

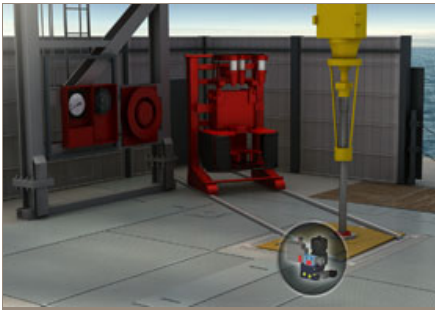
## MOVING YOUR WORLD

Ideas in Motion Control for Machine Builders and Users

June 11, 2012

Issue #27

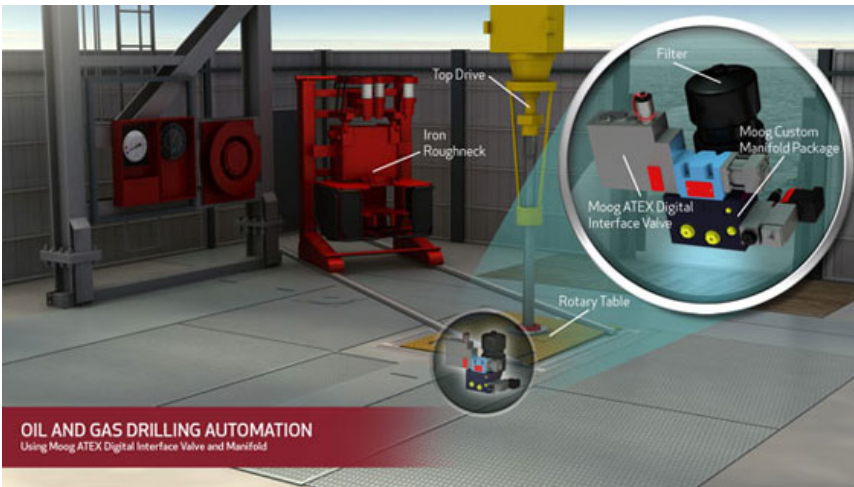
### Where Hazardous Duty Meets Digital Hydraulic Control



#### IN THIS ARTICLE:

- ATEX Digital Interface Valve is a flexible, high efficient motion control for use in hazardous environments.
- Rugged construction and advanced functionality of this valve are ideal for applications such as downhole drilling with vibration and heavy use.
- Moog is helping customers to find many benefits to their applications from using digital valve technology.

### New Moog Servo Valves With Fieldbus and ATEX Explosion-Proof Certification Used in Oil and Gas Drilling Applications



Oil and Gas Drilling Automation Using Moog ATEX Digital Interface Valve and Manifold

Oil and gas drilling represents one of the world's most extreme operating environments. Reaching deep below the surface, under heavy use and constant vibration with the looming potential to release underground gas pockets takes a significant toll on drilling subsystems. To offer machine builders better options in motion control technologies, Moog expanded its successful Digital Interface Valve Family of servo valves with onboard microprocessing to meet the rugged requirements for applications in hazardous environments such as oil and gas drilling. These valves combine a rugged construction with fieldbus functionality to offer customers around the world the ability to communicate seamlessly with other fieldbus devices and obtain advanced functionality and system diagnostics.

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DIV with ATEX certification

### What is an ATEX or explosion-proof Valve?

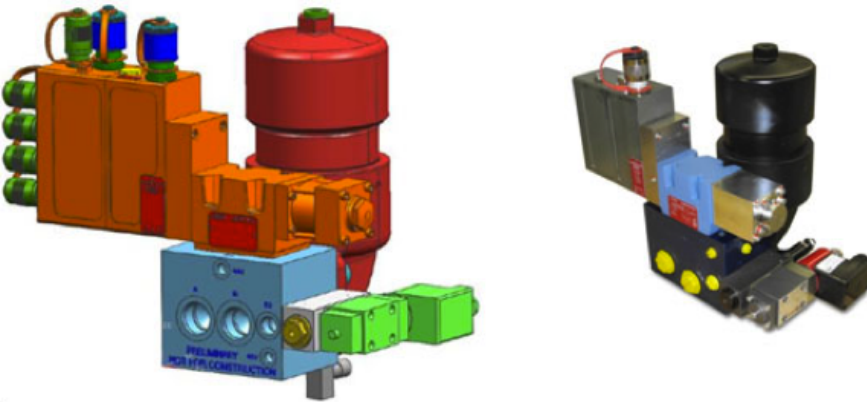
There are a range of certifications required for products used where fire or explosion hazards exist due to the presence of flammable gases or vapors, and flammable liquids. ATEX is a global certification for products such as servo valves that are used in these environments and it is typically required by companies that sell into the European Union. A range of levels is defined by the regulations ( e.g. II 2G Ex d e IIC T6/T5/T4/T3 Gb) and Moog engineers will work with you to obtain the performance you need and ensure compliance to appropriate regulations

The new valves have been ATEX certified to meet the safety requirements for explosive gas atmospheres. To ensure these valves can withstand high vibration, Moog completed the qualification for vibration transmission and tested the valve (according to DIN EN 60068-2-6) with 10 g sinusoidal vibration from 10 Hz to 2000 Hz in all axes.

### The Application and its Challenges

To better understand how an [ATEX Digital Valve](#) can benefit a machine builder, we will describe a recent application that Moog worked on with a major energy systems company looking to improve the way they control a large hydraulic motor in a drilling subsystem. Although the pressure and flow rates were easily achieved at 210 bar (3,000 psi) and 190 lpm (50 gpm ) respectively, the drilling environment is demanding with heavy use, constant vibration and the potential to release underground gas pockets.

Initially, the request was for advanced flow control to dynamically control the hydraulic motor speed with minimal pressure drop and to reduce piping connections. While working with the customer's engineers, Moog also learned that future systems could benefit from pressure control that would allow repeatable output torque at slow speed.



ATEX Digital Valve and Custom Manifold Package

### Greater Functionality Drives New Opportunities

Moog's unique solution consists of the single stage ATEX Digital Interface Valve with a unique 4-way spool configuration and a custom manifold package, consolidated piping connections with mounting for the servo valve, a solenoid valve, backpressure valve and a drainable pressure filter.

In the ATEX Valve, sensors coupled to onboard electronics provide closed-loop control for both flow and pressure which correlate to highly accurate control of speed, torque, position and force. In the past, only pressure or flow control with Moog's explosion proof valves was possible. Now with the new valve series both pressure and flow control are possible with one valve, offering machine builders new opportunities in motion control.

The application evolved over time as more functionality of the digital valve was used. Initial models provided proportional flow control with a 4-20 mA analog interface. Later configurations used more advanced valve features with combined flow and pressure control (pQ control) and the Profibus-DP® fieldbus interface. The pQ configured valve is capable of closed-loop speed control through the hydraulic motor's encoder and closed

loop pressure control through a pressure sensor within the valve for active control of the motor's output torque.

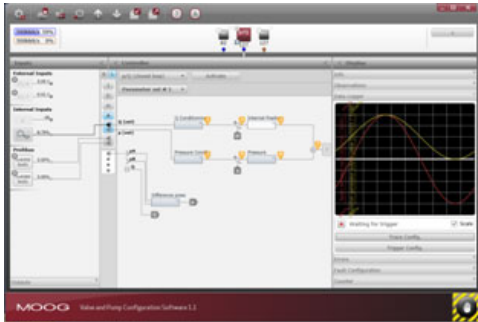
#### Why did the customer select Moog?

- Inventor of the first commercialized Servo Valve with 60 years of application experience
- Performance based solutions - tailored to advanced application requirements
- Specialize in motion applications for hazardous environment including the oil and gas drilling, power generation, and test.
- World wide support by experts in motion control

The manifold package and internal passages were modelled in 3D which was used for fluid velocity and internal stress validation to insure calculated pressure drops and a 4 to 1 factor of safety could be maintained. Once validated, the customer directly imported the detailed Moog solid model into their higher level system schematics.

#### How Does the ATEX DIV Work?

Control electronics are completely integrated within the ATEX Valve, incorporating a microprocessor-based system for executing all key functions via embedded software. This offers flexibility for the valve to adapt to a wide range of operating conditions while maintaining high accuracy and repeatability. In particular, it enables highly optimized system performance even with significant variations in pressure and temperature.



User interface of [Moog Valve and Pump Configuration Software](#)

Since control parameters may be downloaded using the fieldbus or a high level PLC program, the valve control function can be tuned during the machine operating cycle. Integrated continuous monitoring of a range of important valve and system functions and remote diagnostics are possible.

With an electrically isolated fieldbus interface, valve parameters can be changed on site or remotely. The built-in fieldbus interface (e.g. CANopen®, Profibus-DP® or EtherCAT®) enables adjustment of operating parameters, controlling the valve and monitoring of performance. In a safe, private or virtually private network, you can communicate directly with the valve from anywhere in the world. These valves are also available in a version without a fieldbus interface that is controlled using analog inputs and includes a service connector for setting parameters.

To reduce downtime due to installation and maintenance, Moog incorporates a unique feature in the ATEX Digital Interface Valve Series called hot plugged connector capability which enables the user to connect and disconnect the valve with the electrical supply switched on. These connectors are the result of a close collaboration between Moog and a supplier to meet the high demands in terms of shock and vibration. For use in rough environments (e.g. off-shore applications) all provided power and data cables are mud-protected.

#### The Benefits of the Digital Interface Valve

- Rugged and reliable hardware with explosion proof certification (ATEX) to withstand the constant vibration up to 10g
- Flexibility to easily interface with existing control system
- Advanced motion control functions such as active control of the hydraulic motor's output torque
- Increased valve functionality replaces the need for multiple valve types, providing weight and space savings in the machine
- No need for tuning in the field as it is factory calibrated using software, thereby reducing commissioning time

#### The Result

Initial builds of the system were completed in 16 weeks from date of order with seamless integration during startup. The new version of the Moog Valve Configuration Software helped make setup, diagnostics and tuning easier. The success in the initial application has led to new projects in areas where proportional control was not typically used.

#### Background on the ATEX Digital Valves

The ATEX Digital Interface Valve series is available in a full range of sizes. Direct driven valves are available in sizes 03 and 05 (according to ISO 4401) and pilot operated valves are available in sizes 05 to 10 and the maximum operating pressure is 350 bar (5,000 psi).

The valves are certified according to ATEX guideline II 2G Ex d e IIC T6/T5/T4/T3 Gb – which defines various environmental conditions of the locations where the product will be used. The products can operate reliably in range of -20 to +60 °C (-4 to +140 °F) for ambient temperature and -20 to +80 °C (-4 to +176 °F) fluid temperature. These temperature ranges depend on certified temperature classes according to ATEX. Applications for low temperatures down to -40 °C (-40 °F) are also available upon request. The IP protection class is IP66. For easy configuration and parameterization, the Moog Valve Configuration Software is provided free of charge as part of the product package.

## Authors

**Thomas Röhlig** started at Moog GmbH in 2006 as Development Engineer for hydraulic pumps, with responsibility for mechanical design and construction. Mid 2009 the field of responsibility for mechanical design and construction has expanded to servo and proportional valves. He studied Mechanical Engineering at the University of Applied Sciences of Jena, Germany.

**Kevin Kolmetz** started at Moog in 2011 as Product Sales Manager for the Topside Oil & Gas Market. Kevin has spent 11 years supporting electro-hydraulic & pneumatic actuation needs of customers in the aerospace, defense & industrial markets. He has completed degrees in mechanical engineering and new product development from Rochester Institute of Technology, Rochester, NY USA.

## A Smooth Approach To Safer Offshore Turbine Access



### IN THIS ARTICLE:

- Unique motion control application to help cancel out wave motion.
- Moog customized control valves to achieve required speed, resolution and integrated safety features.

## Revolutionary Ampelmann Access Platform Utilizes Moog Control and Safety Valves

Increasingly, wind turbines are being sited offshore, where strong winds are more consistent and the visual and environmental impact is reduced. However, there are numerous logistical difficulties in installing and maintaining these turbines in such a remote and hostile environment.



Offshore Wind Turbines

Consider for instance the difficulty of deploying maintenance staff onto the turbine in poor weather conditions and rough seas. On most fixed offshore structures this can be achieved with the use of a helicopter, but obviously this isn't feasible with a wind turbine. Traditionally, maintenance crews using small boats had to wait for a 'window' of good weather before undertaking both routine and unscheduled maintenance. Ironically, this often meant a very long wait, as the optimum locations for Wind Turbines inherently experience extended periods of rough sea conditions.

Today, there is another alternative thanks to Moog hydraulics technology and the innovative Dutch company [Ampelmann](#).



## A New Kind of Bridge

Back in 2007, Jan van der Tempel, now Ampelmann's CEO, hit upon the idea of using a shipboard platform mounted on an inverted 6-axis motion base, to cancel out the wave motion. This technology is widely used in flight simulators, but for generating rather than absorbing precise motion.

Mounted on the stabilized platform is a telescopic walkway or bridge which can be extended to reach the wind turbine base. The movement of the bridge to the static structure is manually controlled, and once in contact a controlled pre-load pressure is applied to ensure contact is maintained.

Because of the exceptional loads and speeds required, it was decided to design a new motion base customised specifically for the long strokes and high loads required for this application. Moog was selected to supply the high flow servo valves and safety cartridge valves crucial for the success of the project. Key to this decision was Moog's ability to customise these control valves to achieve the speed, resolution and incorporate the integrated safety features required.



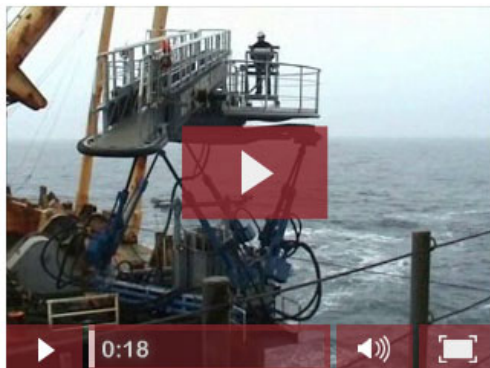
Ampelmann System Using Moog Inverted 6-Axis Motion Base - Source: Ampelmann

## Ensuring Stability at Sea

The inverted motion base is employed to produce a platform which is stationary in space independent of the ship's motion. (This type of control is often referred to as a 'sky-hook' system). To achieve this result, a sophisticated gyro-based transducer or motion reference unit (MRU) is mounted on the platform to detect vertical and horizontal accelerations. The gyro output signals are processed by a custom designed controller which sends signals to the hydraulic actuators with the objective of producing zero acceleration in all axes.

Secondary position control loops tend to force the actuators to mid-stroke, ensuring that any inevitable small acceleration errors don't accumulate and cause the actuators to extend or retract and hit the mechanical end-stops.

The video below illustrates the high degree of stabilisation that can be achieved:



*Video showing the Ampelmann System with high degree of stabilisation. Source: Ampelmann*

This motion base differs from established flight simulator technology in a number of areas, such as the long operating stroke and offset asymmetric loads. Another notable difference is the level of system redundancy,

essential for reasons of safety, namely:

- Duplex motion sensor on platform
- Triplex position sensors in the hydraulic rams
- Duplex hydraulic system with 'switchable' control valves
- Control valves with integral 'abort' function as in a flight simulator
- Duplex control cabinets



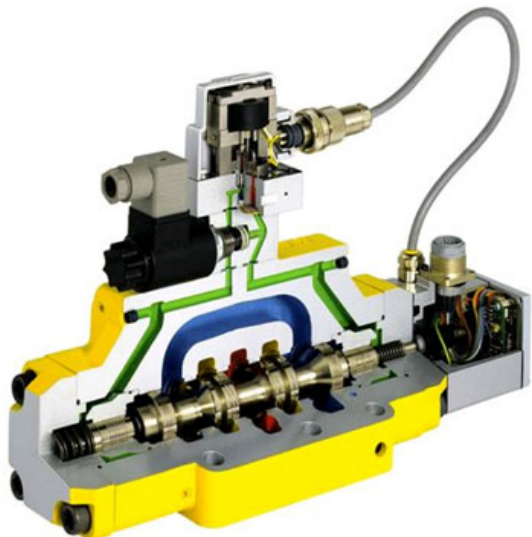
Inverted Motion Base used in Ampelmann - Source: Ampelmann



Moog D663 Servo Valve

Absolutely crucial to the system's ability to operate in extreme sea states, is the performance of the servo valves used to control the hydraulic rams. The [Moog D663 Valves](#) selected for this demanding application have the following characteristics:

- High Flow: Flows of up to 645 lpm (170 gpm) at 70 bar (1000 psi) pressure drop
- Fast Response : Up to 90 Hz with 90 degrees phase-lag at 25% signal
- Fine Resolution: Responds to very small command signal changes: < 0.1%
- Integrated Control Electronics: With error monitoring function
- Integral 'Abort' Function: Gives a 'soft' failure mode in the event of a complete electrical failure.



A Moog D663 series valve sectioned to show the solenoid operated failsafe mechanism. This device allows the spool to move to a 'pre-determined' safe position, under the influence of a spring detent, when the electrical supply is lost for any reason.

In this application, in the event of a complete loss of electrical power to the system, the failsafe mechanism in

the Moog valve mechanically produces a small pre-determined spool offset. This offset ensures that the actuators retract slowly to lower the motion base to the safe 'home' position, in exactly the same manner as a flight simulator.

The latest generation of Ampelmann platform also utilises a Moog Active [Cartridge Valve](#) to ensure reliable switching between the duplex hydraulic circuits. This unit incorporates a position monitoring system to provide an extra level of system integrity.

## A Bright Future for the Technology



Moog Active Cartridge Valve for switching between hydraulic circuits

To date, Ampelmann has produced a total of eight access platforms, leased to customers who operate them all over the world. It has been proven in practice that these platforms can be successfully deployed in sea states of up to +/- 3 m (+/- 9.8 ft) depending on where the platform is mounted on the vessel. The most effective location is the centre of the ship as this minimizes the influence of pitch and roll on the motion of the platform.

This new technology permits the servicing of wind turbines in all but the most extreme conditions, increasing the efficiency and attractiveness of these installations. Also, these access platforms have been applied to other applications such as transferring personnel and materials during the construction of offshore structures.

Ampelmann is about to introduce an even larger access platform, incorporating similar Moog technology. This unit, - the 'E-type' will have an even higher payload capacity and will work in sea conditions in excess of +/- 3 m (9.8 ft) to enable operation in a wider spectrum of sea conditions.



Ampelmann System Source: Ampelmann

## Author

**Martin S. Jones** is responsible for the [Motorsport](#) business around the world and is also the Market Manager for Niche and Emerging Markets in Europe. He has worked for Moog for 30 years in sales and applications engineering for a range of industries including mobile equipment, marine and offshore, blow molding and rolling mills. He studied Physics and Economics at the University of East Anglia.

# Moog Innovation Prize Recognizes Breakthrough Virtual Reality-Based Dental Simulator



## IN THIS ARTICLE:

- Moog promotes innovation in its corporate culture and measures it through a process called InnoScore.
- Analyzing the InnoScore trends shows diversity in the source of ideas and common characteristics of individuals who participate.
- The Simodont Dental Trainer is a success story of using Haptics technology to improve training of dental students around the world.

## Moog Uses the InnoScore Process to Reward Innovative Products and Solutions

How do you create a corporate culture that not only encourages innovation, but rewards it too? First, you offer engineers, product development professionals and market development managers the chance to showcase their ideas. Then, you score the ideas using a proven system of metrics. Finally, you commemorate the best idea with a prestigious award.

Since the mid 1980s, Moog has adhered to this process with tremendous results for its global industrial business. In 2011, the Moog Innovation Prize was awarded to the [Moog Simodont Dental Trainer](#), a virtual reality simulator that borrows high fidelity flight simulation technologies to help train dental students in a more realistic, more cost-effective fashion. As more companies strive to find new uses for technology and commercialize their R&D efforts into new business, this success story may offer some helpful insights.

## How to Assess Innovation?

### *What is Innovation?*

We define Innovation as the creation of new, better or more effective products and solutions which results in an obvious advantage for the customer.

To reward innovation, it is necessary to measure it and assess trends. Moog uses the InnoScore process as an indicator of innovation in the Control Solutions Group and to provide a longer term assessment of trends. Some guidelines in the InnoScore process include:

- Must be based on an idea which is not obvious.
- Must have impact - an idea combined with a customer need and acceptance from the market results in an innovation
- Must result in advantage to the customer - such as better performance, higher accuracy, reduced cost, greater reliability, better maintainability, lower weight, reduced ecological impact, more compact form or other similar attributes.

## Description of the InnoScore Process

At the end of each fiscal year, each Moog market development team nominates a solution or product that must fulfil three fundamental requirements:

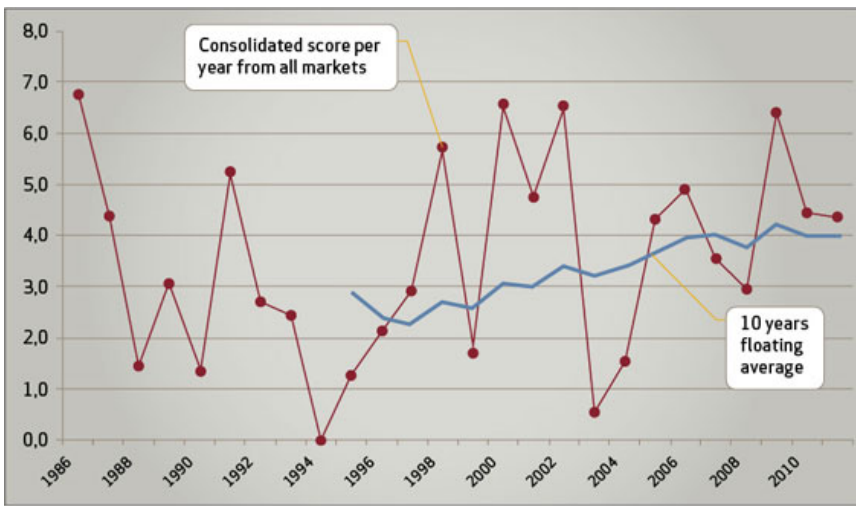
1. The innovation applied to a product or solution must be new and be accepted by Moog sales and customers (this score is weighted at 50%). For example, it must be in the sales forecast for the first time that year and must offer the potential for obvious sales growth.
2. It must offer clear differentiation over existing products and must have clear advantages for the customer compared to former solutions (this score is weighted at 25%).
3. It must not be obvious how it is done and not easily copied. Highest rating is achieved when patents are applied (this score is weighted at 25%).

An innovation can be nominated by the members of the business development organization to the ten-member Moog innovation board which represents engineering, program management and market development.

## Driving Innovation

Since 1986, a total of 91 products or solutions have achieved been nominated and scored. The highest possible rating in each category is 8.





InnoScore graph showing the consolidated Innovation scores and a 10 years floating average to illustrate the longer term trend

The technologies, the type of innovation and the source for the ideas are highly diverse. It includes solutions and products ranging from new controls and sensor concepts to electrical and hydraulic products to complete turnkey machine solutions. Some innovations have required very high investment and long schedules while others have achieved good scores in a short time frame with very low budgets. The source for the ideas in many cases came from discussion with customers about their needs. Ideas were generated by employees at all levels in sales, business development, engineering and marketing. Even with this diversity, there are some key takeaways from all the innovative solutions which are scored. For example:

- Moog employees are open to new ideas and willing to take a risk.
- All scored innovations have contributed to Moog's ongoing success and growth
- Innovation has helped Moog to develop the types of high performance solutions for which we are known in the marketplace

Simply put, the culture of Moog encourages creativity and provides the necessary tools and motivation required for widespread innovation.

### 2011 InnoScore Winner - The Moog Simodont Dental Trainer

When analyzing the results of the InnoScore program, a good example is the Moog Simodont Dental Trainer innovation which achieved the maximum triple 8 scoring. This innovation helped create a completely new business segment for Moog that is now growing worldwide.



Will Opie, European Market Development Manager, Simulation congratulates Dental Trainer Team

The development of the Moog Simodont Dental Trainer was initiated in 2007 from a request from the [Dental University in Amsterdam \(ACTA\)](#). The requirement was to develop a virtual reality training simulator that could bridge the gap between training on plastic teeth and treating a real patient. This meant that realistic 3D images of teeth were required as well as the ability to generate a realistic virtual drilling feel. A partnership was formed between ACTA and Moog where ACTA provided the knowledge of dentistry and dental education and Moog offered expertise in [haptics simulation technology](#). The end result is a dental trainer that truly meets the needs of dental education and has created a new paradigm in realistic training.

## Motion Control Challenges in the Dental Trainer

You may have never thought about what skills are required for a good dentist, but development of hand skills in complex scenarios is essential. Currently schools use a type of simulated training called phantom heads and plastic teeth for training. Unfortunately, many found this is not a substitute for working on a real patient as the feel of performing a treatment was not the same.

### What is Haptics?

**Haptics** is the science of creating a realistic sense of touch to the user in a virtual environment.

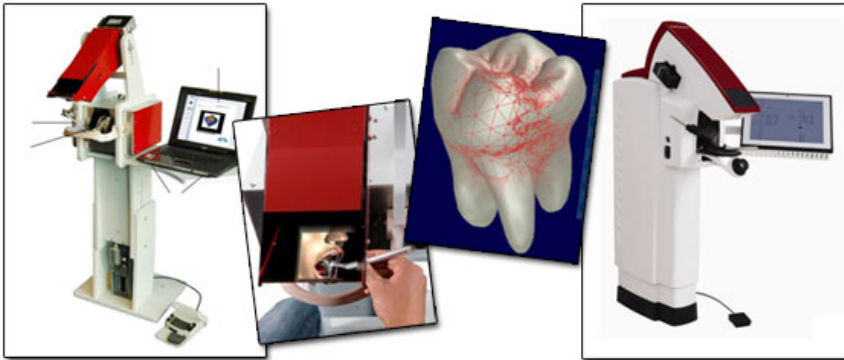
To help the dental student obtain these skills in a virtual way, it is critical that the training system generates the precise sense of touch in a simulator. This involves applying haptics technology. In some ways, it is a similar problem to teaching a pilot to fly a plane using a simulator that provides a training experience so real that it counts as training hours. In fact, the basis of haptic technology within Moog originates from the company's expertise with [flight simulators](#) and [control loading technologies](#). An instrumental tool in this process was the Haptic Master technology demonstrator, a 3-degree of freedom force controlled technology demonstrator used to demonstrate Moog's technical capabilities and help customers develop new applications requiring haptic feedback.

In engineering the dental trainer, significant technical challenges had to be overcome:

1. A realistic co-located 3D visual representation of a tooth with sufficient resolution and intensity of light needed to be developed. No standard solution was available and stereo projection on a mirror had been used. Tooth models with realistic density modelling and realistic colouring had been developed from CT scans but existing tooth models around the globe were not meeting the requirements.
2. The mechanical design needed to be stiff but provide frictionless force control with a high dynamic range and low inertia
3. The design had to provide a large range of movement, but not interfere with the user.

## The Solution

For such a large innovation, only very basic initial specifications can be defined. This development was completed in iterative steps using a total of seven prototypes that were evaluated by teachers, students and Moog engineers on multiple aspects. This resulted in a more detailed specification allowing different implementations to be tested and compared.



Proto types and resulting DentalTrainer

The result is a product with unique advantages over conventional training as the feel is much more realistic and it uses true size 3D images. The student's performance can be measured in great detail and the system allows for objective comparison of the student's individual results. Mistakes can easily be corrected by stepping back in the simulator and immediately repeating part of a procedure. This is not possible on plastic teeth and certainly not when treating a real patient.

No other simulator in the market currently supports these features so it is a truly unique result. A Moog patent is pending on the mechanical design in combination with the integration of graphical collision detection in the force control loop.

## The Results

The experience up to now indicates that students can use their time about three times more efficiently and can also practice much more independently without the need of a teacher. This provides a lower cost of ownership, especially in combination with elimination of real dental tools (e.g. diamond burs and handpieces).



Usage at ACTA Dental University

The system is now in use at ACTA and is being introduced in more than ten other schools around the world. The number of dental procedures that it can support is continuously being expanded. The business volume in the Haptic Technology Group has grown in the first year after introduction with several new customers and the future is promising with several renowned universities in Europe, Asia Pacific and Americas showing interest in the system.

The next steps considered by Moog are to deepen the content of the procedures to provide further support to the needs of these regional schools. Other medical simulation and training applications are also being considered, where similar needs are present and the technology can be reused and refined. Here the market potential is also very significant and current training methods are expensive and time consuming. Lastly, enabling good training of dental and medical procedures will have a significant impact on improving patient safety. Commercialization of an innovation like this relies upon a strong team, a great partnership with industry experts and the support of a company culture that encourages and rewards innovation.

## Authors

**Bernd Stehlin**, the Market Manager Defence Controls Europe and a Member of the Moog Control Solutions Innovation Board, has worked 29 years for Moog in different Engineering, Business Development and Management roles. Has a Masters (Dipl. Ing) in Mechanical and Control Engineering. He is also the Inventor and Co-Inventor of several Moog Patents in Motion Controls technology.

**Karel van Gelder**, the Business Development Manager for Medical Simulation and Training is responsible for helping Moog to enter the Medical Simulation and Rehabilitation Markets. He has worked at Moog for 15 years in different roles from Project Management to management of Product Development to Business Development. Karel holds a Masters Degree in Electrical and Control Engineering.

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