Smarter Multiphysics CFD

Software Cradle Empowers the Future of Co-simulation

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HEXAGON | Cradle

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In the real world we all inhabit, we know that we experience physics-related phenomena: fluids act in harmony with structures, fluids with magnetics, fluids with electrics, and all in a myriad of complex and very complicated ways. Numerical approximations such as Computational Fluid Dynamics (CFD) have to grapple with these phenomena; frequently with simplistic empirical models to approximate boundary conditions, include chemical and biological reaction effects, fluid and solid phase change and multiphase flows, and not least transient phenomena related to turbulence that still is approximated by the scientific community. Nevertheless, the inherent technical benefits of CFD from its predictive insights to product verification & validation, and business benefits such as reducing costs, right-first-time designs, higher manufacturing productivity, elimination of waste, minimizing product recalls, and faster product time-to-market still remain.

The commercial CFD industry is almost 50 years old today and over $1 billion per year in size, and it has come on a long way in its first five decades. We have migrated from cartesian, castellated, stair-step grids, and simple models run on mainframe computers to embracing body-fitted geometries, and the CAD and PLM revolution. Further, rapid advances in computer hardware and memory speed fueled by 'Moore's Law' have transformed the software to what we see today with easy-to-use software available on-demand on our laptops and now increasingly on the cloud. Better postprocessing and interrogation of results, design space optimization, and virtual reality have all been embraced by CFD. Yet, the fundamental equations of fluid flow, heat and mass transfer are still the very same and the challenge of multi-disciplinary physics simulation in the context of CFD is still not being fully harnessed by the industry.

This e-Book sheds some light on the diversity of cutting-edge applications touched by fluids engineering today, encompassing compelling case studies demonstrating the scope and range of applications in which CFD simulation is helping industries and companies innovate. Industrial leaders and technology innovation centres from all industries are leveraging CFD solutions to better understand, improve and validate their new designs or enact countermeasures. Discover in this e-Book how Panasonic, Boostheat, Analog Way, Goldwin, and Stirling Aviation relies on Cradle CFD simulation to meet both their customers' expectations and legislative regulations. A less obvious sector where CFD plays a significant role today is the environmental and sustainability sector. Tokai University in Japan has used CFD simulation for over a decade to validate the integrity of their multiple competition winning Trans-Australia solar car designs. Finally, you can also read about how engineers at Kindai University are employing Cradle CFD solutions to understand the movement of Bluefin tuna in our oceans to help preserve and grow fish stocks.

At Software Cradle, we are proud of our suite of CFD products that embrace everything from simulating Couette flows to hypersonic shocks, from applications spanning aerospace and automotive to shipbuilding and mining applications, and everything in between. And, with a 36 year pedigree of robust, accurate, pragmatic, usable tools we have put in place a strategy to deliver multiphysics-focused CFD solutions to our community of users led by our flagship scFLOW and MSC CoSim software products, the most modern toolsets in the CFD market. Since CFD, now more than ever, is at the centre of global environmental challenges and product technology differentiators, this e-book intends to serve as a compilation of useful customer application insights on the role of modern multiphysics-focused CFD led co-simulations pioneered by Software Cradle and MSC Software today.

Jonas Wigart

Product Marketing Manager –
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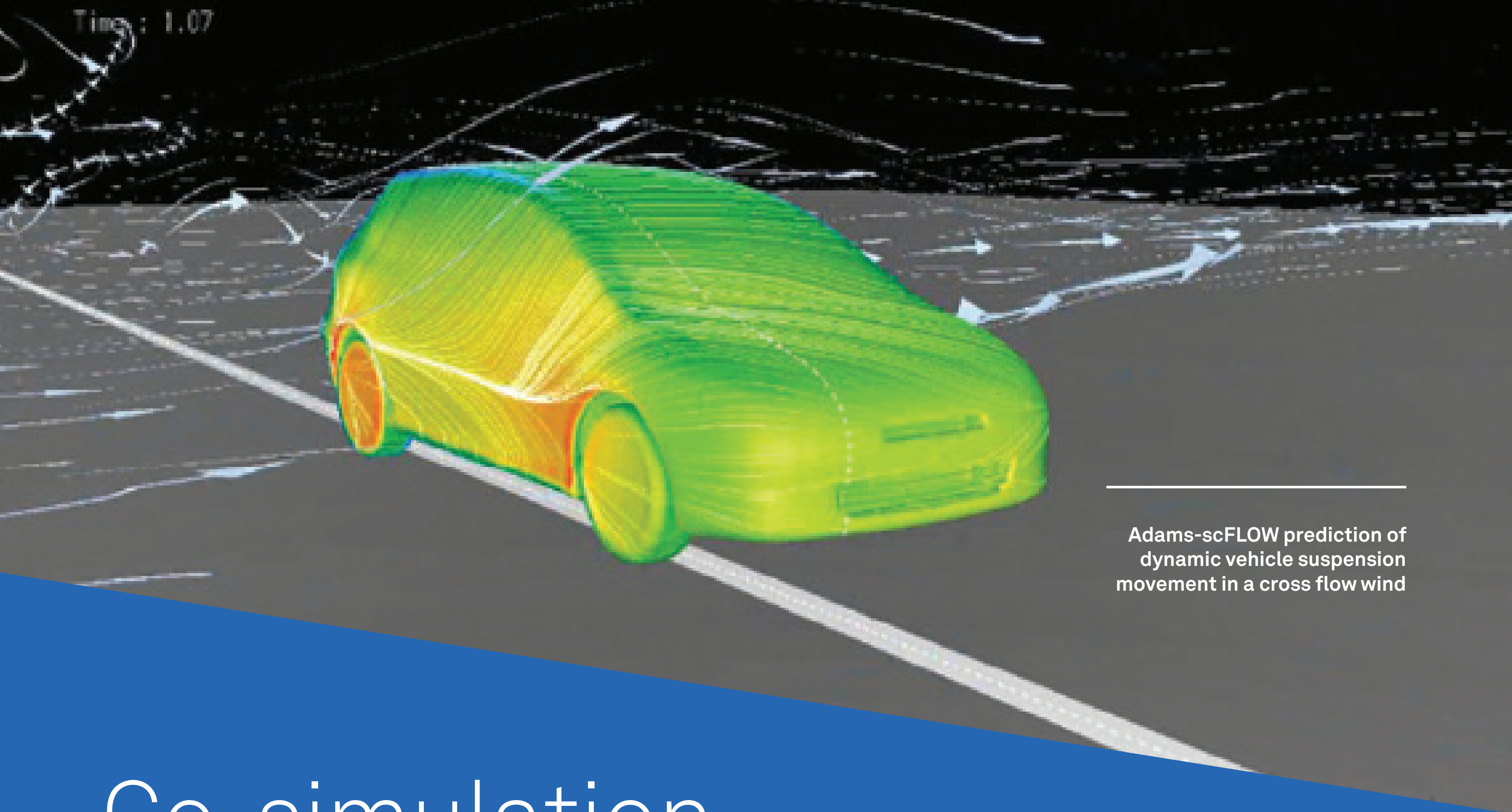

Adams-scFLOW prediction of dynamic vehicle suspension movement in a cross flow wind

Co-simulation - Breaking the Back of **Multiphysics CAE Simulation**

By **Dr. Keith Hanna, Vice President Marketing, MSC Software**

Over the last 20 years or so, one of the 'holy grails' of Computer-Aided Engineering (CAE) has been 'multiphysics' simulations, i.e. co-simulations between different physics simulation types (Ref. 1). Multiphysics, even though an ill-defined term, kind of feels intuitively right to us engineers from the perspective of real-world engineering simulation. Fluids don't usually exist in isolation from structural effects, or acoustics, or dynamics in the real world we inhabit, yet for many years past, engineers have simulated these subdomains of physics as isolated point simulation solutions in CAE. I have to add a rider here that my Physics teacher at High School, Mr Copeland, would have taken me to task for using the word 'multiphysics' at all because strictly it is wrong. There is actually only one discipline of physics, as there is for chemistry and biology. Within physics, there are subdisciplines like Newtownian Laws of Motion (and fluids),

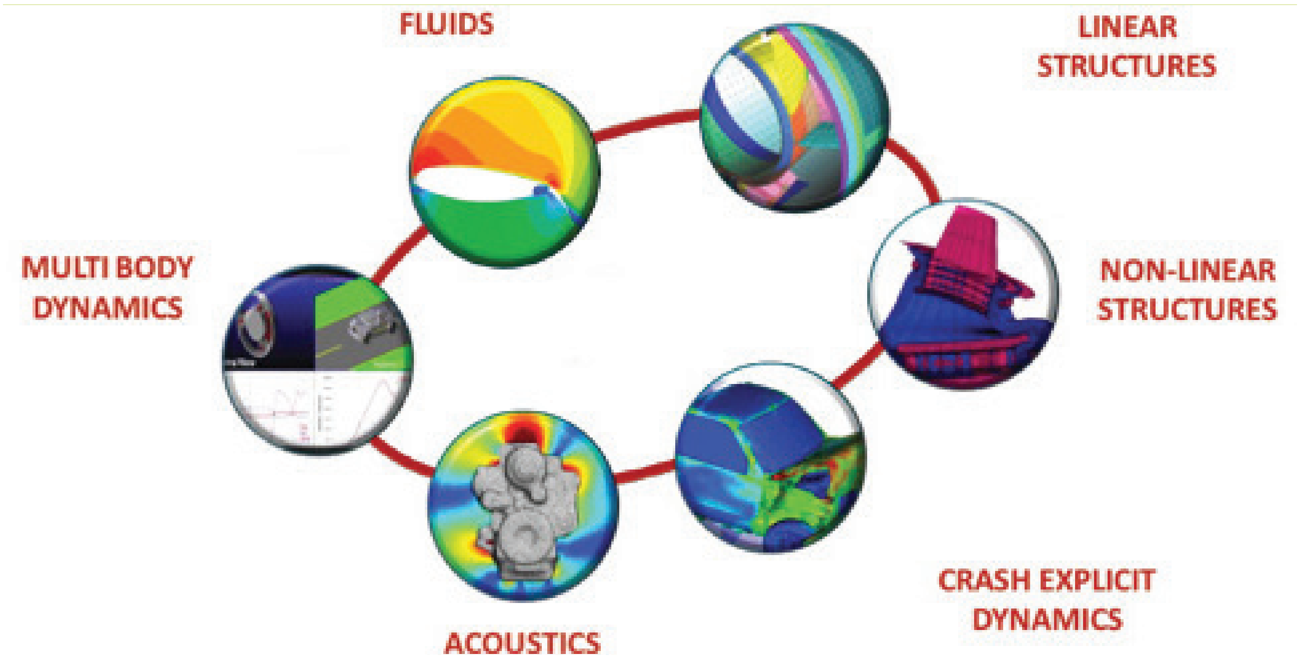

Figure 1. MSC's Unique Multiphysics Co-Simulation Capabilities

Maxwell's Laws of Electromagnetics, Structural Stress-Strain laws, etc. This 'multiphysics' word that was coined in the 1990s is actually a consequence of a failure of the CAE industry to solve the fundamental underlying physics equations in a combined way, in my opinion. Partly, this is due to practical problems that we find because of different mathematical techniques. For instance, Finite Volume Methods (best for fluids), Finite Element Methods (best for structures and acoustics) mean that for more efficient solver convergence in real world engineering problems, one or the other is chosen as the best methodology. And partly, software vendors have struggled to grapple with the multiphysics challenge to deliver usable engineering simulation tools because the mathematical approaches don't tend to gel well together when combined.

Co-Simulation Multiphysics area	Products Involved	Industries	Applications
Fluid-Structure Interaction (FSI)	Nastran / Marc + scFLOW/scSTREAM	All	Aeroflutter, Valve opening, MEMs, VIV, Suspension Loads, Thermo-Mechanical Stress...
Structural & Aeroacoustics	Nastran / Marc + scFLOW + Actran	All	Cabin Noise, Door Rattle, Noise & Vibration...
Multi-Body Dynamics & Fluids	Adams + scFLOW	All	Large Particle Movement, Vehicle Side Wind Events, Vehicle Running Over a Puddle...
Virtual Drive & Vehicle Dynamics	Adams + Vires VTD	Automotive	Autonomous Vehicles, ADAS Validation, Real Time Vehicle Driving Simulator...
Particulates & MBD & CFD	Adams + EDEM, EDEM + scFLOW	Auto, Aero, Chem & Proc,	Car Stability on a Surface, Filtration, Bulk Material Handling...
MBD & Nonlinear FEA	Adams + Marc	Automotive	Door Sag & Closing, Vehicle Extreme Load Cases (eg. hitting a kerb), Running Over an Obstacle, Battery Pack Deformation...
1d Systems & MBD & Controls	Adams + Easy5 / Matlab Simulink / Maplesoft / GT Suite etc.	All	Robot Arms, Machinery, Landing Gear system, Vehicle ABS, ESC, Traction Control...

Table 1. A cross Section of Co-Simulation CAE applications connected to the MSC Software Solution Suite

What was very striking about MSC Software when I joined earlier this year, apart from its 50+ year history stretching back to the early NASA moon landing project, and the desire for accuracy in software solutions, is a largely understated history of endeavoring to provide world-class CAE co-simulation solutions to its customers as well as engineers everywhere. Everything from acoustics to Multi Body Dynamics (MBD), to CFD, to structural analysis, and explicit crash dynamics can be connected together in MSC (see Fig 1). I have gathered together a multiplicity of multiphysics co-simulation applications that can be done with MSC software tools today, both in two-product couplings, as well as in toolchains of product simulations that were mere pipe dreams a few years ago (see Table 1).

Multi-Body Dynamics Led Co-Simulation

When one digs down, one soon discovers that the market leading Adams MBD product is being used extensively for industrial grade co-simulations around the world today as a matter of course, and is open to connections with all sorts of commercial and open-source software (see Figure 2). Some notable recent innovations are connections to the market leading Discrete Element Modeling software, EDEM, from DEM Solutions, as illustrated by Figure 3, VIRES Virtual Test Drive (VTD) for ADAS and autonomous vehicle drive simulation (VIRES has been part of MSC/Hexagon since 2017), and of course MATLAB & SIMULINK for 0D/1D systems and controls modeling (from MathWorks). Adams coupled with Marc can solve wiper blade movements, hydraulic actuators, rubber door seals, and full vehicle bush modeling. I will go into more detail below about the exciting new co-simulation multiphysics capabilities that the CFD software acquisition of Software Cradle by MSC Software in 2016 is now beginning to open up for CFD and CAE engineers alike. A very complex and challenging dynamic co-simulation is shown in Fig 4 where a non-linear bending and twisting metallic flap in a cross flow was simulated in an scFLOW - Marc - MSC Nastran toolchain.

Acoustics Led Co-Simulation

Actran is recognized to be the market leader in acoustics simulation with a twenty-year history behind it and a blue chip user base worldwide. It has many multiphysics acoustic applications like the classic one of coupling with CFD for aeroacoustic analysis. Actran provides today a complete end-toend solution from mechanical load prediction to noise and

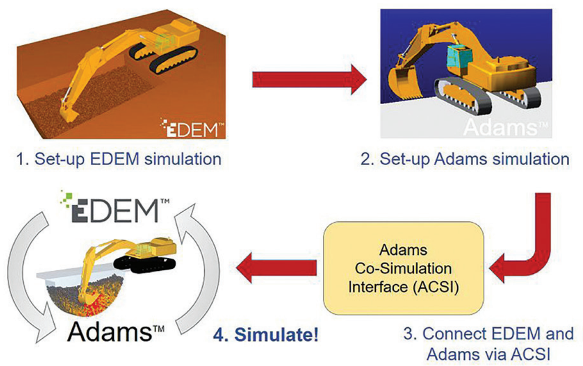

Figure 3. MSC's Adams MBD Co-Simulation Capability with EDEM from DEM Solutions

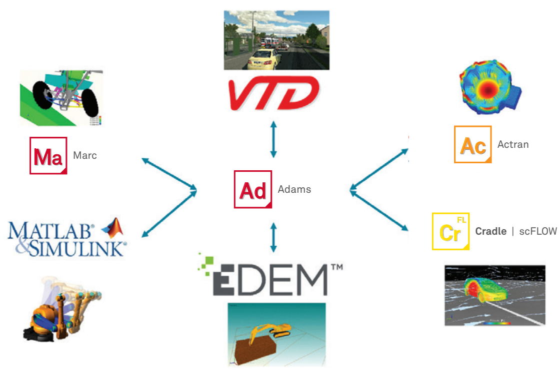

Figure 2. MSC's Adams MBD Co-Simulation Capability Ecosystem

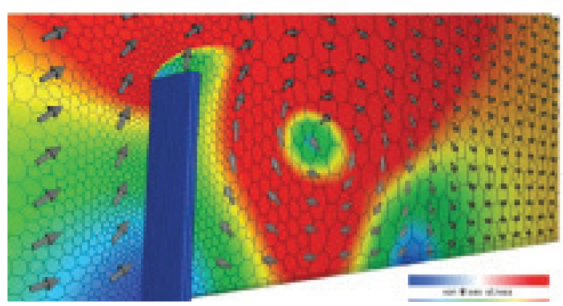

Figure 4. MSC's Nastran – scFLOW - Marc Co-Simulation of a flap bending and twisting in a crossflow

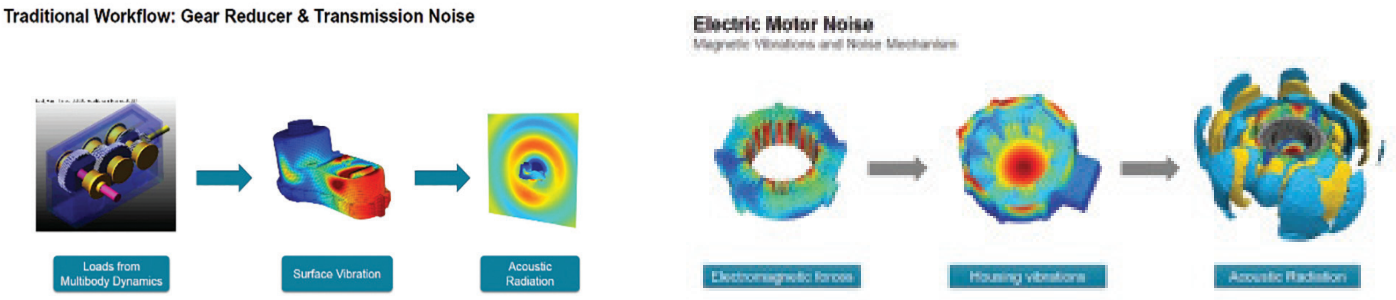

Figure 5. MSC's Adams – Nastran and Actran Conventional Automotive Powertrain Co-Simulation Toolchain (left) and E-Mag – Nastran – Actran e-Powertrain Toolchain for Acoustics (right)

mechanical load prediction to noise and vibration assessment. In a recent Webinar, (Ref. 2) my colleagues Romain Baudson and Yijun Fan looked at acoustic predictions for electric vehicles with Actran-led toolchains. Fig 5 shows the two toolchains they employed in their cosimulation analyses. Multibody simulation with Adams provides the structural loads when the conventional powertrain is operating, then MSC Nastran was used for vibration analysis. Finally, noise radiation is then computed with Actran with high accuracy in a fully automated process. By comparison, for Electric Vehicles, electromagnetic simulation results from various third party software (for example, JMAG, MagNet, Maxwell…) can be integrated with MSC's FEA tools for electric motor noise prediction. In doing so, Actran provides accurate noise predictions for both the electric motor and the gear reducer. Finally, a relatively recent acoustics and fluids co-simulation is illustrated in Figure 6 between Actran and scFLOW from Software Cradle where an automotive exhaust and muffler system was modeled in CFD and coupled with Actran for acoustic noise prediction.

CFD Led Co-Simulation

Computational Fluid Dynamics (CFD) has long been a passion of mine and it is genuinely quite exciting to see what is happening in Japan with Software Cradle's co-simulation CFD efforts. They have devised a remarkably robust and open software platform for co-simulation (see Fig 7). Software Cradle's CFD products – scFLOW (that employs polyhedral meshes), scSTREAM (with Cartesian meshes) and SC/Tetra (with tetrahedral meshes) have a long history of use by large OEMs and leading Japanese companies and come with a strong technical pedigree.

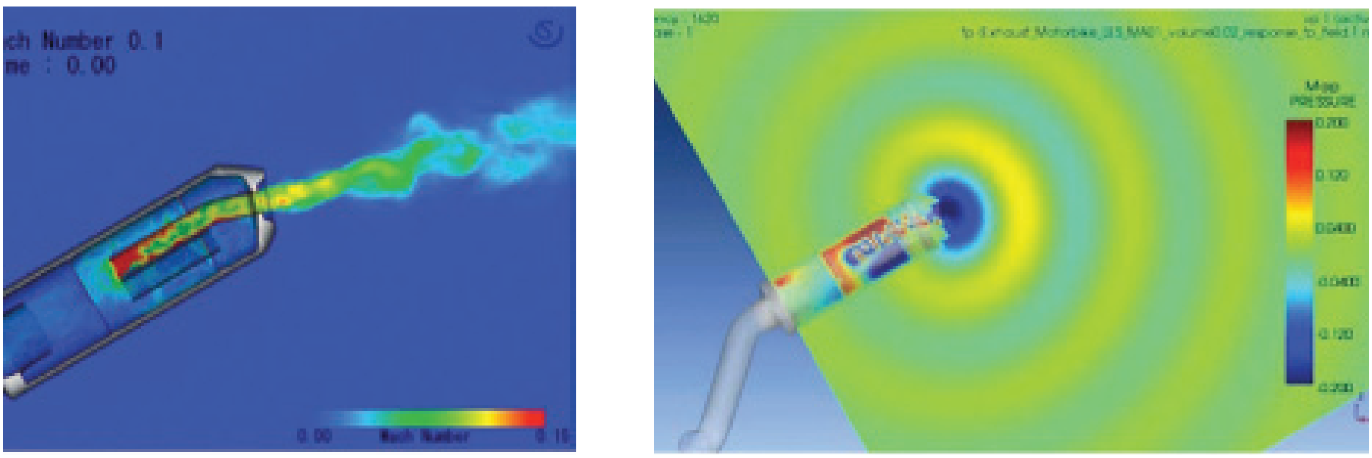

Figure 6. MSC's Cradle CFD and Actran Acoustics co-simulation for an Automotive Exhaust and Muffler Aeroacoustics Prediction

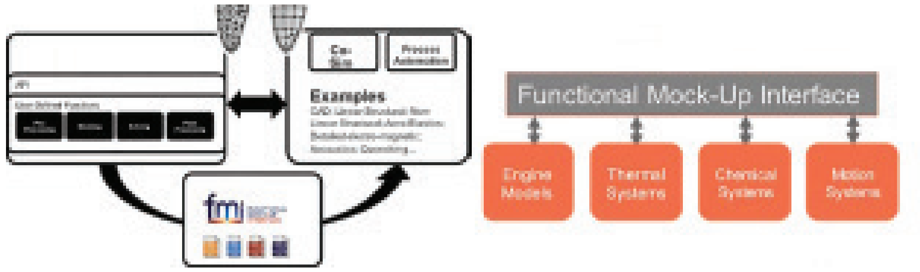

Figure 7. Software Cradle's Open Coupling CFD Platform (Left) and FMI Interfaces (Right)

They are technology leading in free surface and overset meshing techniques with fast, accurate and robust approaches. Physical quantities can be passed between third party and MSC's CAE software and Cradle's CFD tools using its FMI (Functional Mockup Interface). The FMI supports general physical quantity settings, user-defined functions, and script languages. With Adams in particular, this co-simulation approach can do large particulate flows on free surfaces (Figure 8), vane pumps, washing machine drum vibration, and MBD fuel tank sloshing (Figure 9) for instance. A really exciting MBD application is that of a vehicle driving through a large puddle with suspension effects taken into account by Adams or the same vehicle's dynamics in a cross wind (Figure 10). Co-simulation with Marc
means that Cradle CFD couplings can do aircraft fuel tank baffles, liquid quenching, flexible plates / membranes / valve seals (Figure 11), and Sirocco fans. When coupled to MSC Nastran, scFLOW can do FSI of ship's propeller with cavitation effects included for example (see Figure 12).

It's the really cool co-simulation CFD applications that catch your eye the most, however. Software Cradle have coupled Adams with scFLOW to look at dynamic aircraft wing and flap deployment aerodynamic predictions (see Fig 13).

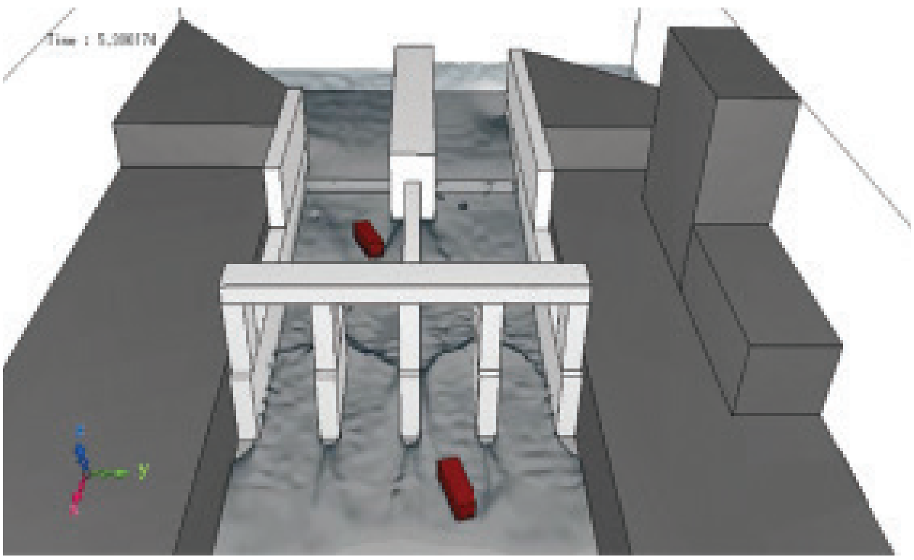

Figure 8. Adams – scSTREAM prediction of large logs in a channel free surface flow

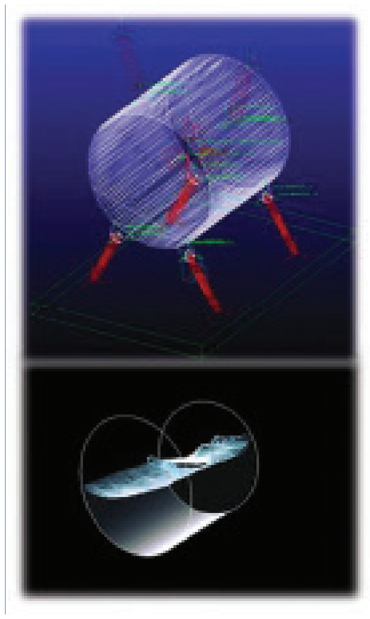

Figure 9. Adams - scFLOW prediction of dynamic sloshing of liquid in a tank

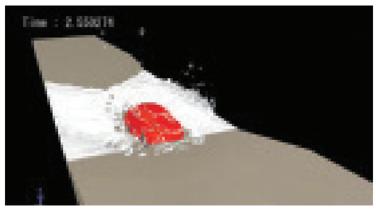

Figure 10. Adams – scSTREAM prediction of a dynamic vehicle suspension movement through a puddle

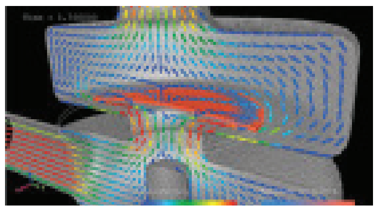

Figure 11. FSI analysis using Marc and scFLOW of a Valve with an Elastic Membrane deformed by flow

Figure 12. MSC Nastran - scFLOW prediction of propeller with free surface and cavitation

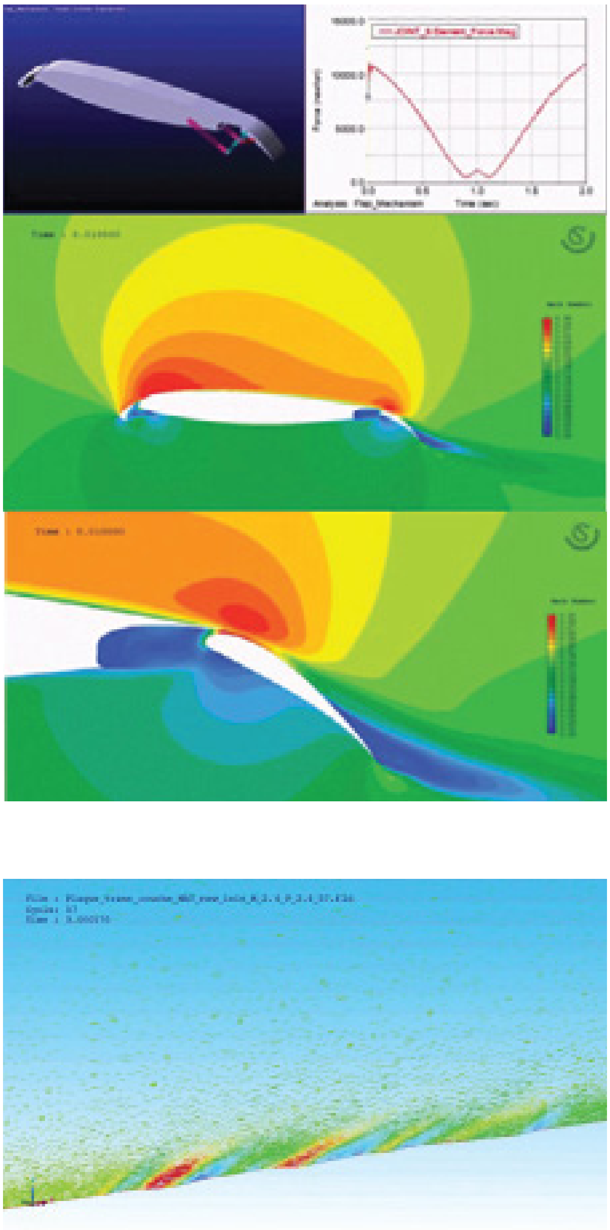

Figure 13. Adams - scFLOW dynamic prediction of wing flap deployment aerodynamics (above top) and a vibrating supersonic plate shock structure co-simulation in MSC Nastran – scFLOW CFD (above bottom)

predictions (see Fig 13). Another exciting new aerodynamic co-simulation application between scFLOW and MSC Nastran / Marc is non-linear panel flutter of a supersonic plate (Ref 3), involving a highly unusual coupled undulating vibration of the flat plate's surface at high speeds resulting in moving shocks on the surface (see Figure 13). It was accomplished by my colleague Fausto Gill di Vincenzo in Italy who employed our seamless MSC Nastran - scFLOW CFD coupling technology for an efficient and fast solution. The CFD domain deformation prediction was done with sliding mesh capabilities and then the FEA was performed by MSC Nastran and Marc. The CFD elements used could be tets, hexas, or polyhedral elements.

Finally, another area of interest of mine is thermomechanical stress predictions for electronic components on chips and PCBs (Printed Circuit Boards). This application too is quite difficult to do as a co-simulation by most commercial vendors. In Figure 14, an electronic chip resistor has been simulated that undergoes repeated heat generation by its own on-off actions (Ref. 4). This will eventually cause the breakage of its solder joints over the lifetime of the component and ultimately product failure. Being able to predict it in advance and to locate high stress areas is very important. Temperature distribution predictions from scSTREAM were mapped onto the mesh of the structural analysis solver (eg MSC Nastran or ANSYS Mechanical). The stress on the solder connection was then predicted. This is a very powerful way of predicting failure mechanisms and their likely locations in the consumer electronics industry and is relatively easy to do in scSTREAM as a co-simulation.

Combined fluid-structure-multibody interaction co-simulation of a washing machine drum using a Cradle CFD – Marc – Adams coupling.

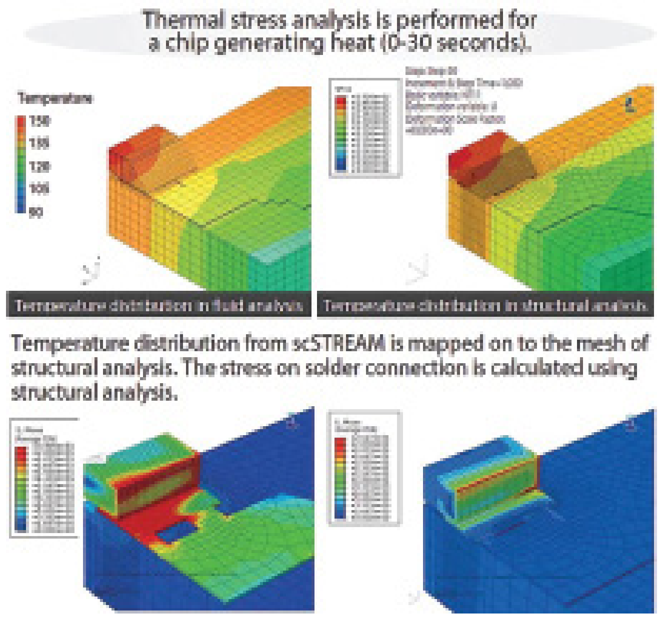

Figure 14. scSTREAM thermo-mechanical stress prediction of electronic component solder stresses

Summary

Classical 'multiphysics' challenges for CAE include fluids and structures (FSI, VIV), structures and acoustics, structures and dynamics, and fluids and dynamics. Multiphysics simulation may sound easy in principle yet many commercial CAE vendors have had point physics solutions for decades now but have failed to implement usable coupled solutions for industrial grade engineering application (either loose- or closelycoupled CAE). So, 'multiphysics' is still one of the 'Holy Grails' of CAE solution even after 40 to 50 years of point simulations in all the physics sub-disciplines. MSC Software has grappled with this co-simulation conundrum and come up with many usable solutions and tool chains for real world engineering applications. I would encourage you to explore what we offer and use MSC One credits to try them out. Ask your local MSC account manager or support engineer if you want to know more. We offer both the technologies and the professional services that can help you solve your industry CAE co-simulation challenges.

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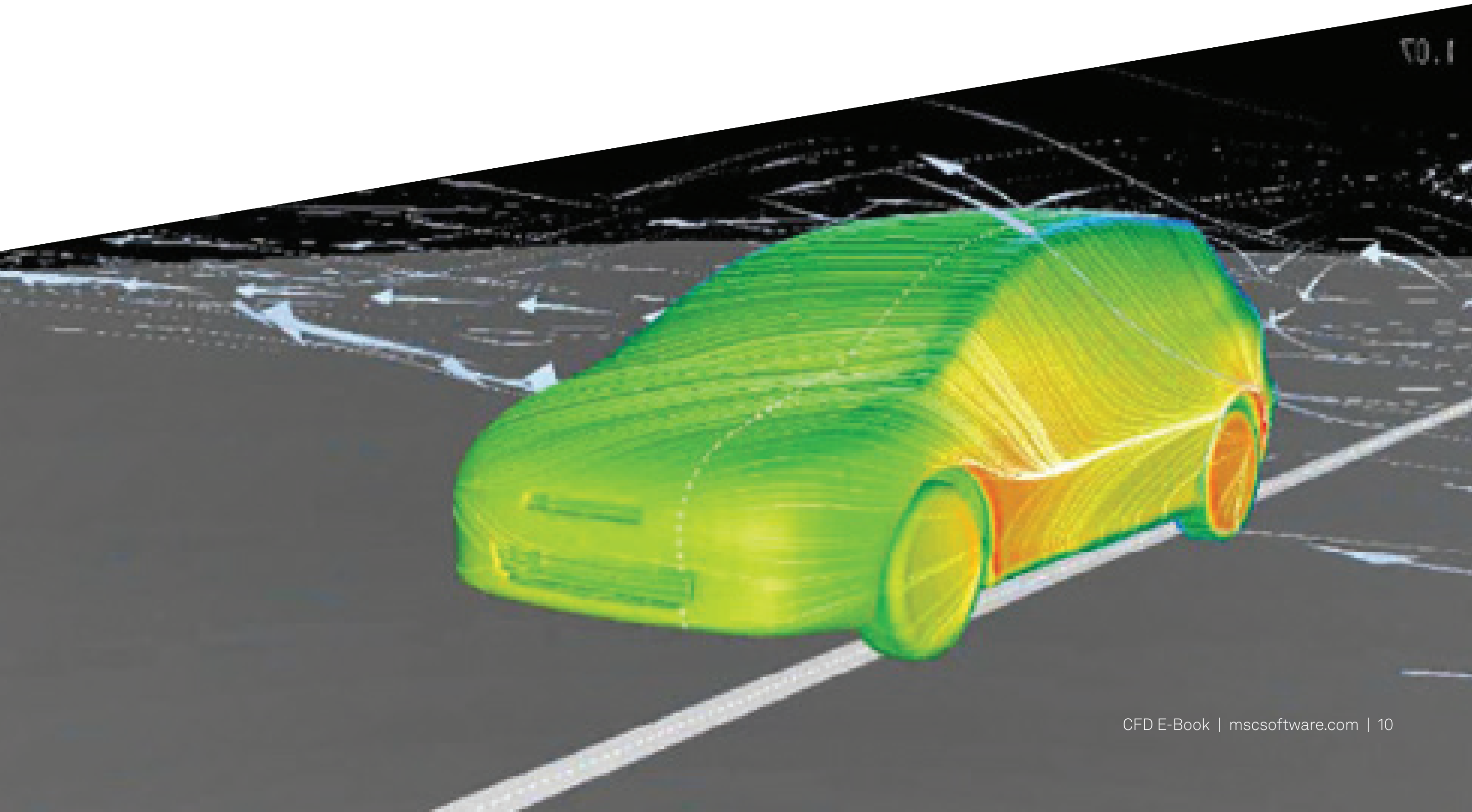

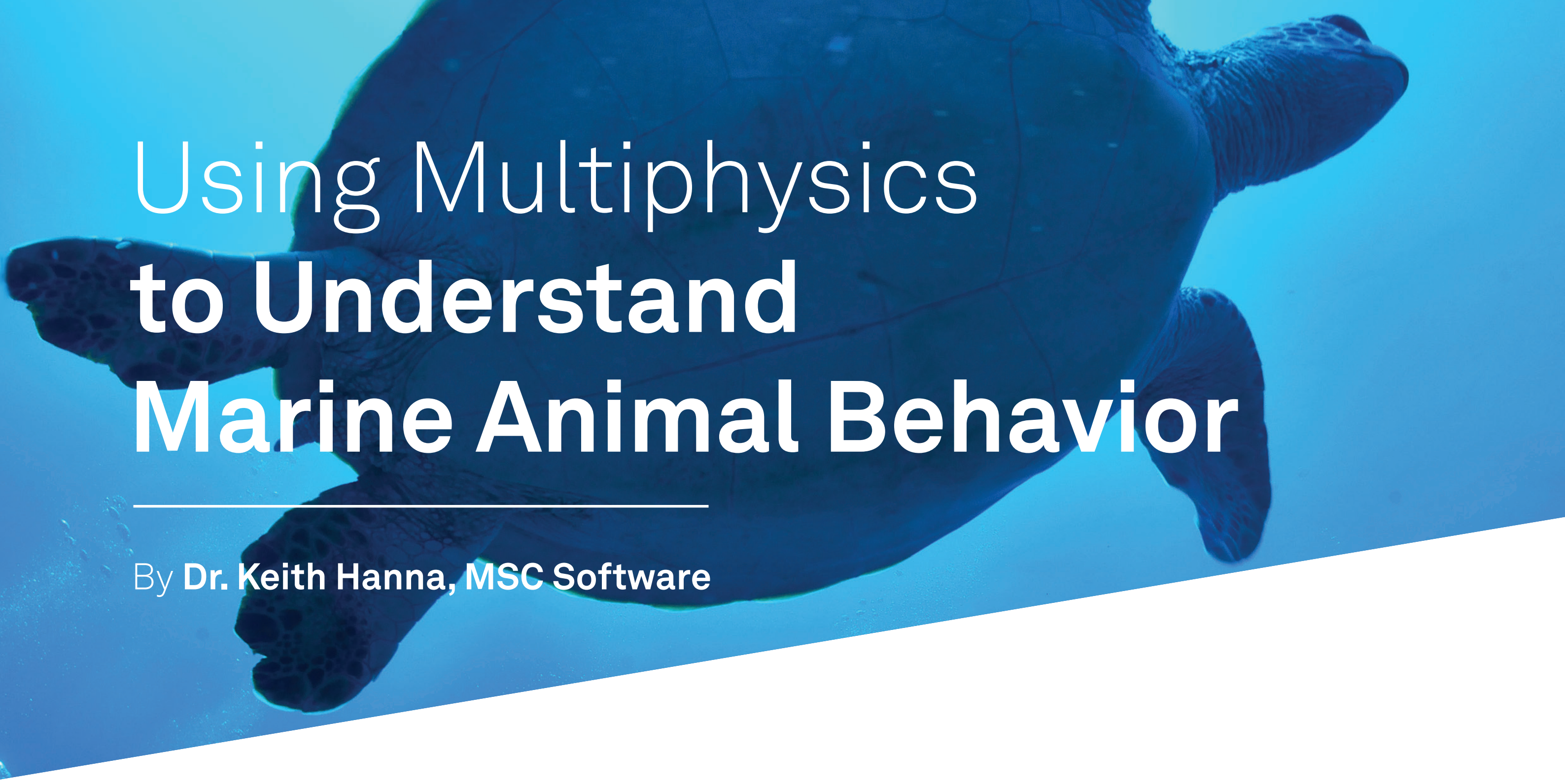

Using Multiphysics **to Understand Marine Animal Behavior**

By **Dr. Keith Hanna, MSC Software**

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Knowledge of our ocean depths and how marine organisms adapt to life under water is still developing in terms of what we know of the underlying science. Two recent studies by MSC Software users, Kindai University in Japan, and Maine Marine Composites LLC in the USA, have helped to throw some interesting light on the true nature of the lives and struggles of bluefin tuna and leatherback turtles respectively.

CFD Uncovers the True Nature of Bluefin Tunas, the 'Diamonds of the Sea'

Pacific Bluefin Tunas (thunnus orientalis) are beautiful large fish known as "the diamonds of the sea" and their nature is to swim freely in the ocean. This makes close examination of their behaviors difficult which is why little of their biological characteristics has truly been explored. Professor Tsutomu Takagi from Kindai University, Faculty of Agriculture, has been applying CFD fluid analysis using scFLOW from MSC Software to reveal the mysterious nature of these animals.

Bluefin tunas are the most prized fish from the tuna family by fishermen and chefs. In 2002, Kindai University even succeeded in farm-raising this special fish and named the breed 'Kindai tuna' which attracted wide public attention for the species. Professor Takagi then started to take an interest in this beautiful creature after noting that biological data for bluefin tunas in the wild have not yet been fully collected. He decided to use the fluid analysis software scFLOW to investigate the true nature and unknown swimming characteristics of fish in general, but with a particular focus on the bluefin tuna.

Tunas are large, carnivorous fish that inhabit the open seas. They are a perciform fish, under the scombroidei suborder, in the scombridae fish family. Their biological classification is actually the same as mackerel and swordfish. Besides bluefin tunas, eight other species of tuna exist, including the familiar yellowfin tunas and bigeye tunas. Bluefin tunas are the largest in the group: they can weigh 400kg (882lb) and be up to 3m (10ft) long. They are known as the 'diamonds of the sea' and they account for only 2% of the entire tuna catch worldwide, but are traded in the fish markets of the world at the highest rates. Professor Takagi and his team decided to use fluid analysis software to investigate bluefin tunas' swimming capabilities to understand this fascinating fish better.

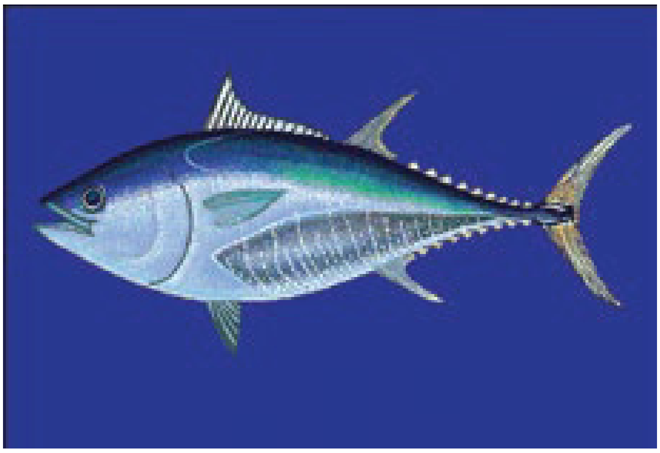
Tunas can swim very fast reaching speeds of nearly 90km/h (56mph) although slower ones, such as the yellowfin tuna, swim at 75km/h (47mph). As a comparison, Indo-Pacific sailfishes, which are known to be the fastest marine creature, can swim at a phenomenal 108km/h (68mph). In terms of the body length speed per second, yellowfin tunas are at 20BL/s (BodyLengths/s) and the Indo-Pacific sailfishes are at 15BL/s, which indicates that tunas are one of the fastest, medium sized fish species in the world.

Considering their speed and ability to swim long distances, the fluid drag force on a tuna's body was thought to be small. But an unanswered question was: how can a tuna's drag force be measured or calculated? To test a live tuna in an underwater environment, Professor Takagi would need a tank that was large enough for the fish to swim. Such a tank would also need the capability to change the fluid velocity and attaching a resistance board to the fish would also be needed. Convinced that the results would be inaccurate, even if the research team did manage to conduct such a test, Professor Takagi explored the application of computational fluid analysis tools. Professor Takagi created a virtual model of a tuna by scanning a real fish using a 3D scanner. It sounds easy, but modeling the fish was a demanding task.It required preparing a frozen tuna (to prevent decay) and painting the frozen fish white to minimize diffuse reflections of the laser beam used (see figure 1).

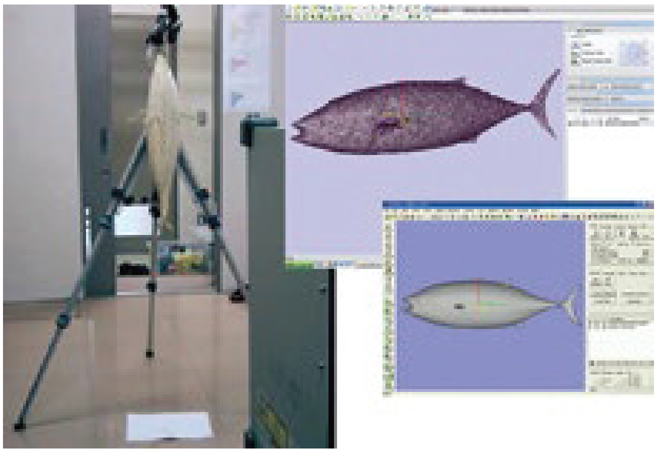
Using CFD, Professor Takagi calculated the drag on a gliding 34-cm (1.1-feet) long tuna to be 5gf (0.355pdl). This is the same drag as a 5-mm (0.2-inch) diameter, 15-cm (a half-foot) long cylinder. For a 100-cm tuna, the drag was 400gf (28.4pdl). This is equal to the drag of a 30-mm (1.2-inch) diameter, 15-cm (a half-foot) long cylinder. These CFD results demonstrated that the tuna's drag is relatively low regardless of the body size.

Professor Takagi conducted a CFD simulation that accounted for the movement of the tail (figure 2) using the moving body capability in scFLOW. He created a smooth virtual representation of a moving tuna by recording a video of a real tuna and approximated the real world motion of each point on the body with periodic functions. This enabled him to investigate the motion of the bluefin tunas further, such as identifying its tail thrust and analyzing the outward movement of its pectoral fins, which effectively function as wings underwater.

The pectoral fin is essential for the swimming ability of tunas, as it generates the lifting force. Although tunas possess swim bladders inside their bodies, the bladders do not fully sustain the upward force needed to keep them buoyant. This is one of the reasons why tunas must keep swimming constantly. They use a similar mechanism underwater as airplanes use to produce lift in air. Professor Takagi's CFD simulations clearly showed that substantial lift can be generated by moving the tuna's pectoral fins outward. In addition, tunas can streamline their bodies to minimize drag by tucking their pectoral fins into the indentions on the sides of their bodies. The caudal peduncles are the bumps attached to the root of the tunas' tails and they also function as minuscule wings.



Bluefin tuna (source: Wikipedia.org)



Tuna being scanned on a 3D scanner in Prof Takagi's laboratory with resultant geometry and surface mesh representation

"For the larger migratory fish such as the Indo-Pacific sailfishes, two layers of caudal peduncles are attached to its body just like a biplane. It's fascinating that the reasons and purposes behind the designs of living organisms become evident when I look at it from the fluid-analysis perspective," comments Professor Takagi.

MSC Adams Helps Save Tangled Leatherback Turtles

Do you like to go fishing in your spare time? Many of us do … but the consequences for marine animals other than the fish that we want to catch may be harmful. materials, which unfortunately leads to turtles getting entangled in mooring lines and cables more and more. Lately, this phenomenon has been happening more frequently, yet little is known about how this occurs. Moreover, it is difficult to measure and (reference 2)

nearly 4,500 turtles a year are estimated to be part of 'bycatch' as they get entangled with mooring lines. The burning question for MMC was: with the scant information researchers have about entanglement, what can they do to remedy this problem and help the turtles with simulation software?

Without proper measurement, simulating a reality we're unfamiliar with, that is, humans are rarely there the moment turtles get entangled, but engineering simulation software is a great alternative to help us to understand the physics of what is going on. As researchers, MMC turned to MSC Adams, the world's leading multibody dynamics software, to help understand what might be happening in this situation and therefore find a solution. They used Adams to develop a computer simulation model of a turtle swimming and then its entanglement behavior with a floating mooring line. It accurately mimicked the behavior of adult leatherback sea turtles (Dermochelys coriacea) using this approach (reference 3-4). Through the successful reproduction of the turtle and

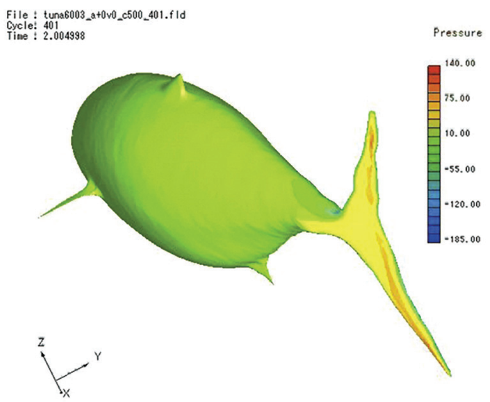
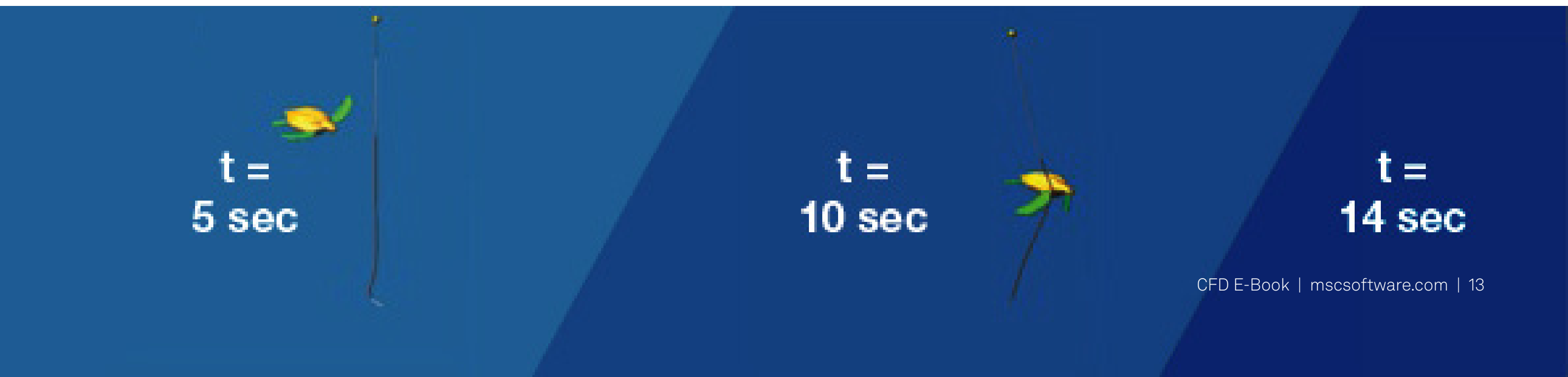


Figure 2. scFLOW CFD analysis prediction of body surface pressure on a bluefin tuna with the tail in motion

Leatherback Turtle (source: Wikipedia.org)



its movements the MMC team was able to drastically increase the bending stiffness of the mooring in hopes of preventing future entanglement. Ultimately, the Adams computer model led to recommendations for an advanced mooring line which will reduce the number of entanglement cases. The result MMC hope will be many fewer turtles getting stuck and more of these beautiful creatures being saved for posterity. A tool like MSC Adams can therefore assist designers of advanced mooring and fishing line technology to reduce the number of leatherback turtle entanglement events (see reference 5 for the full story).

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3. Leatherback Turtle Adams Entanglement simulation: https://www.youtube. com/watch?v=7tlBn_jcl28\

4. Leatherback Turtle Entanglement Webinar:

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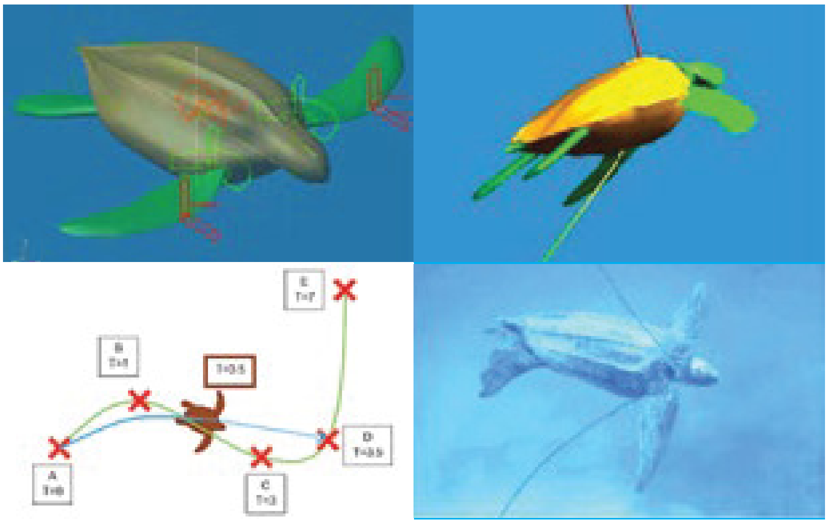
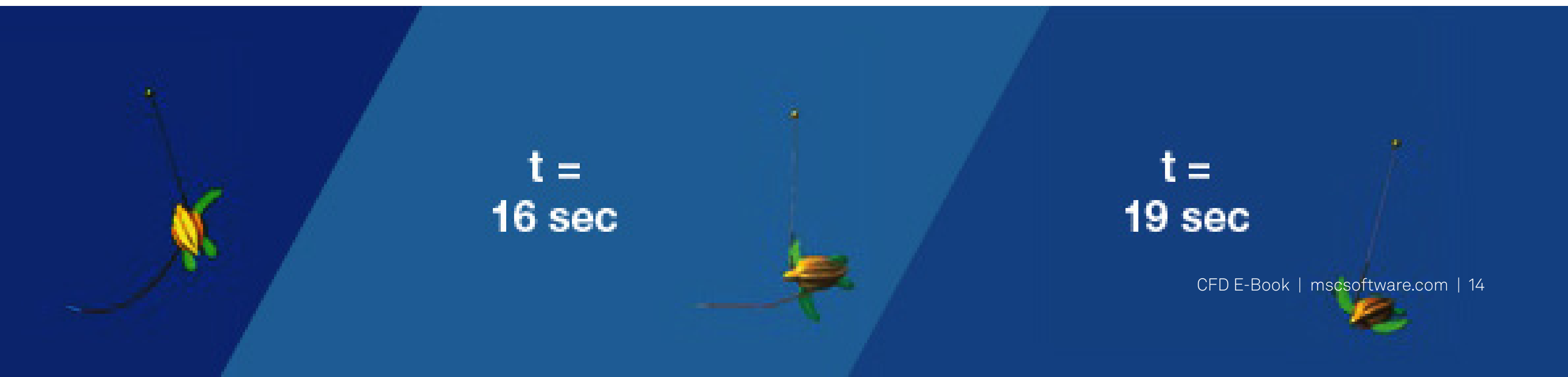


Figure 3. MSC Adams MBD model of a Leatherback Turtle, an entanglement event timeline with a mooring line, the predicted entanglement end point after entanglement and a typical photo of an actual turtle after entanglement

Figure 4. MSC Adams MBD analysis of a Leatherback Turtle entanglement motion over 19 seconds with a floating mooring line



Aeroelastic Co-Simulation **Flight Loads Toolkit**

By **Martijn Renooij, Stirling Dynamics, UK**

A part of the Expleo Group of companies, Stirling Dynamics is a fast-growing, advanced engineering company that delivers a range of complex systems and technical services to the aerospace and marine markets. Trading since 1987, the company has accumulated a wealth of knowledge on over 70 different aircraft types and delivered to both civil and military programmes around the globe Recognised as leading experts in the areas of aircraft loads, fluid dynamics and aeroelastics, Stirling Dynamics is approved to the global aerospace quality standard AS9100 as well as being a member of the ITAR Approved Community.

Introduction

Stirling Dynamics has developed a non-linear aeroelastic toolkit for aircraft loads (Reference1) as part of a UK NATEP (National Aerospace Technology Programme) initiative in collaboration with MSC Software UK and supported by the end-user, BAE Systems. Aircraft loads assessments (like gusts and manoeuvre loads) are typically performed using linear aircraft models and, although this is generally considered to be an acceptable means of analysis, including non-linear terms improves the modelling accuracy and reliability. Non-linear aeroelastic solutions are generally only available to the major aerospace OEMs who have their own tailored toolkits. The current processes used by most aircraft companies, excluding the two largest OEMs, is based on linear assumptions and this has been accepted as means of compliance for generating gust and manoeuvre loads for aircraft design by the certification authorities. This puts smaller OEMs into a disadvantageous position as the linear models are generally considered to be overly conservative. The project objective for Stirling Dynamics was to develop their own in-house toolset. In parallel, as part of the same programme, tool development at MSC Software UK was aimed at developing a commercially available product. A more detailed description of the MSC development is covered in the following sections.

MSC Software Co-Simulation CFD-FEA Coupling

A key feature of the Aeroelastic CFD Manoeuvres Toolkit is that it is based on the widely used MSC Nastran for FEA structural analysis, and scFLOW from Cradle for CFD, plus inputs from the end-user, BAE Systems. The tool allows for increased fidelity of the nonlinear aeroelastic effects that contribute to the loads experienced by an aircraft over a wide design-of-experiment (DoE) design space. The tool takes nonlinear aerodynamic effects into account from shock movements or flow separations around an aircraft, improving the accuracy and simplicity of loads modelling on flexing structures such as aircraft wings. MSC Software provided a robust and reliable commercial CFD and FEA solver co-simulation toolset to enable this. The toolkit also automates the simulation process very substantially. The toolkit includes new methods and it provides for:

- Extraction of aeroelastic loads from multiple scFLOW CFD analyses
- Application of the fluid load to an aeroelastic MSC Nastran model for various trim conditions

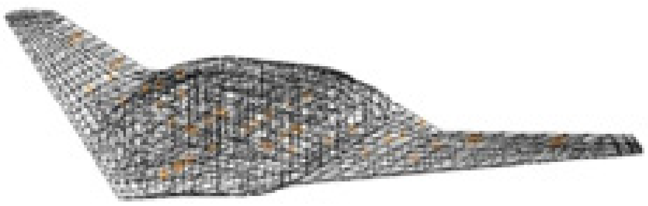


Figure 1. Generic UAV Model for this study (courtesy of BAE Systems)

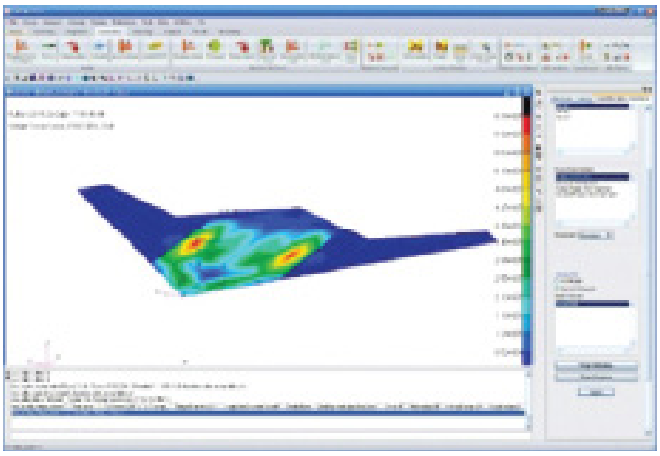


Figure 2. Generic UAV Model inside the Toolkit user interface

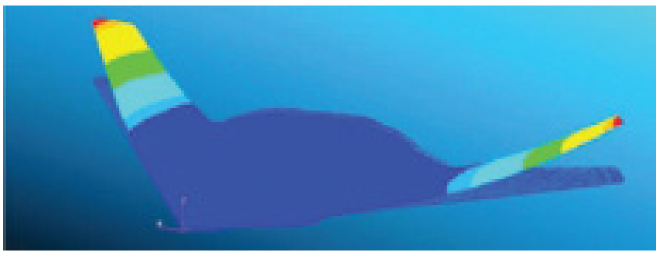


Figure 3. Non-linear UAV shape prediction of wing deflection displayed in the Toolkit

"Stirling has a long history of developing independent aircraft design tools. Working on this NATEP project together with MSC Software and BAE Systems has been an excellent opportunity to develop our capabilities further and to use these new tools for future aircraft design."

R&D Manager, Stirling Dynamics,
Dr Simon Hancock

- Coupling of the aerodynamic loads in all 6 degrees of freedom (DOFs) to the structural FEA model

In tandem with BAE Systems, a generic Unmanned Aerial Vehicle (UAV) demonstration was created for BAE Systems to showcase the tool (Figure 1). The toolkit user interface (Figure 2) automates the direct mapping of CFD results from scFLOW onto finite element models from MSC Nastran to then predict and visualise aeroelastic effects.

Summary

As part of a UK NATEP (National Aerospace Technology Programme) initiative in collaboration with MSC Software UK and supported by the end-user, BAE Systems, Stirling Dynamics has developed a non-linear aeroelastic toolkit for aircraft loads for use in their engineering programmes. In parallel and part of the same programme, MSC Software has been able to develop an innovative non-linear structural analysis-CFD solution with MSC Software simulation tools that will lead to more optimised aircraft aeroelastic models, and higher simulation fidelity resulting in the reduction of uncertainties in fluid-structure analysis predictions.

The *Aeroelastic CFD Manoeuvres Toolkit* means that uncertainties in the aircraft modelling process will be reduced, which results in increased accuracy in the CAE models produced, less conservative aircraft designs and lighter future aircraft. The key benefit of lighter aircraft will be less fuel burn and therefore more fuel-efficient flights and significant cost savings to aircraft manufacturers and users; this ultimately has environmental benefits for us all.

A demonstration of this toolkit by way of a generic UAV model was produced for BAE Systems in the UK. This toolkit will be valuable to aid in future aircraft certification requirements for emerging and small OEM aircraft manufacturers.

Reference

1. UK NATEP Website Projects: http://www.natep.org.uk/projectdesign-modelling and http://www.natep.org.uk/documents/ADS%20Natep%20210%20x%20210%20Supplement%20v5.pdf

Cradle CFD Innovation that **Achieves Excellent Indoor Air Circulation**

By **Mr. Masahiro Shigemori, Panasonic**

Panasonic Ecology Systems (hereafter the Company) has been tackling Indoor Air Quality (IAQ) improvement for many years. As well as dealing with ventilation and dehumidification, the Company has pursued achieving quality living environments through providing pleasant air flow and smell. Their market leading product range includes ventilation fans, kitchen hoods, air cleaners, and roof fans, and is also available in many countries in Southeast Asia. To design and develop the equipment needed to facilitate such environments, highly advanced technology and expertise are required. Cradle CFD has been an innovation that brought significant improvement to their design evaluation process. To help them with product development, Cradle CFD has been in use and "has played a vital role in the process," according to Mr. Masahiro Shigemori, Chief of Ventilation Technology Development Division, Thermo-Fluid Development Department, R&D Head Office (Picture).

Ceiling Fans Designed by Fluid-Structural Co-Simulation

Ceiling fans are popular in southeast Asia and middle east countries. The Company has provided various types of ceiling fans according to design preferences and feature requirements in each country (Figure 1).

Ceiling fans are given safety measures such as falling prevention. Mr. Shigemori says that ceiling fans can be damaged or can crash to the floor by blade vibration, and in some cases by wind from air-conditioners, which could add wind pressures (external pressures) when hitting the fan. Caution notices are written on fan manuals, but as fans can be allocated near air-conditioners, the Company needs to validate safety by simulations.

As the analysis involved calculating the force applied to fan blades and how they could deform blades, the Company has been using co-simulations of fluid and structural analysis. To perform, Software Cradle's scFLOW and MSC Software's

Figure 1. Ceiling fans provided across countries

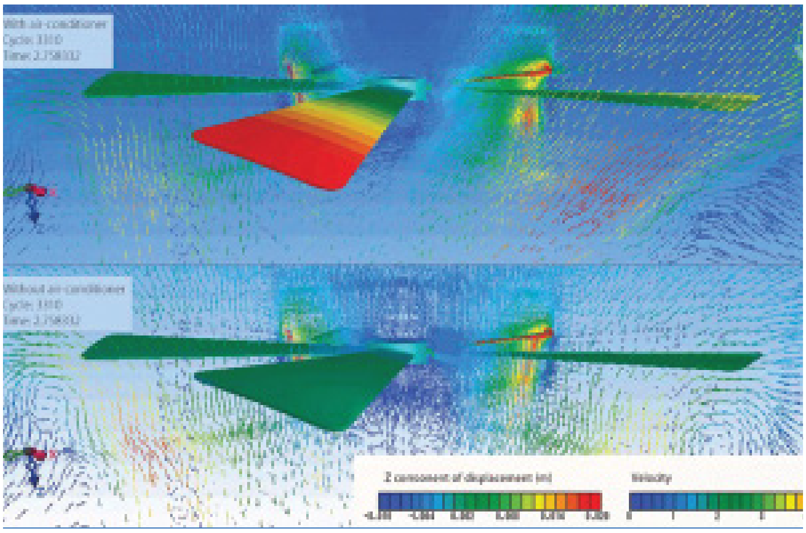


Figure 2. Transient deformation of ceiling fan caused by air-conditioner wind evaluations

MSC Nastran have been in use. These were initially devised separately, and data import was inconvenient. The recently introduced MSC Co-Sim engine has enabled better connection and control.

Values of pressure on blade surfaces evaluated by scFLOW are provided to MSC Nastran, and in reverse, the degree of deformation evaluated by MSC Nastran are provided to scFLOW. From this, where and when deformation and vibration could take place can be evaluated. Result comparison shows that fans rotate at stable rates of deformation when there is no external force (bottom of Figure 2), whereas when there is wind from air-conditioners, the fan blade vibrates in a complicated manner (top of Figure 2). "We can observe the complicated behavior by looking at simulation results in animation format," says Mr. Shigemori.

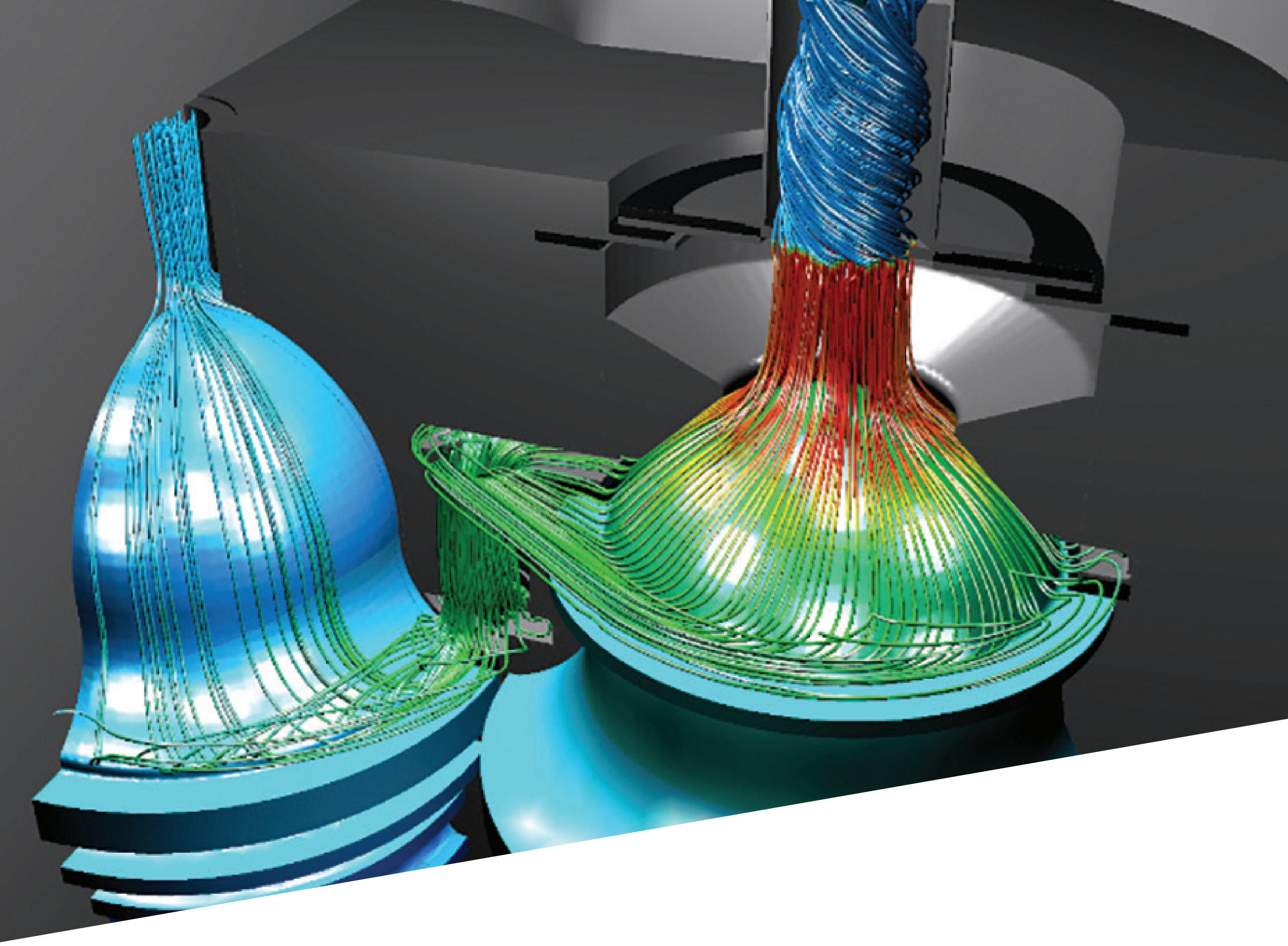
Applying simulation technology and evaluating models in the conditions and environments that products are actually used, the Company achieved safety validation of products as well as its performance improvement.

Future Challenges

Going forward, Mr. Shigemori comments: "We have been applying simulations for qualitative comparison and evaluations, but we are hoping to improve accuracy and one day apply it for qualitative evaluations. Another goal is to expand the areas of co-simulation."

It is certain that the Company will continue to pursue IAQ improvement through innovative research and development.

Mr. Masahiro Shigemori, Panasonic



Using scFlow BoostHEAT Develops the World's Most Efficient Boiler

By **Thomas Pedot, R&D Lead, BoostHEAT, France**

BoostHEAT.20 20kW Boiler for domestic applications

Traditional residential heating & cooling systems are designed and configured with fairly standard systems and components. As a consequence, most of the systems on the market today have similar performance criteria, often well below the sorts of performance expectations required for the future. BoostHEAT was founded in 2011 when we recognized that this is an industry with huge potential for change. Increasing demands for more ecologically friendly products, accompanying changes in regulations, and the on-going end customer cost pressures means change is inevitable we believe. With our recent innovations around heat transfer, we are determined to revolutionise a traditionally very conservative market place, reducing customers' ecological footprint as well as their utility bills. With over 5 years in the market now, and numerous awards and accolades, we are poised to make a significant impact in the boiler market.

At BoostHEAT we realised that by introducing higher performance, more industrial grade, capabilities to the residential market, we could start to reset expectations for more ecologically minded systems, and significantly differentiate our offerings. In short we recognized a significant business opportunity for an entirely new way of doing things.

Traditional heat pumps are composed of four important elements in which there are fluid flows:

- Evaporator: Captures energy in the outside air
- Compressor: Provides the compression of the gas
- Condenser: Transfers energy to the heating circuit
- Regulator: Expansion valve to lower the pressure

In a heat pump, a compressor varies refrigerant pressure and temperature inside a closed chamber (see Figure 1). When connected to a heating circuit, and together with condensers and evaporators, it's possible to capture the energy contained in the outside air and then transmit it to the heating circuit, thus heating it up. The same is true in reverse of course for cooling.

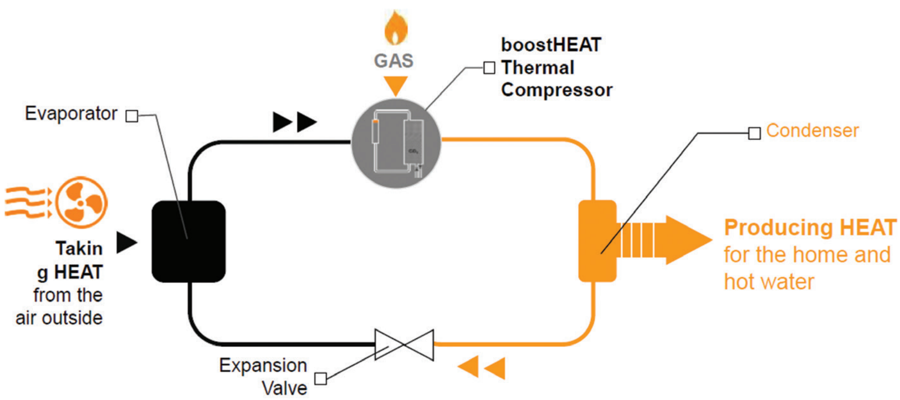


Figure 1. The BoostHEAT heat pump boiler principle

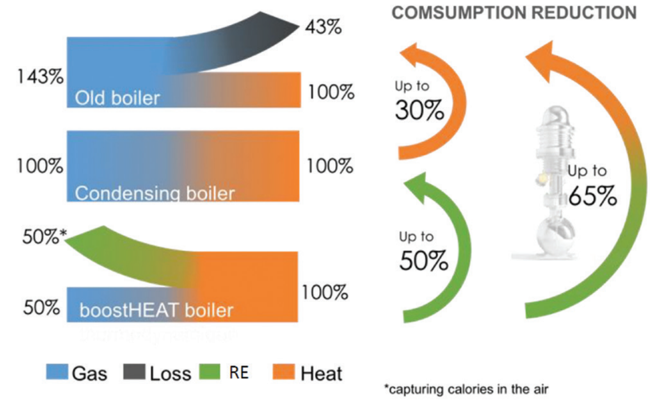


Figure 2. The BoostHEAT heat pump boiler versus alternative boiler types

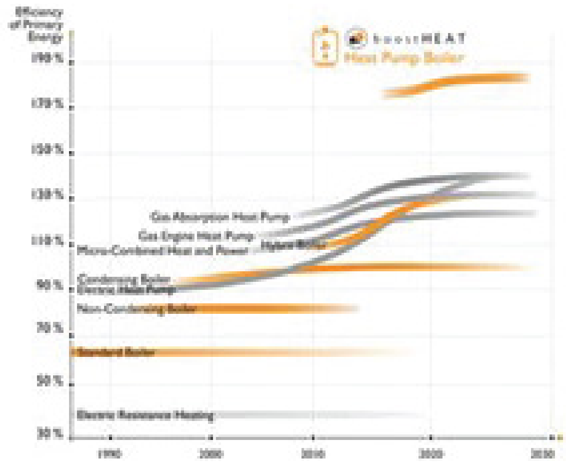


Figure 3. BoostHEAT independent audit by CRIGEN (GDF SUEZ) in June 2013

BoostHEAT's innovation in our boiler design, for which we have multiple patents, is to use the energy produced by the combustion of gas (natural or propane) to carry out the work of the compressor. By combining the use of gas with the heat pump cycle, BoostHEAT's regenerative thermal compressor, effectively merges these technologies to achieve up to 200% efficiency when compared to last generation conventional condensation boilers. The result of our research and development is that the boostHEAT.20, our latest product, is the best-performing boiler in its class. Its thermal compressor is frictionless (without oil) which makes it almost indestructible.

Our patented technology more closely integrates the idea of a boiler and a heat pump in one unit and is based on the Stirling Cycle such that our unique design of a regenerative thermal compressor can achieve a high temperature thermal compression cycle around 700 °C at a high pressure of 80 Bar while generating very high thermal outputs. Moreover, with no mechanical power transmission, our compressors can operate for 50,000 hours without any need to change oil or for maintenance, contrary to other standard technological solutions for engines and compressors. The net result is a new generation of heat pump that better utilizes the complete thermodynamic cycle, and produces a natural gas energy efficiency of up to 200% (see Figure 2). In independent audits our technology has scored very highly (see Figure 3).

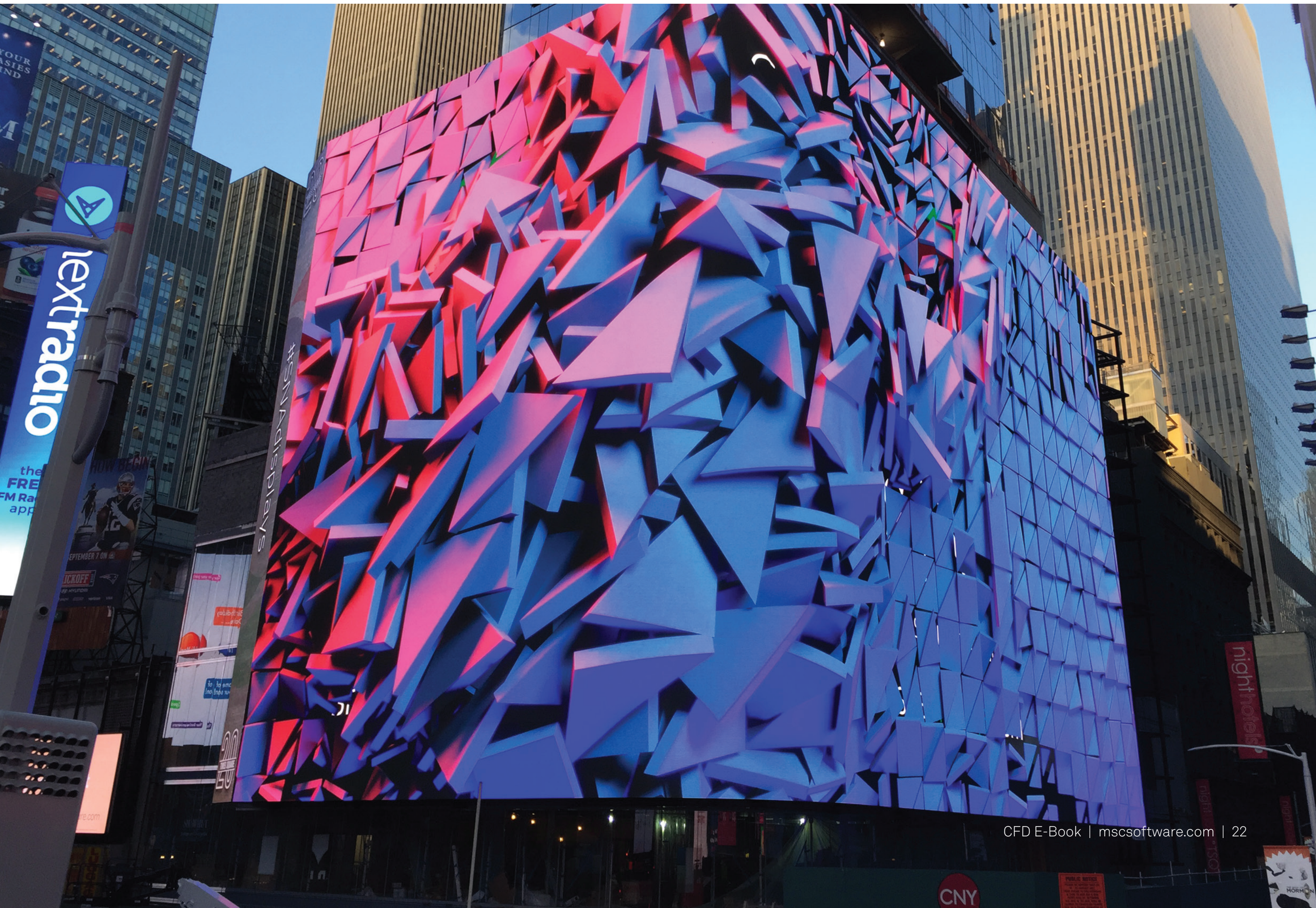
Obviously, innovation is key to our success. We have been using computational fluid dynamics (CFD) tools from MSC Software in the form of scFlow (see Figure 4). It has been pivotal in our design exploration process because we originally set out to deliver the world's most efficient boiler system that could optimize heat flux (the transfer of heat energy). New physics, new materials and methods, new designs, new manufacturing processes, not to mention the pressure of residential compliance regulations meant we had to gain as much insight as possible in the shortest period of time. Without access to CFD, we would not have been able to ascertain the complexity and performance of our new designs… there's simply no way we could get the details we need. With scFlow you can explore; it's like we have thermocouples everywhere.

Employing scFlow we worked through 20 key boiler design iterations, creating our 'digital twin'. We then validated our CFD predictions against physical tests linked to our compliance needs. At each stage we've achieved higher temperatures and higher pressures, with increasing correlation to physical tests than previously. This momentum is important for us as a start-up company. CFD with MSC has helped us to achieve that.

What about the future? If you ask our team you'll get a wry smile. We have successfully released our initial designs and we are taking orders. However, we are not done yet. I foresee more simulation, more multiphysics, more optimization and more innovation is on the cards. This is an exciting time for us as a company…

For more information on BoostHEAT the company and its products: http://www.boostheat.com/en/


HIGHEST RESOLUTION
VIDEO DISPLAY
IN THE HISTORY OF
TIMES SQUARE



Designing

Premium Innovative Solutions for 30 Years

By **Philippe Vitali, Marketing & Comms Director, Analog Way**

Analog Way was initially founded in France in 1989. Since then, I am proud to say we've established a worldwide reputation for quality, reliability and performance. For 30 years, we have pioneered the design and engineering of numerous award-winning image processing solutions.

At Analog Way, we have delivered some incredible experiences to our customers. From panoramic LED canvas in sports books to large live corporate events and concerts, from product launches to installations in prestigious locations. As an example of our capabilities, we've delivered equipment to drive the highestresolution LED screen in Times Square. For this project, we partnered with SNA Displays to provide a full 8K resolution processing solution for a massive wraparound display canvas, one of the largest continuous exterior displays in the world representing more than 17,000 square feet of LED display technology. For the record this is equivalent to almost 4 basketball courts.

Our only real way forward to drive this sort of innovation was Cradle CFD simulation

As a result of efforts like these, Analog Way is seen as one of the undisputed leaders in video presentation experiences. This is an important element of who we are, and the capabilities we want to be able to deliver to our customers.

It feels great to be able to talk about these capabilities and how we strive to offer premium innovative solutions to our customers. It doesn't come accidently and is the result of a clearly choregraphed, and very intentional, effort.

So, how do you follow up an example like Times Square? How do you maintain, or extend your high-end positioning? This is the real question. It's one thing to want to be among the leaders on your market. How do you actually do that though?

We knew we needed to maintain our extreme performance edge. However, to really make a difference, we had to start with some basics. We had to turn our desire to be a leader into something tangible that meant something to our customers. We know our customers need to power increasingly rich, interactive experiences. We know they demand industrial grade reliability. They also need a high degree of customization built into some very flexible, modular, systems.

In order to deliver what we considered the next generation of video processing, we estimated we're going to need a system capable of dealing with 24 x 4K inputs, as well as evolving requirements around 8K. This meant we needed deliver 3 x times the video processing performance over and above what we'd achieved in Times Square.

These are significant improvements in core performance. In practical reality these improvements needed to be delivered with the same, or tougher, physical constraints. In fact, we needed to deliver this performance in one of the most compact systems in the world. This increase in power meant a huge power footprint in a relatively small confined space, often in some tough conditions.

Consider an outside display in Las Vegas. During the day it is not uncommon to see temperatures hitting 40 C, dropping during the evening, and incorporating all the dust and dirt you might expect with a desert environment. In these environments, the effective dissipation of heat, and the management of severe temperature variation is key to maintaining effective performance our customers can rely on. We therefore needed to absolutely, 110%, ensure our systems are able to deliver 24/7 in these environments.

Already a tough engineering challenge, we then needed to ensure we can commit to our performance considerations for all of the design variations our customers are going to be

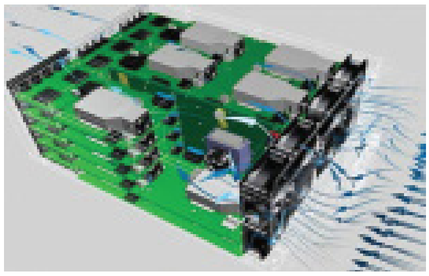


Figure 1. Cradle CFD Solution

able to select. The modular design of the LivePremier™ series allows customers to easily swap in I/O cards to accommodate a variety of connectivity arrangements to match their source and display requirements. In fact, per chassis, the LivePremier™ series features up to 24 inputs and 20 outputs configurable as single screens, edge-blended widescreens or scaled auxiliary outputs, 2 dedicated multiviewer outputs and up to 24x 4K or 48x HD freely assignable layers.

Clearly, there's a lot to consider... and we hadn't even considered our own deadlines and design processes. For example, how would we iterate on our designs in a timely manner so we could reach our performance goals. We feel we have an extremely talented engineering team, that is arguably the best in our industry. However, it quickly became clear that traditional processes, relying on experience, educated guess work and physical testing was going to struggle as we tried to ensure we reach our goals.

Our only real way forward to drive this sort of innovation was Cradle CFD Solution simulation. We'd be able to iterate on our

designs, and simulate our performance in a fraction of the time we'd done in the past, and gain more insight along the way.

For this we chose MSC Cradle scStream. Until MSC Cradle, frankly, we'd not considered Computational Fluid Dynamics (CFD) too much. However, our needs here meant we needed something pragmatic that could actively help our team reach our goals. We were not looking for a fluid dynamics science project. We simply wanted to drive our design forward.

We needed something that was able to deal with our fairly large, configurable, assemblies and help us gain the insight we needed, quickly, accurately, and effectively. We needed to get a clear view on the thermal conditions in our compact footprint. In particular we needed to understand the parameters required to maximize air cooling system performance, and clearly ascertain maximum temperatures, and their fluctuation.

The initial model, with some support from MSC, only took 2-3 days to setup, and we had some of the detailed results we needed within a week. From a physical perspective we're now confident we can effectively and reliably dissipate some 2KW across 133 In2 (approx. 800cm2). To provide some context the amount of energy we're generating is similar to a household electric fire. It's therefore important we get this right.

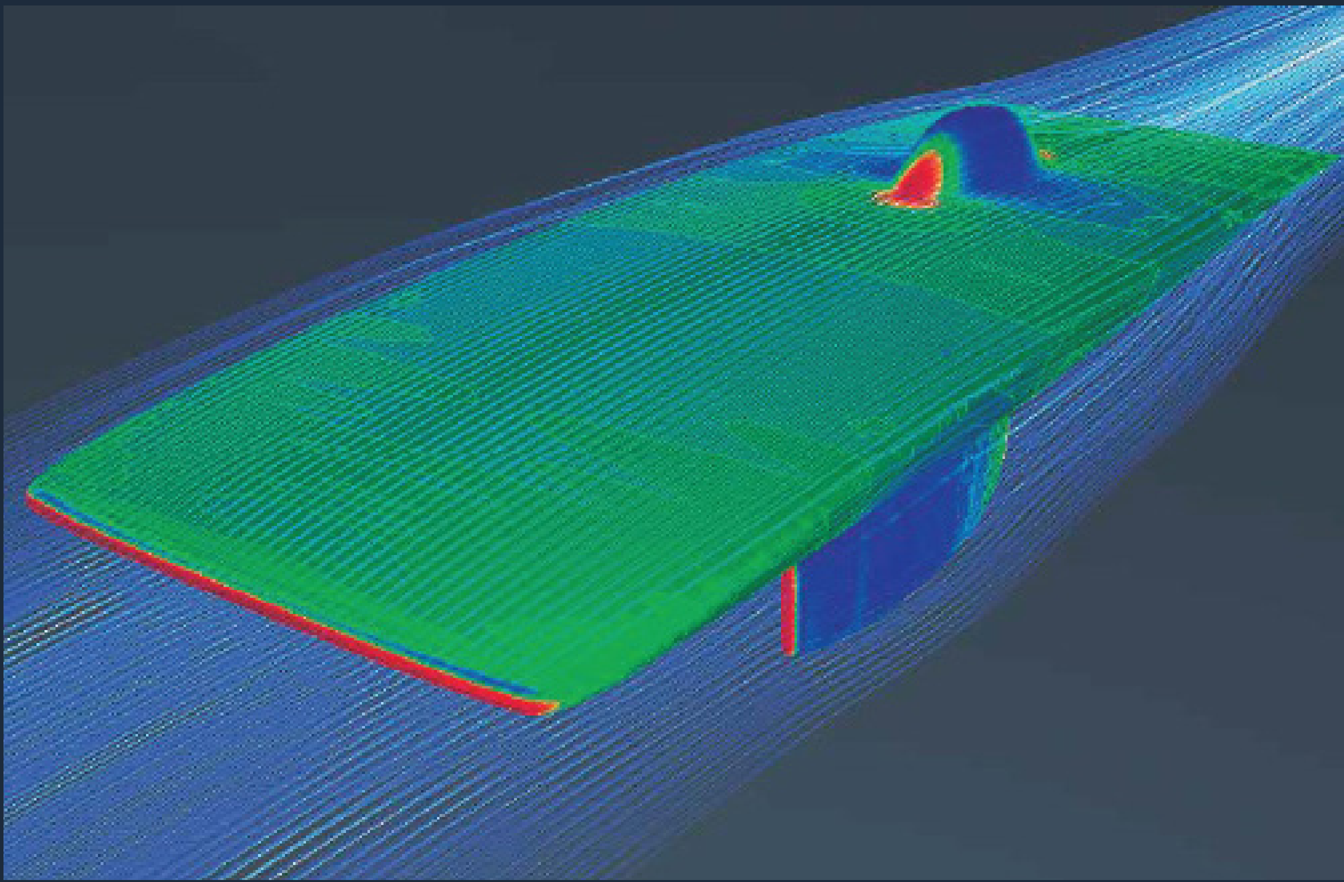
So far, we've been pleased with our decision. So much so, we also used MSC Cradle CFD to produce an 8K video to highlight our core differentiative features - front panel configuration, swappable cards, redundant power supplies, and of course our industry leading cooling. We even featured it's results on our website!

However, it's not enough to make us happy. It's our customers we need to impress. Our LivePremier™ solution line won two best of show awards at the 2019 Infocomm show in Orlando, and this is only the beginning!

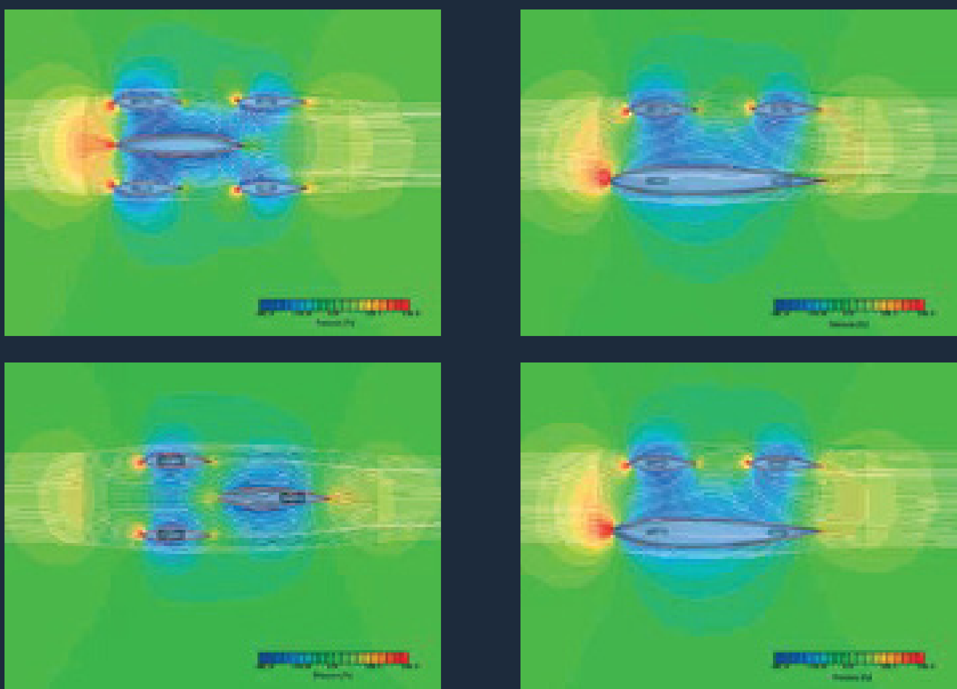
Trans-Continental Australian Outback world solar car CFD challenges

For over 30 years, the biennial sustainable transportation related Bridgestone World Solar Challenge has attracted some of the greatest minds at high schools and universities from around the world to Australia to push the limits of technological innovation and travel the Outback in a vehicle powered only by the energy of the sun. The course traverses 3,000km from Darwin to Adelaide.

The race is based on the simple notion that a 1000W car should be able to complete the journey in 50 hours without recourse to carbon based fuels. Solar cars that take up the competition are allowed a nominal 5kW hours of stored energy, which is 10% of the theoretical figure to get from Darwin to Adelaide. All other energy must come from the sun or be recovered from the kinetic energy of the vehicle. The solar cars developed for the Race are arguably some of the most efficient electric vehicles in the world.



Once teams leave Darwin they must travel as far as they can up until 5:00pm in the afternoon where they have to make camp in the desert where-ever they happen to be. All teams must be fully self-sufficient. During the journey there are 9 mandatory check points where observers are changed and team managers may update themselves with the latest information on the weather and their position in the field. At check points, teams can perform the most basic of maintenance only like checking and maintenance of tyre pressure and cleaning of debris from the vehicle. Students and their support team have the awesome challenge of engineering and building a modern solar powered vehicle with their own hands and powering it across some of the world's most inhospitable landscapes.



Tokai University in Japan have been competing in the Single Seat Challenge since 2009 and have won it twice runner up three times making them one of the most successful universities in the world regularly competing in this arduous Race. Tokai University have been using Cradle CFD software from Software Cradle for the last 12 years to design their Tokai Challenger cars because one of the most critical aspects of a solar car's design is its aerodynamic performance and minimizing its drag in particular. Solar cars, if well designed are the ultimate road vehicle because they do not require refueling.

Tokai University has partnered with Panasonic over the years to use their advanced Solar Cells which have a 22% conversion efficiency when connected to 5kWh Lithium-Ion batteries (1, 2). The Car frames have been constructed from carbon fiber reinforced plastics and they have used Japanese suppliers for carbon fibers, plus also highly efficient motors to produce vehicles that can travel at 90km/h (56mph) using solar power and a maximum speed of 160 km/h (99mph)!

Cradle CFD software was chosen to optimize Tokai's aerodynamic designs because it provides highly accurate and efficient meshing of CAD geometries and it has a very good aerodynamic solver that picks up flow details and forces that match with measurements they have. In addition, the software is easy to use by their students with a short learning curve and fast times to useful engineering results (Figure 1). It is also very good at examining parametric design spaces (Figure 2).

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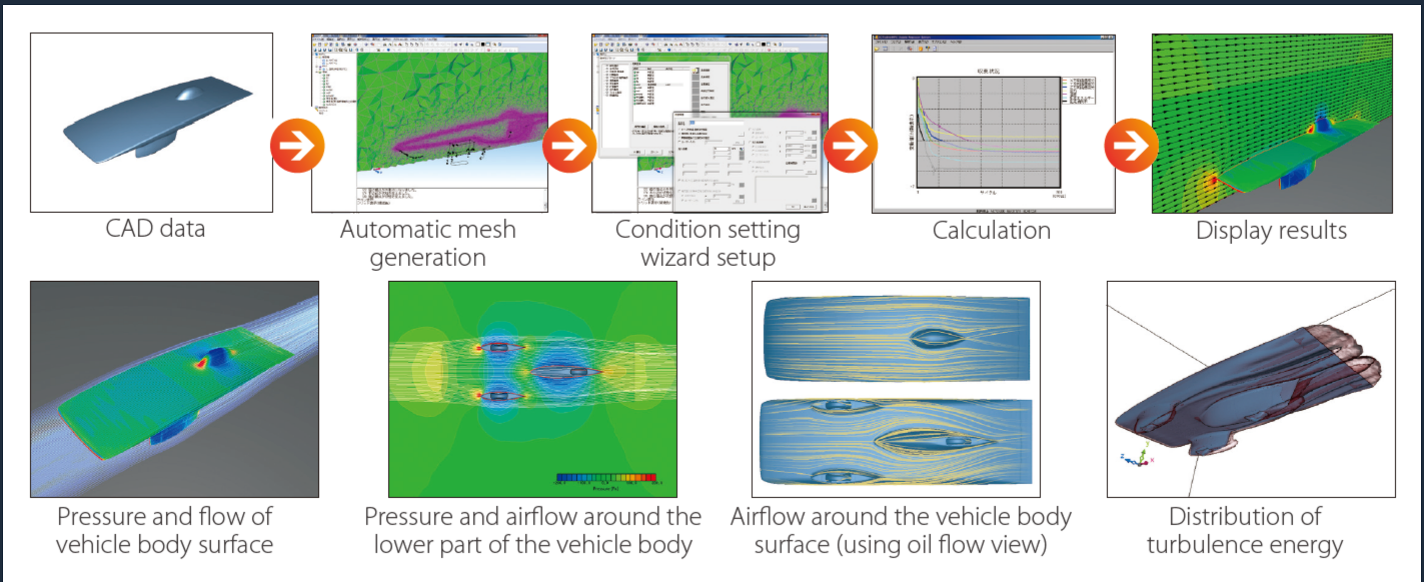


Figure 1. Typical Cradle CFD Analysis Process for a Tokai University Challenger Car

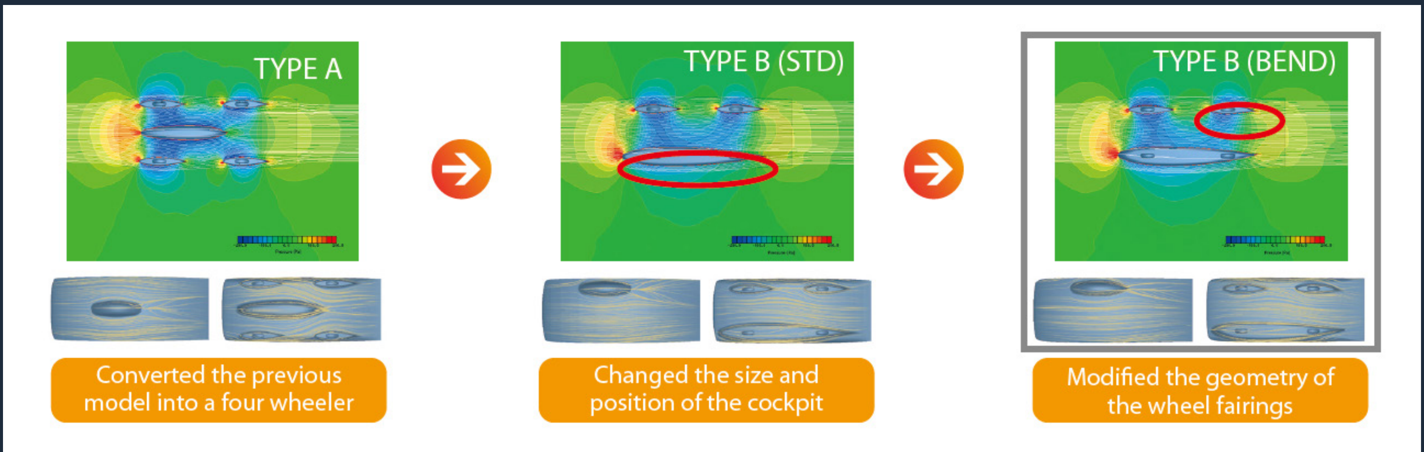


Figure 2. Predicted Pressure and Airflow CFD analysis of Tokai Challenger Car design variants

MSC Cradle CFD helping Goldwin & The North Face developing unique high-performance sportswear.

Takayuki AIMI, Future Design Group, Technical Laboratory, GOLDWIN INC. Mikako KAMATANI, Future Design Group, Technical Laboratory, GOLDWIN INC. Kota KIMURA, R&D Marketing Group, Technical Laboratory, GOLDWIN INC.

Goldwin is a leading athletic sports gear manufacturer, based in Toyama, in the northwestern region of Japan. Originally founded in 1950 as knitwear factory, Goldwin soon anticipated the sports industry prosperity at the day of the post-war reconstruction phase, and transitioned to sportswear specialized manufacturer.

Since then, they have been pursuing a corporate philosophy of "Encouraging a healthier, meaningful life through sports". Through its attitude of "sports first", Goldwin is working to improve the quality of life for all sports lovers. Goldwin likes to say it integrates the rationality of outdoors, comfort and usability with simple and basic designs. With it's extensive experience of developing ski wear, Goldwin now presents a premium lifestyle choice.

As an example, in 1964, Goldwin's athletic wear was selected as competition uniforms for the Tokyo Summer Olympics. The uniforms were worn by 80% of Japan's gold medalists in sports ranging from gymnastics to volleyball to wrestling. Following the Olympics, Goldwin began collaborating with major global brands, including Ellesse, The North Face, Helly Hansen, and Speedo, and established itself as a leading athletic gear manufacturer in Japan.

Since then other successes have included supporting Yuichiro Miura, holder of the world record as the oldest climber at Everest, the world's highest peak. More recently, and still fresh in our minds, Goldwin supplied the official uniform of the Japanese national rugby team. The "Brave Blossoms" lived up to their name in in the 2019 Rugby World Cup Japan Games. Goldwin have a long-time history of involving deeply into the world of sports.

Goldwin Tech Lab and cradle CFD supporting the development of next generation, high performance sportswear

Goldwin advocates the idea of "Craftsmanship" across the company and develops sports gear that boast high functionality and high quality. The embodiment of this idea is the Goldwin Tech Lab, a research and development facility opened at Toyama, in their head office. This state-of-the-art laboratory includes a wide range of cutting edge equipment, such as a 3D scanning, artificial climate control chamber, motion capture, in addition to the latest design software. These are all used in cutting-edge product design, alongside MSC Cradle.

Why MSC Cradle? Goldwin's aim is to provide high performance apparel. In order to do this they need to optimize the cut and materials of their apparel, which in turn demands that they have a clear understanding of the air flow and thermal environment in, and around, the clothing, and crucially the wearer's body.

To know more we interviewed to Mr. Aimi, Ms. Kamatani, and Mr. Kimura of Goldwin Tech Lab about how they used MSC Cradle to develop some their latest sportswear, for The North Face.

The North Face® Spiral Jackets (Only sold inside Japanese local market)

Development of highly breathable jacket using Cradle CFD scFLOW

The North Face® have over 50 years of exploration and innovation. The North Face fundamental mission remains unchanged since 1966: Provide the best gear for our athletes and the modern day explorer, support the preservation of the outdoors, and inspire a global movement of exploration. In 2018, North Face released it's "Spiral Jacket".

One of the major features of this jacket is that there are two openings on the sleeve, to improve air flow between the body and arms. Intended to reduce "stuffiness" inside the jacket and allow it to breathe this provides the wearer with increased comfort. It's therefore important to be able to understand how much ventilation could be provided by these openings. As such , it was analyzed by scFLOW.

Naturally Goldwin began by scanning people and the jackets, upon which they could digitally vary designs, motion capture studies to consider movement, and ultimately, advanced flow simulation using MSC Cradle. They could then start to vary key design considerations of the openings.

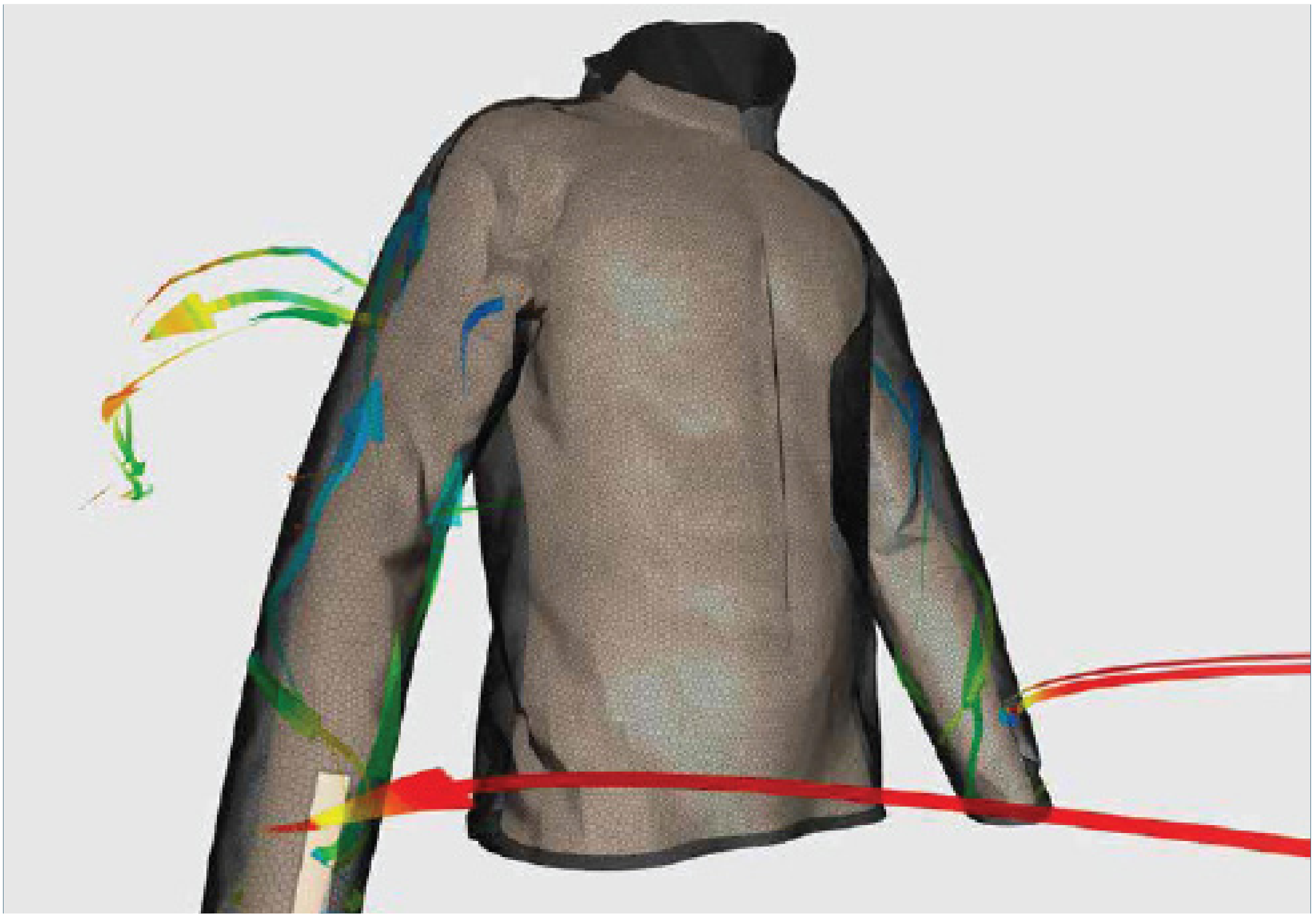
Yuichiro Miura at Everest

According to Ms. Kamatani, when performing analysis, the results of 3D scans or dressing simulations are used for the shapes of clothes and human bodies as a calculation model. Traditionally this is difficult to handle well with ordinary CAD software because the shapes are very complicated. With scFLOW, however, this is easily overcome. "scFLOW has powerful shape fixing function, such as wrapping, and can go through smoothly from meshing to analysis", says Ms. Kamatani.

The simulations included arm swing movements, obtained from motion capture measurement as boundary condition. From this MSC Cradle CFD calculated optimized sleeve openings. These results showed air entering from the inlet opening, at the cuffs, and spiraling towards the outlet opening at the armpit. This very unique feature ultimately named the jacket... "The Spiral Jacket".

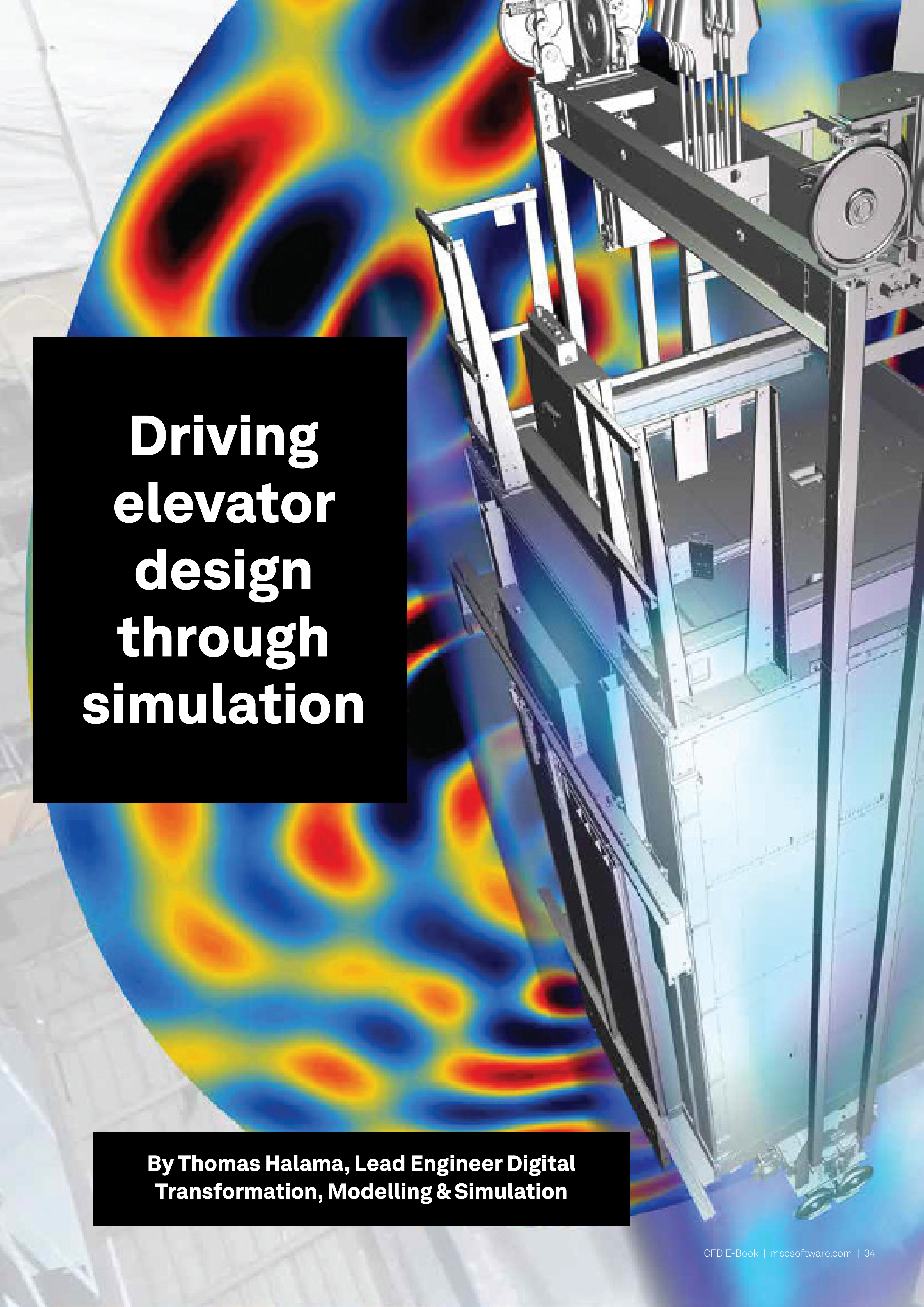
The future of sports gear development using Cradle CFD

In the future, Goldwin plan to increase the adoption of MSC Cradle, developing more functional products, with increased levels of digital realism, realizing benefits for top athletes and all sports lovers alike. We wish them all, the best of success.



Flow around the "Spiral Jacket"

"Product development using MSC Cradle CFD has, with respect to sportswear such as ski clothing and running wear, allowed us to more innovatively design for comfort, to a degree, which was not considered previously", said by Mr. Aimi.



Driving elevator design through simulation

By Thomas Halama, Lead Engineer Digital Transformation, Modelling & Simulation

Schindler

By 2050, mega cities and mega urban regions will boom. In such a world, building "up" is inevitable, in order to make the most efficient use of valuable space. It means that elevators and escalators will become even more critical to keep societies and economies functioning.

Schindler moves more than 1.5 billion people each day. Therefore, we believe we have a unique role to play in helping the world deal with urbanization. We need to do more than just keep up with the latest innovation: we need to help re-imagine the urban environment. No matter whether it's for residential properties, or for offices, airports, hospitals, hotels, cruise ships, stadiums, malls other retail projects, Schindler is resolved to so while providing reliable customer service and high-quality mobility solutions that ensure safe and efficient use for the public, as well as cost-effective, superior performing equipment for building owners and operators.

Over the years, Schindler has successfully launched numerous innovations, such as destination control systems or the first-ever patent for elevators without a machine room. With the advent of artificial intelligence (AI), Schindler has also established itself as a leading company in the development of the Internet of Elevators and Escalators (IoEE).

Digital Twin

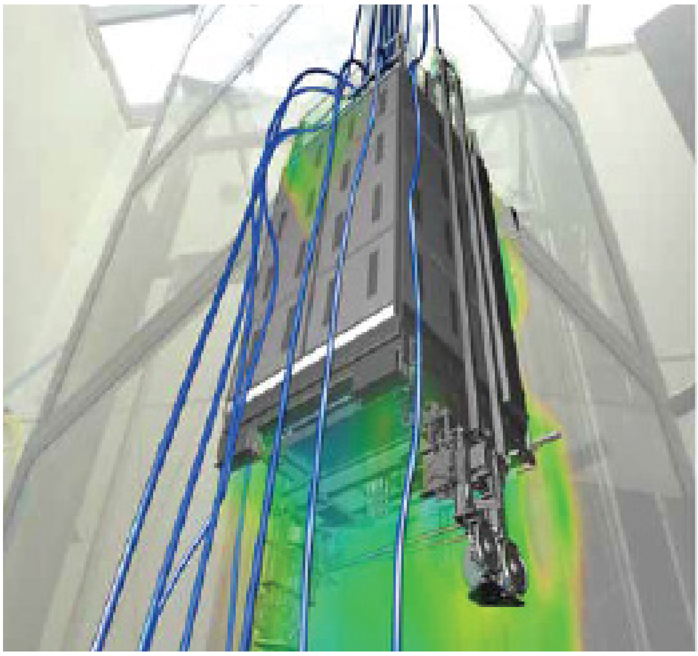
Moreover, we have invested in Digital Twin technology to capture the full potential of AI across the entire value chain and incorporate fresh thinking around how we help people move.

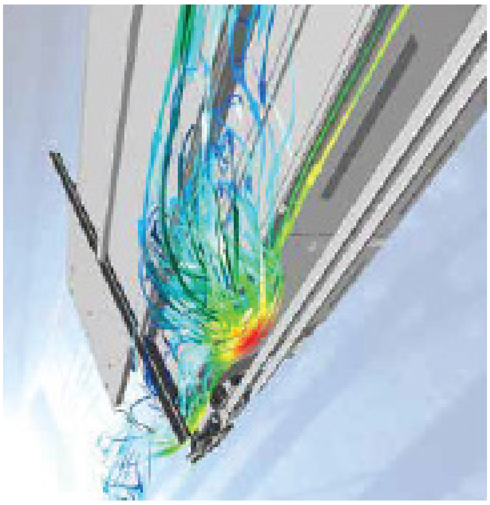
At our company's research and development facilities we replicate complete elevator systems as well as components for applications, while applying new design and engineering features. Digital twin technology also allows us to try things out by incorporating new ideas into a design that would otherwise be hard to test (it's not like we can build a 500-meter tall test building every). Therefore, we incorporate more and more simulation into our designs earlier into the design process. With this simulation-driven approach to design we can get things right immediately, without having to wait for field testing.

Some important aspects include the testing of energy recuperation elements (where we capture and re-use energy created by the movement of elevators), the usage of more eco-friendly material, better space utilization, double-decker cars, or even more simply… the smooth running of an elevator! This last point is one in which Schindler Elevator excels: you should be able to stand a coin up on its edge on any handrail of a Schindler Elevator in motion without the coin falling over.

Field Testing

Field testing remains necessary though, in order to verify each aspect of our installations and deliver on our promises. In a recent installation of a dual shaft elevator our tests showed disruptive noise propagating into the elevator car. We developed a hypothesis that the noise was due to air flowing around openings between the shafts. Our elevator shaft was basically a giant whistle.





Bust as we didn't just want to identify the issue, but also try out design improvements, we created a 180-meter long CFD simulation model containing two shafts and coarse models of our elevator cars. This provided a complete, detailed, view of the flow model, and the sort of turbulence we could expect in and around the shafts of our "giant whistle".

Armed with a view of how the air moved through our shafts, we then undertook aero and vibro-acoustic simulation. We now also had a picture of noise at any point in the shaft and cabin, even including the fact that the cars are comprised of some fairly complex composite materials, with plastics, metals, foams, all interacting with each other. It turns out that the openings were not responsible for the whistle noise. Soberingly, most of the noise was simply due to the movement of air around and through the cabin.

Now that we'd debunked our hypothesis, we had to identify the specific sources of noise in and around the cabins. Armed with detailed CAD models of the cabins we found the actual cause of the problem. There was a specific design element uniquely interacting with some gaps at the bottom of the car doors causing resonant noise.

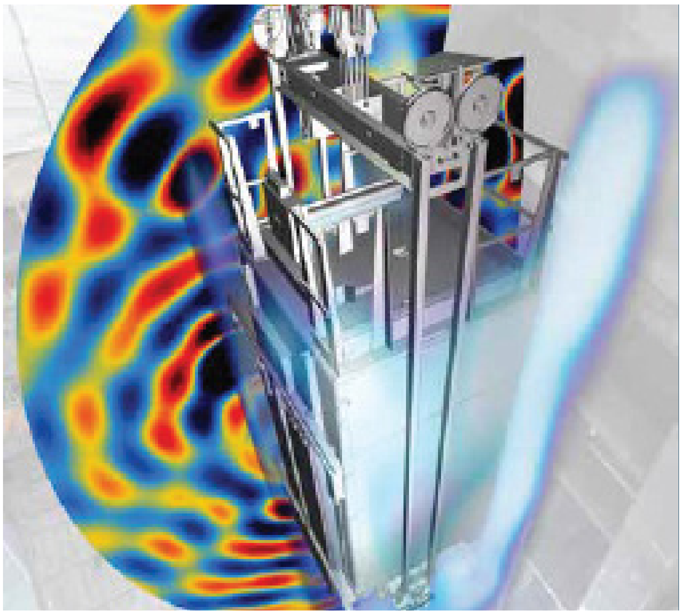
Now that we understood what was causing the noise, and where it was coming from, we modelled the airflow in detail to understand what specific design features were causing the resonant whistling. We could at that stage evaluate design changes to remove the unwanted whistling... Easy, right?

After that we could focus on other sources of noise from the outside of the cabin, addressing each design challenge according to our simulation work.

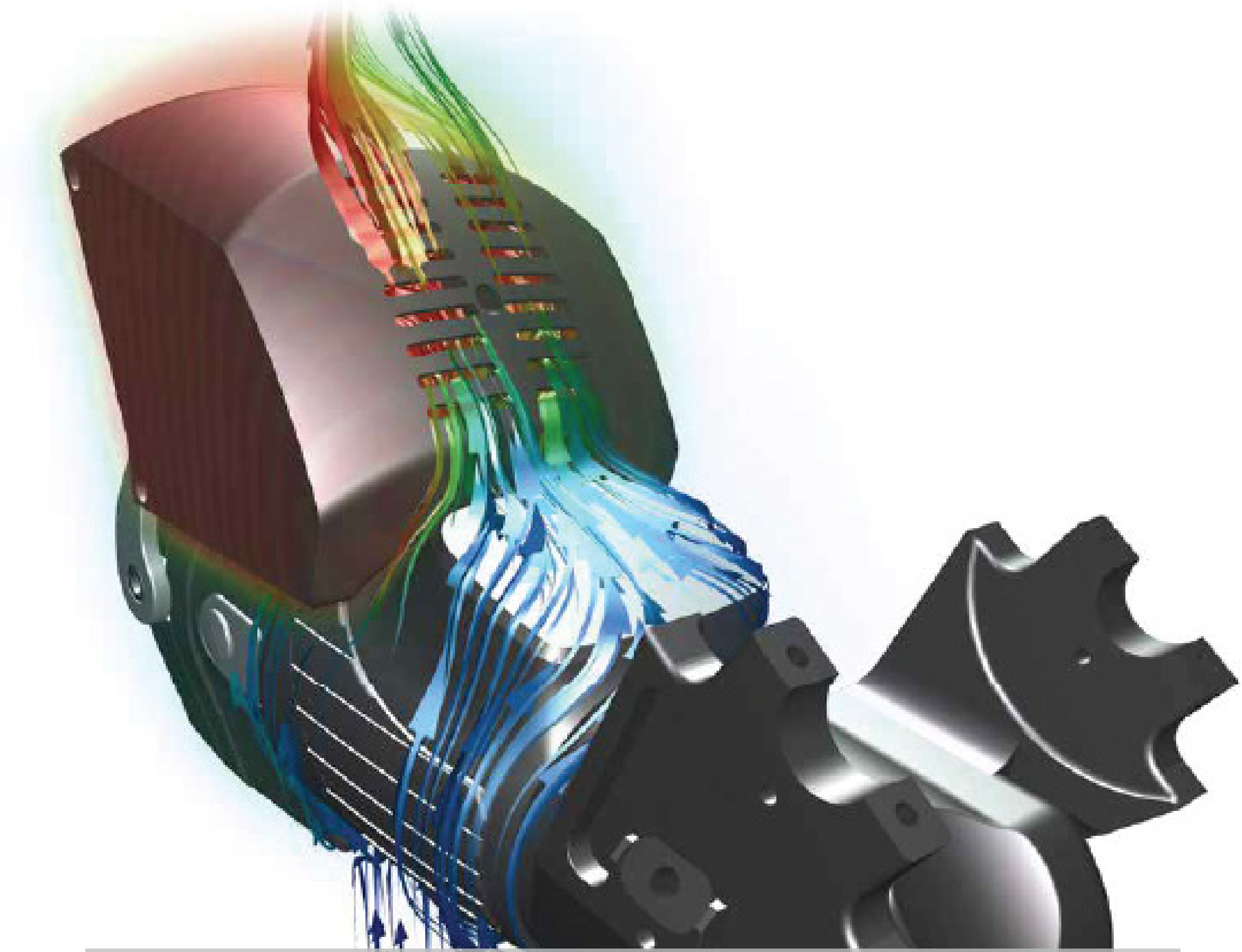
Since doing this we've undertaken some 16 individual simulations and identified and addressed seven design features, each of which helped reduce noise.

In this iterative manner we drive design forward through simulation. And in addition to pragmatically trying out new design ideas, we can evaluate more design variants faster, in particular as we automate more routine simulations. Moreover, we can share the simulation models we create with internal development departments to drive innovation further.

At the end of the day, simulation helps us drive our designs, allowing us to hit our quality targets faster.



Learn more about Schindler Elevators: www.schindler.com



Seeing into the future to develop the world's leading reality Capture devices

A digital thread to deliver world-leading accuracy, precision, certainty, and productivity.

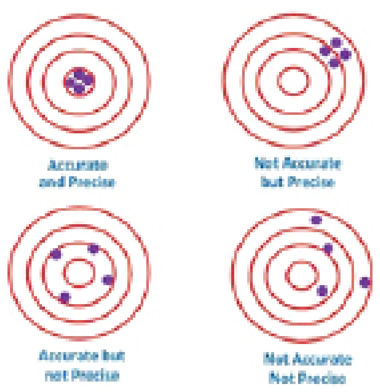
By Silvan Meile, team lead, virtual prototyping, Hexagon Technology Center
Keith Perrin, Industry Director, Hexagon | MSC Software

When it comes to assuring quality, many world-leading companies in the most demanding and highly regulated industries rely on Hexagons reality capture equipment.

Our customers in sectors from aerospace, automotive and medical device supply through to surveying, heavy construction, and mining turn to us for measurement equipment. They use our devices to attain the highest levels of precision and accuracy as they deploy new designs, materials and operational processes. For Hexagon, that means constantly innovating so that our customers can too.

With over 4,000 employees in R&D and more than 3,700 active patents, Hexagon, of which MSC Software is a part, is clearly not afraid to try out new ideas. And the virtual prototyping team at Hexagon is at the centre of many of these efforts, including in the field of reality capture.

The team provides a centralised set of simulation services for the rest of Hexagon, providing insight, expertise and advice so that Hexagons product development teams can remain at the cutting edge. Our virtual prototyping team has carried out hundreds of simulation jobs in support of our company. We're like the swiss army knife of simulation, wielded by a team with a wealth of expertise across a broad number of individual applications. Our work covers advanced materials, mechanical structural simulation (linear and non-linear), crash (shock, drop), motion, controls, thermal, thermo-mechanical, fluid, steady state and transient, electromagnetic, and topology optimisation.



Making use of virtual prototyping is a natural continuation of Hexagons 200-year history of pioneering advances in quality and precision. Simulation allows us to develop faster, thus reducing the number of physical prototypes. Crucially, it enables us to explore more optimized designs leading to products that are more reliable, accurate and precise. The marriage of accuracy and precision is important for our customers. It is not enough to capture a precise result. Our clients also need to be able to demonstrate its accuracy to their own customers and industry regulators.

Figure 2. The Leica MS60 surveyor device

Historically, accuracy and precision were defined solely by mechanical design, manufacturing capabilities and assembly. Luckily, today's devices can make use of the concept of compensation, which separates the ideas of accuracy and precision. What does this mean for modern design? First, the foundation of precision lies in designing a device that behaves as predictably (or repeatably) as possible. Second, the final accuracy is achieved by compensation and requires the act of calibration, creating a compensation map between theoretical observations and traceable values. Simulation can support all of these necessary steps. Clearly designing measuring instruments entails taking into account how even the tiniest details can affect accuracy and precision. Practically, what does all this mean? One example is the Leica Nova MS60 MultiStation from Hexagons Geosystems. It has an angular accuracy of one arc second or three thousandths of an angular degree. Being that accurate means, you can kick a football from Munich to Barcelona, which is a distance of just over 1,000km, and be sure of scoring a goal between standard goalposts. Obviously, the simulation must perform at this level as well.

Details Matter

Taking these requirements very seriously means paying attention to both a wide array of physics and the smallest details.

For example as we utilise more and more electronic equipment and computational power to deliver increased accuracy, fidelity and robustness, we're also increasingly trying to fit more into smaller, more flexible packaging designs. The result is hugely complex, very tight designs, which are generating more and more heat, in ever smaller packages.

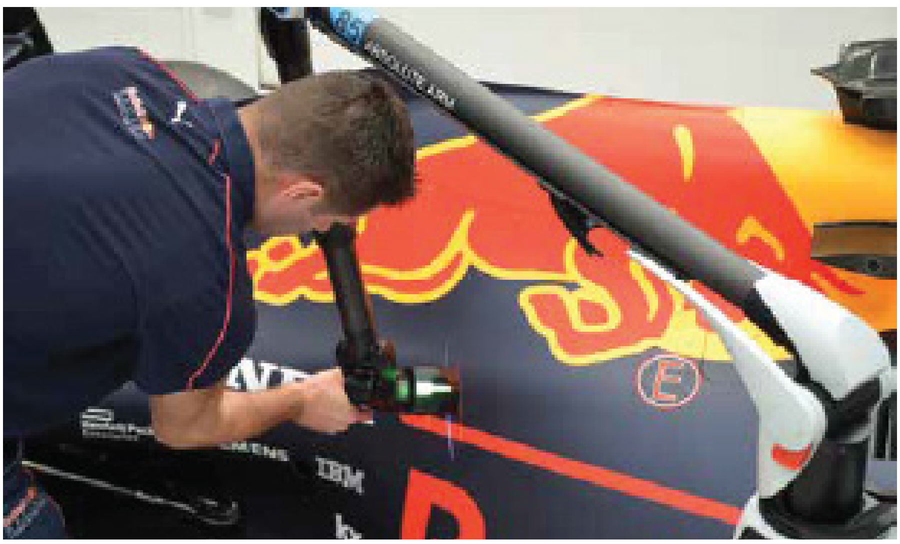
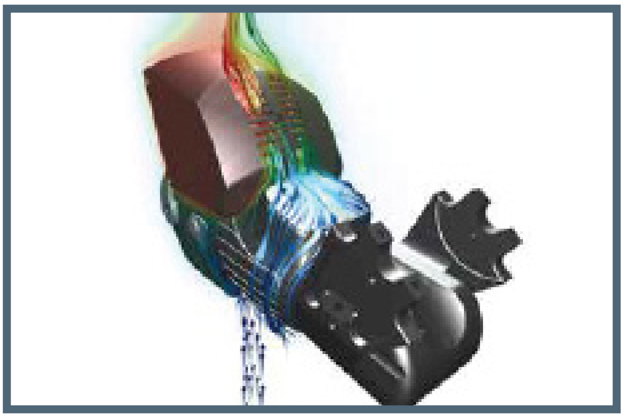


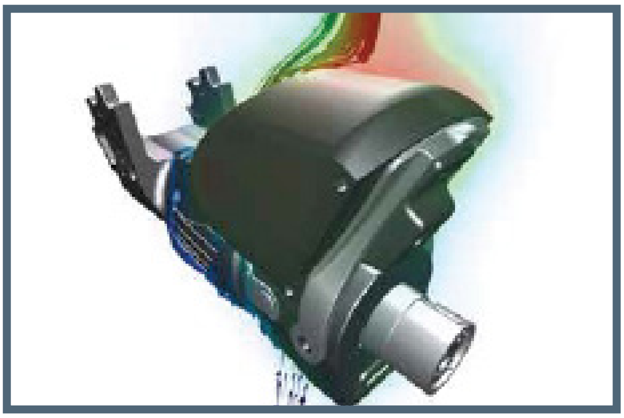
Figure 3. The RS6 laser scanner

Without advances in virtual prototyping, the reality capture devices we're delivering today would most certainly not be possible, simply because the complexity and cost associated with developing them would have been showstoppers. A great example is another reality capture device, Hexagons RS6 laser scanner. The RS6 is a blue laser line scanner that collects extremely high-density point cloud data at high speeds and high accuracy. With a scan line 150 millimetres wide at mid-range, it covers 30 percent more surface area than the previous generation of portable measuring arm laser scanners from Hexagon.

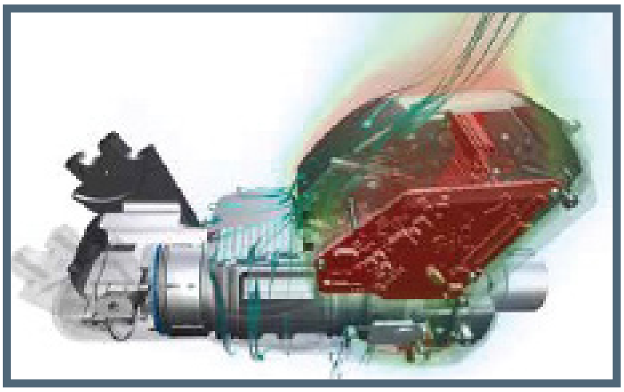
At the foundation of its functionality is what Hexagon calls SHINE technology – Systematic High- Intelligence Noise Elimination. Put simply, this means it can scan more types of surfaces, more reliably, faster and more easily, with almost every measurement job achievable. The RS6 has a more compact design than previous generations of laser scanners from Hexagon, while also adding new hardware and software elements. That made it vital that we paid close attention to the thermal and thermo-structural aspects of the scanner design. Any operating laser scanner generates heat, and this only increases as the scanner design becomes more advanced and complex. This in tur creates



Hexagon Leica RS 6 Scanner
Thermal convection around the cooling grill



Hexagon Leica RS 6 Scanner
Thermal convection around scanner head



Hexagon Leica RS 6 Scanner
Internal thermal convection & conduction

Hexagon Leica RS 6 Scanner
Internal thermal convection & conduction

creates mechanical displacements, strains and stresses within the scanner. All of this generates greater variation, uncertainty and variance in the measurements, which must be accounted for in the scanner's operational performance. Virtual prototyping made it possible to find design solutions to overcome these challenges. Simulation allowed the designers to test and benchmark concepts and fine tune details, leading to many simulation runs. The complexity of development projects such as the RS6 is one of the many reasons we took the decision to increase our virtual prototyping capabilities, by adopting Cradle scSTREAM, from MSC Software.

Our previous simulation toolset required a high degree of expertise, patience and time to set up. For example, with more complex thermal and cooling simulation, preparing a model and meshing it to be ready for simulation could take as much as a week in some cases. With scSTREAM, we can now drive through this in a matter of hours and take more effective design decisions.

The result has been a sevenfold increase in overall productivity for certain tasks. This is tremendously valuable to us. We can react far more quickly to simulation requests. We can more thoroughly investigate ideas and innovations if needed. We can drive up quality. Finally, what sets scSTREAM apart for our simulation engineers is its computational speed. The time needed to get to a simulation result speeds up in an almost linear relationship with the amount of computer cores you have available.

In addition, scSTREAM fits in well with the rest of our tools and processes, creating a digital thread across our design toolsets and processes. As a simple example, scSTREAM can easily read the design details we get from our engineers. This allows us to move fast. We don't have to painfully re-create models to move from one step in our process to another.

It has also had a clear impact on the depth of insight we can gain. Our previous toolset was great from a scientific perspective, as it was able to give us insight into the thermal performance of our designs. But we need to know how the whole design works, not just a singular aspect of it and this meant ensuring our thermal and structural simulation tools are able to work together and deliver what applications demand. As mentioned above very, very small movements matter when it comes to designing measuring instruments, making it important to understand the impact of even slight environmental temperature changes. Moving forward, we can use scStream with tools from MSC Software, as well as other vendors, to give us more detailed insight into the coupled thermal and structural impact of our designs for the whole of Hexagon.

Because that's another key aspect of our work for Hexagon -- it extends beyond reality capture to all areas of the business. MSC's simulation software gives our team the versatility to support Hexagons innovation across multiple products that range from laser measuring, safety monitoring and detection systems, through to UAVs (unmanned aerial vehicles), mobile scanning and machine control systems. Simulation tools give engineers a view of how the future can be, and when you work for Hexagon that future is the technology that will transform and drive the industries and cities of tomorrow.

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2020 VISION

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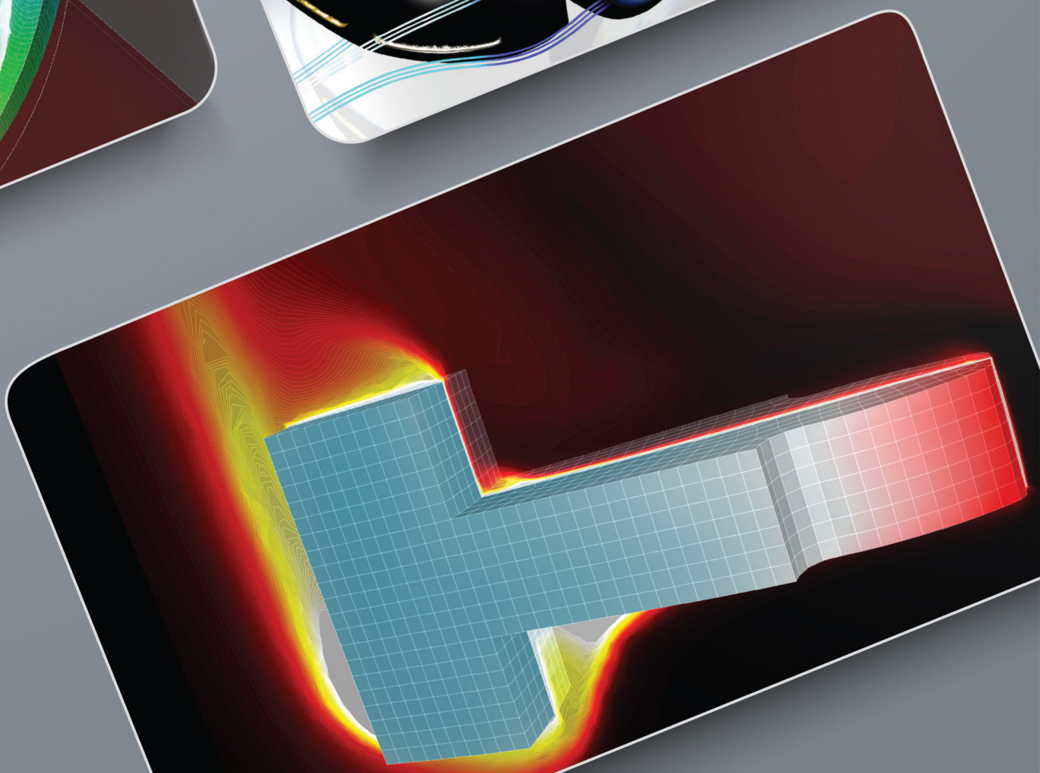

Makoto Shibahara

President and CEO, Software Cradle

Makoto holds a Masters Degree in Mechanical Engineering from Keio University in Japan and has spent his whole career in Software Cradle since 2002 starting as a Computer Programmer to become Product Manager, then Head of Development, and since 2019, President and CEO of Software Cradle, that is now a Hexagon company. He is passionate about delivering quality Computational Fluid Dynamics (CFD) software that is fast, accurate yet usable by engineers around the world to solve real-world engineering problems.

Jonas Wirgart

Product Marketing Manager, Software Cradle

Jonas has a Bachelor's Degree in Mechanical Engineering from Chalmers University, Sweden and Master's Degree in Nuclear Engineering and Management from The University of Tokyo, Japan and extensive experience at MSC Software in Scandinavia with a wide range of Computer-Aided Engineering software, from fluids to structures, as a technical specialist and a consultant. He has real-world engineering experience from working in both the Automotive and Aerospace industries before joining MSC Software. He is passionate about multiphysics-focused CFD and how it will push the frontiers of CFD in the 21st century.

Dr. Keith Hanna

VP Marketing, MSC Software

Keith is the Vice President of Marketing of MSC Software. Dr. Hanna is a veteran of the CFD industry with over 30 years of experience in the CAE, EDA and PLM industries, spanning a wide range of global technical and marketing roles inside Siemens PLM, Mentor Graphics Corp., ANSYS Inc., and Fluent Inc. He has practical experience of the metallurgical and mining industry at both Br. Steel and De Beers having gained both BSc and PhD engineering degrees from the University of Birmingham in England. He is a thought leader and respected commentator on the CFD/CAE industry, a pioneer of CFD in sport, and a former member of the Executive Committee of the International Sports Engineering Association.