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Paper Title: Applying Agile Software Principles and Practices for Fast Automotive Development

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Topic: Vehicle Design and Testing: Lightweight Design Technology

#### Engineering Questions and Objective

The Progressive Insurance Automotive X PRIZE was held in 2010 to determine whether it is possible to produce a full-sized road-legal car getting 100+ mpg (2.25 l/100 km). Our team produced the WIKISPEED car and entered it in the X PRIZE. WIKISPEED faced the additional challenges of a shoestring budget with a geographically distributed all-volunteer team. The car is one of the few contest finishers seriously contemplating production. Are there new, non-capital intensive construction methods that allow building cars with no financing from established car companies, banks or major investors?

#### Methodology

Agile Methods were introduced for software projects and give product cycle times measured in weeks, not years. Good software design demands modules that are loosely coupled and can be tested apart from the entire system. These principles have led to a modular automotive design. On the WIKISPEED car, major subassemblies such as suspension, motor, and body can be replaced in the time it takes to change a flat tire. The wheels and suspension bolt to the chassis and can be repositioned or replaced. The composite body bolts to the chassis and allows exchange of external shells. The same car can be a race car today and a pick-up truck tomorrow. This modularity allows for rapid iterations and experimentations during development, testing, and after purchase. A mid-engine design ensures that the center of gravity is well-positioned no matter what engine is used. Production does not use metal stamping, molds, or autoclaves.

#### Results

Estimated EPA mileage rating for the WIKISPEED car is 104 mpg city and 114 mpg highway. This is achieved using a stock Honda gasoline engine with the ECU modified to run in the most efficient region. Out of 136 entries, WIKISPEED tied for 10<sup>th</sup> place in the mainstream class of the Automotive X PRIZE. The car entered in the contest was built in three months for less than \$100,000 by an all-volunteer team distributed across 5 countries. Computer stress analysis and design refinement led to the production of an aluminum chassis capable of distributing impact forces across the structure. The result is a 68 kg chassis achieving the highest U.S. DOT level of crash protection. Car dimensions are 1.96 x 4.22 meters. It weighs 636 kg and seats four riders. The car is available today for US \$25,000.

#### Limitations of the study

The paper describes design and production of a small number of prototypes. It does not cover mass production or maintenance.

#### What is new in this paper

These results have been presented in some talks and videos, but there is little written record of the WIKISPEED process, practices and results. The WIKISPEED story has not previously been published or presented at an automotive or academic conference.

#### Conclusions

The WIKISPEED project demonstrates how software design methods apply to the design of physical products. It has long been known that the Waterfall Method (first requirements, then design, then build, then test) does not work well with software where requirements are unknowable and subject to rapid change. It has generally been accepted that the Waterfall Method is much more appropriate for mass-produced engineering products. Our experience indicates otherwise. The application of some key software design methods to automotive engineering can dramatically speed up the automotive development time and reduce the need for expensive tooling.