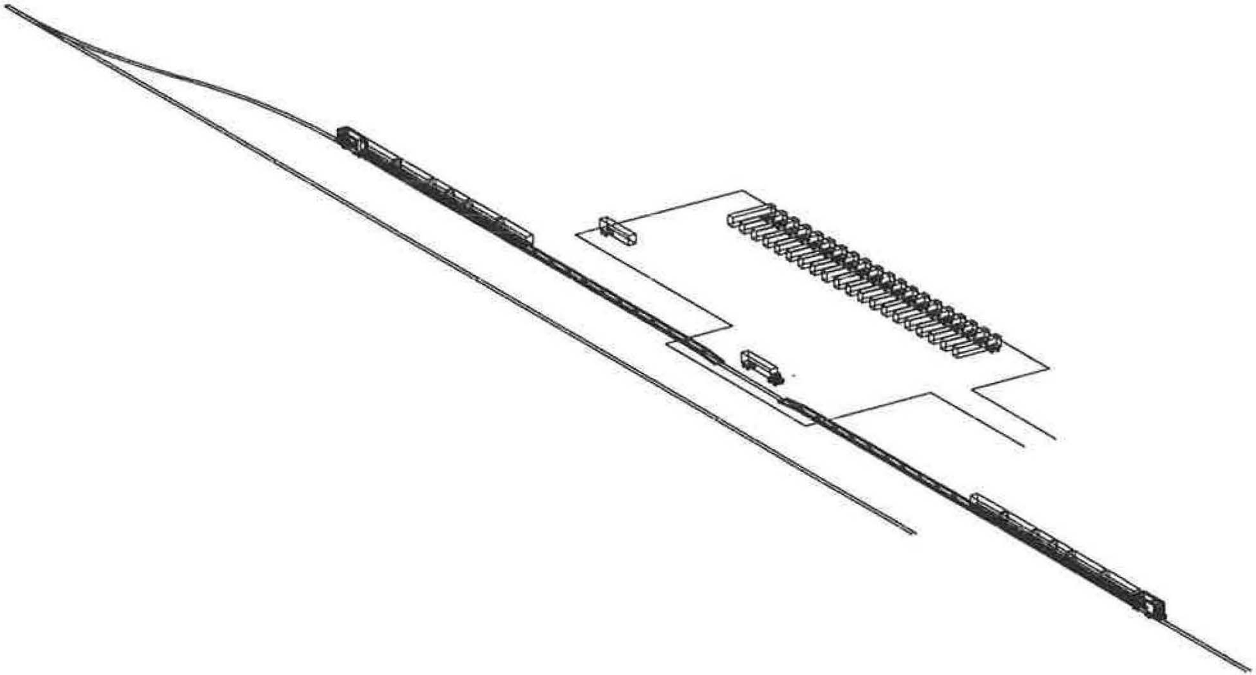

FIGURE 4 Minimum facility for iron highway loading.

With a minimum investment, terminals can be located at any point along a rail line that has convenient highway access and room for a siding. Under the proper circumstances, such business would originate at a motor carrier's terminal, a large manufacturer's facility, or a consolidation center for agricultural products. A sufficiently large concentration of trailers destined for common geographic areas already exists in locations throughout the United States.

Because Iron Highway terminals are so easily established, customers can have rail-intermodal terminals located at sites most convenient to their foci of operations. With reduction in truck-haul distance, there would be lower drayage costs and faster service. Possibly, by having terminals at their plants, larger customers located along rail lines could eliminate the need for drayage. Trucking company customers could colocate rail terminals with distribution terminals located outside of congested areas, avoiding traffic delays and further congestion.

TERMINAL DESIGN

Introduction

There may be two types of Iron Highway terminals at loading point terminals, Loading Points and Rail Only. Trailers may be transferred from, to, or between Iron Highway trains. A loading- point terminal can range in size and capability from a single siding, long enough for one element with limited train maintenance and servicing available, to a multitrack facility, with room for many elements and a fully equipped maintenance shop. Iron Highway elements are marshalled at rail-only terminals, where servicing capability may be available but trailer loading and unloading operations do not take place.

Minimum Loading-Point Terminal: Requirements, Space, and Facility Requirements

The minimum length for a loading point siding is approximately 1,350 ft (412 m) of straight-level track. The loading area with a surface level to the top of rail is located in the middle 150 ft (46 m) of the siding. Parking space for trailers waiting for loading or pickup must be provided. Since parking a 53-ft trailer requires about 560 ft^2 (52 m^2), 20 trailers (for a load-only minimum facility) would require at least 11,200 ft^2 (1 042 m^2). If trailers are to be exchanged, twice this space would be required, as all 20 trailers arriving on an element would have to be unloaded and parked before loading the 20 outbounds could begin. A minimum facility meeting these criteria is shown in Figure 4.

The costs for developing such a facility will vary, depending on the extent of the total space requirements for parking and other needs. Cost estimates for the minimum requirements include:

- Site preparation, $1,000;
- Gravel paving with geo-textile fabric base, $1.50/ft^2;
- Single wide office trailer (if needed), $12,500;
- Utility hookups (if needed), $1,500;
- Fencing (if needed), $8/ft; and
- Contractor's markup, 40–50 % of total.

It is assumed that: no trackwork is needed (i.e., the siding is already in place); no real estate is to be purchased; and there are no subsurface interferences (e.g., pipeline, buried cable) at the site. The total cost will increase accordingly if the trackwork requires rehabilitation, land is to be purchased, or other site-specific problems exist.

DWELL TIME

Dwell time and the frequency of service will affect terminal requirements in terms of personnel, security provisions, and other site facilities. Based on the results of the loading tests discussed above, it is estimated that the dwell time needed for loading an Iron Highway train, using two hostlers per element, would be on the order of one hr. Unloading time would be less, about 45 min. The optimum dwell times to unload then load a train, again using two hostlers per element, would be approximately 2 hr. The expected dwell times for a given minimum terminal will, of course, vary greatly, depending on the availability of hostlers and other site-specific conditions.

INSPECTION MAINTENANCE AND REPAIR

There are two critical points to inspect before leaving a terminal. First, the proper functioning of the brake system must be verified. Second, the trailers must be checked to confirm that they are all locked into their stanchions, with stanchions locked erect. Both of these inspections are incorporated into the train's unique full-time electronic inspection system. A visual pull-by inspection must be made to check wheels and brake shoes to determine whether there is any broken or dragging equipment. By making a pull-by inspection when an element arrives, running repairs can be accomplished during loading operations.

Maintenance and repair activities at a minimum facility would be limited. Repairs made at this type of facility would consist of the minimum necessary to assure safe operation. Items found defective on inbound inspections would either be repaired before departure, if possible, or cut out and logged into the maintenance computer for later correction at a terminal with suitable facilities. Developing conditions such as a fraying hose or fluid leak would be reported for future attention at a facility equipped for light running repairs.

Since visual inspections are done on a pull-by basis, they do not require an inspector to walk the train. Minor repairs, however, do require access to the train from the ground. Therefore, a safe walkway for repair personnel is a necessity, and vehicle access to at least one side of the train should be provided, even in a minimum facilities.

SECURITY

Terminal operators can, via contract, arrange and schedule the hours trailers wait during loading and load pickups without the presence of drivers. Since minimum facilities do not have permanent personnel, contracted security services can guard and control the trailers, releasing them to drivers with proper documentation. Security costs vary according to location. For example, this service can be provided for an estimated $160 fee per 8-hr shift in Tennessee (Guardsmark Security Service, Inc., Memphis, Tennessee, *unpublished data*).

TERMINAL TYPES AND MARKETS SERVED

Agricultural Terminal

Several industries can benefit from the ease and low cost of a minimum load-point terminal with Iron Highway service. However, the agricultural commodity business faces a barrier to these benefits due to its seasonal nature. But this barrier to Iron Highway service can be overcome. For example, a group of farmers could agree to load trailers and haul them (often taking advantage of special rules for farmer-operated trucks) to a suitable location, such as a coop-owned grain elevator, where adequate rail and parking facilities suitable for a minimum terminal exist (Fig. 5).

Under this arrangement, contracts with the intermodal operator would specify the period of service and could allocate space on a required 24-hr cancellation basis. Given the minimum capital outlay for the service, an agricultural shuttle can be established at roughly the cost of sending a salesperson to arrange paperwork and procedures with the farmers' group.

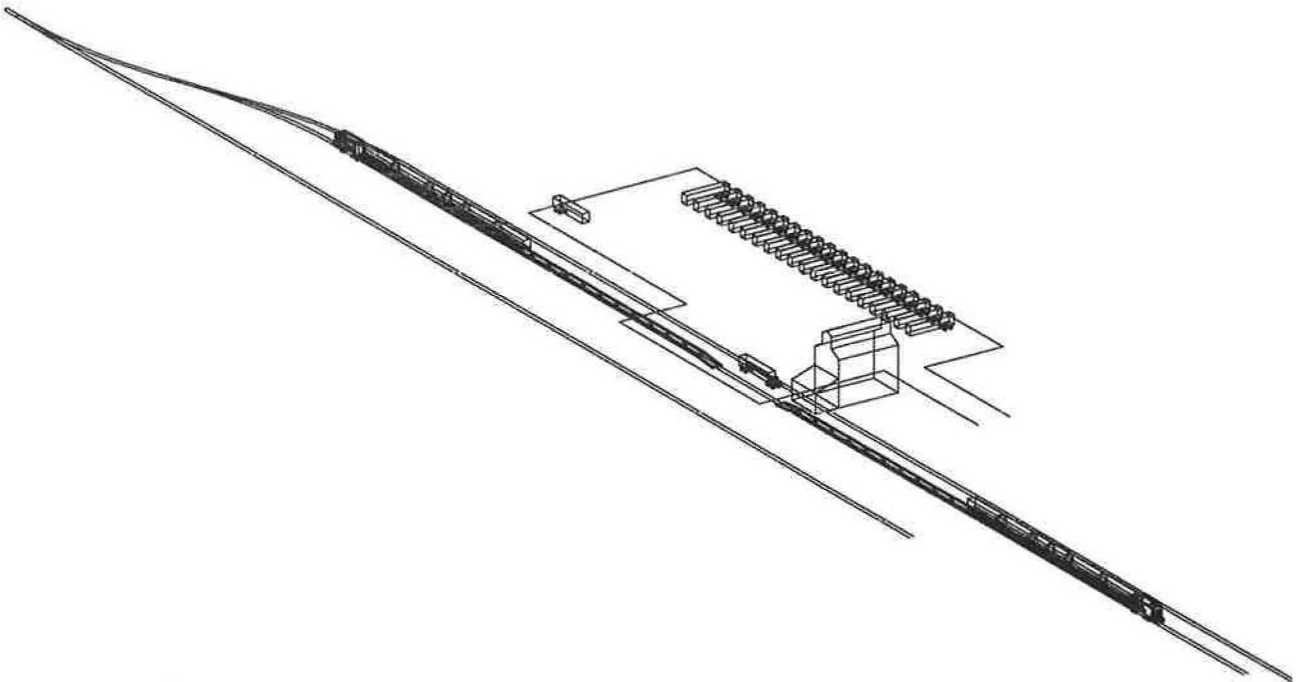

FIGURE 5 Agricultural co-op facility for iron highway loading.

The hostler tractor for loading trailers can be transported to and from the terminal and towed on the train's split ramp. Although loading one trailer at a time is slow, with trailer loading at 5 min. per trailer and with no trailers to unload, the train dwell time would be under 2 hrs. A typical harvest period of 3 or 4 weeks could easily see the dispatch of several 100 trailers. Here, security service might not be necessary, given the location and nature of the cargo. Fueling, if desired, could be handled by a local fuel/oil supplier, and inspection could be carried out by either a member of the train crew or by a mechanic trained and contracted for the purpose.

While the harvest season for most crops is less than one-month long, climate changes across North America begin in the south as early as late February, and continue in the north through September. Thus the possibility for a relatively long period of use of I-H equipment exists, provided that equipment can be shifted to follow the harvest.

Dedicated Industry Terminal

A number of large industries dispatch over 20 trailers per week in one direction. For such businesses it might be worthwhile to establish a minimum terminal within their factory gates, as shown in Figure 6, for use one or two times per week. In many industries this can be a year-round operation. The factory can provide hostler tractors to support loading/unloading operations. With proper logistical support from factory management, back-haul business can even be contracted. Since the operation can be entirely within plant gates, security is not likely to be an added cost.

Exchange Terminal

While Iron Highway technology may be used to gather and distribute trailers for common destinations with ease, there still may be a need to exchange trailers between elements in the familiar hub and spoke arrangement. Since individual cars cannot be switched, a "rubber-tire" interchange of trailers is required. A terminal serving this need is shown in Figure 7. Note that there are two sets of five tracks with parking spaces for 200 trailers between them, and a 200-ft- (61-m)-wide surfaced apron across each track group. The purpose of this apron is twofold. One, it allows positioning of a half-element at either side, and, two, it permits a 57-ft (17.4-m) trailer to swing 90° while departing a split ramp, avoiding interference with operations on adjacent tracks or the opposite half of the same element.

If 10 tractors are used to work five elements on one side of the parking area and 8 min. are required from

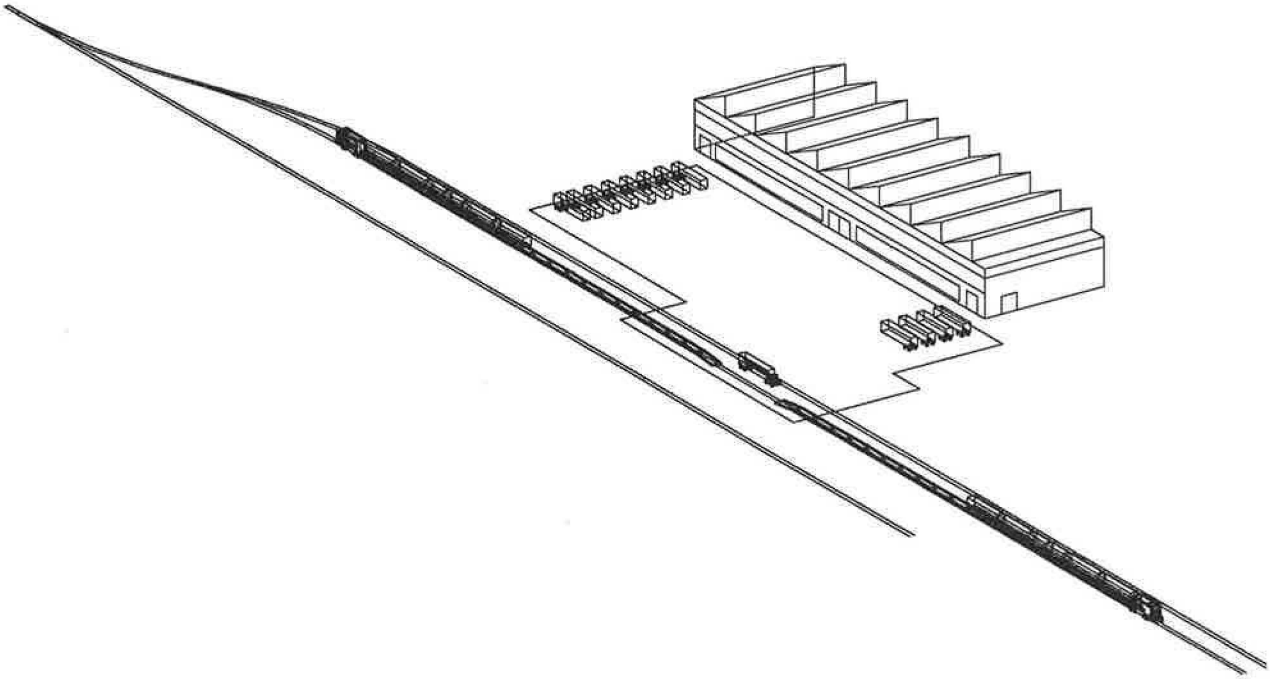

FIGURE 6 Private facility for iron highway loading.

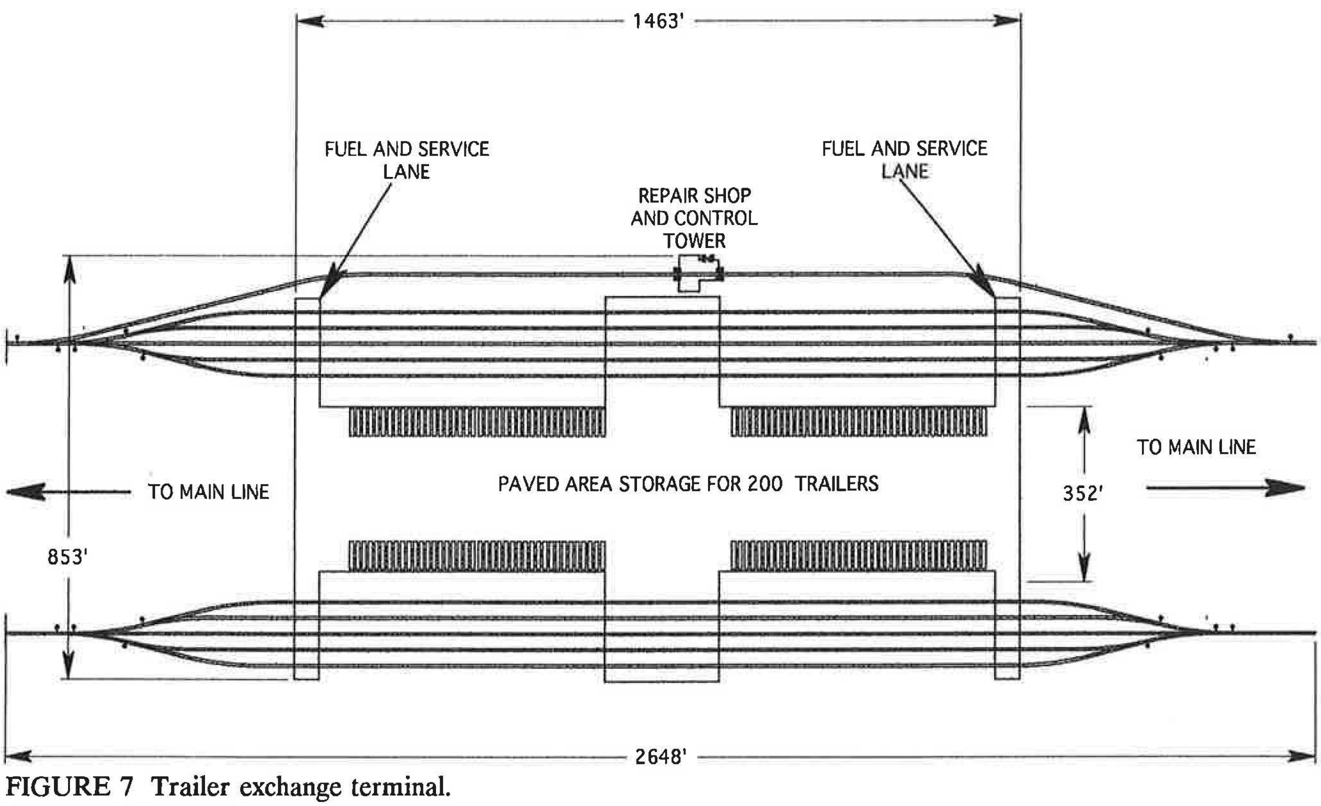

FIGURE 7 Trailer exchange terminal.

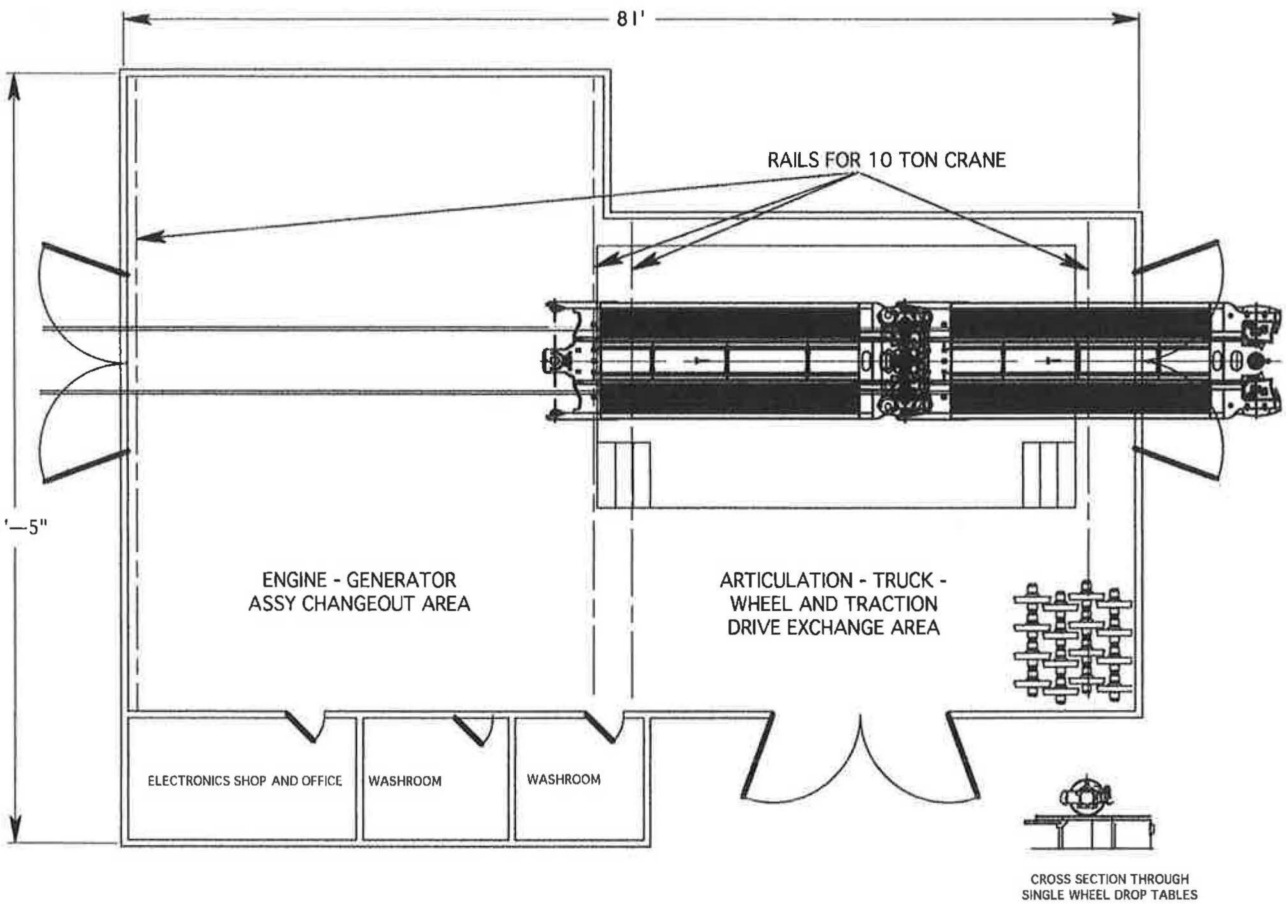

FIGURE 8 Major terminal maintenance facility.

spot to spot, a tractor will be in the area between ramps every 48 seconds. Given this timing and the 200-ft (61-m) apron width, it should be possible to avoid conflict, even when exchanging trailers among a total of 10 elements (five on either side of the center lot). Actual dwell times for equipment depend on the number of hostlers per element, the distance to parking/pickup spot, and the number of elements actually in the yard.

Experience with the phase $2^1/_2$ trains will guide needed refinement of this aspect of the design as the apron might be better, were it wider, to avoid congestion and bottlenecks. If one five-element train were in the facility, it would be desirable to spot three elements on one side of the parking area and the remaining two on the other side. This would allow the same number of drivers to handle trailers with a reduced possibility of interference.

Another feature of the exchange terminal is the repair shop located to the north of the bowl. This facility, shown in Figure 8, can handle all I-H repairs except for the repair of wreckage. This facility includes a pit-and-drop table to enable: rapid wheel change; sufficient crane capacity for platform pick up; quick traction removal and replacement; and other under-car equipment manipulations. Engine-pod unit exchange can also be easily accomplished in this building.

Maintenance requirements dictate the 32-ft (9.8-m) track spacing, as this leaves 20 ft (6 m) of roadway between tracks, permitting easy access for maintenance vehicles and personnel. It is anticipated that, other than for brake shoe changes and very minor repairs, nonsafety critical defects developing on line-of-road or found at outlying terminals will either be cut out or isolated and corrected when the train reaches the terminal, such as that illustrated. With the maintenance-vehicle access at this facility, any defective part other than a major assembly, such as an engine, wheel, or traction motor, can be unit exchanged on the terminal tracks during reload operations through the side access to the entire element, which this arrangement provides.

Servicing power and control units (P&CU) at either end of the train are also made possible by the fuelling

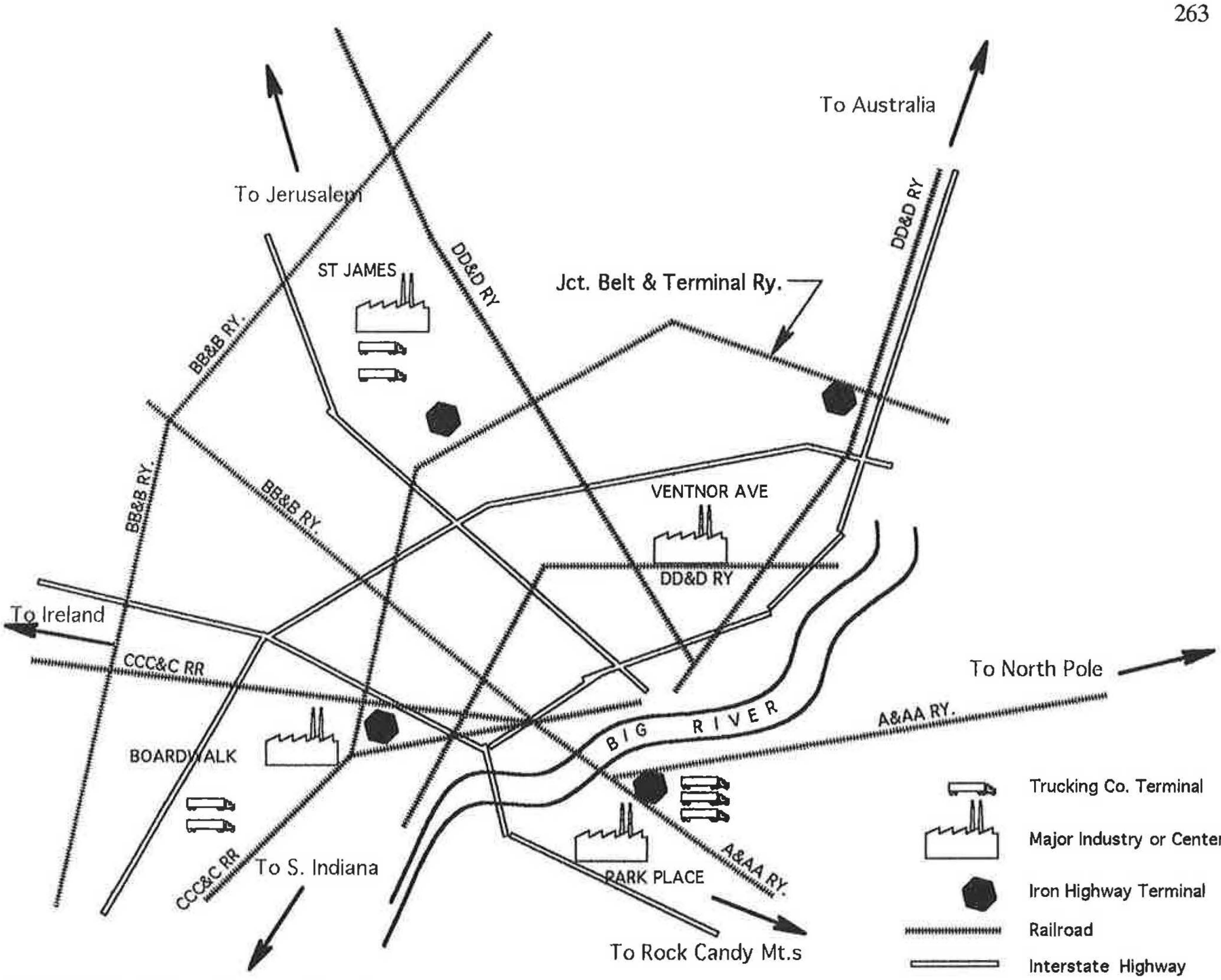

FIGURE 9 Major Metropolitan Area transport map.

lanes. Depending on business development, it might be more economical to run fuel and drain lines to the P&CU spots on each track or to provide access to them from a roving fuel truck. Automatic shutoff and drain lines reduce fuel waste and protect the environment during refueling operations.

The exchange terminal would most probably be located in or near a major metropolitan area. In addition to receiving trailers from inbound elements for subsequent dispatch on outbound elements, the exchange terminal can accept trailers for loading and unloading trailers for pick up.

Satellite Terminals

Another important opportunity the Iron Highway creates is the establishment of satellite terminals in metropolitan areas to handle concentrated business. This introduces no new features, but becomes a beneficial location that can minimize drayage, which in turn relieves costs, congestion, and environmental pressures.

Figure 9 shows a metropolitan area with features found in many cities throughout North America. Four Iron Highway terminals are shown, one of which is an exchange terminal. The others, cheaply and easily established, are essentially satellite terminals which load trailers onto individual elements that have a common destination.

Given proper contracting arrangements with motor carriers, satellite terminals may be economical even when handling as little as one element per day. For example, by gathering and distributing trailers in the Ventnor Avenue industrial district—instead of in the central terminal (located in the boardwalk district) —

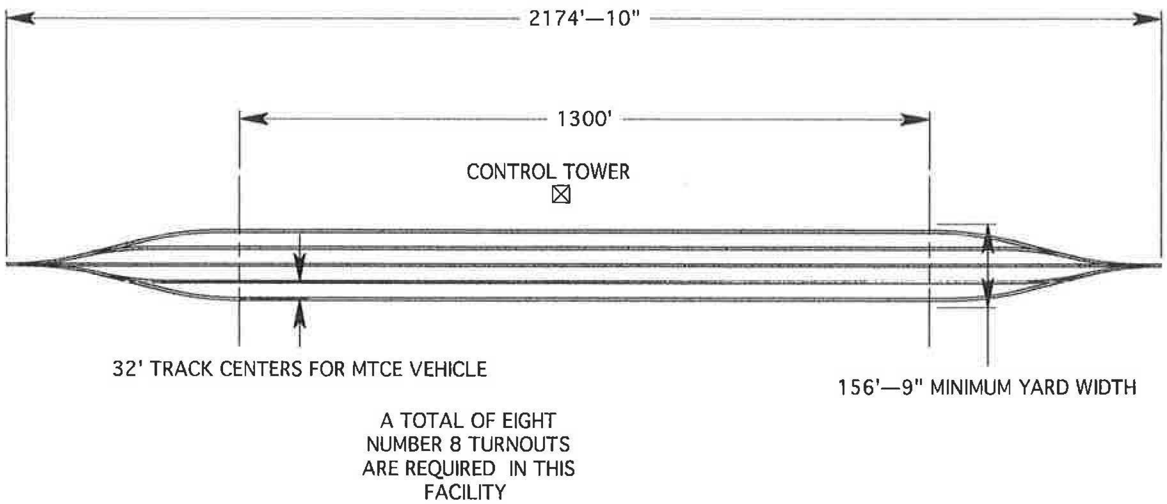

FIGURE 10 Rail-only facility for exchange of four elements from a train of five — includes area for operation of maintenance vehicle.

drayage cost, fuel consumption, congestion on city streets, and air pollution would be reduced.

In some cases it might be possible to locate the satellite terminals on a belt railway similar to the one shown. For example, this could permit the loading of dedicated elements which are bound for southern Indiana to be handled and loaded by an Iron Highway crew in the Ventnor Industrial District. The crew then would handle the loaded element over the Belt line and into the central terminal. Once there, the dedicated element would quickly join other southern Indiana-bound elements for operation over the line as a multi-element train. In this way, the remote control capabilities of the Iron Highway can be exploited to avoid delay while improving safety and operation reliability. The way in which elements can be marshalled into train operations is best understood by considering another potential type of terminal operation, the rail-only hub.

The Rail-Only Terminal

Figure 10 illustrates a terminal intended for use for the interchange of elements in and out of trains. Such a facility may be required at important rail-junction points which are not significant origins or destinations for trailers. Such points as Bellefontaine or Crestline, Ohio, Ashland, Kentucky, or El Reno, Oklahoma, might fall into this category. The facility illustrated includes a control tower which might be equipped with radio remote control of I-H elements. This feature is easily added along with logical control limitations as the elements are already controlled from on board computers. All that is required for remote-controlled operation is the installation of a modem interface to a radio and proper software safeguards. Different strategies can be used for this, including absolute speed limiting and continuity monitoring (requiring the presence of a coded track signal or an inductive signal from a wire laid between the rails, to enable remote operation).

The junction terminal is required for quick exchange elements within trains. For example, a train leaving southern Indiana for Australia with elements for Ireland, Israel, and the North Pole can drop those elements when passing the junction leading to these destinations and pick up Australia-bound elements in the process, with little impact on the overall travel time of the southern-Indiana-to-Australia delivery. Figure 11 shows how the exchange is handled, taking advantage of radio control, the fully-automatic remote-control couplers, and the full-time inspection system that is built into the train.

CONCLUSION

The Iron Highway technology has passed the stage of initial testing. When introduced to the market place it can address not only the desire of rail and trucking businesses for profitable growth, but social concerns as well, including concerns of metropolitan congestion, air pollution, and economical utilization of limited petroleum supplies.

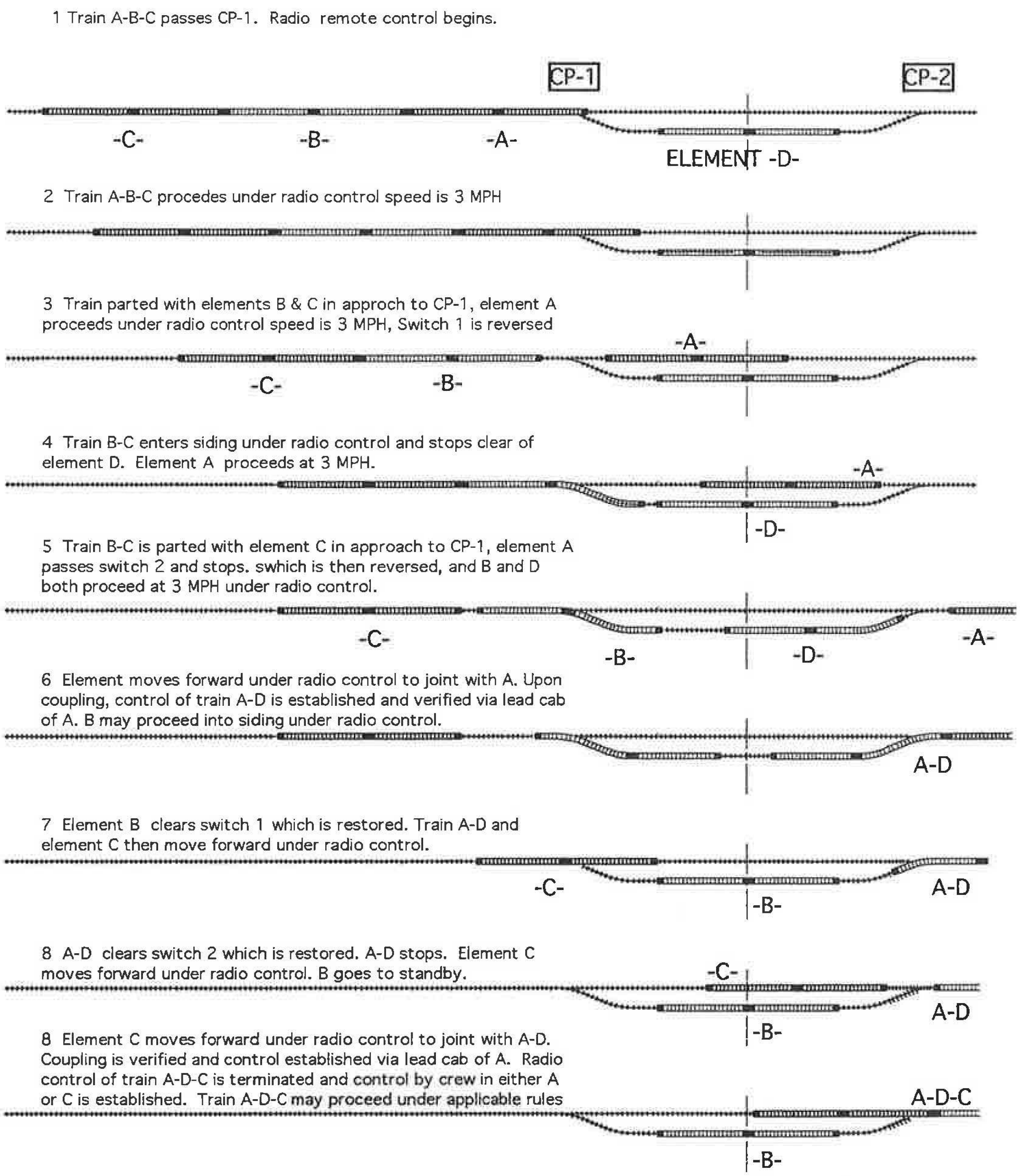

FIGURE 11 Steps in complete exhange of an iron highway element in a train.

It has been said that the only basic activities of humans are "growing things, making things, and carrying things." Iron Highway technology, by economically combining the performance and flexibility of trucking with the economies and social benefits of rail transport, allows intermodalism to expand into areas for which it was formerly unsuited. This growth can only positively affect people's third basic activity, "carrying things," and the degree of this benefit (great or small) will be achieved in the terminals.

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