

## **Innovations in Shipping Food Products, Past and Future**

**Brian McGregor, Agricultural Marketing Service**

Wherever we are transporting product, we want to deliver it in good condition. And the principles for doing that have been around for decades: maintain temperature using the latest packaging and other recommendations to get the product from one point to another in good condition. Of course, the overriding objectives are to maintain quality, reduce handling, reduce time in transit, increase utilization of the refrigerated transport equipment because of the high capital costs, and keep overall costs to a minimum. If we did all these things, we'd probably put a lot of farmers out of business, as well as some people in other parts of the cold chain. So we know that this perfect world could never be, but it's still a goal that should be worked toward. Things can go wrong at many stages in the cold chain. Here's what was happening in Tokyo back in 1987: the containers were opened right on the dock and exposed to the elements while the inspectors looked over the citrus. Now, this is done in a controlled refrigerated environment.

You can go to any market in the United States or any other part of the world and see high-quality products brought in and then subjected to temperature abuse or you can see poor-quality products that have had the added expense of transportation and packaging, and you wonder why the product was shipped that way and why is it being presented that way. And the fact is, with economics, you can work on the margins. It's certainly not a goal. Every perishable product, whether it's a fruit, vegetable or meat, ice cream, or whatever has a recommended temperature and a practical storage life. The goal is to get the product to the correct temperature as soon as possible after it is harvested or produced and maintain it there.

With all the recent food safety scares, I maintain that food has become a relatively low-risk product. One potential benefit from all this focus on food safety may be big improvements in the cold chain. This is certainly happening in Europe. Another long-term goal has been reducing the number and sizes of boxes. This is something ARS worked on back in the 1970's with fresh fruits and vegetables and there is still a lot of work to be done. Another area with a lot of problems is transport equipment quality and maintenance. You can go anywhere and find poorly maintained, poorly sanitized equipment. This may change with the increased emphasis on food safety. When making decisions about the cold chain, as I learned from my first boss at USDA, you've got to consider the whole system, not just the transport vehicle or the package or the product, but all the things that make it possible to get a product safely from one point to another.

An essential issue in shipping is proper documentation. A lot of products are destroyed due to delays in documentation or improper documentation, so we have a lot of challenges. We do a lot of field packing, a lot of shed packing, and of course, good packing requires good training and good technology to reduce the number of times a product is handled. One extreme example is the company Del Agro in Bogotá, Colombia, which was way ahead of the food safety curve back in 1990 using hospital conditions for packing raspberries. And they took enormous care harvesting the raspberries under plastic. These people were serious. Of course berries are very susceptible to microorganisms, Guatemala suffered a lot with this, and Del Agro wanted to do everything possible to protect their market in Europe and make sure the berries arrived in good condition.

While all packaging is subject to abuse, poorly designed packaging suffers the most. We still have lots of problems where the packaging doesn't match the pallet size, and you quickly lose the strength of the box. Also, when you cross-stack you lose strength. These are mistakes that continue to be made every day throughout the world. Hopefully, with digital imaging cameras, we'll be able to get more feedback through the Internet about how an exported product looks to receivers and buyers when it reaches the other end.

We still have to take individual products and mix them together, and there's a whole science concerning what products can be put together without causing damage. Here's another instance where we could benefit from reducing the number of different packaging sizes and trying to come to some standardization. Then we have the consumer pack issue, which has really undergone a revolution, especially with the advent of fresh-cut salads. The plastics and other materials create an internal atmosphere that gives the product a longer shelf life.

When I was in Japan in 1987, cherries were transported by sea on an experimental basis. But to my knowledge, the majority of cherries still go by air. So even though things are technically feasible, other factors are involved, such as the back-haul capacity of air freighters or the fact that the shipper and receiver are comfortable paying the extra air transport costs to receive the cherries quickly. Of course the packaging has to be designed for the product, such as using a special machine to inject broccoli with ice. Wax, of course, is on the way out because of the concern about recycling and is being replaced by plastic coatings. There's also a package design called iceless broccoli, where a plastic film is put inside the fiberboard to provide a controlled or modified atmosphere. Then maintaining the proper temperature becomes paramount. Broccoli gives off a lot of heat and needs a high-humidity environment, otherwise the product can be damaged and lose shelf life rapidly. And a lot of frozen product is moved. For example, slipsheets of frozen french fries are transported by rail.

Slipsheets are a technology that never took off, however, because of the need for specialized handling equipment at both origin and destination. Although large-volume shippers have the necessary equipment, slipsheets never cut into the wood pallet market very much. Without the necessary equipment, you had to take the load apart box by box and put it on the pallet. And each product has an ideal method of cooling after harvest.

Another example of new technology is vacuum-cooling lettuce. It's still hard for me to understand that after you put the lettuce in the machine and the water boils off the lettuce isn't cooked. It's because lettuce, like most produce, has a very high moisture content. Hardy products that may not need to be cooled as fast are room-cooled. And that's another cost that's factored in. But my experience is that a lot of people take shortcuts in cooling and never get the product to the recommended temperature. Therefore, the product is loaded into a vehicle at a warmer-than-ideal temperature and most refrigerated transport vehicles are not designed to bring down temperature, just to maintain it.

ARS and the National Bureau of Standards helped the trucking industry come up with a system of testing trucks for insulation and refrigeration capacity. That takes us into the 1960's when the container revolution occurred, and then Sea-Land Service. Malcolm McLean, the so-called father

of containerization, and his employees worked with the ARS on the recommended temperatures for ocean transport. ARS had been doing research for decades on recommended temperatures for various products.

In the United States, trucking is still one of the weak links in the transportation system because it's a fragmented industry. Truckers are forced to hire people to help unload the trucks. They are forced to wait with little or no compensation for unloading. The ideal, of course, is the palletized system of handling, with theoretically less damage to the product. And, of course, there are jokes about how containerization of trucking has minimized pilferage. In many countries today, whole containers or trailers are hijacked. This is a big problem in Mexico where two-and-a-half trailers a day are stolen. Some of the hijackings are inside jobs; some are done by criminal syndicates. So the industry in Mexico is having to make a big investment in background checks of employees and in various technical devices to keep track of its containers and trailers.

Modified atmosphere for strawberries, for example, is another packing innovation. Bags are wrapped around the pallets and a higher level of carbon dioxide is put in. Keeping the product away from the walls where they can absorb heat is another recommended loading practice, using either vinyl or kraft air bags. Highway trailers generally have a top air-delivery system so you need good air circulation around the load. In ocean shipping, air is typically delivered from below. So in a maritime application, you want to cover all the remaining floor space to try to force the air up through the load.

The modified/controlled atmosphere work was done in the 1950's and I'm sure ARS was involved. Whirlpool Corporation held some of the patents on the modified/controlled atmosphere. They were looking at higher tech refrigerators. That's one interesting thing about the technology that is becoming popular today: the research was done decades ago. Basically, ocean shipping is now dominated by refrigerated containers with the built-in unit on top powered by electricity and sometimes with built-in fuel tanks and generator sets. Alternatively, palletized units are loaded as many as four to eight pallets at a time into a refrigerated vessel, or a clip-on refrigeration system is used in which the containers have two large holes in the top and bottom where they plug into the ship's air supply. On land, the containers need a complete refrigeration and generator set bolted on for land travel whereas the refrigerated containers only need to bolt on a generator set or put it underneath the chassis to provide the electricity for refrigeration. And the problem you'll find in port areas, including the United States, is the attitude: "We're pretty close to a destination. We're not going to fool with a gen set." And the insulation on these containers is not that good, especially during summer or the cold of winter. So that's a problem that needs to be managed.

Container operators have invested quite a bit in new technology. Of course, Sea-Land was the leader and they provided a great labor pool for the other shipping lines, like American President Lines. But in the United States, Sea-Land and American President Lines used ARS data to develop their own booklets and guidelines about how to load their equipment. They invested in test shipments. They provided a lot of funds toward research at the University of California at Davis to develop better equipment and come up with better recommendations.

Most containers today are capable of providing a controlled atmosphere. The Transfresh system is basically a little computer that is inserted above the fan and helps adjust the air composition inside the container during transit. A vent allows air exchange because some products give off ethylene, which, if not vented, can cause premature ripening or excessive ripening of the product in transit.

Sea-Land now has a container that adds humidity. While we've known for years, that most products would benefit from constant humidity levels of between 90-98 percent, in reality, refrigeration withdraws humidity from the air, just like a home air conditioning system. So Sea-Land and others have introduced a water source in their systems to increase humidity levels.

I don't know what's happened with rail. Having worked with a railroad company, I'm always saddened that the railroads more or less haven't aggressively pursued getting back market share from the trucking companies. Probably because they feel it's a hassle and not worth it. The same could be said for a lot of the airlines. So we have a dwindling supply of box cars. Most were built in the 1970's and only Tropicana, which has a closed system for shipping juices and concentrates, has invested in new cars. Union Pacific has an experimental fleet of 50 cars and Burlington Northern (BN) has also experimented with a few cars. But basically, they've allowed the number of cars to go from about 12,000 in the late 1970's to about 5,000 or 6,000 cars today. Box cars are primarily used for frozen food, hardy products like apples, some citrus, and potatoes. Without the proper equipment, cars have to be unloaded box by box, and you end up with some damage.

It was Sea-Land and APL, not the railroads, that really pushed double-stacked containers. Railroads were too conservative, so ocean shipping companies invested in flat cars. They more or less rented the use of the locomotives and the track. That has really taken off, but not refrigeration. That's been a disappointment, because we could sure use the extra highway capacity if more products could move by rail. But there's still a breakdown in service with the railroads. You still hear horror stories such as a boxcar of potatoes ending up in Florida when it's supposed to be in Chicago. So even though the railroads have been deregulated and consolidated, it seems their attitude towards customer service has not changed.

It's important throughout the whole transport process to keep good temperature records. And of course, I'm hoping the food safety scares encourage people to think more about proper cooling to the recommended temperature and maintaining that temperature. The larger companies, without government regulation, already require this because of their own concerns about customer satisfaction and, more importantly, liability. So I think we will see an increase in good temperature control and more control by electronic means versus intrusive means.

Time and temperature indicators have been around for 20 years, but the science of interpreting how much temperature abuse has occurred and how the product quality and safety have been impaired still needs to be developed. Of course we're not going to be able to keep each product at its ideal temperature throughout the wholesale/retail chain, so we have to compromise and at all times make sure that different products are compatible when they are stored together. For a short period, maybe a day or so, you don't have to be as concerned. But some products are sensitive to being too cold and can be just as easily damaged as if they were too hot.

In Europe, they actually regulate the temperatures of meat, poultry, fish, seafood, and frozen products during transport. There's been talk of doing this in the United States, but I just don't see it happening. What we may see in the States is regulation requiring proof of sanitation of the refrigerated vehicle. A law was passed in 1990 in reaction to back-hauling of trash, but no regulations have ever been developed for that.

Asparagus is a good example of the importance of transportation. The number of marketing days you get with asparagus depends on how close you get to the recommended temperature during transport: the range is from 4 to 17 days. It's amazing how often this is violated. If you go into Safeway or Giant or go to Jessup Wholesale Market here in Maryland, you'll see constant temperature abuse. Again, the manner in which the product is loaded and temperature control are key.

You have the same problems in air cargo. Most air cargo moves without refrigeration. Ideally, the product is cold when it gets to the airport and is kept in a small cold room at the terminal and quickly put into refrigeration afterwards. There are gel packs and other types of refrigeration, such as dry ice, but most product goes without refrigeration. In Europe, because of the greater food safety concerns there, they've done a lot with air shipping perishables to make sure the proper facilities are at the origin and destination.

Another big issue, of course, is recycling. Although we have sufficient landfill space in the United States, people don't like landfills, though they are probably one of the safer places to put things. Concern about landfills has led to a reduction in the amount of packaging used. That's still the key. We're doing a great job of recycling, but from an economic point of view, it's better to reduce the amount of packaging. Yet you still need to protect the product because inadequately protected product results in an environmental cost. There's a big debate now in the United States about whether to use plastic returnable crates, which of course have to be cleaned and sanitized and transported back. The effect on market share of using returnable plastic crates will be interesting. And, of course, with the plastic crates, you're going to lose the nice graphics. The debate is, who really sees the nice graphics? So we are slowly moving toward fewer pallets and less packaging.

The plastic crate picked by the industry is 600 millimeters by 400 millimeters. The size of the crate has to be standard for it to work. The same with the pallet. Fortunately, even though we've never adopted the metric system in the United States and probably never will, the 48- by 40-inch pallet that's widely used in the United States pretty much matches the 1,200- by 1,000-millimeter one used in Europe. The Europeans also like a smaller one (1,200 mm by 800 mm) for their smaller cold chain operations.

Some U.S. inspections now offer digital imaging services to the interested parties. As people get better feedback about what's happening to their product at the destination, it should push responsibility for the poor quality back down the chain.

We have a number of publications. Heidi Reichert has put two of our newer ones on the Internet: our *Agricultural Export Transportation Handbook* and also our *Freight Forwarder Directory*

(see [www.ams.usda.gov](http://www.ams.usda.gov)). *The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks* is the so-called bible of the USDA. This book has been put out for many decades by ARS, with recommended temperatures and handling for a variety of products. *Protecting Perishable Foods During Transport by Truck* is our popular trucking handbook. It's now brown or purple in color. ThermoKing and Carrier use it to train their employees. A lot of trucking companies order copies of it. All of our handbooks have similar information written in different formats for slightly different audiences. Thank you.

### **William Hall, Seaport Consultants**

I would like to talk about the structure of the ocean shipping industry, the broad impact of technology on the industry in the past 30 years, and how future changes may affect U.S. shippers and ports. Also, since we are looking at ways of analyzing transportation activity in this seminar, I would like to share some personal experiences about how these structural changes in ocean shipping are affecting our ability to analyze the industry. The changes present a challenge to institutions such as USDA that want to analyze ocean shipping and its impact on U.S. producers and their foreign competitors.

Containers, for those who may be unfamiliar with them, are based on internationally standardized modules. They come in two sizes, basically, 8 feet by 8 feet by 20 feet and 8 feet by 8 feet by 40 feet. There's some variation, especially in U.S. domestic service, but for international service these two sizes predominate. Containers can be handled equally well on ships, road vehicles, and rail cars. They can be stacked one atop the other. The idea was to create a simple, rugged, standardized unit that expedites vehicle loading and unloading, one that can be transferred quickly from one mode of transportation to another, and one that permits high-density storage of cargo.

The standard unit of capacity measurement is a 20-foot module, the 8- by 8- by 20-foot module, which is known as a TEU, or a Twenty-foot Equivalent Unit. In the maritime press and elsewhere, you'll see references to ship capacity in numbers of TEU. Ship capacities have been increasing steadily since the 1950's, starting at about 150 TEU and going up to 2,000- 3,000 TEU by about 1980. Today we're up to somewhere between 6,000 and 8,000 TEU, with really no end in sight.

The first impact of containerization and intermodal technology was to radically increase the speed and reliability of ocean service and thus to drastically increase the effective capacity of general cargo vessels. Imagine an old freighter--an old-style Marlon Brando *On The Waterfront* kind of ship--stuffed with barrels and boxes and crates and everything put together in a hold and extracted manually at the port of destination. That's a system of transportation that's like a moving van, something that we all have a lot of experience with in our lives. The moving van shows up in front of your house in the morning and you spend five hours loading it. You have to make sure that everything is secured and that the floor lamps don't fall over and that one thing doesn't crash into another. You put a great deal of time and energy into very carefully arranging items in a logical way.

So you spend five hours in the morning packing the van and then you spend about half an hour driving across town to your new house and another five hours in the afternoon unloading the

moving van. In a similar way, a conventional ship, an old-style break-bulk ship, would spend about a third of its operational life in a port, loading and unloading.

The first impact of containerization was to radically reduce the time spent working cargo on each end of the voyage. With standardized containers, it was simple to develop a system in which ships could be rapidly loaded and unloaded by large cranes. Since containers could be stacked and could easily fit on a truck chassis or rail car, loading and unloading became much more efficient. A vessel now spent about a tenth, rather than a third, of its operational life in port. Which means in practice that cargo moves between A and B much more reliably and quickly, despite the fact that the vessel isn't traveling any faster than its ancestor.

In fact, it might even be going slower. In the 1950's and 1960's, when you couldn't do very much about the technology on either end, the focus was on the speed of the transoceanic passage. Shippers would try to squeeze another extra two or three knots out of the vessel perhaps with a sophisticated, expensive turbine power plant. After containerization, the speed of the vessels became much less critical, since so much time was being saved in the ports, as well as in newly efficient inland connections. During the fuel crisis of the 1970's, container ships actually slowed down a little bit and today are frequently slower than the vessels of 20 or 30 years ago. But cargo moves across the ocean at much faster and more reliable transit times.

The versatility of the container, the fact that it can go from a ship to being towed behind a truck or to being loaded on a specialized rail car, has totally transformed the ways in which these firms see themselves. The industry progressed from one that focused solely on moving things by water to becoming an industry that focuses on the reliable movement of boxes around the world by any one of several modes. The industry is less about ocean shipping per se and more about being global movers of containers.

The invention of containerization coincided with the massive postwar expansion of Western economies, culminating with the Asian boom of the 1980's. This upsurge in activity allowed container companies to integrate into other complementary forms of transportation. Electronics from East Asia moving to a chain store in the U.S. Midwest, for example, could be tracked from the production line to the display shelf. All of this was made possible by the introduction of new electronic tracking and inventory management systems. Today, these firms have progressed one more step--not only do they consider themselves global movers of containers by various modes, but they also see themselves as inventory schedulers and managers, as extensions of the global production lines of their major customers.

Vessels keep getting larger. As they do, some interesting things may start to happen among ports and their associated trade routes. The largest container ships afloat now have a capacity of about 8,000 TEU, or the equivalent of 8,000 20-foot boxes. Naval architects are now seriously talking about even larger vessels. If this happens in a major way, some ports in North America would be clear winners and others would lose.

For example, a *megaship*, that is to say, a vessel of 12,000 to 15,000 TEU, now in the conceptual design stages, would draw about 50 feet of water. Suppose for the moment that these vessels

eventually become standard in the major U.S. trade lanes. Many ports in America simply couldn't accommodate such vessels, except at great expense. And ports are differently endowed through the vagaries of geography or geology. Gulfport, Mississippi, for example, has about 36 feet of draft. New Orleans has about 40 feet, with all that sediment coming down the Mississippi. The Seattle approach channel, on the other hand, was glacier-carved; it averages 175 feet. Halifax, Nova Scotia, averages about 60 feet, Baltimore and Hampton Roads average about 50 feet, while New York/New Jersey presently averages 40 to 45 feet.

Thus, some U.S. ports will have an easier time of it when accommodating megaships, with the consequent potential for some reshuffling of rank among various North American ports. This would be very similar to another change that happened 40 years ago during the advent of containerization. Some people could make it--some people couldn't make it. San Francisco decided it didn't have the room to pursue containerization. It became a tourist waterfront and gave all of its cargo up to Oakland. Manhattan decided that it couldn't do it and gave it all to New Jersey.

I hasten to add that *megaships* face quite a few hurdles. There is the enormous cost of modifying infrastructure--everything from piers to cranes and the inland infrastructure to handle the massive increases in road and rail traffic. Dredging a harbor, especially when contaminated sediment is present, is an enormously costly undertaking. So the widespread adoption of *megaships* may be a decade or two away. But, taking the longer view, the increase in vehicle size seems inexorable; it has been progressing on the ocean since the invention of steam navigation and shows little sign of reversing.

Container shipping also has a way of bringing new kinds of cargo into its orbit. In large part, it is due to the increases in vessel size and the need to keep them full in both directions. Remember that containers were originally designed to transport manufactured goods--Sony TV sets packed in cardboard boxes all moving in a steel container from Yokohama to Sears in Chicago. What can they carry back to Yokohama?

The answer is that cargoes that used to go by break-bulk ships or even specialty product tankers now increasingly travel by container. When I worked for Burlington Northern in the 1980's, we had quite a healthy trade in containerized auto parts from Japan going to the newly established Japanese assembly plants in places like Smyrna, Tennessee, and in Ohio, and so forth. And we would get trains of empty containers coming back. That lasted for about six months to a year. Then the containers going back to Japan started passing through Seattle full. They contained several commodities, but primarily eastern hardwood going back to Japan to be transformed into Yamaha pianos or furniture. Traditionally, such a commodity would have gone by rail or truck perhaps to Savannah or Charleston, and then have been put on a conventional ship that would have gone around the Gulf of Mexico and through the Panama Canal and out across the Pacific. Instead, because the Japanese established an assembly plant for automobiles in Tennessee, containerized Midwest hardwood started going through Seattle.

New container trade, in this case, auto parts, often will create commercial opportunities in its wake, like a new trade route for export hardwood, that are subtle and can be very difficult to



predict, but which are quite important. This movement of new commodities in container ships has some implications for U.S. agricultural trade. We have done vessel cost and container forecasts for various ports within the Pacific Basin and have also looked at the possible cargoes that could be carried in larger container ships--the *megaships*, if you will. These exercises have been very interesting. Once you get up past around 11,000 or 12,000 TEU, or about 25 to 30 percent larger than the largest ships afloat today, you can start moving grain in them, at least in some trades.

This is a very interesting development. Bear in mind that we are predicting the commercial behavior of ships that have not been fully designed in the theoretical trading environment of the future. But there's obviously something in the wind here that has potential implications for U.S. shippers and may indicate eventual new patterns of movement within the United States.

This ability of containers to attract new cargoes has implications for all sorts of trades--not only those capable of supporting megaships. In the developing world, where efficient conventional grain-handling infrastructure often doesn't exist, but where a reasonably efficient container terminal may be present, containerized intermodal movements may open up numerous possibilities.

Let me explain this latter point in more detail. Containerization allows ports throughout the developing world to leapfrog past a stage of older technology--rather like cell phones in the telecommunications market. Go to someplace like Jakarta and every other person has a cell phone growing out of his ear. Well, you see the same kind of thing in the ports of the developing world. Oftentimes a nation will have a small colonial port in one portion of the harbor, rather ramshackle, with antiquated technology and very low productivity. But on the other side of the harbor is a bustling container terminal that is bursting at the seams. This has considerable significance for how U.S. producers may move small consignments or food aid, for example, in the future. Again, going back to a port like Dar Es Salaam and looking at the total costs, would I automatically bring food aid to East Africa on pallets or in bags in a single large shipment aboard a break-bulk ship, with all of the attendant difficulties of storage and inland distribution? The alternative might be to bring it in containers on a scheduled service and deliver the aid directly to the point of consumption in much smaller shipments over a longer period of time. Ten years ago, before that container terminal existed, there would have been only one answer. Today, well, the answer is not quite so clear cut.

We have seen that ocean shipping technology has changed radically over the past 30 years. Cargo handling is more efficient, transit times are lower and more reliable, and there is a greater emphasis on managing the entire transport chain. Ports have changed, grown or fallen behind, trade patterns will continue to develop in new ways as a result of the new technology, and there are various implications for the developing world.

In addition, there have been and will continue to be fundamental institutional changes that have equally important effects. I am speaking of a continued tendency toward consolidation, rationalization of services, and oligopoly. This trend has a long history. When steamships were first introduced in the 19th century, suddenly you could predict how long it would take you to get between Southhampton and New York. And you knew what your annual capacity would be, in a

way that you didn't know in the days of sail. As steamship technology progressed, the danger of excess capacity grew. The introduction of compound steam engines in the mid-19th century meant that marine power plants could become smaller--in other words, that the cargo capacity of a given vessel could increase by perhaps 25 percent. And advances in metallurgy and engineering meant that hulls were getting larger all the time.

And all of this capacity was very capital intensive. And capacity, once created, is very difficult to reduce. Before World War I, the problem for the new steamship industry was how to control losses in a downturn and how to control the effects of predatory pricing by a player seeking a temporary advantage. The next logical step was to form shipping cartels to regulate capacity and to fix prices. These cartels existed from the advent of steam, through World War II, and beyond.

When containers were first adopted worldwide, one school of thought, especially in Britain, maintained that cartels would become more powerful than ever. Containerization would bring a new round of inevitable and massive capital commitments, creating high barriers to entry and vastly increased capacity that would lead to a repetition of the situation existing before World War I.

In fact, in the 1970's and 1980's, the traditional shipping cartels more or less fell apart. They are no longer very powerful at all for several reasons. The first thing that conventional wisdom overlooked was the rise of the Asian economies; the traditional European and other operators were undercut by low-cost Asian carriers in the 1970's and 1980's, and by the Russians and East Europeans with their highly subsidized shipping companies. These firms--because of cost structures or subsidies--could stand outside the cartel structure and still survive. The second thing that helped to break up the ocean cartels was deregulation of transport in the United States, which meant that much of the cartels' price-fixing activity became illegal in U.S. trade. Now, more than two decades later, we have a very different picture. I would argue, unlike what was said before, that despite the influence of national governments, which continues, and protectionist policies, which also continue, cartels don't amount to very much today.

I suppose the larger question is whether the earlier assessment was simply premature. You might say that the Asian boom of the 1970's and 1980's simply stalled the inevitable by injecting new entrants into the system. In reality, all of the fundamental factors that people worried about in the late 1950's and early 1960's are still with us--huge capital investments, high barriers to entry, and large capacity increases, with all of the consequent tendencies to ally, rationalize, and merge. Since the entry of the East Asians, it is not immediately clear who else is poised to create a large merchant fleet that could shake the system up once again. In fact, it is a closed club.

So today we see an incipient oligopoly in container shipping. The conventional wisdom is that, in a few years' time, the world will have maybe two European carriers, two Japanese carriers, one or two Chinese, perhaps a Korean, and a Taiwanese. And that's basically it. It will be rather like oil, or airline alliances--a small group of very large, global players.

One interesting thing about this list is that it doesn't have any Americans on it.

Sea-Land, a U.S. company founded by the inventor of containerization, Malcolm McLean, is still a presence, but we don't know what's going to happen to this company. It may fold into Maersk, a Danish firm with which it is tightly allied, in the way that American President Lines has folded into Neptune Orient, a Singaporean company. But in any event, it seems there will be no Americans on the list in a few years time (Maersk Line acquired the global shipping operation of Sea-Land Service, Inc. in July 1999).

All this raises many currently unanswerable questions about the effects of concentrated market power and the lack of American participation. How effective will the United States be in regulating a global industry in which it primarily participates only as a very large customer? This would seem to differ from the airline industry in which, Airbus notwithstanding, U.S. industry builds the vehicles, its businesses are among the major users of the vehicles, and where the U.S. government is the major regulator of industry activity. Other national and international aviation agencies follow its lead, especially in certain technical areas related to aircraft inspections and airworthiness, for example. In ocean container shipping, the structure of the industry is fundamentally different.

What happens to the smaller shipping lines, especially those created by developing nations? Do they become niche players? Or do they become subsidiaries in the way that today's commuter airlines are subsidiaries serving the hubs of major air carriers?

If a few seaports turn into hubs for *megacarriers* and their megaships, in the way that Atlanta and Dallas-Ft. Worth are airline hubs, what happens to the other, smaller ports? Do we reallocate public resources to build some ports at the expense of others? How will we decide how this is to be done?

In a deregulated oligopoly environment--again, think of the airlines--how will the smaller shipper fare? The one who has no corporate volume travel discount?

In summary, we have seen a continued tendency, stretching back over a century, for ocean shipping companies to collude in matters of pricing and capacity regulation. This collusion was spurred initially by the risk inherent in such heavy capital investment and by the excess capacity caused by technological advances in the early era of steam navigation. It has persisted for over a century, even though the old cartels weakened with the entry of the Asian newcomers in the 1980's. Given that entry costs are now so high, capacity so great, and consolidations and alliances seemingly will continue, what happens next?

There is another aspect we should mention, something subtle and less quantifiable, but important in the context of a workshop such as this. When a domestic industry loses a critical mass of talent and when decisionmakers congregate in other parts of the world, you have to work all that much harder to stay current when you want to analyze the industry.

The kind of analytical work that we do in the U.S. maritime consulting community, and to some extent in government, is now the kind of analysis done by a culture that's the passive recipient of the shipping services of others. How deeply should we dredge this channel? Does our port build

the Koreans a new terminal over here or over there? It's an infrastructure-oriented, consulting engineer's way of analyzing shipping. And we are rather good at it.

But U.S. consultants, as an industry, are not so good at other kinds of questions, questions that I think you folks would be very interested in answering, especially given that American agriculture faces some new competitive challenges overseas. Here are some examples of these kinds of questions: Will rates for soybeans between Brazil and Malaysia rise or fall next year? How will capacity increases in Chinese shipyards affect the secondhand price of grain ships and, consequently, impact future grain rates? These kinds of questions presuppose a different body of knowledge on the part of the person answering them--a greater knowledge of the industry itself, as opposed to knowledge of the physical aspects of the technology. And I would argue that this sort of public knowledge is becoming somewhat more difficult to come by as a result of the industry consolidating overseas.

As an aside, I want to relate some experiences I had in 1997 in East Africa that illustrate something about our collective position as a nation in this matter. I was doing a mining logistics job, looking at getting copper out of Central Africa. One of the ports that I had to study was Dar es Salaam and I ended up going to a steamship industry party. We were outside, in the middle of the rainy season, all sitting around in suits under a blue-and-white-striped party tent at the end of a warehouse in a sea of mud. And the conversation was very interesting. The group was largely Scandinavian, with some British, and a South African or two. The Danish guy told me about how his dad had worked for the same company, and how his grandfather had signed on back in the days of sail. And you had people from different companies who had spent their lives abroad and who had crossed paths elsewhere in the world. You know, "Remember when we were both in Chile back in the 1980's?" In that tent, I realized that this kind of pragmatic knowledge, that depth of global experience, combined with a training in which ocean transportation is still a subject of extensive academic analysis, is something that we as a culture no longer possess. When I go to the Propeller Club dinner in Seattle, the conversation is not the same as it was in that tent in Dar es Salaam.

Now, don't misunderstand me - there are some exceptionally bright people in the private sector in this country as well as in the government spending their lives analyzing the maritime business. At issue is more the climate in which this analysis is conducted. In the United States, ocean transportation analysis tends to be highly proprietary and narrowly focused--in the petroleum, agribusiness, or mining sectors, for example. In contrast, in the UK and elsewhere in Europe, they design and build the ships, finance the ships, insure them, and manage them. The industry is centered there, in other words, and there is a wider and deeper pool of publicly available maritime knowledge coupled with strong academic traditions in transportation economics and maritime business management. And its product is the bright fellows sitting in the tent in Dar es Salaam. So in the face of a consolidating industry that has largely left the United States, I would argue that any government institution, such as USDA, wanting to study ocean shipping must focus its analytical talent overseas. And this would seem doubly important in a climate of increased competition from foreign agricultural producers. You will somehow have to introduce yourself into the global nerve centers of the industry, perhaps stationing transport attachés in places like London and Tokyo and Singapore. That is another consequence of this fundamental industry

change.

The upshot is that we're seeing a massive consolidation of the industry. There will be larger, fewer players with their fingers in many pies, active in complementary modes of transportation, all over the globe. This is an industry that is very capital-intensive and where the barriers to entry seem to be getting higher; there are no new entrants in this game. And none of the players, the conventional wisdom goes, will be American in the next few years. And all of these things are probably of some importance.

Thanks very much for your time.

**Richard Parry, Agricultural Research Service**

It's a pleasure indeed for me to be with you today, especially as a biologist invited to speak with all of these noted economists. I would like to present an overview about the ARS research program and its impact on transportation technologies of the past, present, and the challenges of the future. The ARS has developed a very diverse research program with its \$8 million annual budget. Our customers include growers, processors, shippers, and several action agencies of the Federal Government, all of which identify specific problems requiring innovative solutions.

American agriculture has a long history of rapidly adapting to technology. The ARS technology that has been mentioned already by Brian McGregor is an indication of the ARS accomplishments that have significantly improved transportation efficiency. ARS does not identify transportation research as a separate program; there is no budget cross-cut specifically identifying this sector. However, many projects within the program portfolio affect the transportation industry. Measuring the economic impact of these improvements has not been successful.

The innovations in refrigeration engineering that occurred in the 1950's, 1960's, and 1970's have had a major impact on commodities traded today. This work led to the creation of the frozen foods industry. The flash freezing of meat and poultry products has significantly extended shelf life and enhanced food safety, making our products some of the safest in the world. Foam-mat drying of processed milk, fruits, and vegetables is another example, which has created new opportunities for the food industry and new challenges for movement of products nationally and internationally.

Controlling that process of ripening of fruits and vegetables extends shelf life and methods to limit food pathogens have increased the diversity and availability of products in retail markets. Also, controlled atmosphere storage and shipment of commodities such as Washington apples have expanded markets and created new technical challenges for the transportation industry. New technologies have also allowed the transportation unit to become part of the commodity quarantine treatments for citrus, and opened markets overseas for U.S. producers.

ARS research programs that will affect the transportation industry in the near term include:

- *Gene expression.* Extending the shelf life of commodities through control of gene expression will be possible as soon as the basic information about gene location and function is known. The mapping of the plant genome, once viewed as a long-term objective, is now on the horizon. The primitive plant *Arabidopsis* will be first, probably in 2000, followed soon thereafter by rice and other species. This information will rapidly be applied to fresh fruits and vegetables and would make it possible to turn genes that produce ethylene on and off. Changing ripening properties will result in major changes for product shipping standards.
- *Edible food films.* Using thin films to reduce spoilage and dehydration of fresh fruits and vegetables has become a common way of extending shelf life. Edible films will be the next advance in commodity treatments. Films are currently made from a variety of natural materials such as pectin and starches. Protein polymers are being developed to extend this practice, which may change shipping parameters for these commodities.
- *Food irradiation.* Research done over several decades may soon make irradiation an acceptable practice for reducing foodborne pathogens. Irradiation may be the method of choice for the fresh fruit and vegetable market, where pre-harvest contamination from the use of animal manure for fertilizer may occur. Maintaining food safety is absolutely essential to maintaining consumer confidence.
- *Product defect detection.* Using a variety of different biosensors in processing plants has been proven to be effective in reducing contaminants and enhancing quality, which reduces transportation losses. Also, using sensory panels to identify product quality characteristics in a variety of different commodities has enhanced the ARS variety development programs.
- *Contaminant sampling and testing.* Improved methods for sampling and testing for contaminants have permitted export of commodities to overseas markets with product quality requirements. Rapid testing for mycotoxins, pesticides, and other environmental contaminants are extremely important to meet international quality standards.

ARS is developing methods to eliminate food pathogens in production as well as post-harvest for meat and poultry products. Bulk commodity shipments are expected to continue to decrease while processed or partially processed food shipments are expected to increase.

Biotechnology is introducing a new era of crops designed for specific end uses, such as wheat products and animal feed from corn. One example is a new variety of feed designed to significantly reduce phosphorus in animal waste. Such improved varieties will only have market value when product identity is preserved, which changes bulk commodity transportation operations. Other genetically improved crops will also need to preserve product identity throughout the production, processing, and marketing channels. These new grains may lead to significant changes in the way grain is handled within the United States and when exported.

Transportation is an important factor within the agricultural system. The impacts of all the new technologies I have mentioned cannot be measured in aggregate economic transportation models. New technology has played and will continue to play an important role in diversifying agricultural

production and enhancing production efficiency. There is a need to measure this economic impact as an indicator of the public good that has come from this research effort.