Vanderplaats
Research and Development, Inc.

CASE STUDY

From Optimization Emerges the *GENESIS* of the Corvette Daytona Prototype

By Grant Browning and Gary Latham
Pratt & Miller Engineering

Pratt & Miller has spent the last decade winning multiple endurance championships with production based Corvettes, so when General Motors approached us to work on a new Corvette Prototype Class car for the Grand Am Series, we knew we were facing an exciting opportunity not only to develop a prototype class racecar but also to take advantage of our recent advancements in optimization based design using the Genesis® software from Vanderplaats Research & Development, Inc. Aptly named, Genesis is a unique structural Finite Element Analysis (FEA) code created for optimization. Despite acquiring this tool set 12 short months ago, Genesis has gained widespread use in-house.

Corvette Daytona Prototype
Designed and built: Pratt & Miller

Take, for example, the prototype's wing/body support (tail frame), a very critical part of the race car. The structure sees up to 1250lbs. of down force (at speed) and the loss or compromise of a wing at over 200 mph can quickly spell disaster for the car and driver. Yet the nature of motorsports is a competitive one where design is driven by the desire to win and only bounded by safety. That is to say, if we found a way to make a component twice as strong, it is more likely this breakthrough would result in a new design that is half the weight and maintained our margin of safety, rather than a design that is twice as safe.

"It's safe to say that Genesis optimization has quickly become a standard step in the majority of critical Pratt & Miller designs"

About Vanderplaats Research and Development, Inc.

VR&D develops and supplies state of the art finite element analysis (FEA) and Multidiscipline Design Optimization software used by aerospace, automotive, and other industrial analysts and designers. VR&D provides robust, user friendly software and services to enhance your product development process. VR&D's software is licensed to numerous commercial, government and academic institutions worldwide. A number of commercially available third-party CAE tools also use VR&D's optimization software.

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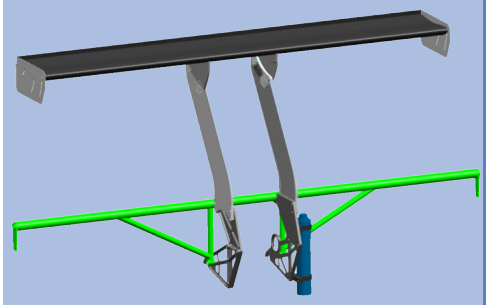
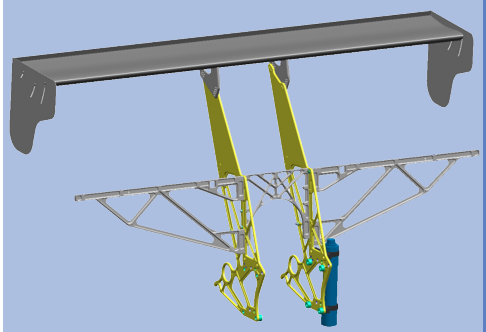
Such high stakes drove our engineers to dive head first into the development and implementation of optimization. A quick look at the Corvette DP's previous tail frame compared to the optimized version clearly shows the ability of Genesis to identify more intricate and efficient load paths, as well as to eliminate redundancies, assisting us in the design we ultimately came up with.

A very common type of optimization which we employed in this example is known as topology optimization. The topology optimization process basically just pulls material away from the chosen designable bodies while maintaining the selected constraints until the sought after objectives are minimized/maximized. These objectives and constraints such as mass, strain energy, deflection, etc. (basically any data calculated by the simulation) are defined by the user and are the basis for driving the optimization process. Genesis also gives one the ability to optimize for multiple objectives and load cases simultaneously with the ability for the significance of each to be weighted differently.



Previous Tail Frame Structure

The topology optimization process begins by defining the available design space within a working FEA model. Preparation for this can be done in two ways. The first is to input an existing design into Genesis and run an optimization to determine where a little extra weight can be pulled out of the existing design. The second is to start with big blocks that, for the most part, fill the available packaging space. In the latter case, the optimization has the freedom to come up with the general shape which often produces more efficient load paths that may not be intuitively obvious. Objectives and constraints must then be implemented. Generally one objective is sought (such as minimizing strain energy) and multiple constraints are applied (such as a maximum weight or volume - in most cases this should be some percentage of the base body and then probably a max stress also).



GENESIS Optimized Tail Frame Structure

When all of the steps above are applied and interpreted properly, optimization can be very advantageous. However, as is the case with most tools, the results are highly dependent on the user's understanding of the tool, how it can be used, and how to check the results. Any physical component has an infinite number of load cases that may be introduced while in operation. To properly optimize a component, a well-rounded set of load cases that captures the essence of these physical loading scenarios needs to be applied. As an example, if too narrow a set of load cases is applied, an optimized

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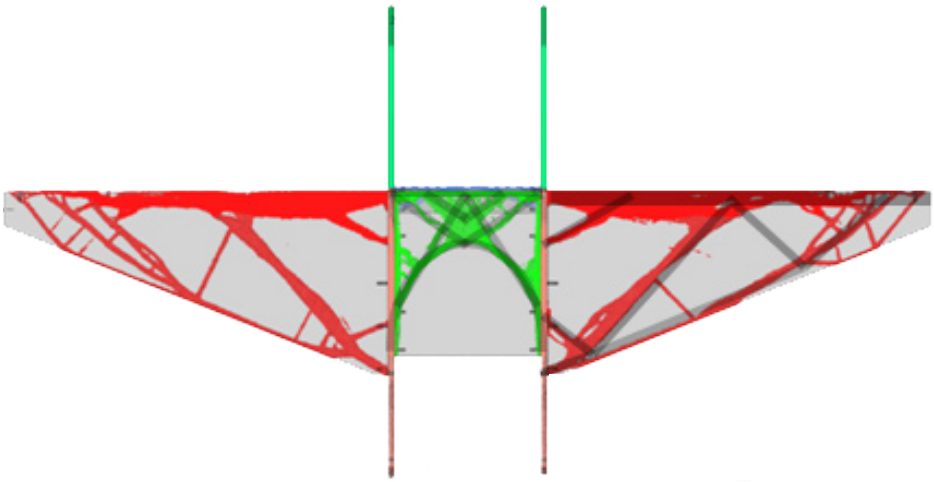
design may result in a tail frame that will work if perfectly loaded vertically but may fail as soon as someone leans on it or when load from aero drag is seen. The same can be said about providing well rounded and logical objectives and constraints. In my experience this is almost never done perfectly the first time around which is why it is critical to have a designer with a good structural understanding to determine what the optimized result is trying to do, how it might possibly be producing too narrow of a solution, and how these issues may be rectified.

The optimization results for the tail frame are shown below with the initial design space grayed out. The load path interpretations by the Analyst are overlaid as translucent black bars.



GENESIS Tail Frame Optimization Results
Frontal View
Analyst: Grant Browning

As the before and after images indicate, the structure became much more elegant, 33% lighter, and surpassed our stiffness and strength requirements. The goal for the optimization was to minimize mass while meeting a specified deflection target and maximum allowable stress.

The parts were made and tested for deflection, with excellent correlation. After bench testing the structure, the parts were bolted onto the car, and after only three short outings the drivers were confident enough to take the cars to full speed (over 200 mph at Daytona while testing for the Rolex 24).

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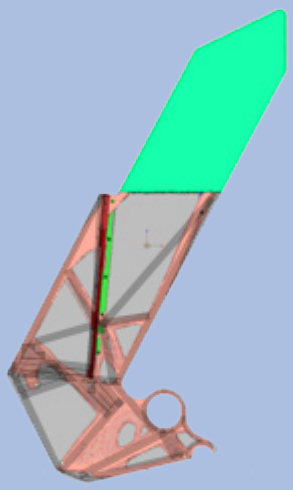

Side View

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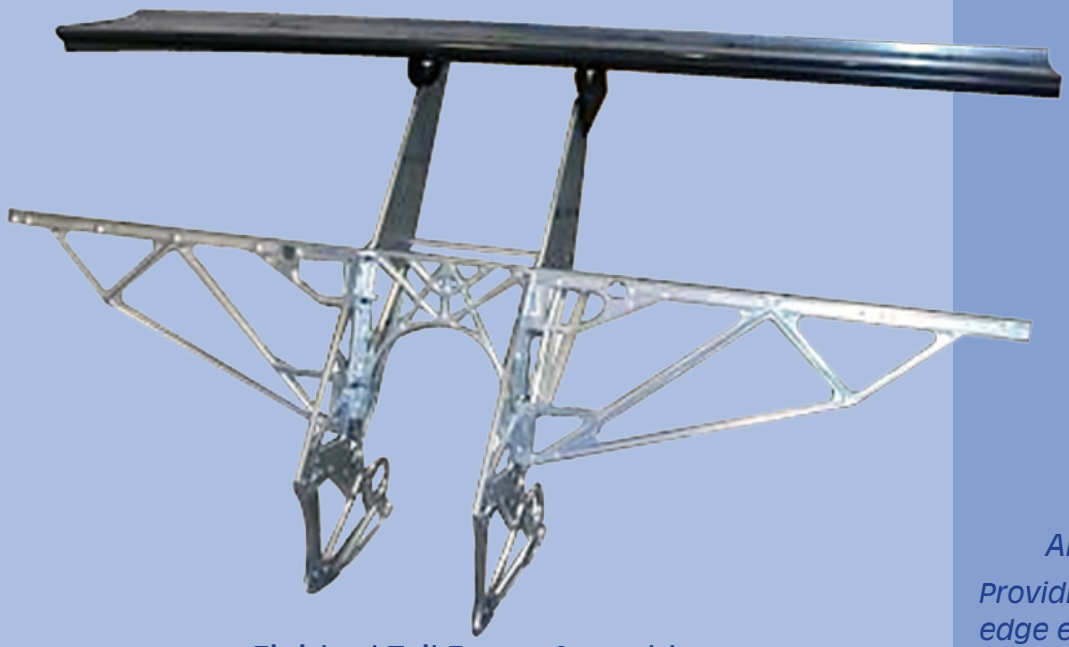

Finished Tail Frame Assembly

The entire race car was built in only six months, so the tools and processes used by Pratt & Miller demand fast and seamless implementation, accurate and understandable feedback and results, as well as the robustness and flexibility to encompass a wide variety of factors into a single model and result.

In the past, Pratt & Miller applied human judgment and experience, combined with non-optimized FEA results to partially guide, but to primarily check our designs. In the last twelve months, we have begun to incorporate Genesis as an optimization based FEA code to guide our designs. The designer uses not only their own experience and the inputs from the fabricators and mechanics, but also the Genesis results to ensure practical race ready parts. Genesis has become an invaluable tool that regularly allows us to cut roughly 30% of the weight out of existing competitive designs without sacrificing the stiffness and strength endurance racing requires.

The optimization driven and relatively radical designs initially created some hesitation by the crew; however over the better part of a year, these critical designs have now started living through seasons of race contact, high temps, and loading cycles. In a competition driven field these results not only demand confidence, but drive us to expand on the applications and potential competitive advantages that optimization and Genesis have to offer. It's safe to say that Genesis optimization has quickly become a standard step in the majority of critical Pratt & Miller designs.

About Pratt & Miller

Providing clients with leading-edge engineering and low-volume manufacturing solutions, Pratt & Miller is a world-class engineering company and a respected industry leader in automotive, commercial, military, and aerospace industries. The company's racing achievements include multiple wins and championship titles at the most prestigious production-based racing events in America and Europe: the 24 Hours of Le Mans, Rolex 24 at Daytona, Sebring 12-hour, and many more.

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