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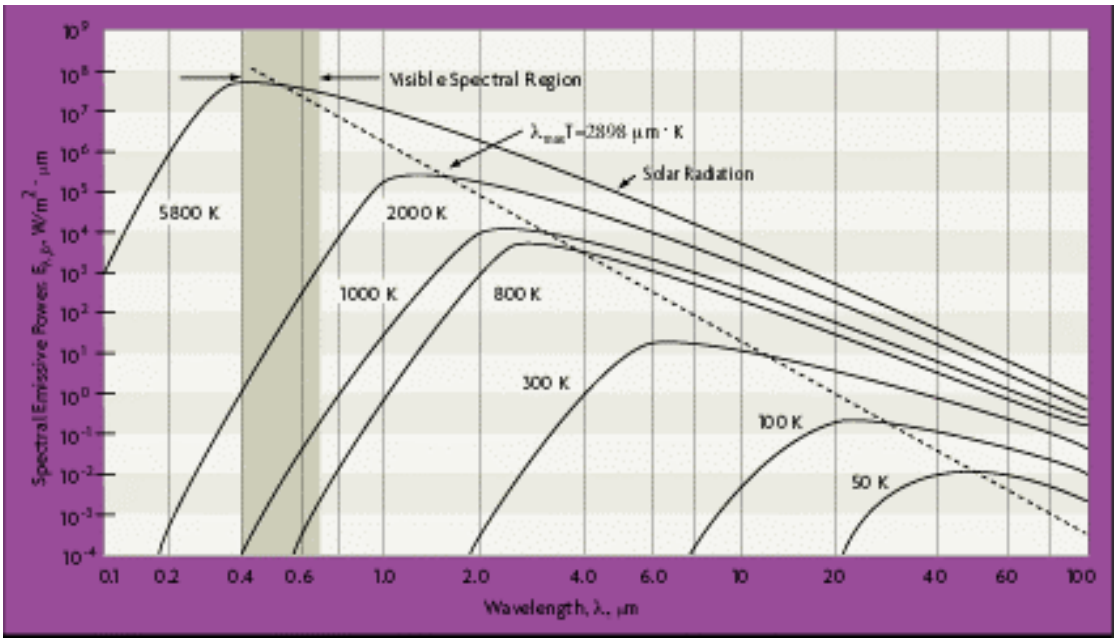
Walking on Fire with LS-DYNA
Art Shapiro – shapiro@lstc.com

The bed of wooden coals was meticulously prepared and simmered all day. By nightfall, the coals were glowing red and posed an intimidating path to cross. The spiritual leader tossed a steak on the coals and it immediately sizzled. The steak was removed from the coals and had a seared surface. Then, miraculously a person walked across the coals without being burnt (or cooked).

Firewalking has been practiced for thousands of years. Abundant information can be found by typing "firewalking" into a web search engine. Many articles are by faith healers who claim successful firewalking is an exercise in connecting the mind and body. A plethora of classes are offered to get you in touch with your inner self by walking on fire. However, as an alternative, you can use LS-DYNA to model the process and avoid chanting mantras all day to get your mind and body in sync – let your computer do the walking.

First, we need to know how hot the coals are. We can use the hemispherical spectral emissive chart [1] below to determine this. The visible wavelength is between 0.4μ (violet) to 0.7μ (red). The 1000K (727C) curve below has an amount of radiant energy sufficient to be observed by the human eye between wavelengths of 0.4 to 0.7 microns. Since a larger percentage of the radiant energy is toward the longer wavelength of 0.7μ, an object at that temperature glows with a dull-red color. Now you also know how hot your hair dryer is.



Second, we need to know the thermal physical properties of skin, fat, muscle, and wood coals. This information can be found in textbooks. Values are presented in Table 1.

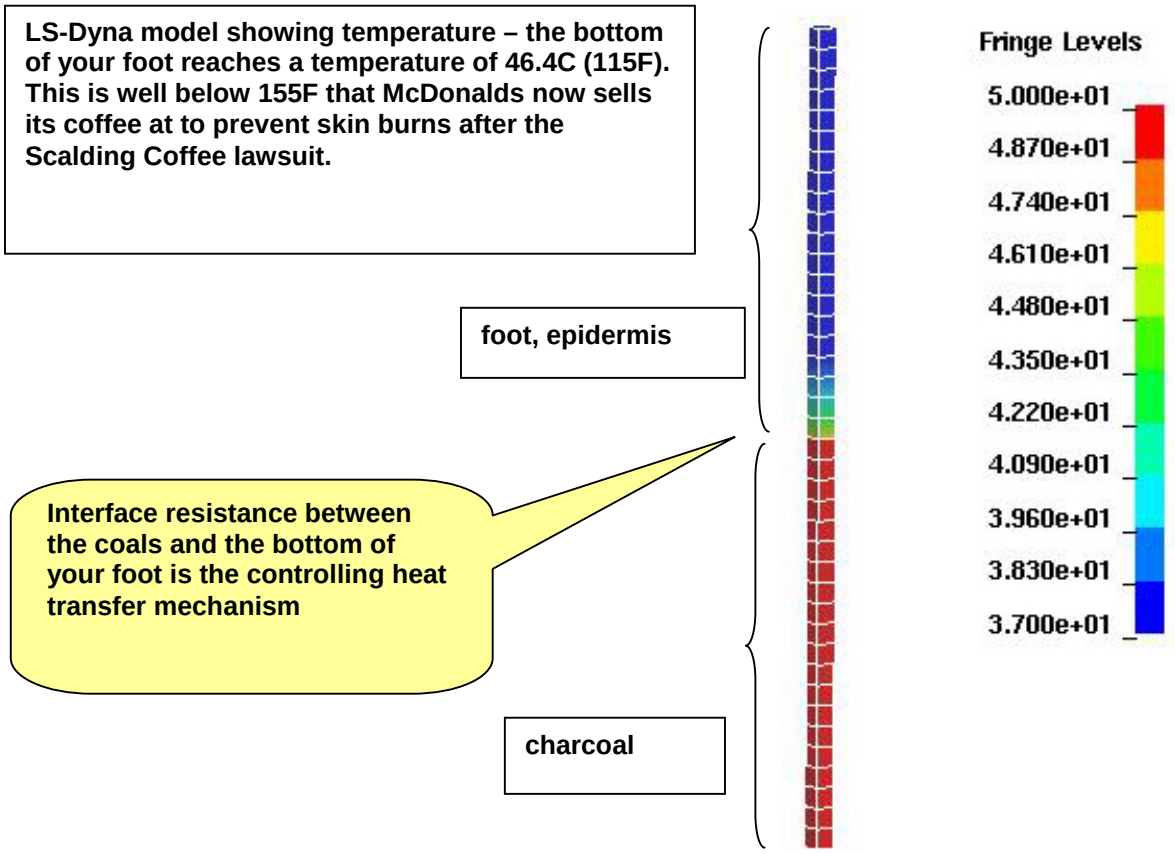
Table 1 Thermal Properties of Selected Materials

material	density, ρ [kg / m3]	heat capacity, c [J / kg C]	conductivity, k [W / m C]
epidermis	1200.	3440.	0.34
muscle / fat	1060.	3350.	1.60
wood charcoal	240.	838	0.052

Third we need to solve the bio-heat equation

$$\rho C \frac{\partial T}{\partial t} = \nabla \cdot k \nabla T - W_b C_b (T - T_b)$$

The second term on the right models heat removal from tissue due to blood flow (W_b=1.8 kg/m^3 sec). This term can be represented as a temperature dependent volumetric heat sink in the thermal material constitutive model. However, in the end, the heat removed by this term is negligible. It doesn't make any difference on the final temperature if you are relaxed or completely tense up and stop the blood flow in your foot. Other heat removal terms that would also work in our favor in reducing foot temperature have been omitted. This includes energy loss due to mass diffusion of water through the skin (i.e., sweating).



The problem can be modeled in 1-dimension with a contact surface between the bottom of the foot and the top of the coals. The coal bed thickness is modeled as 3cm with a temperature initial condition of 727C. The epidermis thickness is 0.2cm with a temperature initial condition of 37C (i.e., normal body temperature). The contact resistance between the coals and your foot is the governing heat transfer mechanism. Because we waited so long before walking on the coals, a grey powdery ash covered them. We will assume the ash is 1mm thick with a thermal conductivity half that of the charcoal. If you time yourself walking, you will find that your foot is in contact with the coals for 0.5 seconds.

LS-Dyna predicts a foot surface temperature of 46.4C (115F) after 0.5 seconds. This is considerably below the temperature of 155F that McDonalds now sells its coffee at to prevent skin burns after the Scalding Coffee lawsuit [2]. The only real chance for a burn is if an ember gets stuck between your toes so walk flat footed. However, walk fast because the time constant for heat transfer is in an exponential term and does mater.

What About the Steak – The thermal diffusivity is defined as $\alpha=k/\rho c$. The reciprocal of the thermal diffusivity is a measure of the time required to heat a material to some temperature level. Using the values given in Table 1., the reciprocal thermal diffusivity for the epidermis is 1.2e+07. Steak is muscle and fat. Its reciprocal thermal diffusivity is 2.2e+06. Steak will heat up 5 times faster than your foot. This presents problems in cooking steak. When meat is heated to temperatures in the range of 125F to 150F, the connective tissue sheaths collapse and shrink. Free water in the muscle cells flow out the ends of the muscle fibers presenting the appetizing appearance of a juicy steak. However, once the “juices” are gone (driven by a much too high energy input), the steak becomes very dry. In a future article, I will discuss using LS-DYNA to cook the perfect steak.

References:

[1] Hemispherical Spectral Emissive Chart from
http://www.omega.com/literature/transactions/volume1/theoretical2.html

[2] McDonald Scalding Coffee
http://www.lectlaw.com/files/cur78.html

Numerical Algorithms Group Teams up with AMD to Provide Mathematical Software Components for AMD Opteron™ Processor

"With the work we've done with AMD, we've demonstrated that accuracy and high performance are not mutually exclusive."

The Numerical Algorithms Group (NAG) was founded by university researchers in the United Kingdom 30 years ago and since then has focused on building mathematical and statistical components, often called math libraries, used by software developers.

"Researchers embed math libraries in their applications to solve complex problems," said Brian Ford, CEO of NAG. "It's critical that a core math library be both extremely efficient and accurate. We have found that the best way to accomplish this is to work closely with microprocessor vendors."

According to Ford, NAG was intrigued by AMD's approach to 64-bit computing, called AMD64, and was anxious to work with AMD on building the math libraries that would support development of software applications for the first AMD64 product, the AMD Opteron™ processor.

Although 64-bit systems have been around for a number of years, Ford notes that some users, specifically in high-performance cluster computing, have been left behind due to incompatibility and poor price performance.

"It's a laudable goal to make it easy for the user to migrate from 32-bit computing to 64-bit computing," he said. "I think it's an excellent approach."

Memory Addressability Driving 64-bit Clusters

High-performance computing clusters today are largely built on 32-bit, x86 processors. These systems execute complex calculations at a cost that is significantly less than 64-bit supercomputers. They have been widely adopted in university and government research settings, but are also prevalent in commercial businesses such as the finance industry.

"In finance, for example, you want to optimize the return for clients based on their risk tolerance so you calculate what's called the 'efficient frontier'," Ford said. "Ideally, within your portfolio, you'll be right on that line as it represents the best balance between risk and return."

In mathematical terms, this is an optimization problem, a complex calculation with many variables that change as stock prices change. According to Ford, NAG provides a number of optimization routines that can perform these calculations and counts a number of large financial institutions among users of its math libraries.

"Users of these large clusters have massive amounts of data they want to address," Ford said. "Unfortunately, 32-bit processors and 32-bit applications are sometimes too limited in memory addressability. I'm convinced that these users are going to need to move to 64-bit computing to address their increasingly sophisticated problems."

AMD and NAG Building 64-bit Foundation

Ford recognizes that the simultaneous 32-bit and 64-bit computing capabilities offered by the AMD Opteron™ processor will provide high performance computing users with an easier migration path.

“Because it offers the flexibility for customers to migrate to 64-bits when they’re ready, we think the AMD Opteron processor is an extremely interesting technology that is going to achieve strong acceptance in the market,” he said. “Obviously we want to be well positioned and ready for that shift.”

With that in mind, NAG has worked closely with AMD to develop the AMD Core Math Library (ACML), which is now available free on the AMD Web site at http://www.developwithamd.com/acml.

To provide software application developers with higher-level mathematical functions, NAG plans to make available later this year a set of NAG Libraries optimized for the AMD Opteron processor.

“A unique aspect of our relationship with AMD is that we worked very closely with AMD to develop ACML,” he said. “With the work we’ve done with AMD, on both ACML and libm, we’ve demonstrated that accuracy and high performance are not mutually exclusive. Our technical goal has been successfully achieved.”

About AMD: AMD is a global supplier of integrated circuits for the personal and networked computer and communications markets with manufacturing facilities in the United States, Europe, Japan, and Asia. AMD produces microprocessors, Flash memory devices, and support circuitry for communications and networking applications. The company was founded in 1969 and is based in Sunnyvale, California (NYSE: AMD).

For more information, contact Phil Hughes, AMD public relations at 512-602-4797.

European Consortium Develops Blood Simulation Tool to Fight Heart Disease

Today, heart disease is commonplace. The combination of a sedentary lifestyle and a rich diet has led to an increase in clogged blood vessels, heart attacks and strokes.

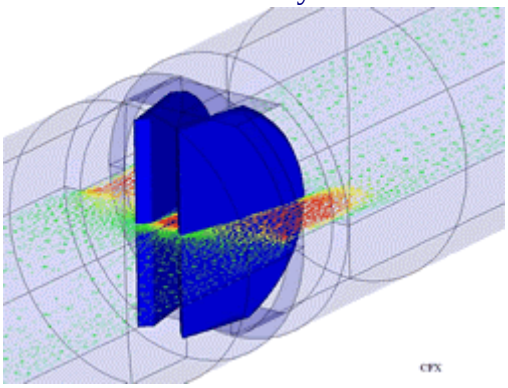
According to the American Heart Association, a person age 40 or older has a one-in-five chance of developing congestive heart failure. Fortunately, the causes of heart disease are known, and to a certain extent, so are the cures. The field of cardiology has grown tremendously to meet the demands of the disease, and tools and techniques for treating it continue to evolve to meet the ever-increasing need.

Challenge

With the aim of reducing heart disease fatalities, a pan-European consortium of OEMs, technology providers and universities has developed a new software tool for simulating blood flow. The new software – entitled BLOODSIM – will enable manufacturers to improve the design of artificial heart valves, pumps and stents, contributing significantly to improving the survival rates of this worldwide killer disease.

Solution

Driven by the University of Sheffield and the Atomic Energy Authority, BLOODSIM version 2.0 software was released to consortium partners in 2001. Working with IDAC Ireland, a leading engineering consultancy, the collaborators have successfully integrated two major simulation software tools, ANSYS and CFX, in order to create a 3-D solver for fluid/structure interaction problems. This ANSYS/CFX link will be made available to analysts in other industries.



A mechanical image of heart valve simulations generated for the BLOODSIM project.

A specific module for simulating fatigue testing of stents has been developed as part of the project and it will be made available to medical device manufacturers via the Internet. Formulated so that the FEA expertise is embedded in the software, end-users will not require analysis experience to use it. And because it is Internet-based, the analysis software, ANSYS, can be used online and does not need to be purchased outright.

Says Derek Sweeney of IDAC Ireland, The coupling of ANSYS finite element technology and CFX's computational fluid dynamics program has enabled us to simulate the flow of blood through arteries and heart valves, which is a major breakthrough in itself. However, the CFX/ANSYS connection will

also have ramifications for other industries where fluid/structure interaction issues are also problem, such as aerospace and automotive.

Artificial organs may cause damage to blood cells and until now there has not been a way to accurately assess this loss. The contribution of ASD Advanced Simulation and Design, a German-based consultancy specializing in medical devices, has been critical because they have provided us with blood clotting expertise and are defining the clotting algorithms. We are confident that BLOODSIM will become a standard blood damage model for use on a global basis.

According to Dr. Rodney Hose of Sheffield University, the development of BLOODSIM represents a considerable advance for the analysis of medical devices. He says, "At Sheffield University, we have a long history in the study of prosthetic heart valves, combining medical engineering expertise with a strong clinical input. There are two primary classes of prosthetic heart valves: mechanical and tissue. The former damage blood cells inducing a clotting process which requires anticoagulation treatment. The latter, most commonly constructed from animal tissue, have a limited life span."

Benefits

"When coupled with ANSYS FEA, CFX enables us to analyze the flow through mechanical heart valves throughout the cardiac cycle, including the critical opening and closing phases. The shear stresses generated in the fluid contribute to the damage to blood cells. The next step towards combating cardiovascular disease is the modeling of blood clotting, which will require chemical reaction models as well as the multi-phase physics."

The partners involved in the BLOODSIM collaboration are Sheffield University (UK), IDAC Ireland, The Atomic Energy Authority (UK), Performance Fluid Dynamics Ltd (Ireland), ASD Advanced Simulation and Design (Germany), Medtronic (Ireland), Angiomed (Germany), Berlin Heart AG (Germany) and Autogenics (UK).

Pilatus Aircraft Flies into the Future with VPD © Copyright MSC.Software
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The name Pilatus is not exactly rare in Lucerne, Switzerland. Mount Pilatus towers 2,132 meters over the area, inspiring the name for many products, including Pilatus Aircraft Inc., located in nearby Stans. In the middle of one of the most beautiful regions in Europe, small aircraft are built which give Switzerland a worldwide reputation in aviation circles.

Pilatus aircraft are highly regarded due to their excellent performance and reliability, which they owe to their turboprop engines. The flagship of the company's reputation is the Pilatus PC-6 Porter, in production for more than 40 years and nicknamed appreciatively by experts as the 'Sky Tractor.' Whether in use in the Arctic Circle or the Australian outback, the Porter has reliably carried out its duties under the most severe weather conditions. The civil program has been supplemented since the mid-1990s by a single-engine business aircraft, the PC-12.

The origins of Pilatus were military in nature, and this market remains extremely important. In 1945, the company produced its first military training aircraft, the Pilatus P-2. Its 'great-grandchild', the PC-9 Advanced Turbo Trainer, debuted in 1984. To date, more than 750 Pilatus trainers have been sold to customers in more than 20 countries.

Worldwide, Pilatus employs approximately 1,150 employees, divided into three business units: general aviation, government aviation, and maintenance. With representatives on practically all continents, a great deal of energy is expended in augmenting the company's good reputation and developing business based on high technical standards and the best possible customer relations. In order to secure the leadership role in the trainer market of the future, Pilatusý high-tech specialists are currently working at full speed on a new project. The PC-21, which undertook its maiden flight last year, is expected to be certified in 2004 and released to the market. For the first time in the history of Pilatus, the most advanced development methods and tools were used to implement this ambitious project.

Aircraft Construction - Engineering at its Best

As is the case throughout the aircraft industry, the order of the day is 'no holds barred.' If a company wants to be successful, not only must it comply with increasing customer requirements and ever-more stringent statutory regulations, it must also be able to implement innovations rapidly and cost-effectively. With product lifecycles and customer relations measured in decades, the motto 'cash and go' simply does not work. Complete product documentation and the availability of technical information is not only desirable but in many segments compulsory.

High technological demands, as well as the need to simultaneously reduce time-to-market and development costs, are practically incompatible with conventional development processes. At Pilatus, the PC-21 project was viewed as the trigger project to subject the product development process to a very thorough re-engineering. At the top of the priority list stood requirements such as reliable and robust design, consideration of lifecycle standpoints, the reduction of design iterations and the more rigorous inclusion of external development partners.

Pilatus saw a solution in turning away from a paper-based sequential development process. Knowledge acquisition as early as possible and the use of an electronic master model, or digital mock-up, based on CAD data were intended to shorten the development process, parallelize task sequences (concurrent engineering), and avoid unforeseen design changes in later steps. The early recognition of functional and technological requirements and links necessitated the use of powerful design and simulation tools that meant relatively high initial investments in terms of time and money. In the long term, however, reduced costs and shorter development time were the result.

It may be that organizational and perhaps technological hurdles are even higher for larger manufacturers of passenger aircraft. But the fact that a medium-sized company with limited capacity uses high-tech tools in manageable dimensions makes the Pilatus interesting and educational.

Of Pilatus' more than 140 developers and designers, over 60 have been involved with the plans for the new PC-21. The development program, which began in January 1999, focused on three core objectives: superior aerodynamic performance when compared with any other turboprop trainer currently on the market; a more powerful, flexible and cost-effective integrated training system than any other turboprop or jet trainer; and a lifecycle support cost that did not exceed current turboprop benchmarks. Designed for basic, advanced and fighter lead-in training, the PC-21 is a single-engine, low-wing, swept monoplane with a stepped tandem cockpit optimized for aircraft handling, tactical navigation training, mission and system management, simulated air-to-ground engagement, simulated air-to-air engagement, and reconnaissance training requirements.

For the PC-21 project, Pilatus engineers used a common digital mock-up generated using Unigraphics CAD software, the components of which are managed in the Unigraphics Fast Standard Part Library. The production and manufacturing data are derived from this master model in later phases. Initially, however, the model data are predominantly used by computation engineers in order to have as comprehensive a picture as possible of the functional behavior of the still-virtual aircraft at an early stage in development.

A Model Case with Many Leading Characters

In accordance with the wide range of tasks, the list of simulation solutions used by Pilatus is very comprehensive, which is why the eight computation engineers working on the PC-21 project cannot complain of lack of work. Aerodynamics, especially in the concept and design phases, obviously has a central significance. In combination with wind tunnel tests, CFD (Computational Fluid Dynamics) simulation rapidly provides important feedback on the reliability of aerodynamic concepts and solutions. Pilatus relies here on CFD++, which is still largely unknown in Europe; the package solves the tasks to their full satisfaction.

However, simulation and analysis serve not just to safeguard development and design but are also part of certification conditions, which have to be fulfilled for submission to the Luftfahrtbundesamt (Federal Office of Civil Aeronautics). For this purpose, Pilatus has decided to follow the majority of the aerospace companies by adopting MSC.Nastran, the simulation program seen in the aerospace industry as a quasi standard.

The aeroelasticity module in MSC.Nastran serves specifically to analyze the flutter response and is therefore, from the safety point of view, of particular importance for the optimization of the flight characteristics.

But the list of simulation tasks is long. MSC.ADAMS is used for the design of control kinematics. In order to increase the use of multi-body simulations in the future, Pilatus engineers plan to use MSC.ADAMS as part of the so-called Multiphysics Applications in which, for example, the kinematic simulation is combined with structural mechanics data. Simulation is completed with LS-DYNA (Livermore Software Technology Corp.) analysis for transient problems, such as bird impacts on the cockpit shield or the function of the ejection seat.

The number of simulations and variations is immense and would not be possible, within tight development schedules, without corresponding computing performance. A. Borel, a leading member of the structure analysis team at Pilatus, estimates that for his team, the number of load cycles investigated is 3,000-4,000, with about 50 critical load cycles reviewed particularly carefully. The size of the computation models varies considerably and can easily comprise several hundred thousand degrees of freedom. Pilatus uses the Linux operating system for its simulation computers; due to its combination of speed, stability, and low investment costs, the system is an attractive alternative for an increasing number of companies. The installed Linux network consists of four Hewlett Packard high performance workstations hp x4000 double processors and an additional head node. Despite this high performance level being available, further capacity is being considered in the light of future needs. Engineering Flight Simulator - Insight into Technology at an Early Stage

With the date of the PC-21's maiden flight coming ever closer, tension increases. The pilot must decide whether the new design actually fulfills expectations. While pilots' wishes and inputs are taken into consideration during development, the 'jargon barrier' often makes it difficult for real communication to take place. At Pilatus, for the first time, a flight simulator is being used to integrate computation and simulation data. Pilots can thus test aircraft that do not yet exist in reality and make assessments and comparisons. The data obtained can be input directly into development and prototype construction. Even if the number of prototypes is not reduced, the simulator represents an essential help with respect to the minimization of design changes - even in the early design phase.

Simulation - The Key to Success

Leonardo Manfriani, chief aerodynamics specialist at Pilatus, is firmly convinced that it was the implementation of Virtual Product Development technologies and the consistent use of simulation tools that made this achievement possible.

The Pilatus concept has proven itself even before the new aircraft has reached series production. Shorter time-to-market, lower investment costs, lower lifecycle costs, and last but not least, the minimization of technical risk are the positive outcomes of this development project. With a positive attitude toward innovation and confidence in the potential of modern computer and simulation systems, Pilatus is poised for more future success.

Increase Your Hit Rate With NEC's Automated PalmPrint System™
Reprinted from the website www.necsolutions-am.com

The Identification Solutions Division of NEC Solutions America delivers a comprehensive palm print identification tool that builds upon our legacy of latent fingerprint accuracy. The Automated PalmPrint™ Identification System is field tested and available today as a stand-alone system or integrated as an AFIS21™ component.

Because palm prints make up approximately 30 percent of the prints taken from crime scenes, they often provide the only available clues to identify suspects. After deploying an automated palm print system from NEC Solutions America, a major metropolitan police agency identified a vehicular hit-and-run suspect within five minutes following entry of a latent palm print from the crime scene

Law enforcement agencies worldwide now realize the benefits of these additional crime-fighting clues and the proven performance of NEC's AFIS technology in solving otherwise "unsolvable" cases.

Features:

It is estimated that unknown prints are found at about 60 percent of crime scenes, and that 30 percent of these are palm prints. Before automated palm print technologies were developed by NEC Solutions America, criminal investigators had no choice but to conduct laborious one-at-a-time manual searches of palm prints taken from suspects against very large databases collected over the past 25 to 30 years. The Automated PalmPrint™ Identification System interfaces with the NEC NIST Archive System and is an ideal complement to existing AFIS21™ systems. It provides a solution of "unsolvable" cases, new opportunities for cooperation among agencies, with cost savings and time savings for investigators. By enabling faster apprehension of suspects. A PalmPrint™ Identification System has great potential to prevent future crimes and lead to quicker and more reliable convictions, while excluding innocent suspects from investigations.

Input and Image Processing:

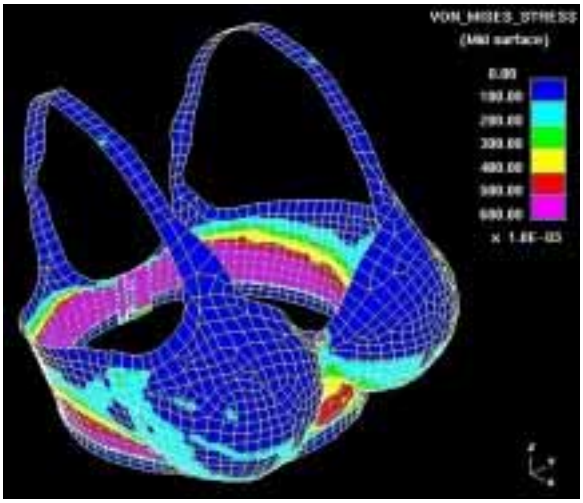
- **Includes scan, cropping and descriptive data input**
- **Selective display of gray, skeleton, minutia, and zone of information**
- **Selective edit of skeleton and zone information**
- **Image enhancing and editing tools for latent palm prints using NEC's Latent Examiner Software (LEXS™)**
- **Side-by-side image verification**

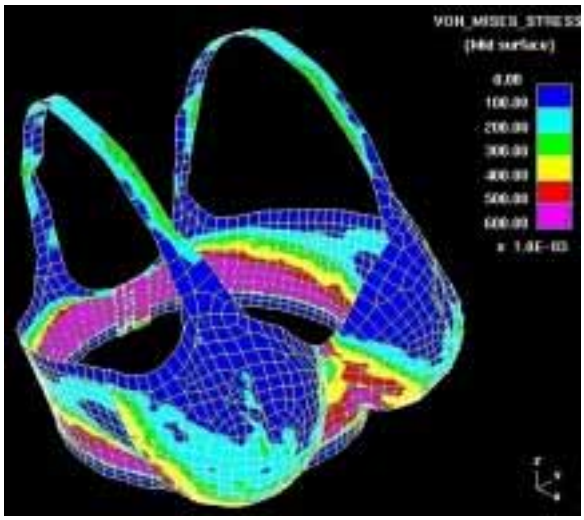
Matching:

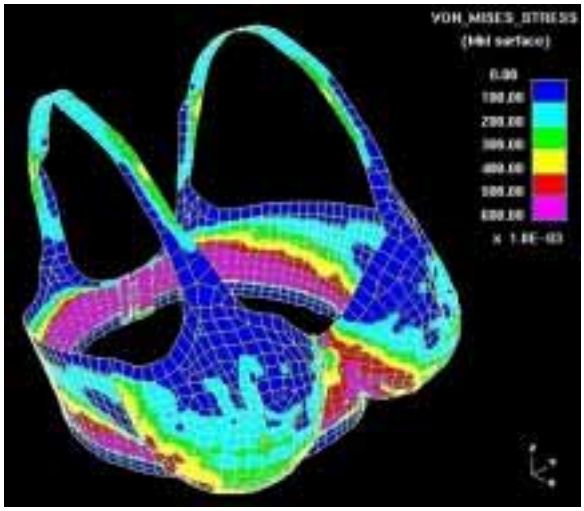
- **Based on NEC's proven relation algorithms (no distinct pattern types are related to palm prints) with additional tailored algorithms**
- **Supports ± 30 to 360° degree matching**
- **High-speed matching solution seamlessly scalable for small to large agencies**
- **Charting of math candidates with rank order notification**
- **Interfaces with NEC's NIST Archive System for storage and retrieval of data and images**
- **No core/axis placement is required**

Strucural Performance - Clothing Manufacturing
www.feainformation.com avi library #62

In this particular case the consulting engineers, Ove Arup & Partners' Advanced Technology Group used dynamic non-linear finite element techniques to analyze the bras structural performance. A computational representation of the bra on a body was created by scanning the geometry of the model, Loen, who was featured in the program. The bra was then constructed using techniques usually associated with the modeling of airbags and seatbelts in cars. This enabled the non-linearity of the bra material, contact interaction with the body and large displacements to be represented. The performance of the bra was then analyzed by applying vertical accelerations to simulate a person jogging lightly or walking briskly. The analysis displayed fluctuating stresses in the bra cups and straps, varying with the walking pattern, and a higher constant stress around the base band where the bra was pulled tight onto the body







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Personal Websites of Interest

Marsha Victory **FEA Information Inc.**	**horse rescue**	**www.livermorehorses.com**
Len Schwer **SE&CS**	**travel diaries -photos**	**www.schwer.net/LenSchwer/**
Ray Jurevicius **Jurevicius Engineering, Inc**	**Miscellaneous details about binoculars made from two 8" f/6.3 Newtonian telescopes.**	**www.j-engineering.com/ATM**

Posted on FEA Information and archived one month on the News Page

Oct 06	**ANSYS Inc.**	**Industry Spotlight – Government and Defense**
	Numerica Srl.	**Distributor located in Italy**
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	JRI	**JMAG**
Oct. 20	**SE&C**	**Engineering Services**
	SGI	**SGI Infinite Storage**
	ETA	**eta/VPG**
	LEAP	**Distributor located in Australia**
Oct. 27	**Oasys**	**Primer**
	HP	**Technical Computing**
	MFAC	**Distributor in Canada**

2004	**If you have a conference to list e-mail details to mv@feainformation.com**
May 2-4	8th International LS-DYNA Users conference will again be held at the Hyatt Regency Dearborn, Fairlane Town Center, Dearborn, MI hosted by LSTC and ETA
May 10-12	OPTECH04, Optimization Technology Meeting 2004
May 24-26	2004 ANSYS Users Conference and Exhibition to be held in Pittsburgh, Pennsylvania, U.S.A.

FEA Information Inc. Website Showcase
LS-DYNA China

Due for Completion during January 2004

www.ls-dyna.cn

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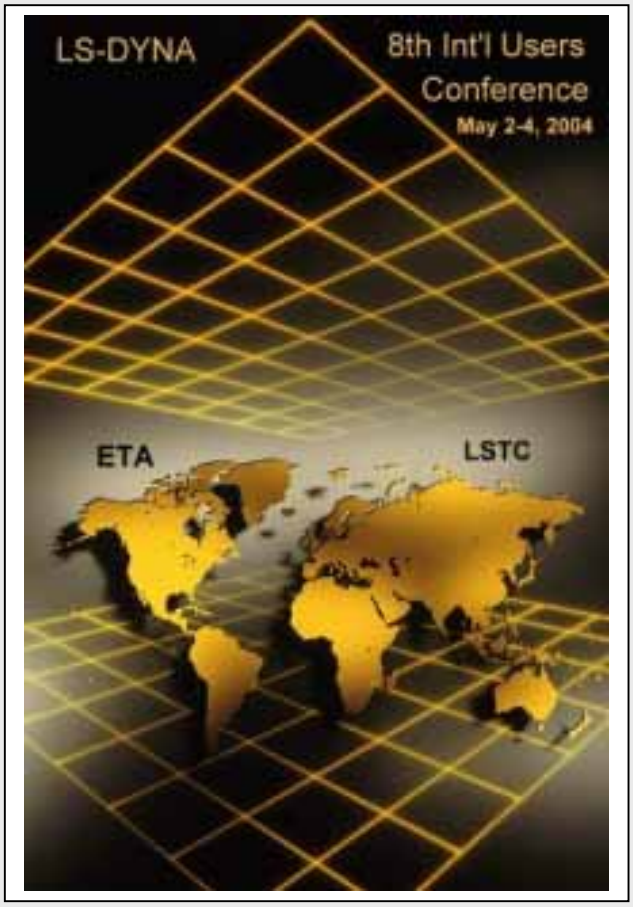
Abstract Reminder
Deadline – December 5, 2003



The 8th International
LS-DYNA Users Conference

May 2 – 4th, 2004

Abstract Deadline: December 5, 2003

email your abstract to: papers@lstc.com

Notification: January 10, 2004

Paper Deadline: March 05, 2004

Conference inquiries: conference@lstc.com

Conference Papers: The first named author of each accepted paper will receive a free admission to the conference if the author registers at the hotel under LSTC Conference registration.

Application Areas Being Accepted for Paper Submission:

- **Aerospace**
- **Ballistic and Penetration**
- **Civil Engineering**
- **Manufacturing Processes**
- **Automotive Crashworthiness**
- **Occupant Safety**
- Seismic Engineering
- **Transportation**
- **Metal Forming**
- **Biomechanics**
- **Impact and Drop Testing**
- **Modeling Techniques**
- **Nuclear Applications**
- **Ship Building**
- **Virtual Proving Ground**

Abstract Length: Approx. 300 words, please include figures, if possible
Paper Length: Maximum of 3,000 words, single-spaced, on 8-1/2" x 11" paper
Format: A MS Word template will be provided
Papers Contact: **papers@lstc.com**

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