"Carbon Fiber Composites Research and Development at *Automobili Lamborghini*"

Maurizio Reggiani
Vice-president of R&D and CTO, Automobili Lamborghini S.p.A.
Sant'Agata Bolognese, Italy

Paolo Feraboli
Professor and Director of the Automobili Lamborghini Composites Laboratory
Department of Aeronautics & Astronautics, University of Washington
Seattle, WA, USA

Polymer composites have been in use at *Automobili Lamborghini* since 1983, and since 2001 carbon fiber composites have been used for the production of all body panels and several portions of the spaceframe structure of the *Murciélago*.

The presentation will be divided in two sections. In the first section, *M. Reggiani* will introduce the corporate strategy to increase the power-to-weight ratio by reducing the overall vehicle weight while at the same time reducing emissions to meet ever more stringent environmental regulations. To achieve this goal, *Automobili Lamborghini* has identified in carbon fiber composites one of its key technologies, and has committed to become a Center of Excellence in terms of amount of material used on a production vehicle as well as degree of technological advancement.

Since 2007, *Automobili Lamborghini* has been working in collaboration with the Department of Aeronautics & Astronautics at the University of Washington and with the Structures Technology group of Boeing Research & Technology in Seattle, WA the for the development and assessment of new technologies for future vehicle systems.

Current R&D efforts are aimed at the development of composite-intensive primary structures that meet weight, cost, and rate requirements for the corporate strategy. This requires evaluating non-conventional technologies and developing new ones. While traditional composites used in the luxury sports car industry have comprised aerospace-derived prepreg materials for autoclave cure, new out-of-autoclave processes can yield unparalleled efficiencies in terms of cost and rate, while leaving performance and quality unaffected. Among these processes, *Automobili Lamborghini* is focusing on liquid resin infusion (VaRTM and RTM), oven-cure prepregs, preforming technologies (braiding, non-crimp fabrics and thermoforming), and advanced compression molding.

The second section, presented by *P. Feraboli*, will review some of the details involved in the R&D efforts in the areas of materials and processing as well as analysis and testing. Challenges include the evaluation and selection of non-destructive inspection techniques to be used both at the laboratory level to assist in defining the most suitable processing methodology, and during production for quality control purposes. New technologies are constantly evaluated in order to find more efficient or performing solutions, and these include joining techniques such as adhesive bonding and fastening, as well as new material systems and forms.

The advent of composite-intensive automotive structures poses new challenges for the designers. Carbon fiber composites have shown to be able to perform extremely well in the case of a crash, and are being used to manufacture dedicated energy-absorbing components, both in the motorsport world (the impact structures of Formula 1 racecars) and in the aerospace world (the

Boeing 787 crushable subfloor). Their ability to dissipate more energy per unit mass than aluminum or steel is however obtained only through a complex and careful design effort. This effort has been traditionally carried out by experiment alone, by crash-testing actual components, partly because of the great complexities associated with crash modeling of composite structures. This practice is however costly and time-consuming, and can results in very large experimental programs.

Borrowing from the aerospace industry, *Automobili Lamborghini* has extended to the automotive world the Building Block Approach, whereby Margin of Safety calculations are based on a complex mix of testing and analysis. Since in the commercial aircraft industry it is accepted that analysis techniques for composites are not sufficiently predictive, by combining testing and analysis at various levels of structural complexity, often beginning with small coupons and progressing through structural elements and sub-components up to full-scale components, it is possible to develop the necessary confidence to reduce the amount of full scale crash tests to be performed. The presentation will review how the building block approach is being utilized at *Automobili Lamborghini* for the design of new structural concepts that are being evaluated as technology demonstrators.