“The Challenge of New Bus Technology to Manufacturers and Operators”

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Abstract

Although there has been much written and discussed about the implications of each change in bus technology on transit systems, little mention has been given to the pace and the total amount of the change on public transportation organizations, procurement practices, training, maintenance and service planning. For example, the complexity of bus designs—two floor heights, various lengths, multiple fuels, new electronic technologies, etc.—means that buses are virtually customized, a far cry from the White Book days. Little wonder manufacturers are financially struggling to cope and that maintenance managers struggle to keep training up-to-date. For service planners, are vehicles getting more or less reliable because of the complexity, and are spare ratios appropriate as a result? These and other issues will be addressed in this paper, along with recommendations.

Introduction

The pace of change in urban bus transportation in America during the past two decades has been nothing short of astounding. Indeed, the past decade alone has only accelerated the pace of change, and if anything the future of transit bus technology will see even a faster rate of change.

Part of this phenomenon has been brought about by the astonishing rate of technology invention and deployment in our society as a whole. Some of it has also been brought about by growing demands on bus services to offer high-quality alternatives to the convenience, flexibility, comfort and reliability of passenger cars. Still another reason for more technology in today's bus fleets is a growing list of regulatory mandates, especially those governing accessibility and emissions. However, some of the pace of technology introduction has been due to lack of discipline in choosing what technologies best improve service quality.

This paper will briefly survey the pace of this technological change and the factors contributing to its onslaught. It will also discuss the effects of new technologies on bus operations and maintenance, many of which are counterproductive. Finally, recommendations for better management of new technology will be considered.

What a Difference Two Decades Make

One need only to go back to 1980 to understand how far the industry has come technologically. At that time, the federal government's *Baseline for Advance Design Buses* (commonly called "the White Book") represented industry technology development. It mandated a single fuel type (diesel), using engine technology that was familiar to mechanics a decade earlier. In addition, a single standard floor height was specified, but with "kneeling systems" incorporated into bus suspensions that permitted easier ingress at the front door. (\1) Articulated buses had begun to be sold in the North

American marketplace, along with a few over-the-road coaches for suburban express applications, but these were still rarities in this country for transit applications. (\2)

Consider now the typical transit bus of 1990. By then, a few fleets were purchasing low-floors buses, brought over from Europe by New Flyer in the late 1980s, an idea from its parent, Dutch bus builder Den Oudsten. Neoplan USA Corp. had also begun to offer low-floor buses, licensing these designs from its namesake in Germany. In 1993, nearly 800 buses in American public transportation revenue service were powered by alternative fuels (excluding electric trolley buses). (\3) More than half the buses in U.S. transit bus fleets were also wheelchair accessible, mostly with powered lifts but because of the advent of low-floor buses, some were accessible with ramps. (\4)

Multiplexed electrical systems were also being introduced in the 1990s. These systems, while dramatically saving weight and increasing reliability by eliminating the electromechanical relays, fundamentally change how vehicle electrical systems are designed and manufactured.

By 2000 all manufacturers had been offering low-floor buses for years. Alternative fuels were also commonplace, and some properties had begun to experiment with hybrid propulsion. By 2001, according to APTA data, more than 5,000 buses—nearly 10% of the active fleet in the U.S.—were powered by nontraditional sources (i.e., other than diesel, gasoline or overhead wire). (\5)

In addition, proliferation of new technologies onboard buses began accelerating in the late 1990s. These technologies include automatic vehicle location using wireless tracking, the global positioning system (GPS) or a combination; automatic vehicle monitoring systems similar to the data recording "black boxes" found on airliners; video surveillance systems using both onboard digital data storage and wireless data transmission; automatic passenger counters; electronic fareboxes that accept a variety of conventional and digital media; automatic voice annuciation systems, which can also be tied and more sophisticated heating, ventilation and air conditioning systems.

The future of technology does not seem to be abating. Indeed, if anything the pace of change will likely accelerate. As just one illustration, a transit agency general manager quoted in a recent newspaper article on new bus technologies predicted that onboard video surveillance would become "standard equipment" on new buses because of its value in crime and threat detection, which is now even more evident after Sept. 11, 2001. (\6)

Other examples of what will speed the pace of innovation are driven by new regulatory mandates. For example, the Environmental Protection Agency is set to make regulations governing engine emissions even stricter in 2007, and more so again in 2010. These expected waves of regulation will at the very least substantially alter the design of diesel engines, and will affect both engine cooling systems and the use of new after-treatment technologies. Some experts predict that the latter round of expected EPA regulations could spell the end of conventional bus drivetrains altogether. (\7)

New bus technology in context

It is important to understand the context in which this technological revolution has occurred, for three important reasons. First, those who work in it must understand that this revolution is not isolated but part of a broader one sweeping virtually all industries throughout the world—which explains why its pace will continue. Second, those who manage transit bus fleets must compete with these other industries for skilled technicians to operate, maintain and service these new systems. Finally, understanding this broader sweep of change might be sources of knowledge that can be applied to bus operations and maintenance in these new technological realities.

The torrid pace of new bus technology development is not unique; nor is it happening in a vacuum. Indeed, all public transportation technologies, like those in most other industries, have been influenced by one overarching technological development of the past three decades: the impact of the microprocessor on the modern world.

Although the microprocessor and personal computer relationship is well known, the first processors were built into a wide range of everyday machines. These include traffic signals, toys, fuel injection control systems, exercise equipment, cellular telephones, fax machines, medical equipment and vending machines. Indeed, virtually all major subsystems on both bus and rail vehicles now have diagnostic and monitoring capabilities that are the result of more powerful and less expensive computer chips that make the onboard systems of the space shuttle and Apollo moon missions of the 1960s and 1970s look primitive. (\8)

These changes have a domino effect, which cascade into further changes that then also spill over into transit bus applications. For example, powerful microprocessors have enabled much more powerful computerized engineering and design tools. These have had the effect of shortening product development times for manufacturers. The product development cycle for a new bus was five years or more only a decade ago; today some manufacturers have introduced new buses in less than two years. (\9)

In a related example, a precursor to the microprocessor, semiconductors, have enabled another invention, the light-emitting diode. These in turn are now being employed in a variety of lighting applications on both the exterior and interior of transit buses.

Effects on Public Transportation

The onslaught of new technologies has had three important effects on the public transportation industry. First, it has increased the initial capital cost of new buses. Second, these new systems have radically changed operations and maintenance, placing very different demands on staff. Finally, the increasing design and manufacturing complexity brought about by new technology has taken its toll on vehicle manufacturers, which threaten to disrupt the industry's supply chain. Each of these effects will be discussed in greater detail below.

The rapid changes aboard buses makes the maintenance operation of today's transit fleet very different from that of the 1980s. The maintenance staff today are more technicians than mechanics, and their technical knowledge will have to be even more impressive a decade from now. All this is placing a huge burden on the ability of transit systems to find, retain and train maintenance personnel, according to variety of industry reports. (\10)

However, an argument can be made that the advent of new technologies improves operations and maintenance productivity. While many new technologies are designed to do just that, there is little evidence that they have made such an impact. In fact, according to APTA data, there is now more 6.4% staff per bus in public transportation services than there was a decade earlier. (\11)

More than likely this is the result of the complexity of these buses. Whatever the reason, technology should be used as a tool to improve fleet productivity. It is true that additional technologies could make transit buses more attractive, especially to choice riders. However, there are several studies that show transit is also getting less productive when measured by riders per vehicle or riders per cost. These are offset by evidence showing that public transportation productivity is also improving. Whether transit is getting more or less productive overall misses the point here: that top management and transit agencies need to be concerned that the greater complexity of systems onboard buses appears to place greater demands on maintenance and operations staffs.

Beyond the effects on operations, the greater complexity of transit buses is taking its toll on bus manufacturers. Table 1 represents just how much greater the complexity—and how much greater the engineering burden—is for procurement of today's buses versus those of two decades ago.

The result is that transit buses are essentially custom built-to-order for each transit property. Aside from the burden placed on manufacturers when each transit property issues its own terms and conditions for the acquisition of buses, many specifications are design-driven and virtually unique to each agency. The proliferation of new technologies further exacerbates this trend.

This situation forces OEMs like NABI s well as their suppliers to (1) consume a large amount of staff time engaged in reviewing these solicitations, especially with regard to how the bus can be engineered to meet the specifications; draft so-called Requests for Approved Equals and Clarifications, which seek either clarifications or modification of the specifications; and then (3) try to cost each variable contained therein.

In many cases, transit agencies require pilot vehicles in order to prove the design of these customized buses and to ensure production quality. The process of making a pilot bus involves many staff-hours at both the OEM and the transit property. Highly skilled workers are working thousands of hours, hand-in-hand with research and development engineers, representative engineers from the transit property, quality control experts and contract administrators, all with the objective of making one transit bus for a particular transit property.

When the pilot bus is produced and approved and the OEM begins serial production, a bill of material uniquely tailored for a particular transit property must be created, which details the thousands of parts to be used in that production run. The result is that the effectiveness of each OEM's buyers to negotiate better terms with suppliers is limited because volumes are reduced when each order is customized. This situation results in higher bus prices passed on to local and federal governments.

An even more wasteful procurement practice is that of brand naming. If the component or systems supplier is aware that it will receive an order regardless of what bus OEM receives the contract, the result is that there is no incentive for the equipment supplier to negotiate with the bus OEM after contract award. This results in higher component costs; according to estimate, approximately 85% of all costs associated with making a heavy-duty transit bus are material costs. (\12)

Finally, the steep learning curve, uncertainties and inefficiencies for the workers on the line that make customized transit buses undermines quality and servicability of transit buses. Lack of standardization of components and subsystems in transit buses also leads to increases in the numbers and types of various diagnostic equipment needed to troubleshoot these systems. Moreover, the complexity and length of the training needed to support these systems not only at the factory but also in the field is also increased, which is also reflected in the steadily growing demand for training as part of solicitation documents advertising new procurements.

While these training costs can be borne by the contractor and transit agency to some degree in the form of building these costs into the bus price, it is worth noting here that many agencies are faced with budget pressures to pay for the time their staffs simply to sit in these training sessions. Indeed, the APTA reauthorization Task Force considered the addition of training as an eligible capital expense for federal funding in forming its reauthorization recommendations, but eventually dropped this proposal because of a lack of consensus.

This growing complexity of wiring harnesses and multiplexing systems to accommodate new electronic systems is a particularly challenging problem. There is very little opportunity to recoup any tooling or setup changes in the design and fabrication of vehicle electrical harnesses due to the low unit volumes and the constantly changing requirements driven either by changes in the products from the component suppliers or by the transit properties. The added impact of this complexity is found in difficult in-plant troubleshooting and quality control processes, as well as high cost training and field maintenance issues once the vehicle is delivered to the customer.

Although it is difficult to directly quantify the costs associated with this complexity, they are large and growing. The design and reprogramming changes just to accommodate engineering change orders can add hundreds of hours of engineering work to one bus order.

Recommendations

Coping with the growing complexity of transit buses requires a multi-faceted approach. The industry should consider the following menu of recommendations:

1. Adopt the Standard Bus Procurement Guidelines (SBPGs). For five years and counting, an FTA-sanctioned set of standard documents for the acquisition of heavy-duty transit buses remains largely unused in the industry;when they are used they are modified so as the delicate balance between manufacturer and operator needs that the committees producing these documents worked so hard to create is lost. In addition to the greater efficiency produced by a single set of procurement documents, the SBPGs also create greater efficiency with performance based specifications. Performance based specifications are well-reasoned, objective performance criteria that all transit bus manufacturers can meet. Such specifications allow each manufacturer to determine how it will design and manufacture the vehicles to meet the performance objectives.

2. Encourage more technical standardization. If developed correctly via consensus among all stakeholders and updated to maintain their relevance, technical standards enhance rational competition and innovation because they describe the interfaces, much as serial bus ports have allowed for so many innovations to be more widely used on computers. Several efforts are underway to develop and adopt the most widely used standards from other industries for transit application, many of which are already being used in the marketplace. These efforts should be encouraged.

3. Develop more technical training, especially for maintenance staffs. The National Transit Institute and other non-government-funded organizations have recently expanded their offerings to the transit industry. Yet much more needs to be done, according to a recent Transit Cooperative Research Program report. (\13)

4. Develop more systematic evaluations of technologies' cost and benefits. A recent television advertisement for computer systems features an executive looking character, who says, "I don't care what kind you get me as long as it's the best in the company." It's a mentality that too often consumes stakeholders in bus procurements. The full impacts of any new system or bus model must be more thoroughly evaluated with concern to staff training, technology maintainability and ultimately, organizational productivity.

Conclusion

The proliferation of new technology on transit buses has begun to overwhelm the staffs who maintain and operate these new buses as well as the companies that design and manufacture them. These pressures do not appear to be ending; if anything, they will only worsen in the future. A more rationalized approach to procuring and encouraging new technology is long overdue—and it can start with the widespread adoption of the Standard Bus Procurement Guidelines.

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