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Chairman: Gerhardt Muller, U.S. Merchant Marine Academy

Intermodal Freight Transportation

WILLIAM DEWITT, *University of Maryland*
JENNIFER CLINGER, *Louis Berger Group, Inc.*

The 21st century will see a renewed focus on intermodal freight transportation driven by the changing requirements of global supply chains. Each of the transportation modes (air, inland water, ocean, pipeline, rail, and road) has gone through technological evolution and has functioned separately under a modally based regulatory structure for most of the 20th century. With the development of containerization in the mid-1900s, the reorientation toward deregulation near the end of the century, and a new focus on logistics and global supply chain requirements, the stage is set for continued intermodal transportation growth.

The growth of intermodal freight transportation will be driven and challenged by four factors: (*a*) measuring, understanding, and responding to the role of intermodalism in the changing customer requirements and hypercompetition of supply chains in a global marketplace; (*b*) the need to reliably and flexibly respond to changing customer requirements with seamless and integrated coordination of freight and equipment flows through various modes; (*c*) knowledge of current and future intermodal operational options and alternatives, as well as the potential for improved information and communications technology and the challenges associated with their application; and (*d*) constraints on and coordination of infrastructure capacity, including policy and regulatory issues, as well as better management of existing infrastructure and broader considerations on future investment in new infrastructure.

DEFINITION OF INTERMODALISM

The term “intermodal” has been used in many applications that include passenger transportation and the containerization of freight. A more descriptive term for this process would be “multimodal,” because of a lack of effective and efficient connectivity for both freight and information among and between the various modes on shipments under a single freight bill. For the purposes of this paper, intermodal freight transport is defined as the use of two or more modes to move a shipment from origin to destination. An intermodal movement involves the physical infrastructure, goods movement and transfer, and information drivers and capabilities under a single freight bill. The "concept of logistically linking a freight movement with two or more transport modes is centuries-old," according to Muller (*1*). The recent focus has been on containerization; however, intermodal transportation, as defined in this paper, encompasses all single-bill shipments using multiple modes.

INTERMODAL TRANSPORTATION AND SUPPLY CHAINS

Intermodal transportation, with the options of integrating multiple modes, provides a flexible response to the changing supply chain management requirements in global markets and distribution systems. The integrating of modes requires a process or systems approach for execution and "a higher degree of skill and broader knowledge of the transportation/supply chain processes . . . information, equipment, and infrastructure" (*1*). Intermodal transport, as it moves from a focus on infrastructure components to a holistic focus on process or systems, will have more viability and applicability in the world of global supply chain management. A supply chain

> is defined as a set of three or more organizations directly linked by one or more of the upstream and downstream flows of products, services, finances, and information from a source to a customer, and supply chain management is defined as the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole. (*2*)

The components of supply chains, much like the modes of transportation, have existed for many years.

It is in this time of information and communications technology and capability that the supply chain processes, and the modes supporting those processes, are gaining the capability of being integrated. This integration can permit the optimization of trade-offs between the components of supply chains as well as between the service and cost aspects of the modes within supply chains. Information capability and supply chain relationships will require careful balancing of all the business objectives of both the customers and the providers. Supply chain participants must respond and compete in the global marketplace, which is evolving rapidly.

An integrated intermodal transport system is a significant and critical factor in the successful execution of supply chains, both domestically and internationally. The awareness of and requirements for options in the intermodal execution of supply chains are being driven heavily by information and communications systems. One example that is gaining global implementation and effectiveness is the use of relational databases—the electronic ability to integrate and operationalize related but different data sets. This comprehensive ability to understand and assess the total supply chain capability and performance will place new demands on supply chain participants, including the transport system. New demands on the transport system will require a rethinking of transportation policy and investment.

STATUS OF INTERMODAL FREIGHT

Intermodal transport continues to be significant in the movement of freight. The railroad industry reports an approximately fivefold growth in trailer and container traffic on the railroads from 1965 to 1995 (*3*). However, intermodal revenues in 1996, defined as rail trailer and container movements, were only $5.6 billion compared with total freight revenues in the United States of $420.2 billion (*4*). Although trailer and container traffic is frequently foremost in mind when intermodal transport is discussed, it is important to note that many other commodities can in fact be intermodal shipments. For example, all grain

moves off the farm by truck before being connected to those movements that will continue by water or rail, and a significant portion of grain transported by rail goes to water transportation. Many other bulk or semibulk commodities such as fertilizers and building products move intermodally. Another intermodal bulk commodity is coal, which goes by road, rail, or river before transfer to rail and river for domestic delivery or to ocean for export. Increasingly, traditional trucking movements from small packages to less than-truckload (LTL) and truckload (TL) shipments are spending part of their time on rail. In fact, all air express shipments are inherently intermodal, with truck links connecting with air linehaul at origin and destination. If intermodal transport were measured as it has been more broadly defined in this paper, as all multiple-mode single-bill shipments rather than the historical narrow measure of containerized freight, the tremendous significance of intermodal movements in the logistics and supply chain structure would be more apparent. True broad measurement of intermodal movements would also affect the perspectives of private and public organizations toward the importance of developing intermodal infrastructure and information and communications capabilities.

Overall, intermodal transport, both containerized and multiple-mode noncontainerized, has performed satisfactorily in the last half of the 20th century as logistics has grown as a profession and responded to deregulation. However, to encourage and allow broadly defined intermodal transport to become as effective and efficient as it needs to be for future global market and supply chains, four issues need to be addressed.

Issue 1: Role in Hypercompetition of Supply Chains

The internationalization and globalization of resources and markets will place demands on intermodal transport in ways never witnessed before. Two- and three-party partnerships will give way to fully integrated supply chains. The competitive world of the future may well be centered between global supply chains and their supporting modal and intermodal capabilities. Linehaul movement and local delivery require intermodal transport as a critical element of supply chain physical execution. This potential for worldwide competition between global supply chains has sometimes been labeled hypercompetition and places new requirements on execution and implementation, including the coordination and integration of intermodal movements. Customers in the future will be indifferent to global sourcing issues and will expect their order to be delivered at the right place, at the right time, in the right condition, and for the right profit.

In order to fully understand this global role and permit effective and efficient planning, response, and resource investment for intermodal transport, accurate and appropriate measurements must exist. Most measurements have focused on containerized intermodal transport. The 21st century needs to have a set of measures for the broader definition of intermodalism, all single-bill multiple-mode shipments. This new intermodal measurement would supplement the historical modal measurements that are a residual of regulation and the needed focus during modal development in the 20th century. Future resource investments, education, and training will require full understanding of the actual and potential interaction between modes that affects the entire transport industry and the infrastructure and information technology that supports and enables effective and efficient execution of intermodalism in global supply chains. For the understanding of and response to intermodal needs, transportation and intermodal measurements need to be recast for the broader definition of all multiple-mode single-bill shipments.

Issue 2: Focus on Changing Customer Requirements

The marketplace of the future will have a diversity of demand worldwide and a multiplicity of sourcing and trading patterns. All of this diversity will be in response to customers' expectations and requirements for small and quickly delivered lot sizes or shipments. Inventory will be held only briefly for staging, such as cross-docking, and the future focus will be primarily on inventory in transit and not inventory in storage, distribution centers, or warehouses. E-commerce will have a substantial future role in the supply chain process and will reinforce information and communications as key factors in supply chains and their intermodal components. The customer will expect highly coordinated and customized delivery by the supply chain with great flexibility as the marketplaces shift and change, driven by increased information flows to the final consumer or producer. In addition, the almost unlimited range of sourcing options and market opportunities will drive rapid and constant change, requiring continued commitment to innovation in intermodal operational and information and communications technology. Reliability levels (i.e., the removal of variance) will be a higher requirement to permit satisfaction of customer demand while minimizing the costs of the supply chain. A single freight bill, possibly a single supply chain bill, will be tendered through electronic means.

Customers will expect the intermodal and transportation systems supporting supply chains to be focused on speed, flexibility, variance elimination, and relationships with other members of the supply chains that permit profit potential for all. The intermodal capability will have to be integrated and seamless, with better connections between the modes at all points.

Issue 3: Knowledge and Skills for New Operational and Information-Communications Technologies

To be able to optimize transport options, managers will have to be highly knowledgeable in all of current and future intermodal options and alternatives. This need may well drive heightened transportation education at all levels, from elementary and secondary education to fundamentals at the undergraduate level, managerial issues at the master's degree level, and conceptual or strategic issues at the doctoral level. Much of this education will be focused toward the operational, marketing, financial, economic, and competitive factors of modes and intermodal execution. This focus must also include the development of innovations such as equipment technology evolution through concepts such as FastShip, which proposes to reduce ocean shipping time by half, and RoadRailer, the blended rail-truck technology that permits substantially lower-cost transfer between the modes without lift devices and therefore uses smaller-scale facilities. It will also require an understanding of the fundamentals of linehaul and terminal structure, capacity, and execution so as to understand the options and alternatives in dealing with growing constraints on the operational side.

All of this knowledge and the resulting management are driven by current and future technology and information capabilities and advances. As shippers and users of supply chain structure continue to implement enterprise-wide relational software and databases, transport and intermodal companies in supply chains will be challenged as well as empowered by information technology and communications capability. As increasingly more pieces of freight equipment, and possibly the freight itself, become electronically tagged for tracking and operational execution, the data available to manage linehaul and terminal operations will

increase dramatically. This increased information-communications technology will give the supply chain managers, and those who contract with supply chain companies, information to make management decisions regarding intermodal trade-offs, alternatives, and options that are just beginning to be fully evaluated and operationalized today. This level of information-communications capability will provide significant challenges to enable information flows in both directions between the marketplace and the sourcing of materials. This capability will also apply to both private- and public-sector applications and management of infrastructure.

Issue 4: Focus on Management, Coordination, and Integration of Infrastructure and Resources by Private and Public Sectors

All the supply chain capability and the related information-communications options are of little value if the infrastructure is constrained and the equipment carrying the freight cannot efficiently and effectively execute the requirements of the customer. Infrastructure and equipment capacity can be evaluated in two contexts, static and dynamic, and it is the dynamic capacity that is the concern for the future.

Static infrastructure and equipment capacity is purely the physical space available for linehaul or terminal operations and the nonmoving carrying capacity of the equipment. It is a physical measure of infrastructure and equipment but is not a reliable capacity measure of either. Dynamic capacity, on the other hand, deals with the throughput that is derived from operating static infrastructure and equipment capacity. Dynamic capacity is a factor of speed and the lack of variability, which causes slowdowns or reworking of the process.

Concerns are beginning to grow regarding constraints on the dynamic capacity of intermodal linehaul connectors and terminals that are becoming the mainstay of supply chains. In addition, impediments are growing on the ability, particularly in densely populated areas, to expand the static capacity of the infrastructure. Limitations on financial and physical resources constrain the ability to add new static capacity. These constraints call for intermodal transport to develop information-communications and management capability for efficient and effective linehaul transit as well as coordinated and integrated connections through terminals to other modes. Once again, information systems are becoming significant and critical to this effective coordination and integration.

There is additional concern with the static capacity of terminals generally located in or near large population centers, whose populations in part drive supply chain demand. However, the physical transport of goods creates environmental externalities such as congestion, air and water quality impacts, and noise and light complications for society, particularly in metropolitan regions. The physical aspects of terminals in urban areas are complicated further by the desire of local municipalities and regions to maximize the tax base, frequently through commercial alternatives, such as retail operations and tourism, rather than transportation, intermodal, and supply chain facilities.

The growth of world populations is heightening global demand for products. The absolute volume of shipments is increasing and will continue to increase. Linehaul or terminal infrastructure built decades ago is being stretched to accommodate the volumes moving intermodally in conjunction with supply chains. A focus of concern for intermodalism continues to be the connectors between the transport linehaul and the terminals, as seen in specific provisions in the Transportation Equity Act for the 21st Century (TEA-21) and the Intermodal Surface Transportation Efficiency Act (ISTEA). Transport managers, policy makers, planners, and taxpayers will have to continually address

these inherent difficulties through innovative technology, both physical and electronic; land use and transportation planning; and management of existing infrastructure.

INTERMODAL DIRECTION FOR THE FUTURE: FASTER, BETTER, SMARTER, AND MORE PROFITABLE

Customers of global supply chains in the future will continue to demand faster supply chain delivery of their commodities and products. Speed—or total transit time through the supply chain—will continue to be a necessary factor for intermodal transport. Customers will demand better execution of the supply chains, represented by quality and reliability. Customers will also have more access to information through the use of information-communications capabilities only dreamt of in the past, and that information will drive higher expectations of performance as well as provide the foundation for alternatives, options, and continued change. Finally, customers and supply chain operators will want all of this done more cheaply, or in a more appropriate perspective, more profitably. Therefore, evaluating the life-cycle cost of prospective technology applications is essential.

Intermodalism will be a significant and critical factor in the success of hypercompetition among supply chains of the future. Its more significant role in global supply chains will require an understanding of supply chain management, the needs and requirements of the marketplace, the capabilities and advances in information and communications technology, and the continuing challenges and constraints on transport infrastructure. It might be argued that the future driver of the intermodal process and options in supply chains needs to come from the demand or supply chain side of the equation rather than the traditional supply or mode-carrier side. But from wherever the future impetus for intermodalism comes, additional insights need to be gained through measuring it in its broader definition and not just the historical containerized context. An increased awareness of the scope and magnitude of broadly defined and measured intermodalism will heighten the need for intermodal education and training for those being asked to manage and execute both new intermodal technologies and information-communications systems and the increasingly constrained infrastructure of intermodalism.

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