ARIELI ASSOCIATES
MANAGEMENT, OPERATIONS AND ENGINEERING CONSULTING

Report No. 1107

THE ADVANCED TECHNOLOGY TRANSIT BUS (ATTB)-TECHNOLOGY TRANSFER

INTRODUCTION

The transit bus is the mainstay of public transportation for most of the transit agencies around the world. The challenge of improving the performance of this critical transit vehicle lies in the judicious application of advanced technology.

The Federal Transit Administration (FTA), because of its ability to coordinate the needs of the transit sector as a whole and to spread the cost of research and development over the entire industry, is the logical sponsor for the application of advanced technology to transit buses.

FTA in cooperation with the Los Angeles County Metropolitan Transportation Authority (LACMTA), who assumed the program management role for the entire transit industry, sponsored, nurtured and saw to completion the ATTB program.

BACKGROUND ON THE ATTB PROGRAM AND VEHICLE

In 1992 the National Transit Board (the forum includes the Federal Government, all the Transit Agencies, all the manufacturers and suppliers, and the non-profit organizations and universities interested in transit) decided that the first R&D priority in transit is a lighter 40 ft. heavy-duty bus.

The objectives of the program were: a revolutionary decrease in weight, affordable price, and full transferability of the design. Then, as today, most if not all transit buses were breaking the law when traveling on the federal roads because of excess rear axle weight. The CHP routinely used to stop Orange County buses on freeways and make alight passengers. The transit market is capital limited and in 1992/1993 the demand for transit buses far exceeded the available budgets. Thus the emphasis on the acquisition price. And, finally, to assure the domestic bus manufacturers that federal funds will not be used to put them out of business as well as to assure manufacturing of the ATTB if Northrop exits at the end of the R&D phase, the transferability became a major objective.

During the first phase of the program extensive interviews were held (operators, maintainers, buyers, planners, etc.), passengers, disabled persons groups, local with transit systems governments, police, etc. The interviews generated 1,003 individual requirements that were later incorporated in engineering trade studies and resulted in the establishment of the design goals.

The major goals were as follows:

- weight reduction of 10, 000 lbs.
- cost not to exceed $300,000 in 1992 $.
- fully ADA compliant.
- 43 seats.
- CNG fuel

- ultra low emissions (ULEV)

Conceptual design studies indicated that the best design to meet the goals would include:

- "clean sheet" concept, to assure creativity and eliminate biases
- integrated system approach to total vehicle design, to optimize the vehicle's performance instead of maximizing individual components' output.
- use of driver-command, vehicle management system (VMS)-assisted, vehicle control philosophy
- composite monocoque body, thus eliminating the chassis
- genset and wheelmotors, thus eliminating axles and differential
- wheelchair ramp, thus eliminating the lift
- flat floor throughout

Programmatically, several decisions were made to meet the objectives:

- establishment of a national review board, Rapid Transit Review Board (RTRB), to review and to approve the major design decisions and represent the voice of the customer. RTRB members met twice a year and received monthly progress reports.
- establishment of a full Configuration Management for the program including complete detail and installation drawings production, drawing release system, change control board, parts list and drawings tree, bill of materials, engineering and procurement specifications, training and maintenance documentation, etc. These activities made up one of the major cost elements of the program but it was essential to achieve transferability, either to production or to another organization.
- the ATTB program will end after the test program and no findings of the test program will be incorporated into the prototypes. The rationale of this decision was the desire to enable the future manufacturer to achieve a competitive advantage.

The conceptual design was thoroughly tested at the component level, through analysis and simulation, and by fabricating and testing a Structural Test Bed (STB) and a Mobile Test Bed (MTB). **It is important to remember that only the structure is unique to the ATTB. All other components must be commercially available, i.e. shared with other applications, in order to be affordable.**

As the MTB was put together it was decided that the flywheel technology was nowhere near the maturity to be installed in a vehicle or even a test bed. Since the ATTB was created specifically for heavy urban traffic, the energy storage requirements were for a high power density device, such as a flywheel or ultracapacitors, and not a high energy density device such as batteries. Simulations indicated that on ATTB batteries would yield a negative energy usage of between 6 and 12%, depending on the driving cycle. Actual MTB tests using batteries packs mounted on the roof validated the simulation results.

During the prototype design phase it became evident that permanent magnet motors must be used if size and weight objectives were to be met. Also for the same reasons, the Detroit Diesel series 30 CNG engine had to be used despite the fact that Detroit Diesel (DD) decided for business considerations not to upgrade the 210 HP model to the desired 235 HP. Later during the prototypes fabrication Detroit Diesel stopped the work on the DD series 30 CNG engine two-thirds of the way through development.

As the test program got underway it became clear that the Kaman Electromagnetics Corp (KEC) did not mature their product completely. The actual electrical rotating machinery components (i.e. the generator and the wheelmotors) performed quite well. So did the embedded controls part of electronics, at least from a functionality point-of-view. Where they fell short was in control and distribution of the current after it was generated and the actual, physical design of the inverters.

The findings of the test program are documented in the Final Test Report for ATTB Prototypes (ATTB-99-03-212) dated April 1999.

TECHNOLOGY TRANSFER

The ATTB program conducted numerous outreach activities. Some of them were:

- six RTRB meetings
- two industry symposiums
- five FTA/LACMTA sponsored meetings
- over twenty presentations at APTA conferences, professional and civic organizations
- vehicle presentation and demonstration at APTA Show, G-7 Heads of States meeting, Capitol Hill, etc.

Moreover, the entire set of the ATTB drawings was made available to the interested domestic companies along with the system specifications, configuration description, complete bill-of-materials and trade study documents, through Aegir Systems (under contract with the FTA/LACMTA).

As a result of the success of the ATTB program and the extensive outreach and technology transfer activities that accompanied the program, a large number of the concepts, technologies, subsystems and components developed by the program are deployed today in transit buses worldwide. A sample of those deployments include:

- every major bus company in the world has an hybrid-bus development underway
- one major North American bus manufacturer is marketing a composite body bus
- every major bus manufacturer in the world is offering low floor (or at least low entry) buses
- wheelchair ramps are becoming standard features, replacing the wheelchair lift
- buses with gensets and wheelmotors (so-called “electronic transmission”) are marketed and deployed in both North America and Europe
- electrically-actuated doors are available on the market

The limitations of the converted CNG internal combustion engines has spurred the interest of turbine manufacturers in transit applications and today at least two manufacturers are offering microturbines capable of powering transit buses. In April 2000, the LACMTA has issued a Request for Information (RFI) for development, test, manufacture and delivery of Advanced Transit Vehicles (ATV). The ATV to be deployed in 2004/2005 will be the first vehicle to integrate into a single platform all the technologies and the subsystems pioneered by the ATTB program.