2000, barge cargo, river-related property taxes, and shipper savings for export grain could be increased substantially. Primary and secondary employment could be increased by as much as 75 percent. A 9 percent increase in employment and a 7 percent increase in the property tax base are possible for the state's total economy through river port development. Clearly this represents a substantial economic stimulus for Missouri.

While river port development generates a wide range of general economic benefits, financing for the proposed development program has been analyzed conservatively and as a business proposition for state government. Spreading new plant opportunities evenly between the years 1980 and 2000 resulted in an approximate increase of $1 270 000/year in state tax revenues and an increase of $1 350 000/year in local property taxes. A benefit/cost analysis (using a 10 percent cost of capital) was then performed on these time-phased cash flows. If this is viewed strictly as a business venture between now and the year 2000, state government could invest up to $9 000 000 annually in port development and recover it completely through increased state revenues. Clearly, the opportunity is there; all that needs to be done is to pursue it, and that Missouri will do.

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Abridgment

Effects of Technological Improvements in Loading and Unloading Containers and Shipborne Barges on Design of Equipment and Inland Ports

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The inland waterway system of the central United States is serviced by the Port of New Orleans, the second largest port in the nation, and by the Port of Baton Rouge, the fourth largest U.S. port. This system includes some 31 000 km (19 000 miles) of waterways that converge at New Orleans and has resulted in a total freight movement through the lower Mississippi of 368 million Mg (405 million tons) in 1975. The value of the trade in 1975 was $19 billion. This movement was accomplished by both ships and barges. In 1975 there were 13 366 ocean-going vessels and over 190 000 barges moving over these waterways through the New Orleans area.

LASH/SEABEE

The LASH concept was developed by a New Orleans firm, Friede and Goldman, Inc. In addition, Avondale Shipyards, located in the port area, has constructed 20 LASH vessels, and Equitable Equipment Company, located in the port area, has constructed over 3000 lighters or LASH barges. Currently, there are 13 LASH vessels operated by 5 different steamship companies and 3 Seabee vessels operated by one steamship company--all operating from the Port of New Orleans.

LASH/Seabee developments have truly been spectacular. In a period of just 5 years, over $500 million has been invested in LASH mothership and lighters for operation out of the Port of New Orleans. Another $225 million will be spent on construction of LASH motherships in the near future. The Port of New Orleans is now the largest LASH port in the world, and this revolutionary trend is continuing at a rapid pace.

In 1975, LASH cargo movements in the Port of New Orleans accounted for 7 percent of the total general cargo, and projections indicate that before the year 2000 one-third of the total general cargo throughput will be handled by this mode. This is truly a remarkable revolution considering that in 1969 no cargo was using this mode.

CONTAINER HANDLING

Until recent years, conventional general cargo wharves in the Port of New Orleans were not designed for handling containers. Since the Port of New Orleans owns land with areas sufficient for the marshalling of containers along the Inner Harbor-Navigation Canal, a master plan for development of 113 hm^2 (280 acres) was prepared. The France Road Terminal, ideally located at the intersection of the Inner Harbor-Navigation Canal and the Mississippi River-Gulf Outlet, is half complete. The terminal is served by roads, railroads, and I-10.

The movement of containers is not limited to full containerships. Containers move on inland waterways by barge to be loaded on LASH or Seabee vessels. They move by rail, highway, or air to be loaded on the decks of many types of vessels.

A convenient form of shipment of containerized cargo involves what is referred to as roll-on/roll-off (ro/ro). Containers or "piggybacks" can be driven onto or from vessels via specially designed ramps and piers. This form of container movement eliminates the need for a crane, and vessel turnaround time is excellent. The ro/ro operation represents progress in door-to-door shipment of general cargo. The effect of this new mode of shipping on the port has been in the form of modifications to general cargo wharves where there is sufficient area for the marshalling of the containers. The facilities at Dwyer Road and Florida Avenue on the Industrial Canal have been augmented to accommodate the ro/ro operations.

In order to supply the throughput of containers to the vessels previously discussed, intermodal facilities for handling containers have evolved in the port area. Many of the rail yards that previously contained boxcars loaded with breakbulk cargo now contain trailers on flatcars and containers on flatcars.

SHALLOW DRAFT RIVER PORTS

The effects of progress made in the transshipment of cargo on the design of inland ports are somewhat similar to the effects on the design of ocean ports but on a smaller scale. On the Mississippi River, the ports of Greenville and Memphis provide good examples of well-planned inland ports.

The Port of Memphis is a regional port 1175 km (730 miles) from the mouth of the Mississippi River. It is located at one of the large metropolitan areas in the mid-South. The organization of the Memphis and Shelby County Port Commission resulted from a navigation project designed to close off the Tennessee chute of the Mississippi River at Memphis, thereby making available almost 2023 hm^2 (5000 acres) of land for industry and more than doubling the harbor frontage in Memphis.

The principal function of the port commission is developing waterfront industrial areas and getting industries to locate on them. It planned and constructed the access road, railroads, utilities, and sewerage and drainage facilities in the industrial areas. The port commission constructed a public terminal that has been leased to a private company. Three other public terminals are contingent on action by the U.S. Army Corps of Engineers. Recommendations have been made by the Mississippi River Commission to the U.S. Army Chief of Engineers that an additional 400 hm^2 (1000 acres) be provided by dredging and maintaining a $27 million general navigation channel extending from the existing Tennessee chute harbor channel to the west of the landfill on President's Island.

Total freight handled through the Port of Memphis in 1976 was over 10 million Mg (12 million tons).

The Port of Greenville, Mississippi, is a subregional port on the Mississippi River 864 km (537 miles) from the mouth.

The Port of Greenville is a U.S. port of entry with a resident collector of customs; it offers facilities to serve industries that handle direct shipments to and from foreign markets. Total cargo handled at the port in 1976 was about 2.4 million Mg (2.7 million tons).

CHANGES IN FUTURE DESIGN OF NAVIGATION STRUCTURES AND PORT LAYOUT AND EQUIPMENT

The impact of barge-carrying ships on port systems and inland waterways is tremendous. The original barge-carrying ships were large and required 11.3- to 12.2-m (37- to 40-ft) channel depths. These vessels are getting larger and will eventually require 16.8 m (55 ft) channel depths. The approximate vessel dimensions for the first motherships are as follows (1 m = 3.3 ft):

Dimension of Vessel	LASH	Seabee
Overall length, m	262	266.7
Breadth, m	36	32.2
Draft, m	11.2	11.6

Thus, in many ocean ports, channels must be deepened to accommodate barge-carrying ships. Channels of 17 m (55 ft) or greater are recommended. Locks through which the motherships must pass ought to be properly sized.

Ideally, inland waterways should be available from the hinterland to the ocean port so that a sufficient number of barges can be fleeted, thus justifying the calling of a barge-carrying vessel.

Barge fleeting areas must be provided in close proximity to ports. Inland waterways should be increased in depth from 3.67 to 4.88 m (12 to 16 ft) and increased in width from 45.7 to 91.4 m (150 to 300 ft). Ship locks should be designed with widths of 45.7 to 61 m (150 to 200 ft), lengths of 366 to 457 m (1200 to 1500 ft), and depths over the sill of 15.2 to 18.3 m (50 to 60 ft). Barge locks should be designed for 33.5-m (110-ft) widths, 366-m (1200-ft) lengths, and 4.9-m (16-ft) depths over the sill.

At coastal ports, general cargo breakbulk wharves must be designed longer, wider, and with deeper water [12.2 to 13.7 m (40 to 45 ft)] alongside to service larger ships. They should have the following design criteria: front apron of 12.2- to 15.2-m (40- to 50-ft) width; 41-kPa (850-lbf/ft^2) uniform live loading capacity; adjacent marshalling area of 2 hm^2 (5 acres) or more depending on the type of cargo to be handled; rail service on the front apron and to the transit shed; and a transit shed per dual berth facility of approximately 14 000 m (150 000 ft^2) of area with an open (without column) construction, lighting of 163 lx (15 fc), a sprinkler system throughout, offices for U.S. Customs agents and shipping clerks, and comfort stations for longshoremen and other personnel. General cargo-breakbulk wharves should have a minimum of two contiguous berths measuring 229 to 274 m (750 to 900 ft) each.

At coastal ports, container facilities should have two contiguous berths of 213 to 274 m (700 to 900 ft) of water frontage. The water depth alongside the berth should be 10.7 to 15.2 m (35 to 50 ft). Design criteria for container berths should include minimum open apron width of 30.5 to 45.7 m (100 to 150 ft); crane for container transfer in the range of 40.6-Mg (40-ton) capacity with a cycle of one box every 2 min; apron crane rails of 15.2 to 30.5 m (50 to 100 ft) gauge and loading capacity of 34 to 41 Mg/crane wheel (75 000 to 90 000 lb/crane wheel); apron uniform live load of 41 to 49 kPa (850 to 1000 lbf/ft^2); upland area for container storage of 7.3 hm^2 (18 acres) per berth; paving for uniform live loading of 95.8 kPa (2000 lbf/ft^2); lighting of 32.3 to 53.8 lx (3 to 5 fc) at the container terminal and 215 lx (20 fc) on the wharf apron; a column-free consolidation shed of 4645 to 9290 m (50 000 to 100 000 ft^2) of area with rail access and truck loading docks; a truck weighing scale; and complete perimeter security and intermodal exchange yard in close proximity to the container terminal.

At coastal ports, roll-on and roll-off facilities should be designed according to criteria similar to general cargo-breakbulk wharves. In addition, a ro/ro terminal should have a fixed ramp or portable ramps designed to accommodate the specific vessels to be calling at the facility. The wharf should have a height above mean water level of 1.8 to 2.7 m (6 to 9 ft), and a minimum of 4 hm^2 (10 acres) of marshalling area should be provided with an intermodal exchange yard in close proximity to the ro/ro facility. Other specialized facilities such as bulk terminals, grain elevators, oil terminals, container-handling equipment, dry docks, shipyards, and ship repair facilities can often be left to the private sector to develop. However, they should be considered in the planning when requirements are determined for the long-term development plan of a port.

At coastal ports, the impact of technological changes in transshipment of materials in bulk has been widespread. Dry bulk vessels, oil tankers, and oil-bulk-ore carriers have increased dramatically in size. This in turn has led to a worldwide requirement for deeper channels to ocean ports. Coastal port terminals that handle bulk materials require larger areas for cargo consolidation and require high transfer rates (with a minimum of pollution) to ensure a rapid vessel turnaround.

A well-planned inland river port would be strategically located to serve an industrial or agricultural

complex by providing the transfer facilities to accommodate cargo movements by water, truck, rail, and pipeline. It would provide adequate ship anchorage and fleeting areas. It would consist of a variety of cargo docks: multiuser and multipurpose, private and public. The docks would be designed for heavy loading. The port would be equipped to transfer either breakbulk cargo or containers to or from the various modes of transportation.

On the land side of the cargo docks, a well-planned inland port would consist of numerous industries and an intermodal facility. Preferably, these industries would be located so that the by-product of one industry could be used as feedstock for an adjacent industry. The industries would be located where there would be joint sharing of flood protection levees; drainage; sewage and wastewater treatment facilities; water, gas, and electric service; road access; rail services; and barge fleeting facilities.

CONCLUSIONS

The effects of progress in vessel design and the effects of progress in transshipment technology have been such that port facilities of 10 to 15 years ago are now obsolete. This progress has required new design criteria for coastal ports, inland ports, and waterways.

Changes in port terminal design are required not only so that coastal ports can remain competitive with other world ports but also so that inland ports can become competitive in world markets. The design changes consist of deeper access channels to coastal ports to accommodate larger vessels, especially bulk carriers; different types of coastal terminals to accommodate full-container, barge-carrier, and ro/ro vessels; expanded waterways to inland ports; larger locks to accommodate barge traffic on inland waterways; and, finally, concentrated industrial development or industrial park development around inland ports to take advantage of container, LASH, and intermodal transshipment possibilities.

All coastal ports have been affected by the need to accommodate larger vessels and container ships. At coastal ports, a major impact of transshipment progress has been that a need for more space for the accumulation of cargo and port development has shifted to areas of less urban congestion. Coastal ports with connections to inland waterways have been affected by increases in barge traffic associated with cargo transshipment via barge carriers such as LASH and Seabee.

At inland ports, a major impact of transshipment progress has been a need for concentrated development in areas of greatest present and potential industrial and agricultural development. This concentrated development consists of public and private multiuser docks and industrial parks.

Long-range coordinated planning is necessary to deal with technological changes in vessel design and transshipment progress. The time frame for improvements such as deeper channels at ocean ports and larger locks along inland waterways may be in the range of 20 to 50 years. Likewise, inland industrial park development may take as long or longer.

A long-range, phased development plan is the first requirement of orderly port development for coastal and inland ports. This long-range plan should be supplemented and updated by short-range implementation plans for 5 to 10 years.

Long-range planning requires coordination with the federal government so that necessary access channels, locks, interstate waterways, roads, and railroads that connect with the planned port facilities can be funded nationally. Close coordination is required with the state and adjacent municipalities for the promotion of port-oriented industry, secondary highway development, and for utilities and municipal services required for the operation of the port and the associated industries.

In order for the port to react to rapid changes in technological improvements and to the demands of commerce, adequate financing is essential. To obtain this financing, the port must sell to the municipalities the economic benefits to be derived from port operations and industrial development. Port authorities must also encourage the national development of waterways so that the nation can continue to benefit from this cost-effective, energy-efficient means of transportation.

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