From Concept to Deployment:

Maple in Action

A collection of Maplesoft customer application stories

Maple™

A Word From Maplesoft's President

Welcome to "From Concept to Deployment: Maple in Action," a collection of Maple customer application stories.

Engineers, scientist and mathematicians from around the world use Maple to solve extremely difficult problems in a diverse range of industries and technical disciplines: Renault uses Maple in the design of a new electric vehicle engine, financial engineers at Mitsubishi UFJ Securities International use Maple in multi-asset product development, Eppstein Technologies use Maple to streamline the development of solar panel foil systems, Ulysse Nardin use Maple to revolutionize the design of springs which lengthen the running time of new watches. In this collection of customer application stories, you'll find these and many other exciting examples of how Maplesoft technology is used in advanced engineering projects.

In engineering research and design, detail is vital. Design engineers and researchers must not only define their problems clearly, but they also require in-depth analytical tools to help them understand on a fundamental level, the intricacies of the problem, and ultimately solve that problem and apply its solution to develop new products and technologies. Fortunately, Maple is available to underpin that process.

The application stories in this collection demonstrate how the use of technical computing software, symbolic and numeric technologies, and algorithms for large-scale problem solving have allowed engineers to reduce design costs significantly, while fulfilling the demands of governments and markets.

Please enjoy this collection of Maple customer application stories, with our thanks.

To learn more, please visit: **www.maplesoft.com/maple**

Sincerely,

Jim Cooper
President and CEO
Maplesoft

Contents

Renault Uses Maple to Develop New Motor for Full Electric Vehicle

Renault

In order to successfully enter the growing electric vehicle market, Renault wanted to create a new motor design. Rather than restricting themselves to existing designs and processes that are often inadequate in handling both driving pleasure and mass production requirements, teams were given the opportunity to start with blank canvases, while respecting standard constraints of deadlines, budgets and quality.

In particular, a group led by Mr. Patrick Orval was in charge of structural analysis for the wound rotor of the motor. In the earlier phases, they turned to Maple and started quickly with first-order approximations of the rotor. They got a sense of how the components would behave with different parameters and operating conditions, allowing accurate choices to be made for the main dimensions.

After analyzing this first set of results, they also understood which topics would demand higher fidelity. From there, they further developed the corresponding mathematical models in Maple based on the physical equations. “As a beginner, I found Maple to be very user friendly and intuitive,” remarks Mr. Orval. “We began by building mathematically-simple models, and were able to get results in line with project goals. Using the wealth of in-product and online support and resources, we were able to gain confidence and develop more sophisticated models in a short amount of time.”

One particular issue of growing complexity that was solved with Maple was that of the slot wedge, which holds the rotor wire in place to ensure reliability over both maximum loads and long-term operation.

By modelling wedge deviation under centrifugal and thermal loads, they determined a first simple rule based on flexural stiffness. By taking into account competitors’ data, they selected the appropriate thickness and material for the wedge.

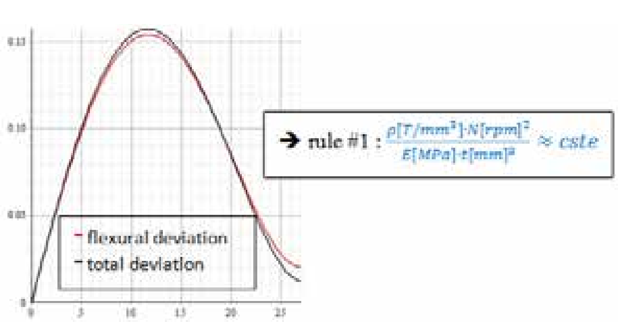
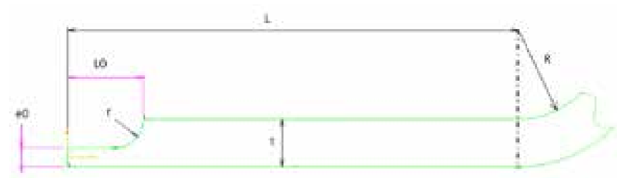
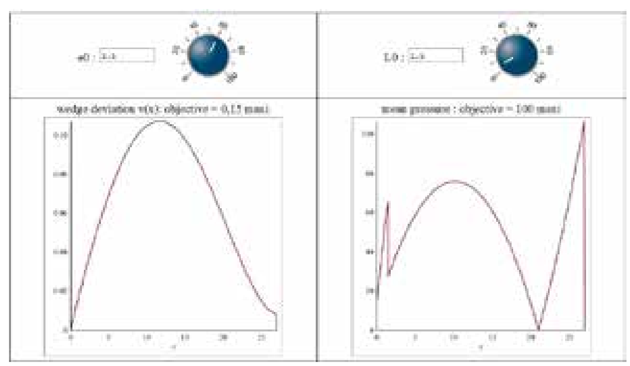


Figure 1 - Modeling the slot wedge at 1st order approximation

Thanks to this simple model, an opportunity for reducing the mass of the rotor was detected (the lighter the better, as the car can go further on the same battery charge). They imagined a solution depicted as two thicknesses that were ‘mathematically connected’ in Maple to create a first-order approximation of a new slot wedge. This was done in a parameterized analytical manner, so that they could easily determine a viable set of dimensions for this ‘new shape’ of the wedge. They then investigated the concentration factors library to limit stresses at the point where the wedge thickness changes, and performed finite element analysis (FEA) to validate the complete design.



(a) Cross-section of the ‘new-shape’ for the slot wedge



(b) Dynamic optimization in Maple for two parameters (e0, L0)

Figure 2: Achieving a 5% reduction in rotor mass

This work not only enabled the team to reduce the rotor mass, but also led to the successful filing of a design patent. Describing this achievement, Mr. Orval says “Maple was instrumental in helping to define the third-generation e-powertrain rotor. Its breadth enabled us to create models that are perfectly suited to our needs and achieve outstanding results early on in the design process. Additionally, the work carried out with Maple significantly contributed to reducing our engineering costs, by enabling us to incorporate third-party technology such as FEA.”

Having developed the slot wedge, the team then went on to examine the resulting internal stresses on the wires in the system. Among other factors, internal stresses are determined by wire

> “Maple was instrumental in helping to define the third-generation e-powertrain rotor. Its breadth enabled us to create models that are perfectly suited to our needs and achieve outstanding results early on in the design process.”
>
> — **Patrick Orval**, Renault

stiffness and the friction between the slot wedge and the stack of metal sheets – both of which were completely unknown and difficult to determine. Previously, they would have used a finite element model. However, that approach would have required a tedious amount of trial and error, and the team would have encountered difficulties with numerical convergence. Using Maple instead, the team was able to model non-linear features such as friction between the wedge and the stack, and local loss of contact between wires and the wedge at high revolution speeds. They expect it to yield good physical results, because the set of ODEs and the conditions governing the wedge deviation were fully coupled.

Summing up this phase of the project, Mr. Orval concluded “Maple greatly reduced the need for experimental learning. Both the development timescales and rotor reliability are in line with project expectations – a combination that would not have been achieved without the use of Maple.” As Mr. Orval and his colleagues work on subsequent phases of the project, they plan to continue using Maple to analyze and validate their design options, enabling them to improve the final product.

Rules of Attraction: Improving the Design of Magnetic Field Control Systems

Oxford Instruments

Oxford Instruments was established in 1959 to manufacture superconducting magnets that would prove to be a key enabling technology in a host of applications ranging from medical imaging to industrial quality control. Since then the company has expanded its scope and designs, and it currently manufactures and supports a broad range of products for academic researchers and industrial users. With applications in fields such as superconducting physics, measurement and nanotechnology, Oxford Instruments today employs nearly 2,000 people at its Oxford headquarters and offices worldwide.

Magnets remain as important to Oxford Instruments today as they were when the business was founded. Among many industrial and research applications of magnet technology in the company's portfolio is a range of bench top nuclear magnetic resonance (NMR) scanning devices. NMR techniques can be used to identify the chemical constituents of a sample of material, based on the tendency for nuclei located in a strong magnetic field to absorb and emit electromagnetic radiation. Oxford Instruments' NMR devices are used for a broad range of measurements, including analysis of the oil content of seeds and foods, the composition of plastic materials and the fluoride content of toothpaste.

To work well, NMR devices require an exceptionally strong and regular magnetic field and Dr Cédric Hugon, a magnet engineer at the company, takes part in the development of the equipment required to deliver such fields. "The magnetic field we need for NMR must usually be as strong as possible, but even more importantly, it must be as homogeneous as possible across the whole sample to be analyzed," he explains. "That means we want a field that varies between a few hundred parts per million in the simplest devices, down to a few parts per billion in the most sophisticated."

The primary magnetic field in an NMR analyzer is usually generated by a permanent magnet, made from a ferrous or rare earth material. The first part of his job, Dr Hugon notes, is optimizing the geometry of the magnet to produce the best possible field. In practice, however, even the best magnets produce fields that must be 'tuned' to give appropriate characteristics for NMR equipment. This tuning is carried out by up to a dozen 'shim coils': electromagnets which are precisely controlled to even out imperfections in the field. After the shim coils, an NMR device will also use up to three 'gradient coils' which modify the magnetic field in three dimensions as a sample is scanned.

The design of these shim and gradient coils, and of the algorithms used to control them, is an extremely complex process, and it is for this that Dr. Hugon relies on Maplesoft's technical computing software Maple. "Maple is good for this sort of complex work because it combines ease of use with a high level of control, which is particularly important when we are trying to optimize complex systems," he says.

Even though Maple makes the process of setting up the required calculations as straightforward as possible, the sheer complexity of the system still requires significant processing power, and that means it can be time consuming. "Some of my most complex optimizations were taking around half an hour to run," notes Dr. Hugon, "And that can make the work slow and frustrating when on each run you may only be changing a single parameter to see what effect it has."

In an effort to improve the speed of his analysis work, Dr. Hugon was advised to take advantage of Maple's multiple processor capability. "I was very impressed with the support I received," he recalls. "I sent a portion of my code to the technical support team and they made the changes required to run the calculations in parallel across multiple processor cores. They also helped me to adapt the same code later on to keep it working with the latest version of Maple."

Since adapting his Maple worksheets to run on multiple processors, Dr. Hugon estimates that the time taken to complete complex analyses has been roughly divided by three, dramatically improving the ease and speed at which optimizations can be carried out. "Maple is proving to be a powerful and versatile tool and we are constantly finding new uses for it as we tackle different projects," he concludes.

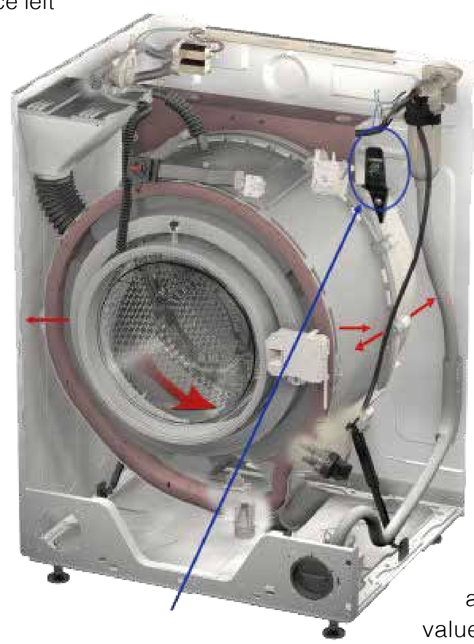
3-D Hall Sensor Algorithm Developed in Maple Produces a More Efficient Washing Machine Design

Marquardt GmbH

Dr. Frank Allmendinger leads a research and development project team at Marquardt GmbH, a German company that develops and manufactures switches and switching systems. His team designed an innovative three-dimensional load and imbalance sensor, which is used in a new washing machine model from a well-known company in the "white goods" sector.

> "I found Maple's user interface very easy and smooth to work with."
>
> — **Dr. Frank Allmendinger**, Marquardt GmbH

In industry, the trend is to move from washing machines with a drum capacity for 5 kg of laundry to larger ones with a capacity of 7 or 8 kg. However, these large drums are still being placed in the standard washing machine housing with a width of 60 cm, which means there is a much smaller space left between the drum and the housing. This means collisions are more probable. It is therefore necessary to measure the position of the drum relative to the housing, use this signal to identify impacts of the drum against the housing in advance, and react accordingly. Marquardt's sensor was developed to detect the relative position, in three dimensions, of the washing machine drum to the housing.



Having the ability to measure the drum position gives several other advantages; for instance, it is possible to sense imbalances and detect resonant frequencies of the mechanical system during the machine's spin cycle. These imbalances can be reduced by slowing the rotation speed and distributing the weight more evenly. It even becomes possible to measure a load of clothing as it is placed into the machine and give a recommendation of how much detergent to use!

The Marquardt team, in close collaboration with the Fraunhofer Institute for Integrated Circuits, developed a new 3-D Hall sensor application-specific integrated circuit (ASIC) that measures the three vector components of a dipole magnetic field. The complete measurement system consists of a magnet affixed to the drum in the washing machine and the 3-D Hall sensor ASIC attached to the unit housing. The Hall sensor measures both the direction and strength of the magnetic field, determining the relative movement of the magnet simultaneously in all three dimensions. This information is then communicated to the onboard microcontroller, which uses a proprietary algorithm to determine how to control the movement of the drum.

To develop the algorithm, the Marquardt group used Maple. Dr. Allmendinger found Maple to be an invaluable tool, allowing him to work on complex problems such as modeling the magnetic fields, estimating the allowed tolerances for the magnet, and determining whether the tilt of the 3-D Hall sensor module was within a very small tolerance of approximately two degrees. The resulting algorithm was translated to C code to run on the controller.

Dr. Allmendinger first worked with Maple while studying at university. He was impressed by Maple's ability to work with symbolic mathematics, its powerful graphing tools, its technical document interface, and its export capabilities to other languages (such as C, MATLAB®, and Java). Dr. Allmendinger said, "It was very simple to work in Maple, even with the complex mathematics involved. We found it quite easy to enter and modify equations, determine whether they had a solution, then go back and make necessary changes. I found Maple's user interface very easy and smooth to work with, especially the export capabilities; interoperability with other technical programs has become much better, and it is now invaluable in rapid solution development."

The new 3-D positioning algorithm in the Hall sensor yields several advantages. First, assembly is simple because there is no mechanical connection between the magnet and the sensor. As the measured values of the three magnetic field components can be recorded simultaneously, the sensor system also offers the option of calculating speed. Overall, the design enables natural resources to be handled more responsibly. The use of mathematic field modeling makes it possible to discard traditional 3-D mapping techniques and use a smaller, more cost-effective microcontroller. Also, fewer resources are used by creating the considerably smaller magnet.

NASA's Jet Propulsion Laboratory Begins Widespread Adoption of Maplesoft Technology

NASA's Jet Propulsion Laboratory

Maplesoft announced a major adoption of its products by NASA's Jet Propulsion Laboratory (JPL). JPL is implementing Maple, MapleSim, and MapleNet in its various projects. Whether creating America's first satellite, Explorer 1, sending the first robotic craft to the moon, or exploring the edges of the solar system, JPL has been at the forefront of pushing the limits of exploration.

Curiosity, JPL's latest space rover, which launched in 2012, aims to explore Mars to investigate whether the planet could have ever supported microbial life. Other JPL projects include spacecraft missions to comets, asteroids, and the edge of the solar system, as well as satellites that monitor the land, oceans, and atmosphere of our own planet.

Maplesoft products are expected to help JPL save time and reduce cost by providing more efficient and smarter methods for mathematical analysis, modeling, and simulation. Maplesoft solutions are built within a natively symbolic framework, avoiding some of the worst sources of error and computational inefficiencies generated by traditional, numeric-based tools, thus providing great tools for precision-rich projects such as those of JPL.

In addition to using Maple for advanced mathematical analysis, JPL will use MapleSim, Maplesoft's high-performance physical modeling and simulation platform, as a key tool in its engineering workflow. MapleSim works in combination with Maple. It accesses Maple's symbolic computation technology to efficiently handle all of the complex mathematics involved in the development of engineering models, including multi-domain systems, multibody systems, plant modeling, and control design.

"Maplesoft products will allow JPL to unify their approach to mathematics, modeling, and simulation," says Paul Goossens, Vice President, Applications Engineering, Maplesoft. "MapleSim's intimate connection to the underlying physics of the system models, combined with the knowledge capture and analysis capabilities inherent in Maple, will make project design and development faster and more accountable. JPL scientists will arrive at optimal solutions much faster, and their models will be much more reusable."

Maple and MapleNet Streamline the Development of Solar Panel Foil Systems

Eppstein Technologies • Dr. P. Waegli-Research

As a technology consultant, Dr. Peter Waegli works with a wide range of companies to bring the latest and most efficient technology to his clients. His firm, Dr. P. Waegli-Research, provides technology-based strategies and solutions to clients.

Dr. Waegli recently advocated the use of Maple in a project related to solar panels. Solar panels are composed of a collection of connected photovoltaic cells, and the type of cell interconnection technology affects the performance of the solar panel. Eppstein Technologies, a subsidiary of EppsteinFOILS, is a developer of innovative foil systems for interconnecting and encapsulating photovoltaic cells. In a recent project with Eppstein Technologies, Dr. Waegli used Maple and MapleNet to help the company streamline the development process of their foil systems.

Figure 1 - Light engine seen under an angle from the measuring plane, where the module is placed

> “Using MapleNet, I feel more in control of the data I share.”
>
> — **Dr. Peter Waegli**, Dr. P. Waegli-Research

Being a consultant, Dr. Waegli needs a software tool that provides him the flexibility to share his work with different teams, located in different places, without his clients having to invest in new software. MapleNet provides him that facility because of its internet-based delivery. “Using MapleNet, I feel more in control of the data I share. Unlike other tools, MapleNet doesn’t need a player, which makes it very easy and convenient to use.”

A simulation model for a module tester, which illuminates the test modules to measure their power conversion performance, was built in Maple. This model simulates the light distribution and intensity for various arrangements and specifications of the LED-sources. These results were then used to optimize LED positions, properties of the LEDs, and the collimation optics and distance of the LED assembly from the measuring plane. Based on the results of this optimization during the modeling phase, the tester light source was built and performed correctly on the very first try. Maple was then used to create simulation models of the modules. With virtual models of both the modules and the test platform, the company was able to optimize their designs early in the process, reducing the number of expensive physical prototypes they need to create and test.

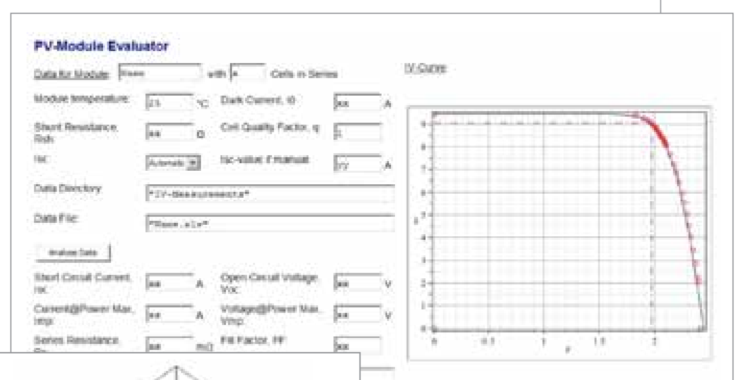


Figure 3 - PV-Module Evaluator user interface

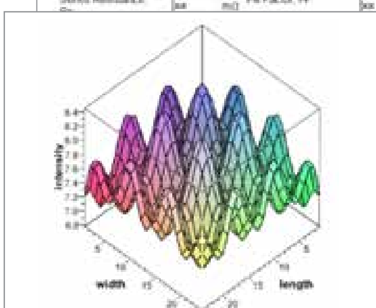


Figure 2 - Typical light distribution in the measuring plane over the area of an individual photo-voltaic cell

The model and the results were fully described in interactive Maple documents and shared using MapleNet. As a result, every design engineer on the project has access to the information and can run simulations with their own parameters online.

Dr. Waegli feels that Maple has significant advantages over its competition, “Maple is much easier to use compared to other, similar products. Its intuitive user interface makes it simple to manipulate parameters, and it has excellent compatibility with other tools. In addition, its document interface is very useful as it provides ample opportunities to document my work.”

Maple is Used by Ulysse Nardin to Lengthen the Running Time of New Watches

Ulysse Nardin

A Swiss watch manufacturer, Ulysse Nardin, is a pioneer in the innovative use of new technologies and materials in wristwatches. This company introduced the first silicon-diamond composite barrel spring in a wristwatch and continues to produce sophisticated new watches based on cutting-edge designs. Maple, the symbolic and mathematical calculation software from Maplesoft, is a key tool in the research process at Ulysse Nardin.

The architecture of mechanical pocket watches and wristwatches has long been based on the same principle. A leaf spring, which is the barrel spring or main spring, is wound inside a barrel drum. Because the dimensions of the spring and the drum are limited by the small volume available in watches, the mechanical energy stored in the barrel is also limited. The power reserve of the watch, that is, the running time of the watch at rest, without user interaction, depends on this stored energy. In most cases, the power reserve of a watch is about 48 hours. If the density of energy storage (the stored energy to volume ratio) can be maximized, the power reserve of the watch is also increased. This is why Ulysse Nardin initiated the development of a barrel spring made of composite materials giving an elastic limit and impact resistance far superior to the best steels known.

The watch designs require the production of several springs that are more than half a meter long on a silicon wafer that is limited to a diameter of 6 inches (15.4 cm). This limits the dimensions of the free spring, which means that a preform that is compatible with the tiling of the springs on the wafer must be selected, while imposing a varying thickness along the spring to obtain constant torque. To meet this challenge, Ulysse Nardin called upon Claude Bourgeois, an engineering consultant and former Centre Suisse d'Electronique et de Microtechnique (CSEM) researcher.

Claude Bourgeois used Maple to model and optimize these new composite barrel springs. The application developed in Maple associates the anisotropy of silicon with the integration of the characteristic differential equations to describe the behavior of the springs under large displacements. Maple made it easy to identify the critical parameters related to the required function and the figures of merit of the system. It also helped to establish analytical macromodels, which are useful elements for analysis and for developing new concepts. The first watch to use the new barrel springs was the Ulysse Nardin Freak Caliber, which has a power reserve of more than seven days.

While employed at the CSEM, Claude Bourgeois developed many other simulation applications with Maple. These applications involved anisotropic elasticity, piezoelectricity and electromagnetism, as well as gaseous and liquid microfluidics, in particular, during the development of high-performance resonators made of quartz, then of silicon activated by AlN, and many types of MEMS sensors and actuators.

Use of Maple optimizes financial modeling at Mitsubishi UFJ Securities International

Mitsubishi UFJ Securities

Maple, from Maplesoft is an advanced mathematics software extensively used in the research, engineering, and academic fields. With its vast functional libraries for symbolic and numeric computation, combined with an intuitive graphical interface, Maple offers finance professionals an ideal platform to develop, design, and implement solutions for various problems. These include visualization and pricing of an interest rate option with stochastic volatility or finding a particular solution to a jump-diffusion PDE. The tool has been used for many years at Mitsubishi UFJ Securities International, a large investment bank headquartered in London, England.

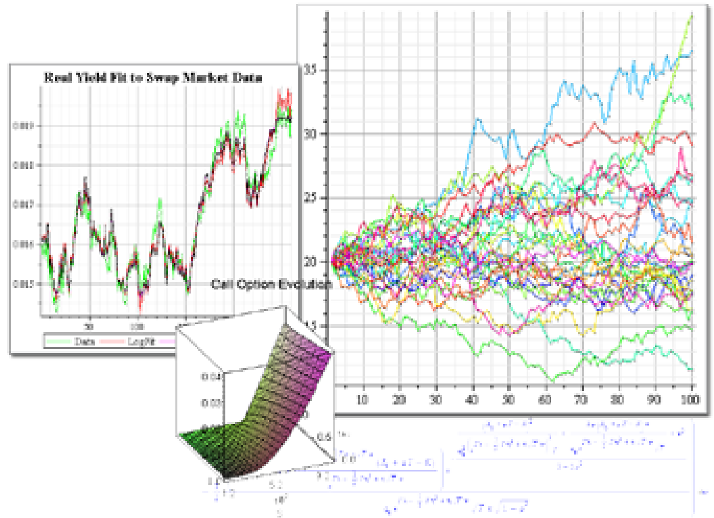
Igor Hlivka, Co-Head of the Quantitative Analytics Group at Mitsubishi UFJ Securities International, has been using the package for the last 10 years at various stages of financial product modeling, design, prototyping, and implementation.

Since modern finance theory draws heavily from theorems, rules and methods of mathematical physics, probability and statistics, Maple is ideally positioned and thoroughly equipped to assist financial modelers, developers, researchers, and structurers in finding the right answer to their needs and tasks. Many problems in finance focus on the notion of fair value, risk, or sensitivity. To get there, one needs to come up with a valuation model, find a set of input parameters, solve equations, and optimize the whole process for speed and accuracy. Equally important is the ability to present, visualize, and document the work so that any user can intuitively understand it. This is where Maple becomes particularly effective.

Hlivka has been working with Maple predominantly in derivative product modeling and development where he relies heavily on Maple's symbolic engine and refined numerical routines to assist him in complex modelling tasks.

"I have worked with a number of mathematics software packages; however, I found Maple the most comprehensive and best-structured product on the market," said Hlivka. "My preference for Maple stems from the attributes I have discovered in it over years of active interaction. From my perspective, Maple is powerful, robust, flexible, intuitive, and user-friendly. I particularly appreciate Maple's ability to prototype models quickly and effectively and use it as a benchmark for implementation work on other programming platforms. One can build a complex model or solution with just a few lines of Maple code and thoroughly document it too. This, for example, is all one needs to visualize and price an interest rate option with stochastic volatility."

Maple is particularly useful when one requires frequent interaction with calculus (both functional and vector), linear



algebra, probability and statistics routines, optimization, integral transforms, and all types of differential equations (ordinary, stochastic, and partial).

For example, finding a particular solution to a jump-diffusion PDE with Maple is not a difficult task.

"Although deriving a model's price is an essential task, where Maple becomes truly competitive is at comparative static – differentiation of a model's price with respect to various input variables," continued Hlivka. "Obtaining CMT (Constant Maturity Treasury)) first and second derivatives with respect to yield is not particularly easy. However, Maple returns an elegant answer that can be evaluated in arbitrary dimension."

What I like in Maple in particular is the intuitive logic. Maple knows how to handle sub-expressions and partial routines even if the process depends on numerical methods to solve it. I can still differentiate an option pricing formula with stochastic / jump-diffusion volatility, even though the final result is derived through numerical integration. That's the clever and highly efficient implementation that makes Maple a versatile tool for financial engineers," added Hlivka.

"Maple's Statistics package is the most comprehensive set of rules and routines in any general purpose math package," explains Hlivka. "It provides the breadth and depth of probabilistic and statistical routines one needs in financial data analysis. On the other hand, the Finance Toolbox is a selection of more than 100 functions and routines designed for modelling, simulation, and pricing of almost every type of financial product currently traded in the market. With this addition, Maplesoft has clearly positioned itself as a serious contender and the first choice solution provider in this market segment. "

Maple Helps Ford Motor Company with Analytical Predictions of Chain Drive System Resonances

Ford Motor Company

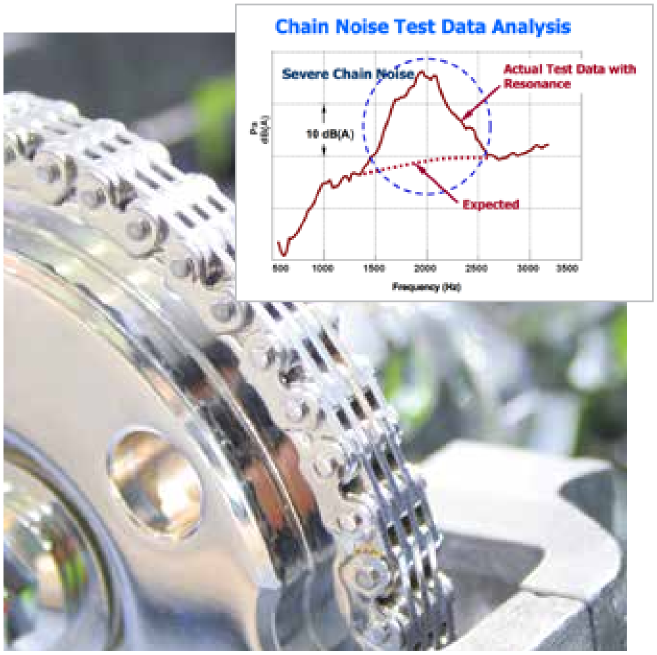
Like other automotive manufacturers, Ford Motor Company wrestled with a common concern – incessant noise and vibration in chain drive systems. Chain drives have been widely used for power transmission in automotive systems for decades. While chain drives are effective, undesirable noise and vibrations have always been a problem. This was particularly the case when Ford detected a severe 1800 – 1900 Hz chain noise in a new transmission prototype. Sound pressure levels were 10 -15 dB over nominal values and the cause was unknown.

At Ford, Jack S.P. Liu, Das Ramnath, and Rajesh Adhikari set out to understand the source of the noise and develop simple, analytical models for quick computation of the chain drive system resonances.

Earlier experimental research identified chain-sprocket meshing noise as the most significant noise source, and suggested that chain drive system dynamic parameters such as speed, tension, mass and pitch of the chain, sprocket inertia, and the natural frequencies of the chain sprocket system are closely related to the meshing noise. The Ford team took on the challenge of analytically predicting chain drive system resonance based on the assumption that existence of chain resonances can amplify the radiated chain meshing noise.

The team started with the analysis of the chain noise test data and compared this with the theoretical mathematical model. Their results indicated that three types of chain resonance existed: the transverse strand resonance, the longitudinal chain sprocket coupled resonance, and the longitudinal chain stress wave type resonance.

To help deal with the complex calculations and analysis involved in developing these advanced models, Ford used the mathematical software Maple. Its extensive symbolic and numeric math solvers were used in modeling the physical system to gain an understanding of the vibrational behavior. The partial differential equations used in the model were solved quickly and easily using Maple's world-leading differential equation features. When presenting results, such as the eigenfunctions that represent the unique mode shapes of the natural resonant frequencies, Maple's extensive plotting capabilities were indispensable. In addition, the unique documentation capability of Maple enabled Ford to publish integrated worksheets and reports for easy and convenient dissemination across the organization.



By using Maple, Ford could validate mathematical model predictions against both an ABAQUS CAE model and the experimental test results. Also, Ford created a predictive design tool to develop analytical models and predict chain drive dynamics using Maple's embedded components, including features such as variable slider inputs to modify design variables. This design tool will enable other technical staff to perform future predictions of chain-drive resonances in a quick and easy manner.

> "We were amazed at the power of Maple. Its analytical power and modeling capabilities enabled us to get the accuracy we were aiming for."
>
> — **Jack S.P. Liu**, Ford Motor Company

"We were amazed at the power of Maple. Its analytical power and modeling capabilities enabled us to get the accuracy we were aiming for," said Jack S.P. Liu, a CAE engineer at Ford Motor Company. "I especially appreciate embedded components and their role in GUI design. Maple's symbolic math capability exceeds that of other CAE tools in areas where we used it."

The Ford team was able to accurately determine the exact locations of the 1800 Hz noise source and the problematic noise peak. By combining transverse and longitudinal natural frequencies, both the analytical and CAE models predicted the 1800-1900 Hz longitudinal chain resonance as observed in chain test data. The team concluded that a thorough understanding of all types of chain resonances is critical for powertrain engineers to design a quiet and smooth chain drive system.

Maple Helps Engineers Design Propulsion Systems For Some of The World's Biggest Ships

MAN Diesel & Turbo

Ships keep the global economy moving. Whether they are ultra large crude carriers transporting oil from the Middle East, container vessels transferring manufactured goods from Asia or car carriers shifting vehicles from factories in Europe, the global maritime industry moves around 32 trillion tonne-miles of cargo every year, four times more than it did at the end of the 1960s.

To deliver this dramatic increase in cargo, the industry has had to change drastically over the past few decades. Vessels have become larger and more efficient as shipping companies work strenuously to keep costs down in the face of rising and ever more volatile fuel costs. For marine engineers, that means constant pressure to refine the performance and reliability of vessels and their systems. Nowhere is that pressure felt more acutely than in the most fundamental component of any modern powered vessel: its propellers.

MAN Diesel & Turbo, headquartered in Germany, is at the forefront of the quest for improved performance in marine propulsion systems. MAN designs and builds marine propulsion systems from 4 to 40MW in size, with controllable pitch propellers (CPP) of up to 11m in diameter and even larger for fixed pitch propellers. The world-leading technical computing software, Maple, from Maplesoft is playing an important role in keeping the propellers efficient and dependable, thus keeping costs down.

In cooperation with Rudolf Diesel, considered the father of the diesel engine, MAN produced the first diesel engine in 1897. The company has been manufacturing propellers for ships since 1902 and has designed, manufactured and supported more than 7,000 propeller plants.

Modern controllable pitch propellers, like the MAN Alpha CPP range, improve the efficiency and manoeuvrability of marine vessels. In propellers of this design, the angle of the blades is controllable, always providing the optimal match between the speed of the engine and the ship, thereby maximizing propulsive efficiency and permitting precise control of the vessel's speed. This is important when manoeuvring into a port, for example. The blades can even be set to provide reverse thrust, which eliminates the need to install a separate reversing gear or use a reversible engine.

Mads Hvoldal is a mechanical engineer at the MAN Diesel & Turbo Propulsion Competence Centre division in Frederikshavn, Denmark. He works for the team that designs the mechanical and hydraulic control systems used to vary propeller pitch. "We produce a range of standard designs but it is the nature of the industry that many propulsion systems are engineered for specific vessels," he explains. During peaks in demand for new vessels, development of hundreds of different designs per year is common. They need a software system that is robust and flexible.

"We start with the basic specifications, the available hydraulic oil pressure, the size of the propeller itself and the rate at which we need the blades to change pitch," says Hvoldal. "We use those parameters to calculate the required sizes of components, both for standard parts like bolts and flanges and for the engineered components used in the system. We then pass those dimensions to our Pro/Engineer 3D modelling system for detailed design."

The part sizing calculations are complex, taking into account the characteristics of the hydraulic control system and the properties of the materials used to make the final parts. They are also critical: transmissions need to perform well and operate reliably over long service lives in tough marine conditions. Shipping is also an intensively cost-competitive business, so over-sizing or over-engineering parts is not an option. After careful consideration, they chose Maple to help them in this complex design process. They chose Maple for its speed and accuracy.

"We started using Maple for our design calculations, replacing another mathematical software package," explains Hvoldal. "The other system required us to transpose all the relevant equations from their original format into its own language before we ran the calculations. It was a time consuming process to write the translations by hand and then to check them."

"I had quite a lot of experience using Maple in hydraulic systems design in a previous role," he explains. "So I could see its potential benefits in our current work." The critical advantage of Maple, he notes, is that the engineers can put the design equations in their original form right into the system. "That makes Maple faster to use, with reduced need to check and debug the code."

MAN Diesel & Turbo, Propulsion Competence Center, Frederikshavn, has been using Maple for around six months and the power, speed and efficiency of the system has convinced its engineers that there is potential to expand their use considerably in the future. "So far, Maple has replaced our previous system for design calculations," concludes Hvoldal, "But we are now exploring the feasibility of building standard models to simplify and automate the process further, and of automating the links between our initial calculations and the detailed part models in the 3D CAD system."

Broadcasting Benefits of Math and Analysis Software

Arqiva

Maple is helping broadcast network operator Arqiva to model antennas and analyze systems, ensuring that broadcast signals are received over the specified range.

Responsible for much of the UK's broadcast and mobile communications infrastructure, Arqiva delivers wireless, satellite, and terrestrial broadcast services to a growing number of countries around the world. All land-based transmissions for UK television stations, including the new digital networks as well as wireless provision for cellular, wireless broadband, voice, and data services for both commercial and government markets, are handled by the company. Ensuring that its stations conform and deliver the power and coverage needed is paramount.

Arqiva engineers are constantly upgrading the capabilities of their products and the software tools they use. "In order to fully understand how our products work and the nature of the maths behind it, we need something to quickly and simply check what is happening," says Arqiva Senior Technologist Karina Beeke. "Maple offers just that, with 3-D graphics and an easy interface."

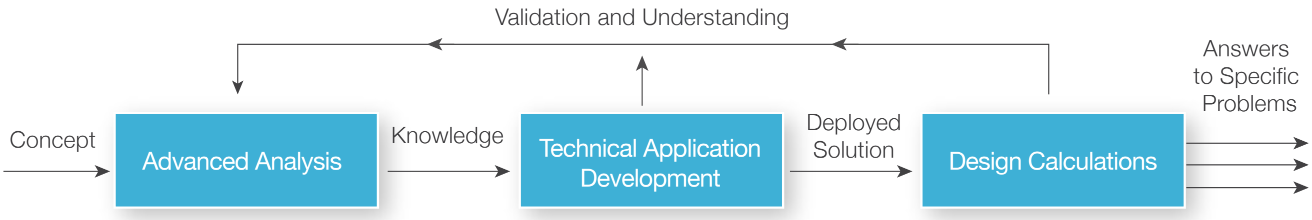
Maple allows analysis in engineering and science projects to be streamlined and the quality enhanced. With fly-through animations and 3-D plot annotations, the package includes advanced mathematical functions and point-and-click tools for control systems design. With features such as context-sensitive menus and powerful problem-solving tools, the software is intuitive and can be used with little training.

Having a wealth of features useful to Arqiva, Maple includes space curve, aptitude, curve fitting, and the ability to rotate and zoom in to elements. A major benefit, according to Karina, is its flexibility and range, "With Maple we can start simply and then develop as we go without having to completely understand the full capability." Arqiva also uses the Maple Global Optimization Toolbox to help with matching antenna features for best fit.

Karina is also positive about the 'very good support' and the extensive online resources available from Maplesoft. A user forum complements an online library of algorithms and a troubleshooting guide.

Maple™: From Concept to Deployment

Maple provides a complete environment for rapid technical solution development within any technical organization. From original concept to solutions deployed in the field, Maple is with you every step of the way.



Advanced Analysis

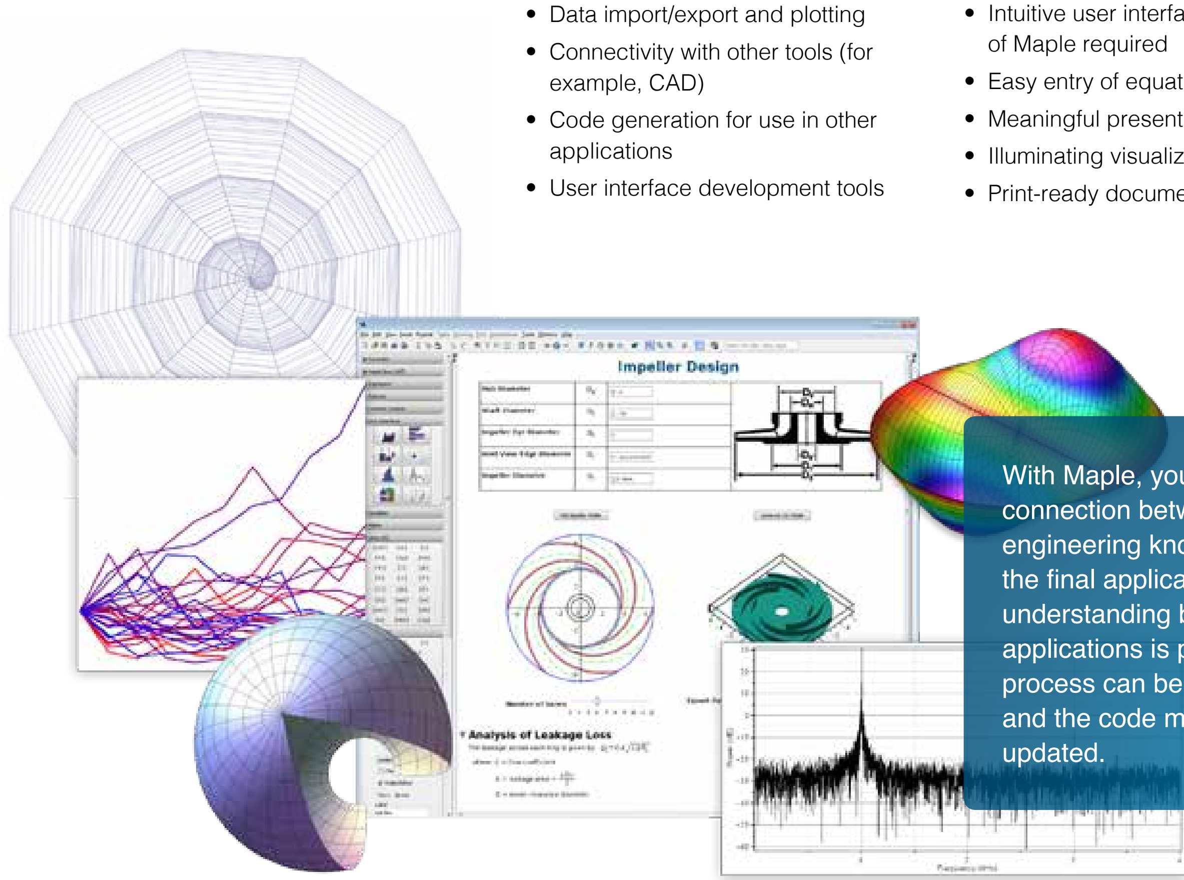
- Intuitive problem entry
- Powerful symbolics
- Advanced numerics
- Data import/export and plotting
- Rich environment for technical documentation

Technical Application Development

- Powerful, flexible language
- Parallel computation
- Advanced code development tools
- Built-in numeric algorithms (for example, signal processing and optimization)
- Data import/export and plotting
- Connectivity with other tools (for example, CAD)
- Code generation for use in other applications
- User interface development tools

Design Calculations

- Multiple deployment options include those that do not require the use of Maple by the end user:
  - The free Maple Player™
  - Online through a MapleNet web server
  - Maple
- Intuitive user interface – no knowledge of Maple required
- Easy entry of equations and data
- Meaningful presentation of results
- Illuminating visualizations
- Print-ready documents



With Maple, you get a strong connection between your engineering knowledge and the final applications, so the understanding behind the applications is preserved, the process can be validated, and the code more easily updated.

About Maplesoft

Maplesoft, a subsidiary of Cybernet Systems Co. Ltd. in Japan, is a global provider of high-performance software tools for engineering, science, and mathematics. Its product suite reflects the philosophy that given great tools, people can do great things.

Maplesoft's products help to reduce errors, shorten design times, lower costs, and improve results. Maplesoft's core technologies include the world's most advanced symbolic computation engine and revolutionary physical modeling techniques. Combined together, these technologies enable the creation of cutting-edge tools for design, modeling, and high-performance simulation.

Engineers, scientists, and mathematicians use Maplesoft products to enable them to work better, faster, and smarter. Maplesoft's customers include Ford, BMW, Bosch, Boeing, NASA, Canadian Space Agency, MDA, Microsoft Research, Ulysse Nardin, Liebherr, Mitsubishi Securities, Cleveland Golf, Stanford University, the University of Waterloo, TU Wien, Cornell University, the State University of New York, and the University of Notre Dame, covering sectors such as automotive, aerospace, robotics, electronics, defense, energy, financial services, entertainment, and academia. With Toyota, Maplesoft founded the Plant Modeling Consortium to promote the development of new design techniques for automotive and related industries.

About Cybernet Systems Co., Ltd.

CYBERNET SYSTEMS in Japan provides world-class solutions and services in the CAE and IT areas.
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