Changes in the U.S. Rail Transit Car Manufacturing Industry

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ABSTRACT

The results of a study of the rail transit car building industry in the United States are presented. The study was undertaken in order to examine the economics of the industry, the factors that have affected it since 1965, and the current conditions, including trends that might provide insight as to its future. In the last 20 years, the industry has lost stability as a result of an influx of new capital, customers, suppliers, and technology and new methods of doing business. Management of transit authorities has changed as operating and maintenance staff from the street railway period have retired. Rail-car manufacturing has become much more risky, and the changes needed to distribute the risk fairly have been too slow in coming. As a result, the character of the domestic car manufacturing industry has changed markedly. Instead of integrated car builders who have final authority over design, fabrication, and assembly of transit cars, there are a number of final assembly plants building cars with substantial foreign content under the supervision of foreign car builders. Among the major elements that will guide the industry in the next few years are the small and uncertain market, the risk of innovation measured against the need for service-proven equipment, and the impact of supplier financing on foreign and domestic competition.

Rail transit cars are sophisticated vehicles that are considerably more complex than automobiles or freight cars. Rail cars consist of interrelated systems, each fitted carefully to the other. They are not built in the same way as an automobile. Instead of using a continuously moving assembly line, rail cars are built at a number of stations, largely by hand.

Car building is something of a misnomer. Cars are not built so much as they are assembled from purchased components and subsystems. For example, the major subsystems of a rail transit car are the car body or shell, the propulsion equipment (motors, controllers, and gears), and the trucks (truck frames, wheels, axles, bearings, and brakes). No car builder fabricates all of the major subsystems in its own shop. Traditionally, the car builder fabricates the body and buys the propulsion equipment and trucks. However, there have been a number of contracts in which the propulsion supplier was the prime contractor and subcontracted the car body.

There are four major tasks involved in the process of rail-car manufacture: design, fabrication, assembly, and systems integration. Design begins with the specification drawn up by the transit authority. The new car may be designed for compatibility with components and dimensions of older cars of the agency. The specification may not be sufficiently detailed to construct a car, so there may be a considerable amount of work to be done after the contract award. Through preliminary engineering and detailed design, the specification requirements are translated into shop drawings.

Fabrication involves forming and welding the car shell from steel shapes, building motors and electronic equipment, casting or welding the truck frames, and building other components. These are assembled, fitted into the car shell, and connected and the interior fittings and seats are installed. Final assembly usually refers to interior finish work and truck installation. Trucks can be assembled by the truck contractor or the car builder.

Systems integration is a continuous process, beginning in the design stage. It involves configuration management in which the proper fit and operation of subsystems and components are assured. Problems with integration may crop up any time during the assembly and fabrication process but often show up during testing. Once the car has been assembled, it must be proof tested and performance tested against the specification before it is shipped to the transit authority.

It is difficult to define precisely what makes a rail-car supplier a car builder. The amount of the car built by the supplier is not a good measure, because even a fully integrated car builder will subcontract 50 to 60 percent of the content of the car. Because designs can be licensed from other builders, the best definition should involve responsibility for the whole car. Whichever supplier has the responsibility for systems integration must be involved in all the components of the car. This is also the supplier who probably has contractual responsibility for the car and who stands behind the warranty. The car builder is therefore best defined as the supplier who signed the contract with the buyer and is responsible for systems integration.

The definition of the domestic industry is another issue. The country of incorporation is not a good measure of a domestic industry, because the rise of multinational corporations has led to wholly owned subsidiaries of parent firms incorporated in countries all over the world. The same is true of ownership. Foreign ownership of local companies, and vice versa, blurs the boundaries of the domestic industry.

The location of the material and labor input of a product defines its content but does not define the responsibility for the car. A rail car designed in this country and built with domestic components using U.S. labor has most of its impact on the local economy and clearly has U.S. content; nevertheless, if the systems integration and warranty responsibility come from another country, the car loses its domestic identity. For the purposes of this paper the domestic rail-car industry is defined as that activity occurring in the United States, and a car builder's location is defined by the country where the builder is headquartered and where systems integration takes place and final responsibility is accepted.

At this time ownership, control, design, and production of rail cars are not concentrated in any single U.S. corporation. It must be concluded that the United States has no completely domestic car builder, although it does have one foreign-owned integrated car builder (the Budd Company), an active supply industry, and several rail-car assemblers. This last segment of the industry has been supported by the Buy America legislation.

HISTORY

A brief history of the U.S. car builders active from 1965 to the present is presented. The approach taken was to examine every passenger car order during this period, selecting those that had the most effect on the car builder's fortunes, both good and bad. This is not intended to be a comprehensive summary of the orders or a complete history of each firm.

In 1966 the Budd Company won the competition for the Metroliner to be operated over the Pennsylvania Railroad's Northeast Corridor. Conceived by the U.S. Department of Transportation, the cars were to run at 160 mph, faster than the Japanese Shinkansen that had recently begun service. The Metroliners were considerably more complex than any previous self-propelled car. They have been described as very advanced prototypes and R&D projects rather than the production cars they were intended to be. The Metroliners were among the first cars to show how a rapid advance in technology could bring problems. Budd is reported to have lost $26 million debugging the cars after delivery.

The following year brought Budd two more orders that caused the company similar problems. The first order of cars for the Port Authority Transit Corporation (PATCO) Lindenwold Line were a significant attempt to advance the state of the art in rail transit, particularly with respect to automation. The Long Island Rail Road at the same time placed an order for its new generation of electric multiple-unit (EMU) commuter cars, the M-1s. A highly innovative new design contributed to problems with automatic train operation, brakes, air conditioning, and motors and alternators. Losses on this order, the other two listed previously, and a concurrent job for the Chicago Transit Authority (CTA) led to Budd's announcement to discontinue rail operations as a prime contractor in 1970. The company continued work as a subcontractor to General Electric (GE) on New York Metropolitan Transportation Authority (MTA) EMU commuter cars.

Budd was not the only car builder wrestling with the problems of sophisticated technology. There were several new orders in 1969, among them the long-awaited Bay Area Rapid Transit (BART) contract. The BART system and its cars were developed as a great leap forward in rail transit technology. Rohr Corporation, an aerospace firm beginning its diversification into urban transportation, underbid Pullman and St. Louis Car Company to win the contract. The cars, built using aerospace techniques, were of a totally new design. They suffered problems with motors, chopper control, automatic train control, and doors. Delays in the prototypes held up production, causing more losses to Rohr. The company wrote off $27 million on the $266.8 million contract.

In 1969-1970, St. Louis Car Company received two large orders from the Illinois Central Railroad and the New York City Transportation Authority (NYCTA) that caused similar problems and delays. The uneven market had left the company short of work and as a result the bids for these two orders were probably lower than the cost of production. The Illinois Central Highliner order first strained St. Louis Car's engineering capacity, then its production capacity. Draftsmen and production personnel who were not experienced in rail-car manufacture were hired in order to meet the tight delivery schedule, which ironically caused delays so that the schedule could not be met. The cars did not incorporate much in the way of new technology, but they were a new design that the company had never built before. Systems integration problems contributed to production and acceptance delays.

The R-44 cars for NYCTA were the first NYCTA cars since the 1930s to be built to a different basic design; they were not compatible with the rest of the fleet. For the R-44 contract, the transit authority specified higher performance, automatic train control, new trucks, propulsion control, and couplers. The cars were longer and heavier than earlier cars and could not be coupled with them into trains. Although St. Louis Car had built hundreds of cars for NYCTA, the newly designed equipment on the R-44 was revolutionary and troublesome; warranty work was extensive. The combination of these two problem orders is said to have forced St. Louis Car out of the business. An unrealistic bid price, too rapid expansion of production and engineering capacity, short delivery schedules, and new designs were contributing factors.

The late 1960s and early 1970s was a period when new competition entered the car-building industry. GE, a major supplier of propulsion equipment, made a corporate decision to take prime responsibility on cars using its subsystems. It first attempted to enter the industry by acquiring Budd but was discouraged by the antitrust laws. The company then bid on and won a contract for 144 M-2 EMU commuter cars for the New York MTA and Connecticut Department of Transportation, subcontracting car body construction to Budd and Canadian Vickers. These high-speed EMU commuter cars may be the most technologically complex in the United States. They were designed to run on either 650-V dc third rail or overhead pickup at 11,000 V ac, 25 Hz, or 12,000 V ac, 60 Hz, with a top speed of 100 mph, automatic train control, air conditioning, and automatic doors. The sophisticated technology and the new design made extensive debugging necessary.

GE followed by winning a contract in 1971 for the Southeastern Pennsylvania Transportation Authority (SEPTA) Silverliner IV EMU cars. Follow-on orders for SEPTA and similar cars for New Jersey Transit represented one of the largest production runs in the transit industry and were the most successful of GE's orders. During the next 7 years, 532 cars were built to essentially the same design, with small changes made between orders. Although the first cars had problems, the long production run contributed to the profitability of the order and the reliability of the last group of cars, the Jersey Arrow III.

In 1972 NYCTA advertised for bids for 745 cars, designated R-46. Pullman-Standard was the low bidder, eliminating GE, Rohr, and Westinghouse, teamed with St. Louis Car. The R-46 order, unfortunately for Pullman, could be considered a case study in everything that can go wrong with a transit car procurement. The specification called for a car similar to the R-44 that St. Louis Car had recently built. The contract was awarded for a fixed price without provision for escalation. During the design phase for the R-46, problems experienced with the R-44 caused NYCTA to request changes in the R-46 design. This delayed production into the 1973-1974 period of high inflation, so that Pullman's cost of production rose significantly higher than the original bid price. There were technical problems with the car as well. The truck frames on the R-46 developed cracks, which NYCTA claimed were covered under the warranty. Pullman was required to pay NYCTA $72 million in claims for this problem alone.

The size of the order strained Pullman's production staff. The work force was increased from 250 to 1,700, resulting in substantial learning-curve, quality control, and schedule problems. By the end of the program, Pullman had lost $45.78 million on the order.

The first contract for new light rail cars in 20 years was awarded in 1973 to Boeing-Vertol, another firm new to the industry. Boston and San Francisco made a joint award for 230 (later 275) cars to be built to an UMTA-sponsored standard light rail vehicle (SLRV) specification. None of the three old-line car builders chose to bid on this order: St. Louis Car was essentially out of the business, Budd was building only unpowered cars at the time, and Pullman was occupied with other work. The cars were complex and the design was new. Reliability and maintenance problems developed that had to be fixed under warranty. Inflation also ended Boeing's profits. The estimated loss on the 175-car Boston order was $40,000 per car.

Foreign competition became an increasingly important factor through the 1970s, as did the question of transit car standardization. As the Metropolitan Atlanta Rapid Transit Authority (MARTA) prepared to order its cars in 1975, there was hope throughout the car-building industry that one of the cars already in production would be suitable for this new rail system. Both Pullman and Rohr had hopes of selling modified versions of the R-46 and the Washington Metropolitan Area Transportation Authority (WMATA) car, respectively. MARTA officials and its consultants decided that these cars did not suit the system requirements and as a result Pullman dropped out of the bidding and Rohr, in a poor financial position from its BART and WMATA orders, withdrew from the market altogether on May 28, 1976.

GE officials spent a year discussing the specifications with MARTA and believed that they had a good understanding of the car design and contract terms. When the bids were opened, Franco-Belge unexpectedly won the contract, underbidding GE, the only U.S. bidder, by more than $10 million on a 100-car order. Later in 1976, following another bid lost to a foreign car builder, GE abandoned the car-manufacturing business, claiming that the sealed-bid low-price procurement favored inexperienced bidders who did not understand the risks involved in the industry.

Nineteen separate bids were received from 10 different bidders in response to the Greater Cleveland Regional Transit Authority's (GCRTA) advertisement for light rail cars, the first since the Boston-San Francisco order. The three remaining U.S. car builders--Budd, Pullman, and Boeing--all submitted bids but were underbid by Breda of Italy. Pullman, the lowest U.S. bidder, sued to halt federal funding but lost. Budd, teamed with the Urban Transportation Development Corporation (UTDC) in a consortium called Cleve-tran, was making its first bid on a self-propelled passenger car since the M-1 in 1967. The company had returned to the market in late 1972 with an order for 25 bilevel commuter cars for the Burlington Northern Railroad, making a decision to concentrate on cars without propulsion systems.

Following the GCRTA award, Congress passed the Surface Transportation Assistance Act of 1978, which included a Buy America clause. This may have had an effect on the competition for the next two orders, for Chicago and Baltimore-Miami, because only the bidders were U.S. companies.

When CTA ordered 300 cars in the 2600 series, Budd, Boeing, and Pullman were in competition once again, with important consequences for all three firms. Budd won a large order and a subsequent follow-on contract, which brought it back fully into the transit car manufacturing business. Boeing, however, had expected to win this order, having just completed a 200-car order for similar cars on which it had lost money. When bids were opened, Budd had underbid Boeing by $140,000 per car. The loss of the order convinced Boeing officials that there was little or no profit to be made in the industry. The CTA bid opening also showed Budd to have underbid Pullman by almost half. Pullman's losses on the R-46 and the National Railroad Passenger Corporation (Amtrak) Superliners, coupled with the failure to win its last two bids in Cleveland and Chicago, caused the company to withdraw completely from the passenger car market on March 21, 1978. Following Pullman's action, Budd remained the sole domestic car builder. Shortly thereafter its stock was acquired by Thyssen of West Germany, and it became a wholly owned subsidiary of that firm.

The domestic industry in the 1980s reflects the language of the Buy America provisions. Recent orders have tended toward use of domestically produced subsystems and final assembly of the cars in plants located near the city for which the cars have been bought.

FACTORS AFFECTING THE INDUSTRY

Analysis of the rail-car orders during the last 15 years and information from interviews with car builders and transit authorities point to a number of factors that affected the industry in the United States. All of them contributed to the one major problem: the lack of profitability of rail-car manufacturing.

Procurement Practices

Low-Bid Criteria for Award

Most rail-car procurements since 1965 have relied on a sealed-bid, fixed-price method. There are a number of problems with this policy. One is that a low-bid award does not take into account operating and maintenance costs over the life of the equipment purchases. Because the capital cost is the only factor governing the award, this may force a car builder to buy lower-quality subsystems and materials in order to win the contract. When the builder cannot put high-quality equipment into the car, performance and reliability are affected, which may lead to high warranty costs and reduced or eliminated profitability of the order. Also, when car builders do bid equipment of higher quality (and perhaps lower maintenance cost), the probability of winning the contract may be reduced.

The low-bid criteria may also discriminate against the experienced bidder. Car builders experienced with the specified equipment and the terms and conditions of a proposed order can assess the risks of the order more accurately than inexperienced firms. Prices reflect perceived risk, and in anticipating this risk, experienced car builders have tended to bid higher, making it less likely that they will win the order.

Foreign bidders, particularly those with little or no experience in the United States, may not fully understand the risks in the U.S. transit market. Foreign business practices differ; for example, court judgments in lawsuits are usually not as high. As a result, foreign bidders may not allow for sufficient bonding or liability insurance, thus lowering the cost of these items and allowing the firm to bid lower.

Escalation and Progress Payments

The method of financing rail-car purchases has also changed during the past 15 years. Until the early 1970s procurements were financed by the car builder using working capital and borrowed funds. The transit authority paid for the cars on acceptance at the end of the contract. The interest costs of whatever money was borrowed were spread across the car order as part of the unit price per car. If there was concern about price escalation for a particular contract, its effects were estimated and also added to the price of the car. The car builder assumed all responsibility for inflation, building protection into the bid price. By taking on the responsibility for inflation and interest fluctuations, the car builders were gambling that these costs would be predictable.

In the early 1970s the financial environment changed drastically. The costs of money and inflation rose much faster than had been anticipated. Figure 1 shows the trend of the prime rate since 1971 plotted quarterly, and Figure 2 shows two indexes of inflation commonly used in calculating escalation factors--the wholesale price index for metals and metal products, code 10, and the average hourly earnings for the Railroad Equipment Group of the Transportation Industry, standard industrial classification (SIC) 374. Both are compiled monthly by the Bureau of Labor Statistics, U.S. Department of Labor. Although wage rates increased at a fairly even pace during this period, there was a 29.4 percent increase in material costs in 1974, most likely caused by the behavior of fuel prices at that time. The prime rate also increased from 6.5 percent at the beginning of 1973 to a high of 11.75 percent in mid-1974.

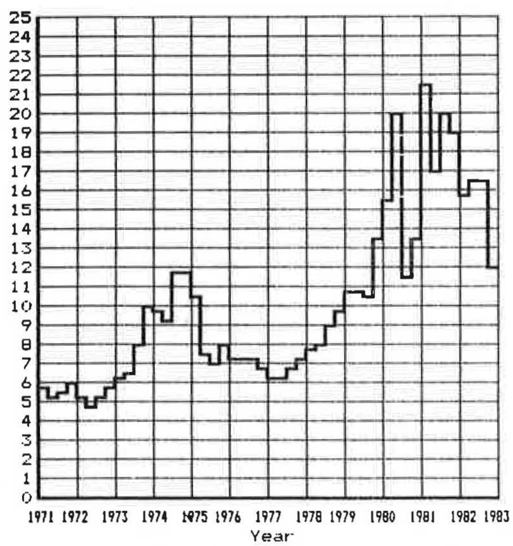

FIGURE 1 Prime rate plotted quarterly, 1971-1983.

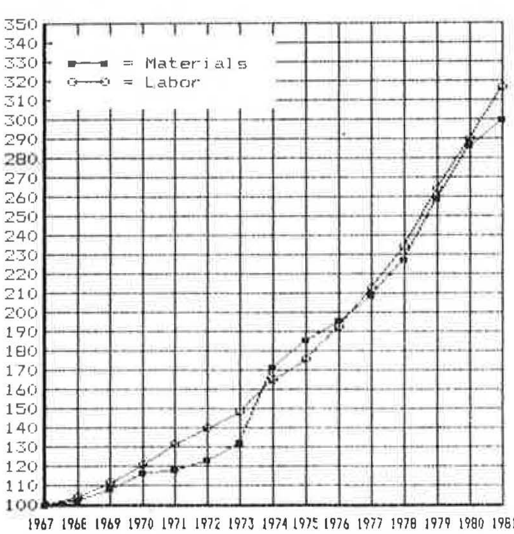

FIGURE 2 Rail-car cost escalation indexes, annual average.

The overall effect was that car builders incurred additional expenses that were not reimbursable. In some cases this occurred only a matter of months after the contract had been awarded. The costs of borrowing money, buying materials, and paying wages necessary to build the car were much higher than what had been reflected in the bid prices.

Pullman was one of the manufacturers caught without provision for inflation. The R-46 was bid for $275,381 per car in 1972. In 1976, while still in production, a modified version was offered to Atlanta for more than $400,000 per car. Boeing's light rail vehicle sold to Boston for approximately $300,000 in 1972 and was bid to Cleveland in 1977 for $870,000 while still in production. The instability of prices and interest rates forced two changes in the method of financing rail-car procurement. Escalation clauses and progress payments became much more prevalent in contracts. Both of these changes help spread the new risks more equitably between the buyer and seller.

In most escalation clauses, the transit authority promises to pay the car builder for increased costs in labor and materials; these increases are based on a published index rather than on the actual costs to the car builder. As a result, the procurement is not a cost-plus arrangement, which would put all the risks of inflation on the buyer. The two indexes most often used in U.S. contracts are those shown earlier in Figure 2. A typical breakdown is the one used in 1979 for the Baltimore-Miami rapid rail-car procurement. The cost of the car is considered to consist of 60 percent materials and 30 percent labor subject to escalation and 10 percent profit, which is not escalated. The Baltimore-Miami contract is one that puts a cap on the escalation clause. Increases in prices and wages over the length of the contract will be paid up to a certain limit but not above it. Baltimore capped escalation at 15 percent of the costs, whereas Miami (which had a longer delivery schedule) capped it at 20 percent.

Progress payments, if planned correctly, remove the necessity for borrowing money to finance car construction. At various points in the contract, the manufacturer is advanced the money needed to buy subsystems and materials, based on proven completion of a portion of the work. There is less agreement in the industry on progress payment schedules than there is for factoring escalation. The importance of progress payments is demonstrated by the R-46 order. Earlier payments by NYCTA allowed Pullman to provide nine more cars without increasing the total contract price.

Other Contract Terms and Conditions

Three types of contractual conditions have affected the industry's ability to make a profit. The first of these controversial practices is the clause called "Authority of the Engineer." In many cases the buyer's engineer or his delegated representatives have had unilateral power to interpret specifications, shut down production lines, or decide when the car builder will be paid for the work. This adds considerable risk to rail-car manufacture. NYCTA used this clause in the R-46 contract to stop Pullman's production and redesign the car. Pullman's expense for labor and materials continued while work, and subsequent payment, was delayed. The net effect was to add time and cost to production without recompense.

The second contractual clause relates to penalties and liquidated damages. According to manufacturers, liquidated damages can be assessed up to the full price of the contract, which they consider unreasonable (1,p.17). These large penalties have not been shown to improve performance in meeting reasonable delivery dates. A penalty to the full price of the contract would result in delivery of cars free to the transit authority, paid for by the manufacturer, which could easily put the firm out of business. Again, risks are added without recompense. Compounding the problem is the Authority of the Engineer clause. "One of the CTA's recent contracts says that it can suspend work any time its engineer see fit, and the CTA has the authority to determine whether construction delays are avoidable--a central decision when the builder must pay a penalty for late delivery of cars" (2). Reasonable penalties for late delivery are not the issue here. The problem has been the lack of an upper limit on penalties.

Guaranty, warranty, and reliability provisions have changed during the last 15 years. Warranties became too abstract, not defining the responsibilities of the buyer and the seller clearly and without ambiguity. Car builders complained that warranties were being used to cover maintenance activities, and transit authorities claimed that the manufacturers were refusing to do warranty work. Problems with new rail cars led to a trend to tighten warranties and make them more stringent. More subsystems were added under separate warranties and the length of coverage was extended. Warranty of reliability was added through fleet failure rate provisions. The increasing length and lack of definition brought more risks to the seller, because it increased the likelihood that more retrofit work would be required. The vague language of some warranties was subject to unilateral interpretation by the transit authority's engineer, again shifting the risks to the car builder without recompense. The net result was a loss of profitability on the order or a higher bid price to cover risks.

Car Design

Design Specifications

There are two basic types of specifications used to purchase rail transit rolling stock: design (hardware) and performance (functional). A design specification tells the suppliers exactly what to build, including material dimensions and in some cases make and model number. Performance specifications tell the supplier how the finished product must perform. Most transit-car specifications combine both these approaches. Design specifications are used in rail-car procurements in order to force compatibility with the purchaser's existing fleet or to ensure that new equipment meets physical and operational constraints on an existing system. Design specifications tend to discourage innovation. Although experience from other jobs may point to better engineering solutions, they may not be allowed. Tooling, manufacturing processes, and shop practices may be constrained by the specification so the supplier cannot use what he considers to be his most efficient techniques. Materials and subsystems may have been specified directly, so price or quality cannot be improved (or degraded) by substitution.

Diffused Responsibility

The buyer, the builder, subsystem suppliers, and consultants (if used) all have partial responsibility for the finished product. It can be difficult to assign liability for problems or failures.

Complex Technology

The long hiatus in rail transit research and development was partly to blame for the explosion of sophisticated technology that affected so many procurements. Technological advances in the 1960s and 1970s caused problems throughout the industry. The Budd Metroliners, PATCO cars and M-1s, Pullman R-46s, St. Louis Car R-44s, GE M-2s, Boeing light rail vehicles, and Rohr cars for BART and WMATA all had problems attributed to trying to introduce new technology too fast or to apply new technologies inappropriate to the operating environment.

A related problem was revolutionary design. In all of the orders just named, cars were specified that had never been built before. Even when subsystems are of proven design, increasing complexity leads to problems when systems are integrated. No one was prepared for these problems, and the prototype stage of development, which can be used to iron them out, was omitted, leaving development and production combined into one step. The result was entire production runs of cars in a hybrid state of development, causing poor reliability and increased maintenance costs.

Standardization

Standardization of rail transit cars has been a long-sought goal but an elusive one. Differences in track radii, tunnel clearances, speed and acceleration requirements, and maintenance practices at different transit agencies have made different car designs necessary. Lack of standardization, however, has contributed to several problems in the industry. One is the lack of economies of scale. In many cases new equipment must be designed for every car order, resulting in engineering, tooling, and start-up costs that must be folded into production costs, even for small production runs.

The lack of standardization has fragmented the marketplace. Instead of a large market for two or three designs, there are many small markets for dozens of designs. It is difficult for a supplier to justify investment in plant and labor for each small production run. There is less interchangeability when every part is different. Buyers face problems with price competition and availability of replacement parts.

Market Conditions

Size of Market

Compared with other transportation markets, the rail transit car market is small. As shown in Table 1, the total number of rail cars ordered is approximately 300 to 600 per year. The number in each order can be as small as the 14 light rail vehicles ordered by San Diego. The market may be too small to support a

TABLE 1 Number of New Vehicles Delivered Annually: 1971-1980 Average

Type of Vehicle	No. of Vehicles
Automobile, taxi, and motorcycle	11,439,000
Truck	3,074,000
Freight car	34,129
General aviation	13,859
Transit bus	3,770
Locomotive[a]	1,181
Intercity bus	738
Rail transit	264
Air carrier	237
Intercity and commuter rail car[a]	184

[a]Includes totals for Amtrak and Class I railroads.

domestic manufacturing industry that does not export. To some extent the industry's problems in the early 1970s were caused by too many large manufacturers competing for too small a market.

The small size contributes to the riskiness of the industry. A large amount of capital and skilled labor must be committed by the car builder in order to win business. This large commitment of resources is made in order to build only a few cars each year; at best only two or three orders are built simultaneously. Because factors beyond the car builder's control make it difficult to predict whether a profit can be made on a particular order, the firm must in effect bet its entire manufacturing facility every time it makes a bid.

Attracting capital to such a small industry is a problem that has been in existence since the 1930s. U.S. capital markets favor growing sectors of the economy out of proportion to their size. A small, declining industry, as this one has been, has the most difficulty issuing stocks and bonds or borrowing funds.

Uncertainty

The number of cars ordered varies widely from year to year. There is no funding commitment for a specific rail-car replacement rate from transit authorities or governments. The uneven market puts a strain on the bidding process. When several requests for proposals (RFPs) are released in just a few months and then none at all for a year, the car builder cannot put together a high-quality bid on all the work that may be available. Long periods with no work mean that the car builder may have to build, dismantle, and rebuild production staff and capacity repeatedly. This adds to nonrecurring costs of personnel recruitment and training when experienced craftsmen are lost.

Delivery Schedules

Delivery schedules are not geared to match the car builder's most economical rate of production. A large order may have to be built in a short period of time, causing a substantial learning curve. Without negotiation of the contract specifications, the car builder has no opportunity to change the delivery schedule, even if this might result in a lower price.

Competition

Intentional Underbidding

In many cases the low-bid selection process encouraged car builders to deliberately bid under cost in order to get an entrance into the market, using one order as a loss leader for the next. This is not a successful tactic in the long run. In the words of Arthur Hitsman of Boeing in 1979 (3): "There is really no opportunity to bid low on a transit car program and hope to make it up on the next order, because there is always going to be some new guy bidding the next order and he is going to be figuring that he will bid low this time and make it up on his next contract."

Entry of Aerospace and Foreign Firms

With the slowdown of traditional aerospace business and increased federal funding of rail equipment in the late 1960s, aircraft manufacturers were encouraged to enter the transit market. Foreign car builders apparently entered a void in the U.S. industry that had opened up because of other factors. The result of new entries into the business was to decrease the fraction of the market available to any one car builder. The market had been too small for the three traditional car builders; new entries made it more difficult for any firm to win enough enough orders to survive. To the extent that foreign markets are closed to U.S. manufacturers (4,p.27), overseas car builders have a sustaining market unavailable to U.S. firms.

Federal Involvement in the Rail Transit Industry

The creation of UMTA in 1964 (as part of the Department of Housing and Urban Development) with funding for capital improvements helped to revitalize a decaying transit industry. Seventy-five percent of the capital grants made between 1965 and 1970 went to rail systems. Of the rail grants, roughly half the amount was spent for rolling stock. The early legislation aided the rail transit industry to a much greater extent than it aided any other mode.

The two most significant pieces of legislation affecting the industry were the Urban Mass Transportation Assistance Act, as amended in 1970, and the Surface Transportation Assistance Act of 1978. The 1970 legislation was important for the level of funding it set for the UMTA program in future years. The 1978 act incorporated several important provisions discussed in the following and signaled increased congressional interest in the workings of UMTA and the mass transit industry.

Section 1 of the Urban Mass Transportation Assistance Act of 1970 called for (5,p.49) "a federal commitment for the expenditure of at least $10 billion over a 12-year period, to permit confident and continuing local planning and greater flexibility in program administration." This was a quantum leap in funding, allowing for an average of $980 million annually during the period compared with an average $113 million in grants from 1965 to 1970. This expansion of the program (shown in Figure 3) essentially created UMTA as it exists today. The commitment to funding allowed the agency to fund new urban rail systems in Baltimore, Atlanta, and Miami. The Washington, D.C., rail system was also begun at this time, funded by a separate appropriation. The commitment encouraged new rail starts both because of its magnitude and because of the 12-year program, which gave the time for planning and implementation needed for rail transit.

One other provision of the 1970 act became very important in the fortunes of the domestic rail-car manufacturers. This was Section 10, which influenced the entry of aerospace firms into the transit business (5,p.50):

SECTION 10. The Secretary of Transportation shall in all ways (including the provision of technical assistance) encourage industries adversely affected by reductions in Federal Government spending on space, military, and other federal projects to compete for the contracts provided for under sections 3 and 6 of the Urban Mass Transportation Act of 1964, as amended by this Act.

Congressional concern about the health of key defense contractors led to this provision. The goal of increased competition was well intentioned, but the size of the market was not increased enough by the funding to allow the goal to be met.

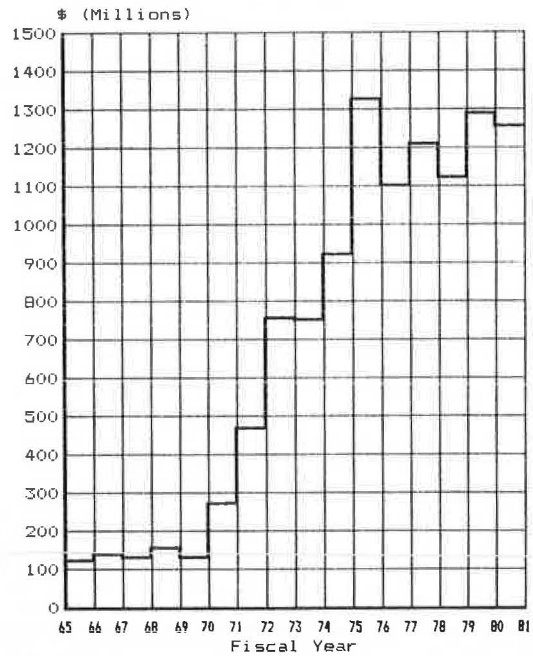

FIGURE 3 UMTA funding for capital improvements, adjusted for inflation ($1970).

The 1978 act incorporated another significant provision for the rail transit industry: Section 401, Buy America. This section had its antecedents in the Buy America Act of 1933, which stated that no federal money could be spent on direct purchases of foreign products. In 1978 Congress wrote a parallel to this act, creating a section that would apply to indirect purchases through federal grants. Until 1978 such purchases had never been covered by any type of Buy America legislation, and since 1978 there have been no other extensions into other federal programs. Section 401 states that (5,p.46) "only such manufactured articles, materials and supplies as have been manufactured in the United States substantially all from articles, materials and supplies mined, produced, or manufactured, as the case may be, in the United States will be used in such project(s)." UMTA has interpreted the phrase "substantially all" to mean that the value of the U.S. content of purchased equipment must be more than 50 percent.

Although the federal government is often blamed for the problems of the rail transit industry, it must be recognized that its influence, on the whole, has been to the industry's benefit through funding of capital improvements. Problems of poor procurement methods attached to public purchasing, although influenced by federal oversight, result from legislation at the state and local level forbidding the use of any method except competitive bidding. When the problem was recognized in 1978, the process was opened up and local governments were encouraged to pass legislation allowing negotiated procurement. This has since occurred in several states.

The large number of competing firms in relation to the size of the market in the early 1970s was a continuation of a problem that had existed for years previously. The addition of a few new companies led to enormous overcapacity for a limited market. Increased funding did not add enough orders to keep all the manufacturers in business, and some firms dropped out.

The replacement of excess domestic competitors by foreign firms was recognized as a problem by 1978, and Buy America legislation was passed to rectify the situation. By now there is less domestic industry to protect, and the increasing trend away from UMTA-funded procurements to other methods of financing has made this provision less effective.

TRENDS

Two forces have been shaping the rail transit car manufacturing industry in the last 2 years. Federal funding of transit programs was reduced so that initially all new rail starts in cities without rail transit were put on hold. Although with passage of the Surface Transportation Assistance Act of 1982 some new starts have proceeded, the future remains unclear. The other force is a reaction by transit authorities to the reliability problems and high cost of transit cars purchased during the last decade. The problems incurred by BART, WMATA, and MARTA have shown that there was something seriously wrong with the method of design and procurement of rolling stock. The shift to local funding has been the catalyst for changes in technical specifications, procurement methods, and financing.

Except in New York and Chicago, transit authorities are becoming less involved in designing cars. Performance specifications are becoming much more common. Houston is using a very general performance specification for its rapid rail procurement and in fact will design much of the system after the car has been chosen in order to allow many possible designs. This same philosophy is being pursued for light rail car procurements in Sacramento, San Jose, and Los Angeles-Long Beach.

Although older transit authorities do not have this liberty because of civil and system constraints of a system already in place, they are writing less detailed specifications. All of the LRT cars bought since the PCC car have used performance specifications that allowed a wide range of design.

A related change is the trend toward service-proven equipment. In some cases, particularly light rail purchases, this means buying a car "off the shelf" from a manufacturer who has built the car before. This was the way San Diego purchased cars for its new light rail line as well as the way in which Santa Clara County and Sacramento are purchasing theirs. Standardization of procurement methods, specifications, and car subsystems can facilitate this process, which should reduce nonrecurring costs to the car builder and bring production lines further along the learning curve.

New York's R-62 procurement is using a design specification that calls for (6,p.2) "equipment previously furnished and found satisfactory on the NYCTS . . . . The R-62 will be made reliable and maintainable by sound design based upon actual operating experience--and not based on some unsubstantiated language written into the technical specification."

The abandonment of the sealed bid in favor of methods allowing more negotiation of technical and contract specifications has helped speed the change in car design. Competitive bidding required a tight specification, because all the bidders had to be on an equal footing. Two-step procurements allow bidders to negotiate the specification requirements until they and the transit authority are satisfied with the result, at which point the price is considered.

San Diego made the first procurement in 20 years that was purely negotiated. State laws have prohibited public agencies in most states from price negotiation, requiring the selection of the lowest bidder. In 1982 both the New York and Georgia legislatures passed laws allowing full negotiation of contract terms and prices in the same manner by which private industry buys its goods, specifically to aid in rail transit purchases. In Atlanta the results of a bid opening for 30 cars to the authority's design with a sealed-bid procurement was a price 31 percent higher than the engineer's estimate. MARTA reissued the contract advertisement to four bidders for negotiation on escalation, price, contract terms and conditions, and technical requirements. When negotiations were concluded in September, Hitachi was the apparent low bidder with a price 84 percent of its original bid.

Insufficient federal funding has prompted a search for alternative methods of paying for rolling stock. New York City has become a leader in this search. Two new sources of funds have been spearheaded by the New York MTA: One is the safe harbor leasing provision written into the 1981 Economic Recovery Tax Act and the other is the concept of supplier financing. Both have been used extensively in other industries; the application to transit is new.

Safe harbor leasing allows transit authorities to sell the tax depreciation of that portion of new rolling stock not federally funded. A private party, after putting up 20 to 25 percent of the price of the vehicle, may depreciate the full cost in 5 years. The authority finances the other 75 to 80 percent through its own bonds. The private party pays the remainder back to the authority over the life of the vehicle and, because that party retains title, the authority leases the vehicle back at the same price. The private party gets the tax write-off, and the authority has full beneficial use of the vehicle at 80 percent of its total cost. This is, of course, an indirect federal subsidy of the capital cost of rolling stock, because the money saved by the authority comes out of the U.S. Treasury via tax write-offs. The New York MTA is the first transit authority in recent years to issue bonds backed by fare revenues. These bonds were used for the R-62 and R-68 purchases.

Purchases without federal funding also removed federal financing, which originally made progress payments more feasible. This makes the question of financing the procurement more important and an element of negotiation. In some cases a supplier can improve his competitive position by arranging financing at a rate below that available to the transit authority.

In the commercial aircraft industry, it has been standard practice for manufacturers to finance purchases of their equipment. When all the suppliers have access to the same interest rates and money markets, competition is fair. However, the interest rates available to a foreign supplier through an export bank may be lower than those available to domestic suppliers. This has caused Boeing some difficulty recently.

In 1982 during the negotiations for the second part of the R-62 order, the prime rate in the United States was 16.5 percent and the municipal bond rate was around 12 percent. Bombardier, through the Canadian Export Development Corporation, was able to arrange 9.7 percent financing, giving the firm a $130 million advantage over Budd and allowing Bombardier to win the order. Had Budd not withdrawn its complaint, a Department of Commerce ruling would have forced Bombardier to pay duties equivalent to the subsidy. In contrast, the financing offered by Hitachi for the recent contract award in Atlanta was rejected as more costly than that available to MARTA.

Supplier financing will most likely become a more common part of procurement negotiations where federal funding is not available, although the choice may be not to use it, as MARTA has done. Houston's recent call for bids requested suppliers to develop a package for financing 85 percent of the cost of the order.

RECOMMENDATIONS

There have been three significant problems in the industry in the past: sealed-bid, fixed-price procurement during high inflation; unreliable technology; and an erratic market. The transit industry has recognized all of these problems and has worked toward a solution of the first two. The market problem remains.

Procurement trends indicate where new problems may arise. Specification requirements that require proven equipment to be supplied will make it more difficult to introduce new technology or innovations or even new cars. The problems that came from attempting to innovate too quickly are well known and the industry is apprehensive about innovation. Nevertheless, as technology progresses, transit car designs should also be improved. Some cars now in production are based on early technology and do not incorporate some of the most successful innovations: low-alloy high-tensile (LAHT) steel (1930s) or chopper control (1960s), for example. The industry must still find a solution to the problem of gradually introducing new technology.

The trend toward supplier financing will have severe impacts on the competition between foreign and domestic car builders. When one car builder has access to financing at a favorable interest rate unavailable to its competitors, there is an advantage. This problem has occurred in other industries with no real solution to date.

The size and shape of the replacement market for rail transit cars is a major factor affecting the car-building industry in the United States. As shown in Figure 4, between 1983 and 1990 there will be approximately 1,000 cars that will require replacement or be needed for new rail starts that have not already been ordered. Between 1990 and 1995 only 900 cars will be required. The market from 1995 until well past the turn of the century is 500 to 600 cars per year, and there is little likelihood of any significant increase in orders beyond this figure.

The erratic market is a problem that has been cited by other studies but has never been confronted. Each transit authority determines when it will go out for bids to order cars. It also sets a delivery schedule for the car builder to meet. This produces periods with too many orders to be bid on efficiently and periods with too few orders to sustain production capacity.

In 1977, UMTA recognized that there were a large number of orders coming up and worked with the

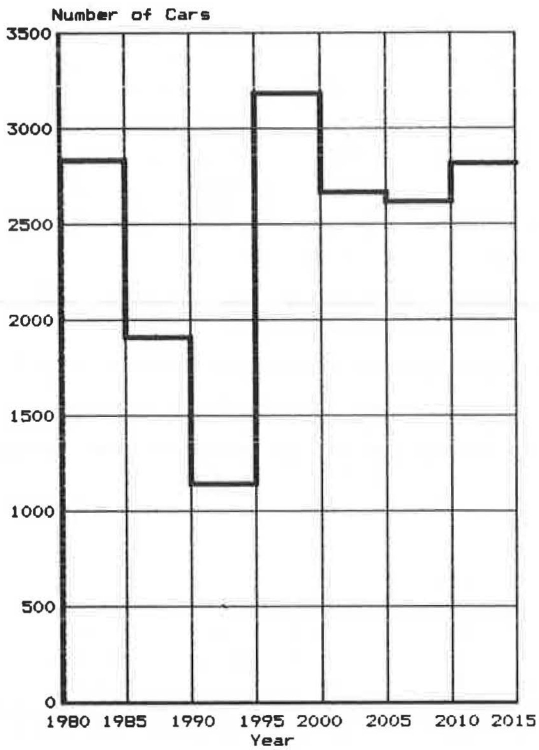

FIGURE 4 Future U.S. rail-car market, 5-year periods.

transit authorities to avoid issuing a large number of RFPs in the same year, but without much success. Neither UMTA nor the federal government has direct control over when a grant recipient will spend his funds. However, UMTA can influence car orders by sequencing grants. Although this has not been tried, it would be a powerful tool to help regularize the market. By holding back grants from the authorities when demand exceeds capacity or making more funds available when orders are scarce, UMTA might help stabilize the market. It would require a consensus from local authorities, Congress, and UMTA that a more regular market and stable supply industry were in their best interests and transcended other concerns.

The trend away from federally funded procurements (San Diego, New York, Houston) will further reduce UMTA's ability to influence the market. The industry could attempt to regularize the market voluntarily through such organizations as the American Public Transit Authority and the Railway Progress Institute. This type of self-regulation has been rare to date, although there are enough signs of cooperation on other matters to make the effort worthwhile.

Another source of stability would be a fixed, certain level of transit funding similar to the Highway Trust Fund that would allow long-range planning and budgeting by transit authorities. Assurance of funds for rail-car purchases over a decade would allow local authorities to spread orders out evenly instead of buying as many cars as possible while funding is available.

If this erratic market remains, it is up to the car builders to make whatever adjustments they can in order to continue in business. Two adjustments are indicated by size and shape of the current market. The first is to maintain a diversified product line. Only the car builders with the engineering and production staff and the capability to build all types of passenger cars will withstand the steep swings in car orders that are projected for each type of rail car. The light rail car builder faces 10 years of virtually no orders in the 1990s, and an average of 50 to 60 cars per year after that. In order to recoup an investment in plant and staff it will be necessary to build some other kind of rail equipment in the lean times. Continual work requires diversification.

The second adjustment is to gear production capacity to a typical order size of 100 cars. Investment in enough capacity to produce 700 cars a year is counterproductive when the market averages 500. U.S. car builders must learn how to turn out a small order of cars profitably. Order sizes will remain small (except for New York), and it will be necessary for a car builder to turn down orders where the method of procurement, design of the car, or terms and conditions will eliminate the chance of a profit. Bombardier decided not to bid the San Jose Santa Clara County Transit District light rail procurement even though it qualified because they said too many changes were requested in the design of the car.

Research, development, and introduction of new technology should be a cooperative effort. It has not been managed well in the rail transit industry, in many cases because the prototype demonstration stage of the cycle has been skipped. Demonstration is the most expensive part of the cycle. A prototype of concepts that have been tested in the lab must be made (essentially by hand), fitted onto existing equipment, and service tested.

Manufacturers have indicated a willingness to fund research through the laboratory stage. Authorities are willing to buy new designs once they have been proven in service. There is a gap in between that neither party believes it has the responsibility for nor the ability to afford. Bridging the gap may be a proper role of UMTA R&D funds, which it now carries out under Section 3 (a)(1)(C). Recently UMTA provided funds through this program for the test and evaluation of a new brake system for the WMATA fleet.

The best method of introducing new technology is to do it slowly and incrementally as a small portion of an overall proven system. Relying on a completely new design invites large risks. The need for high reliability in rail transit and the small market limit the amount of innovation that is feasible for each car order.

Rail-car manufacturing is not the only industry facing the problem of competing for credit against export financing. This problem has to be addressed at high levels of government. It is one that only the federal government can resolve because it also affects steel, aircraft, machine tools, and other industries. Protectionism is one solution--high tariffs on imports that raise the cost of imported goods to the advantage of domestic industry. From the standpoint of free and open markets, this is an unacceptable solution. Legislation that allows the Export-Import Bank or another arm of the federal banking system to match the credit rates offered by foreign suppliers is another possible solution. This would allow every manufacturer to offer more equal terms, reducing the importance of financing in the choice of a car supplier.

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Automated and Passenger-Based Transit Performance Measures

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ABSTRACT

Operational performance measures of a transit system are often best expressed in terms of the passenger. These include measures of productivity per passenger trip or per passenger mile, measures of crowding or seat capacity, and measures of on-time performance or schedule adherence. At the Bay Area Rapid Transit, detailed operational data are available daily as a by-product of automation, which saves considerable manual data collection. A computer program to use these data to produce operational performance measures is described. The program runs daily to allow schedulers to allocate vehicles accurately, which yields energy and maintenance savings, and for ongoing analysis of delays. Passenger-based delay measures are produced that have hitherto been unavailable.

Measurement of crowding or seat occupancy is relevant in two ways. First, during the peak periods, most transit systems are subject to a fleet size constraint. There are only so many buses or rail cars available, and some passengers have to stand. It is important to balance capacity among all routes to avoid an excess of standees on any particular route. Passenger demand varies within the peak period; for example, it may be highest between 7:30 and 8:00 a.m. but still heavy at 8:30 a.m. Schedulers must also balance capacity between the different times within the peak. Second, during the off-peak periods, it is important to operate no more vehicles than the minimum needed to guarantee most passengers a seat. This can be done in train systems by changing headways or train lengths. Headways may be mandated by externally imposed minimum service requirements, but train lengths are adjustable subject only to physical constraints such as the minimum indivisible train set length. An excess of vehicles will incur unnecessary energy and maintenance costs because of extra vehicle miles traveled. An undersupply of vehicles causes crowding, which may drive passengers away.

Measurement of on-time performance is generally done in terms of the number of late or missed bus runs or train runs. However, it is useful to produce statistical information on train delays as experienced from the passenger's point of view. Passenger-based on-time performance measurement puts in proper perspective the magnitude of system delays, differentiating, for example, between a 30-min peak-period delay versus a 30-min off-peak delay. It can assist a transit system in better allocating its resources toward various planned improvements and also provide a better measure of understanding of the actual impact of these improvements on passenger service.

The major distinction between the standard train on-time reporting of passenger service and passenger-based service measures is the weighting or importance given to a delay event. In train on-time reporting, as much value is given to an empty 3-car train delayed for 10 min as to a packed 10-car train delayed for the same 10 min. Obviously, the packed 10-car train carries a greater impact on passenger service than the empty 3-car train and should be so measured. Passenger-based delay measures reflect this proper weighting by basing calculations on passenger trips that are on time rather than trains that are on time.

A report prepared for UMTA in 1978 (1) addressed service availability at length, where service availability is defined as the impingement of failures on passenger-perceived service. The report is for automated guideway transit (AGT) systems, but the concepts discussed in the report are applicable to any transit system where there is substantial control over the vehicle and right-of-way, whether automated or not. In the report it is found that passenger-based service availability measures are most desirable but that these require more data than are collected by most operating systems.

In 1979 Heimann (2,pp.314-322) developed a pas-