

## Developing the World's First Series Hydraulic Hybrid Bus through Simulation Driven Design



### Key Highlights

#### Industry

Automotive

#### Challenge

Develop a new innovative, fuel efficient bus platform

#### Altair Solution

World's first series hydraulic hybrid bus developed with a focus on minimizing weight to maximize fuel economy

#### Benefits

- 30% improved fuel efficiency
- 30% lower cost of ownership

The Federal Transit Administration (FTA) requires modern transit bus systems to provide more efficient services across America. Currently, U.S. public transit authorities are subsidized to meet operating budgets, with state and local subsidies exceeding \$19 billion per year and federal subsidies exceeding \$7 billion annually. Increasingly high fuel costs, coupled with emission legislation, have led transit authorities to look for vehicles that minimize fuel consumption and lower operating costs. The BUSolutions project is a public-private advanced transit-bus development initiative by Altair that aims to address these needs.

The inspiration behind Altair's BUSolutions program initiative was driven by its

global product development consulting organization, Altair ProductDesign. Through a consulting practice in the transportation industry, it became clear that the business challenges faced by owners and operators required an entirely new bus-development process and design.

Comprising senior management, designers, simulation experts and vehicle development engineers, BUSolutions was launched by Altair as an internally sponsored program. The cross-functional team members sought to apply their deep domain knowledge and a simulation-driven design methodology to fully develop a fuel-efficient, next-generation bus design.

From its inception, the BUSolutions program

***“We would not have exceeded the goals we had set for ourselves had we not applied our knowledge and unique technologies to produce this revolutionary bus. BUSolutions demonstrates Altair’s expertise and capabilities as a concept-to-release, full vehicle development partner.”***

**Mike Heskitt, Chief Operating Officer, Altair ProductDesign**

has continually involved industry experts from the manufacturing segment, transit authorities and rider advocacy groups to ensure that the program goals align with industry needs. Based on the merits of an innovative design and predicted performance benefits, in 2005 Altair partnered with Automation Alley, Michigan’s largest technology business association, to explore government grant opportunities to support the physical build and testing of a technology demonstrator to validate the design.

The program attracted the attention of officials from the U.S. Department of Transportation (DOT) and its Federal Transit Administration (FTA). Since 2005, the FTA has provided funding support to

Altair, with additional program support from the Michigan Economic Development Corporation (MEDC) and Automation Alley to produce a prototype bus demonstrator.

### **Solution: Simulation-Driven Design**

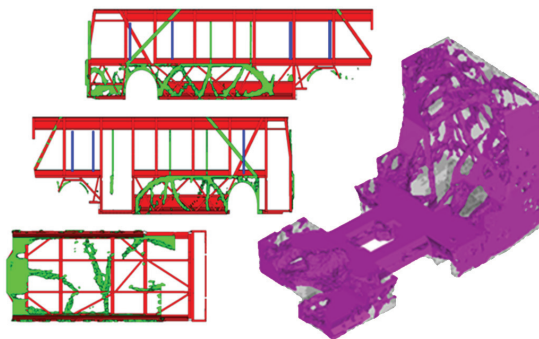
Throughout the development process, vehicle weight was a focus due to its impact on fuel efficiency. When developing the bus, Altair ProductDesign implemented its simulation-driven design process, in which advanced computer-aided engineering (CAE) and simulation technologies are employed at the very start of the design process. Optimization techniques were used to rapidly explore multiple design variations and suggest the ideal layout of structural material. This process gave invaluable

insight to the engineers, who used the initial analysis results to form a weight and performance optimized structure very early in the design process.

The core design synthesis tool for the project was OptiStruct, the Altair HyperWorks finite-element-based technology that helps engineers rapidly develop lightweight, structurally efficient designs. Combining Altair ProductDesign’s engineering knowledge with the OptiStruct tool allowed engineers to generate an innovative, lightweight aluminum frame for the bus.

The drive for minimizing weight went far beyond the aluminum frame, incorporating thin profile seats and composite stanchions

***Utilizing a Simulation-Driven Design approach to product development allowed Altair ProductDesign to develop a bus frame that is 30% lighter than conventional vehicles.***



*Topology Optimization Studies to Find the Ideal Material Layout*



*Photograph of the Optimized Bus Frame*



## About Altair ProductDesign

Altair ProductDesign is a product engineering and development company staffed by a team of 500+ people from over 40 offices worldwide. Altair has pioneered a Simulation-Driven Design approach which leads to design solutions that exhibit minimum weight and outstanding performance.

installed along with balsa-core laminate floor/roof material and lightweight tires, to name just a few of the design considerations.

## Series Hydraulic Hybrid Technology

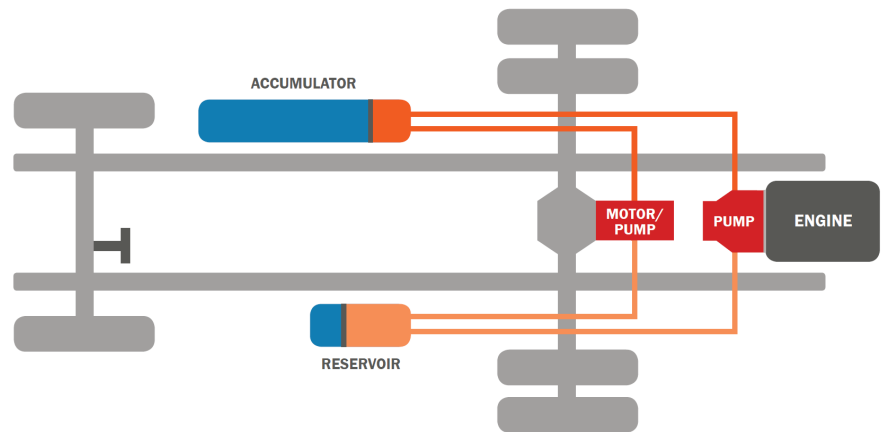
To maximize the fuel economy of the bus, an efficient powertrain system was required. After reviewing the potential systems, from pure electric drive to more traditional diesel engines, Altair chose a hydraulic hybrid system, the first of its kind in a bus platform. Unlike electric hybrid technology, the LCO-140H bus (Low Cost of Ownership—1st 40-foot Hybrid) uses hydraulic pressure instead of electricity to propel the vehicle. Through combination hydraulic pump/motor units, it captures braking energy to pressurize fluid, which is then re-used to accelerate the bus. The engine runs only on demand and has periods when it is off and the bus relies solely on the stored hydraulic pressure for propulsion.

## Maximizing Miles Per Gallon

Compared to the database of buses tested at Altoona, Penn., where the FTA certification program is run, the LCO-140H

was determined to be more than twice as fuel-efficient as the average conventional bus — delivering 110 percent more miles per gallon. Compared to today's best diesel-electric hybrid bus, the LCO-140H offers 30 percent better mileage and 30 percent lower cost of ownership. This lower cost also comes with higher-level features to meet today's demands for clean technology and simplified maintenance. These include:

- A design that is 15 percent lighter than other hybrid buses and 10 percent lighter than a conventional diesel bus
- Better cost and performance than diesel and electric hybrid buses
- Industry-leading 41 passenger seats, which are 70 percent lighter than conventional systems
- Innovative cooling system with a 50 percent larger surface area and air drawn from the top of the bus through Altair's "clean air corridor" design
- Reduced accessory power draw
- Durable LED interior lighting
- Ergonomically tailored driver's environment with increased visibility
- Disc brakes on all wheels



***BUSolutions' Hydraulic Hybrid Powertrain Helps to Maximize the Vehicle's Fuel Efficiency***

## Conclusion: Twice the Fuel Efficiency at a Lower Cost

What started as an internally funded "stretch" project, today has resulted in an industry-first, series hydraulic hybrid bus design that is ready for manufacture. Having successfully completed the testing phase to validate its design and performance metrics, the BUSolutions LCO-140H is the lowest-cost, most fuel-efficient hybrid bus designed to date.

Based on a "clean-sheet" design approach, the extremely lightweight bus design yields more than twice the fuel efficiency of conventional buses and is projected to save \$25,000 per year per vehicle for transit authorities using the platform. Requiring no infrastructure upgrades to operate, the LCO-140H is an attractive option for transit authorities to cost-effectively upgrade aging fleets with hybrid vehicle technology.

Find out more about BUSolutions at:  
**[www.altairbusolutions.com](http://www.altairbusolutions.com)**

Find out more about Altair ProductDesign at:  
**[www.altairproductdesign.com](http://www.altairproductdesign.com)**

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## About Altair

Altair empowers client innovation and decision-making through technology that optimizes the analysis, management and visualization of business and engineering information. Privately held with more than 1,800 employees, Altair has offices throughout North America, South America, Europe and Asia/Pacific. With a 25-year-plus track record for innovative product design and development, advanced engineering software and grid computing technologies, Altair has more than 3,500 corporate clients representing the automotive, aerospace, government and defense, and consumer products verticals. Altair also has a growing client presence in the life sciences, financial services and energy markets.



Altair ProductDesign is a global, multi-disciplinary product development consultancy of more than 700 designers, engineers, scientists, and creative thinkers. As a wholly owned subsidiary of Altair Engineering Inc., this organization is best known for its market leadership in combining its engineering expertise with computer aided engineering (CAE) technology to deliver innovation and automate processes. Altair ProductDesign firmly advocates a user-centered, team-based design approach, and utilizes proprietary simulation and optimization technologies (such as Altair HyperWorks) to help clients bring innovative, profitable products to market on a tighter, more efficient time-scale.

[www.altairproductdesign.com](http://www.altairproductdesign.com)



HyperWorks is an enterprise simulation solution for rapid design exploration and decision-making. As one of the most comprehensive, open-architecture CAE solutions in the industry, HyperWorks includes best-in-class modeling, analysis, visualization and data management solutions for linear, nonlinear, structural optimization, fluid-structure interaction, and multi-body dynamics applications.

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