Vanderplaats Research & Development, Inc.
Creators of Design Optimization Technologies

VR&D Winter 2012 Newsletter

Index

1 Obituary of Dr. Iku Kosaka

It is with great sadness that we inform you of the passing of our colleague and friend Dr. Iku Kosaka on May 19, 2011. Iku passed away after a courageous fight with cancer.

Dr. Kosaka contributed immensely to the development of Genesis, Design Studio, and the implementation of the Equivalent Static Load (ESL) method that couples Genesis and LS-DYNA. He also helped to grow VR&D business nationally and internationally and was instrumental in expanding the use of VR&D software in Japan.

October 2, 1966 – May 19, 2011

Dr. Kosaka is survived by his wife Valerie, his son Ian, and his daughter Lily. Memorial services were held in May at the Universalist Unitarian Church of Farmington Hills, MI and in October in Nagoya, Japan.

Obituary details can be found at: http://deathnotices.michigan.com/view-single.php?id=268733

2 *New Distributors*

2.1 FAST-ER - *Russia*

We are pleased to announce that FAST-ER, based in Moscow is the new distributor of VR&D software in Russia and Kazakhstan. It offers consulting, technical expertise, and services in high-tech industries. It was founded by Alain Fournier-Sicre, former engineer at the European Space Agency and head of the diplomatic mission of the ESA in Moscow until 2006. VR&D welcomes FAST-ER to its family of distributors. For more information on FAST-ER, please visit their website: http://www.fast-er-web.com

2.2 Marutee - *India*

We are delighted that Marutee has become a distributor of VR&D software in India. Marutee is an engineering services company, based in Bangalore, India. It focuses on providing CAE and CAD solutions for clients across the globe in sectors ranging from automotive to alternative energy. VR&D welcomes Marutee to its family of distributors. For more information on Marutee, please visit their website: http://www.marutee.com

3 *Recent Events*

3.1 SAE 2011 World Congress – Technical Session Keynote

Mr. Juan P. Leiva, President and COO of VR&D, delivered the session keynote at the SAE 2011 World Congress held in April 2011 in Detroit, Michigan. The title of his keynote was "**Structural Optimization Methods and Techniques to Design Light and Efficient Vehicles**". The following is the abstract of his keynote:

Current difficult economic environment and intense competition in the global automobile market impose automobile companies and their engineers the need to design and build vehicles that perform better than their previous models, that are lighter, more fuel efficient, more quiet, pollute less, and yet be cheaper to manufacture. In this presentation, different optimization methods and techniques that can be used to address some of these issues are discussed. Methods such as sizing, shape, topology, topometry, topography, and freeform optimization are described and examples of their use are presented. The presentation concludes that today optimization methods are mature and can be used at different stages of the design process of vehicles.

3.2 Keynote at NATO Research and Technology Organization

Dr. Gary Vanderplaats, CEO of VR&D, delivered a keynote presentation at the NATO Research and Technology Organization (RTO) Applied Vehicle Technology (AVT) Panel Workshop titled "**Virtual Prototyping of Affordable Military Vehicles using Advanced MDO**". The workshop was held in May 2011 in Sofia, Bulgaria. The title of his talk was: **MDO: Past, Present, and Future.** The abstract of the talk is as follows:

The field of numerical optimization based structural synthesis was begun by Prof. Lucien Schmit in 1960. Prof. Schmit together with Mr. Thornton also published the first multidiscipline design optimization (MDO) paper in the early 1960s. These works led to thousands of research papers, as well as numerous commercial products. The purpose here is to offer a brief overview of the MDO field and related developments since its inception, discuss the current state of the art and address possible future needs and directions. The discussion of the past will include general optimization algorithms, as well as specific methods that make structural synthesis efficient and reliable. Some past works in MDO, as well as efforts to provide a formal mathematical framework, will be discussed and evaluated. The overview of the past will naturally lead to an assessment of the present state of the art. Here, we will discuss what is possible today using COTS (Commercial Off the Shelf Software). Various examples will be offered to demonstrate the current capabilities. It will be seen that not only the state of the art is well developed for single discipline design optimization but that formal multidiscipline design optimization technology remains an elusive goal. Finally, we will consider the future of MDO. While it is not possible to predict future directions with certainty, present successes demonstrate that MDO has a strong future. We will attempt to identify some key needs for research and development and generate discussion on what the goals should be and how to achieve them. It is argued that a key issue is not just what is possible or needed but how to encourage the widespread use of the technology we have now. It is concluded that MDO is matured to the point where we can make widespread use of this powerful tool to meet our need to produce better products in a timely manner while making best use of our limited resources. A more widespread use of existing technology will be the strongest driver in identifying and implementing future technologies.

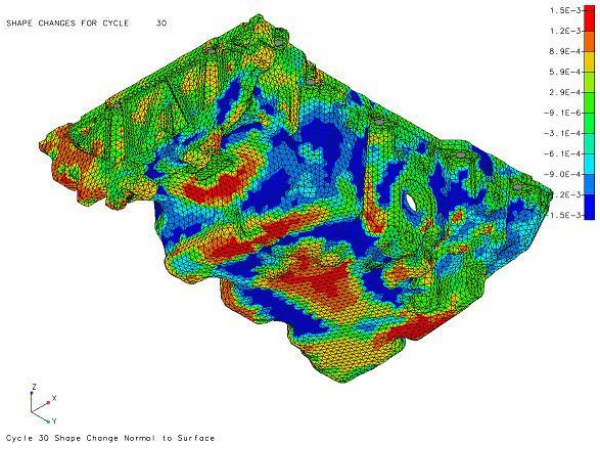
3.3 The Future Commercial Aircraft Workshop

Dr. Gary Vanderplaats was an invited speaker at The Future Commercial Aircraft Workshop held in May 2011 in Shanghai, China. The workshop was organized by the Joint Institute of Aeronautical Science and Engineering (JIASE). The theme of this workshop was similar to the NATO RTO workshop and here also he delivered a lecture on MDO: Past, Present, and Future.

3.4 SAE Noise and Vibration Conference

VR&D engineers attended the 2011 SAE Noise and Vibration Conference held in May 2011 in Grand Rapids, MI and together with AISIN AW presented a paper titled "**Structural Optimization Method Techniques to Reduce Radiation Noise**". The talk was given by Dr. Phani Adduri. In this paper, Genesis optimization is used to reduce the structural radiated noise. The abstract of the paper is as follows:

A methodology to optimize sound pressure responses of a structure, producing a radiation noise due to structural vibration, is presented. The method involves a finite element analysis module to calculate structural vibration, an optimization module to perform sensitivity analysis and structural optimization, and an acoustic module to compute acoustic transfer vectors. The proposed design system is successfully implemented and is demonstrated in the paper using several example problems.



3.5 VR&D Users Meeting in Japan

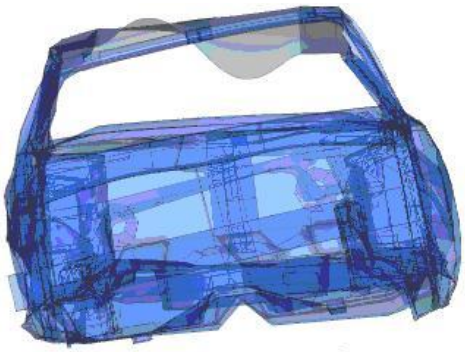
DiSquare, the distributor of VR&D software in Japan, organized the Japanese VR&D Users Meeting which was held in October 2011. The event was attended by our CEO, Dr. Gary Vanderplaats, our President and COO, Mr. Juan P. Leiva, and some of our customers and their representatives from Japan.

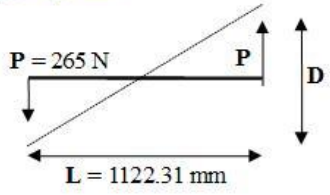
The highlights of the meeting were presentations from Mr. Takanori Ide of AISIN AW about "**NVH Performance for Automatic Transmission using Large Scale Optimization**"; Dr. Gary Vanderplaats about "**Multidisciplinary Optimization and VisualDOC**"; Mr. Juan P. Leiva about "**Structural Optimization and Genesis**"; and Mr. Martin Gambling of GRM Consulting, UK about "**Use of Genesis Structural Optimization in the European Market**".

3.6 International Automobile Body Congress

Mr. Juan P. Leiva, President and COO of VR&D, presented a paper titled "**Structural Optimization Methods and Techniques to Design Efficient Car Bodies**" at the International Automotive Body Congress held in November 2011 in Troy, Michigan. An excerpt from the talk is as follows:

For most of the history of design, designers have relied on their intuition and/or improving previous models to design their new models. Most designs could not be tested as analytical formulae could not be used for real problems. Only in these last few decades finite element analysis has been used. Optimization as a design tool only in the recent years has started to be used more commonly in the marketplace. Structural optimization software has only been available in the last two decades, but some of the optimization that software offers today did not even exist ten years ago. The novelty of these techniques shows that the potential of structural optimization is not yet fully utilized. In this paper we will discuss some examples that show what is possible for car body design. First, we will summarize the general methods and then, we will show examples for car body design.





$$K = P \cdot \left(\frac{L^2}{D}\right) * \left(\frac{Pi}{180}\right) * \left(\frac{1}{1000}\right)$$

3.7 Evolutionary Optimization and its Scope in Practical Problem Solving

On November 3, 2011, VR&D organized a seminar on Evolutionary Optimization and its Scope in Practical Problem Solving. The main speaker at the seminar was Prof. Kalyanmoy Deb of Indian Institute of Technology, Kanpur, India. Prof. Deb gave an informative and thorough presentation on Evolutionary Algorithms, their application to Engineering Problem Solving, and the process of Innovization (the process of creating innovation through optimization). Additional speakers at the seminar included our President, Mr. Juan P. Leiva, who talked about VR&D's vision for Optimization; Dr. Brian Watson, who presented the Design Studio for Genesis software; and Dr. Santosh Tiwari, who gave an overview of the VisualDOC software.

3.8 INFORMS 2011 Annual Meeting

Dr. Santosh Tiwari was invited to give a talk on the use of Evolutionary Optimization in Industry at the INFORMS 2011 Annual Meeting that was held in November 2011 in Charlotte, NC. The title of the talk was: **Evolutionary Optimization in Industry: State-of-the-art and Future Directions**. The abstract of the talk is as follows:

In this talk, an industry perspective on the application of evolutionary algorithms (EAs) to solve engineering optimization problems is presented. The benefits and the challenges that EAs present, the lessons learned from using EAs, and the best practices are also discussed. A discussion on the associated computational cost to perform optimization is also presented. Finally, the talk concludes with desired/needed advancements in EAs that may benefit the optimization practitioners in industry.

4 *Recent Software Releases*

4.1 Genesis 12.1 (October 2011)

Genesis is a fully integrated finite element analysis and design optimization software. It can perform sizing, shape, topology, topography, topometry, and freeform optimization. We recently released a new version. Some of the key new features and enhancements include:

- **15-node CPENTA Element** – The 15-node CPENTA element has been added: The new element can be used for any type of analysis. The new element is supported in all types of optimization. Stress and strain are recovered for statics, frequency response, and random response. Grid stresses are recovered for statics and frequency response. The results can be printed in the output file and/or post-processing files.
- **Improvements to 10-node CTETRA** – The stress and strain of the 10-node CTETRA element have been improved. A new procedure that results in more accurate element results has been added.
- **CWELD Element** – Stress and force results for the CWELD element are now available: These results are available for statics, frequency response, and random response analysis. The results can be printed in the output file and/or post-processing files.
- **CGAP Element** – Forces results for the CGAP element are now available: These results are available for statics analysis. The results can be printed in the output file and/or post-processing files.
- **New Built-in Functions** – New built-in functions are now available. New types for DRESP3 and TRESP3 are SDEV and PNORM2.
- **Interlaminar Shear** – Interlaminar shear results for the composite elements are now available: The responses are available for statics analysis and for optimization. The results can be printed in the output file and/or post-processing files.

Genesis 12.1 continued…

- **Improvements to Topology Preprocessor** – The topology pre-processor has been improved: The memory requirement for geometry-based fabrication constraint pre-processing has been dramatically reduced for solid structures. The overall pre-processor calculation has been improved resulting in lower memory usage and a speedier process.
- **Uniform Fabrication Constraints** – Uniform fabrication constraints have been enhanced. The existing uniform fabrication constraints, UXY, UYZ and UZX, can now be used as geometry-based constraints. Previously these were only available for element-based topology optimization.
- **Enhancements to Anti-Checkerboard Filter** – The anti-checkerboard filter controls for topology have been enhanced. New options for the filtering allow control over which neighbor shell elements will participate within a single filter region.
- **New Shifted Response Types** – New shifted response types have been added. Shifted responses allow easy creation of constraints which have bounds that are frequency dependent. Shifted responses are now available for random response power spectral density displacements, velocities, and accelerations.
- **New Topography Options** – New topography options are now available: New perturbation method FFORM and shape type UNIF add flexibility to topography problem setup.
- **Nested Include Files** – Nested include files are now allowed: Included bulk data files are now allowed to include other files to give users greater flexibility in organizing their input data.

4.2 Design Studio for Genesis 12.1 (October 2011)

Design Studio for Genesis is a design oriented pre- and post-processor graphical interface for the Genesis Structural Analysis and Optimization Software. The key enhancements in release 12.1 are as follows:

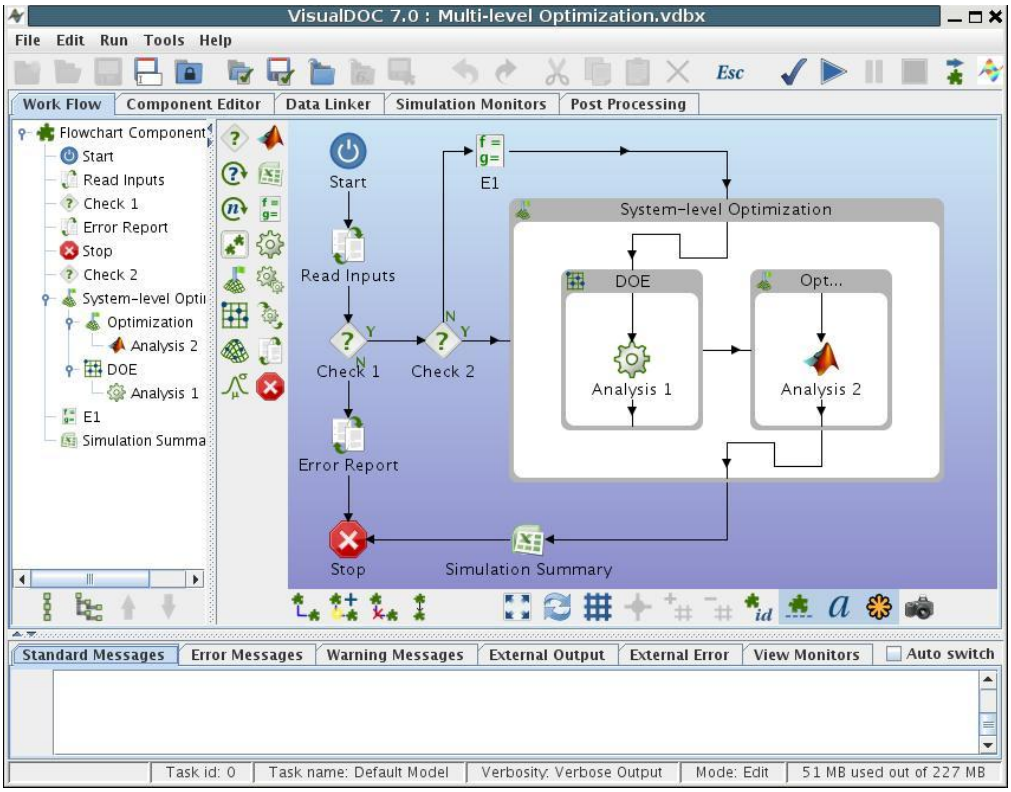
- Genesis 12.1 Compatibility
- Recent Files List
- Tab Keyboard Navigation Enhancement
- Select All and Deselect All Edit Menu Toolbar Buttons
- Selected Item Count
- Rotation Center Enhancements
- Select Design Variables by Group
- View/Edit DSCREEN Parameters
- View/Edit All DOPT Parameters
- Viewport Tracking for Deform Mesh Animation
- Animate Frequency Response Displacements/Velocities/Accelerations

Design Studio 12.1 continued…

- Plot Random Displacement/Velocity/Acceleration PSDF Results
- Post-Processing Display Customization
- New Composite Post-Processing Capabilities
- Von Mises Stress Post-Processing Enhancement
- Oscillate Animation Fidelity Control
- History Plot Enhancements

4.3 VisualDOC 7.0 (December 2011)

VisualDOC is a general purpose multi-disciplinary design, optimization, and process integration software. It includes design modules such as Optimization, Design of Experiments, Response Surface Approximation, and Probabilistic Analysis which it can add to almost any analysis program. Its features include comprehensive concurrent monitoring and visualization tools, storage and reuse of generated simulation data for post-processing, full debugging support for model execution, and the ability to interactively inspect and monitor the design process.



VisualDOC 7.0 is a major release and the new GUI elements are as follows:

- **Workflow** – In the new design, the user creates a *connected workflow of components* resembling a flowchart. Multi-level, cyclic, and conditional workflows are supported.
- **Data Editor** – Simulation data and its attributes corresponding to each component are defined in the generic data editor.
- **Component-specific Property Editor** – Property editors specific to each component are used to configure attributes such as tuning parameters, input/output files, etc.

VisualDOC 7.0 continued…

- **Data Linker** – The data linker UI allows for easy linking (transfer of information) of data between different components in the workflow.
- **Task Manager** – Multiple versions of the same model can be stored in the database and the user can switch back-and-forth, import/export/reuse data between different versions.
- **Simulation Monitors and Post-Processors** – Any number of simulation monitors can be added to a VisualDOC model before/during/after a simulation. These include visualization plots, data tables, animations, etc. A large number of data mining and statistical analysis tools are also supported.

Apart from the main GUI elements, a brief list of new features is presented below:

- **Debugging** – Add/Remove break-points. Start/Stop/Pause/Continue a simulation.
- **Parameterization** – Link any configuration property to a data for reading/writing.
- **Partial Execution** – Execute only a single component or part of a sub-flow.
- **Auto-completion** – Automatically connect/rearrange components; create/link data, etc.
- **Import/Export** – Save only a component or sub-flow, import into existing workflow, etc.
- **Reuse Data** – Use data from a previous run, import/export from/to external sources, etc.

4.4 DOT 6.0 and BIGDOT 3.0 (December 2011)

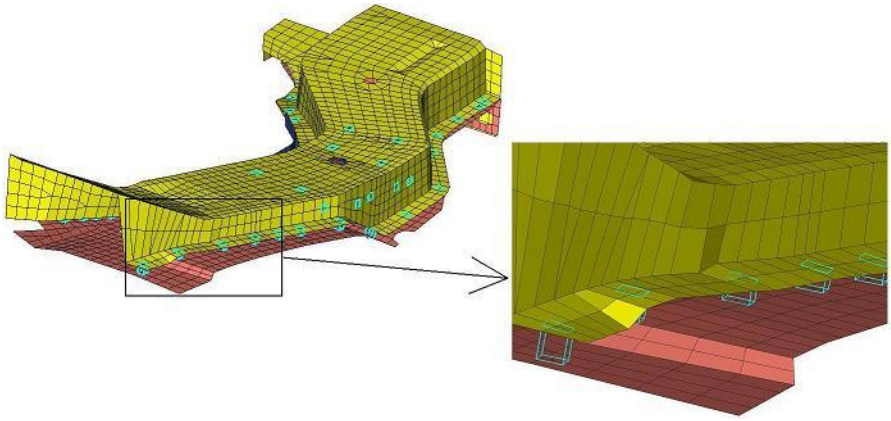
DOT is a general purpose numerical optimization library used for solving a wide variety of linear and non-linear constrained optimization problems. BIGDOT is intended to solve very large, linear or non-linear constrained optimization problems. Both DOT and BIGDOT can be directly embedded into your own program. The key features of the new release of DOT and BIGDOT are as follows:

- **One-dimensional Search** – Golden Section method is now available in one-dimensional search.
- **SLP Method** – Simplex algorithm has been added to the Sequential Linear Programming method.
- **MMFD Method** – Major changes have been made to the Modified Method of Feasible Directions algorithm to better follow curved constraints.
- **SQP Algorithm** – Sequential Quadratic Programming algorithm has been modified to improve efficiency and robustness.
- **64-bit Support on Windows** – Both the DOT and BIGDOT libraries are now natively 64-bit on 64-bit Windows. A 32-bit version is also available for 32- and 64-bit Windows. On Linux/Unix, only 64 bit version of the libraries is provided.
- **Double Precision** – Single precision support has been deprecated and double precision is the default. All the included examples have been updated to double precision.
- **Language Support** – Both the DOT and BIGDOT libraries provide Fortran, C, and C++ API. For C and C++, a header file is also provided for easy usage.

5 Tips and Tricks

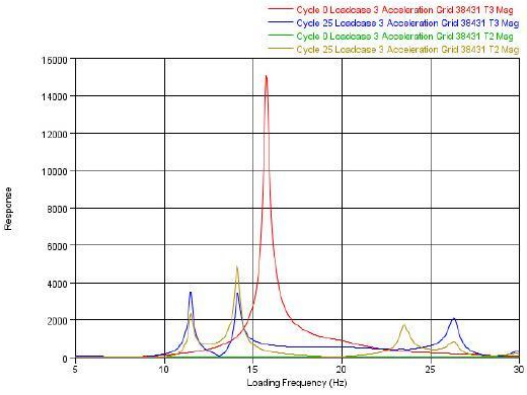
5.1 Genesis

Output Connection Points in a Weld Element: CWELD elements are general purpose connector elements used to model spot weld connections. The welded connections can be specified as point-to-point, point-to-patch or patch-to-patch. Point-to-point is a connection between two grids and can be easily visualized on the model. However, the point-to-patch and patch-to-patch specifications require Genesis to do search and projection calculations to determine the actual connection points on the model which are generally not nodes. Bulk data SWLDPRM can be used to output details of the search procedure and connection point coordinates for each weld. Additionally, one can visualize the model with the actual weld connection points in Design Studio by generating an update file with SWLDPRM, PRTSW=2. This option will make Genesis add bulk data in the form of PLOTEL elements to the update file so that the welds can be visualized in Design Studio.



5.2 Design Studio for Genesis

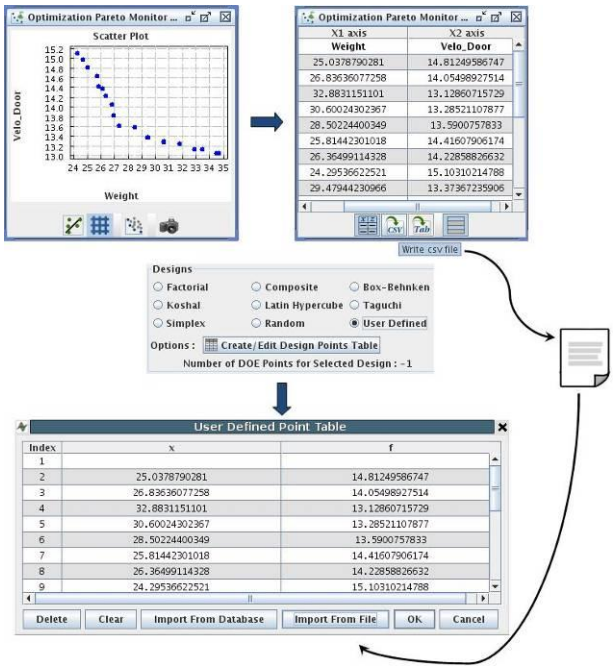
Exporting X-Y Charts: Design Studio can create X-Y charts for both frequency response data and design history data. Right-clicking on either type of chart will bring up a menu with some useful options. The chart can be saved into a picture file using the "Save Image..." option, or the chart data can be written to a text file using the "Export Curve Data..." option. The text file writes each X and Y value pair to a line, separated by a tab. This file can easily be imported into most spreadsheet programs. In fact, Design Studio itself can import this exported curve data. This trick can be used to produce a chart that contains the design histories of two different runs. First, import the two history files. Next, create a plot for each one and export the curve data into two files. Then, import the curve data files. Now, the curve data is available in the frequency response plot trail and both curves can be added to the same chart.



5.3 VisualDOC

***Use the Data Displayed in a Monitor as Starting/Initial Sample for a Component*:** Example: Fit an approximation to the Pareto-optimal (PO) front obtained from multi-objective optimization. To accomplish this task, execute the following steps:

1. Setup and run the multi-objective optimization example.
2. Add an Optimization Pareto Monitor; select the desired data to which a response surface is to be fitted. Run the monitor to display the PO front.
3. Change the display type to table. The data will now be shown in tabular format.
4. Export the displayed data to a Comma-Separated-Values file (click the CSV export button).
5. In the DOE component, choose the option "User-defined" for design type.
6. To specify the user-defined data, click the "Create/Edit Design Point Table" button.
7. In the "User-defined Point Table" dialog, click the "Import from File" button and select the CSV file to which you just exported the data.
8. Now the DOE component uses the data from the Pareto Optimization monitor as the sample to which it will fit an approximation.



In general, the user can export the data displayed in any monitor to a CSV file. The CSV file can then be imported into any component that supports user-defined data.

6 *VR&D Workshops*

VR&D offers free one-day workshops on optimization and related topics. The workshops are designed to give attendees a brief overview of the capabilities of our software, teach them optimization concepts, and help them use our software in solving their problems. The workshops are offered at our Novi office throughout the year. We currently offer workshops on the following topics:

Structural Optimization (*Genesis and Design Studio*) – This workshop is designed to demonstrate the ease of running structural optimization using Design Studio and Genesis. The workshop covers topology, sizing, shape, topography, topometry, and freeform optimization.

General Optimization (*VisualDOC*) – This workshop highlights how VisualDOC can be used to model and execute a design process, couple optimization to an existing analysis, and perform various design studies.

Automobile Body Optimization – This workshop provides an overview of important capabilities of Genesis for optimizing car bodies including complete automobile bodies.

Shape Optimization – This workshop provides an in-depth look at shape, topography, and freeform optimization using Genesis and Design Studio. In this workshop, we will look at the basics of shape optimization. It also goes through Topography optimization and explores Freeform Optimization, a new shape optimization capability. This special shape optimization capability allows the user to find the best location and shape of rib patterns that stiffen solid structures. It can also be used to find the best location of grids in any type of structure.

Freeform and Composite Optimization – This workshop provides an in-depth look at freeform and composite optimization using Genesis and Design Studio. In this workshop, the capabilities of Genesis to optimize laminated composites are discussed. Freeform optimization (a new shape optimization capability) is also discussed. This new shape optimization capability allows the user to find the best location and shape of rib patterns that stiffen solid structures. It can also be used to find the best location of grids in any type of structure.

Composite and Frequency Response Optimization – This workshop provides an in-depth look at optimization using frequency response analysis using Genesis and Design Studio. The beta method, used for minimizing the maximum value, is used to optimize based on frequency response. In this workshop we will also look at the capabilities of Genesis to optimize laminated composites. Optimization for layer thickness, angles, and shape are also covered.

Non-Linear Response Optimization – This workshop provides an in-depth look at optimization of non-linear responses using Genesis and Design Studio. The Equivalent Static Loads (ESL) method is briefly presented. The ESLDYNA interface, which uses LS-DYNA to solve the non-linear analysis and Genesis to perform the optimization, is explained. In this workshop, we will look at the different optimization capabilities of Genesis. We will also look at a plugin to Design Studio that serves as a graphical interface to setup and run the ESLDYNA interface.

Please check our website (http://www.vrand.com) for future workshops and the latest announcements. **The upcoming workshops on Structural Optimization and General Optimization are scheduled for March 1st, and March 2nd 2012 respectively.**

VR&D Webinar Series

Starting in 2011, VR&D began our Webinar series which includes presentation on topics related to optimization. The presentations are given by VR&D staff, as well as our customers and collaborators. In 2011 and January 2012, we offered webinars on the following topics:

1. Fifty Years of Structural Synthesis
2. Structural Optimization using Genesis
3. Structural Optimization using Design Studio
4. Full Automobile Topology Optimization with Multiple Load Cases including Inertial Relief

VR&D Webinar Series continued …

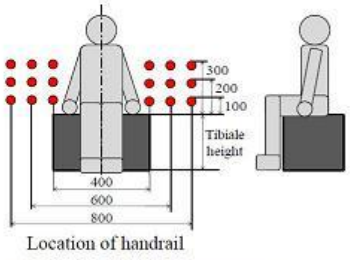
5. Structural Optimization Method and Techniques to Reduce Radiated Noise
6. Design Optimization and Process Integration with VisualDOC
7. Test-Analysis Correlation with Design Optimization

The Videos of the Webinars can be obtained by sending a request to info@vrand.com. Please check our website (http://www.vrand.com) for future webinars and latest announcements.

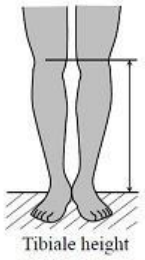
8 *General Optimization Corner*

The featured article in the general optimization section of this newsletter is from Dr. Chihara and his group from Tokyo Metropolitan University, Japan. His group is working on the design of ergonomic handrails for sit-to-stand movement. The research involves multi-objective optimization of the handrail and experimental analysis and verification with live subjects. The title of their research paper is "**Comprehensive Evaluation of Muscle Load for Ergonomic Design through Multi-objective Optimization**". A brief summary of their research is as follows:

The comprehensive muscle load evaluation is formulated as a multi-objective optimization problem. The proposed method is applied to the problem of designing the handrail position (height *h* and distance *d*) for the sit-to-stand movement. The height and distance of the handrails were the design variables, and surface electromyograms (EMGs) of the anterior deltoid, triceps brachii, rectus femoris, and tibialis anterior of nine participants were measured. From the results of the measurement, it was found that there is a trade-off between the muscle load of triceps brachii and that of tibialis anterior. The lower the position of handrails, the lower the muscle load of tibialis anterior is, conversely, the higher the position of handrails, the higher the muscle load of triceps brachii is. The two muscle loads were defined as objective functions that should be minimized. The optimization problem was solved by the satisficing trade-off method.



Location of handrail


Tibiale height


(a) Anterior deltoid


(b) Triceps brachii


(c) Rectus femoris


(d) Tibialis anterior

Reference: Chihara, T., Seo, A., 2011. *Comprehensive Evaluation of Muscle Load by Applying Multi-objective Optimization*, 9th World Congress on Structural and Multidisciplinary Optimization, Paper No. 075_1, Shizuoka, Japan.

Fun Stuff

VR&D Visits Pratt & Miller

In December 2011, VR&D visited Pratt & Miller Engineering, the official General Motors racing team in New Hudson, Michigan. During the visit, some members of the VR&D staff had the opportunity to tour the workshop, check out some of the race cars built over the years, and also see some of the components designed and optimized using VR&D software.

Vanderplaats Research & Development, Inc.

Creators of Design Optimization Technologies

Colorado Office:
1767 S. 8th Street, Suite 200
Colorado Springs, CO 80905
Ph: 719-473-4611
Fax: 719-473-4638
Email: info@vrand.com

Michigan Office:
41700 Gardenbrook, Suite 115
Novi, MI 48375
Ph: 248-596-1611
Fax: 248-596-1911
Email: info@vrand.com

California Office:
398 Foam Street, Suite 205
Monterey, CA 93940
Ph: 831-869-5222
Email: info@vrand.com