November 2004

FEA Information Inc.

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November 2004 – Announcements

Participant:

We would like to welcome FIGES as a Distributor Participant.

FIGES is the only direct LSTC LS-DYNA distributor, and ANSYS Channel Partner in Turkey.

"What is" Series:

A monthly series of up to three short introductions to software/hardware that will be technically oriented.

Publication Section:

We keep the news less than 600KB. If we receive a paper too large to include an introduction/abstract will be listed. The paper itself will be archived on www.feapublications.com under the sidebar link "Feature"

January 2005:

1. **We will be opening participation listings on our Consulting News Page and Consulting Page on the internet sites.**
2. **We will be opening educational participants – If you teach LS-DYNA and would like your University listed please contact us – There is no fee for the directory educational listing.**

If you're interested please contact mv@feainformation.com

Sincerely,

Trent Eggleston & Marsha Victory

**FEA Information would like to dedicate this next article:
In honor Kalpana Chawla, a NASA scientist lost in the Columbia accident**

One Giant Leap

How NASA, SGI and Intel managed to build and deploy history's most powerful supercomputer in 15 blistering weeks.

NASA's 10,240-processor Columbia supercomputer is built from 20 Altix nodes, each powered by 512 Intel Itanium 2 processors

Dick Harkness describes the sensation that motivated him when he first heard that SGI and Intel wanted to build history's most powerful supercomputer for NASA - in fewer than 120 days.

"The best word is adrenaline," says Harkness, vice president of SGI's manufacturing facilities in Chippewa Falls, Wis. "The thought of building a 10,240-processor system in a little over three months was an exhilarating prospect, especially since we still had to maintain our normal manufacturing pace. We honestly wondered what people were thinking."

What people were thinking, it turns out, was to spectacularly revitalize NASA's computing resources with a single system - one that would put more supercomputing power into the Agency's hands than anyone, anywhere had ever seen before. But getting there quickly meant overcoming colossal challenges, from congressional approvals to the breakneck delivery and deployment of new products.

And yet it worked. NASA's "Columbia" supercomputer, so named to honor the crew lost in the 2003 shuttle accident, may have been born of necessity. But it was brought to life by NASA, SGI and Intel in a dramatic sprint to a finish line that at first seemed all but unreachable.

Here's how it happened.

A Modest Proposal: As NASA's Advanced Supercomputing (NAS) Division Chief Walt Brooks tells it, the Columbia Project happened so swiftly only because several factors converged at the right time. In March, Brooks began meeting with NASA simulation and supercomputing experts from throughout the nation to develop a program to revitalize high-performance computing at the agency. The effort was guided by a report from the High End Computing Revitalization Task Force of the White House Office of Science and Technology Policy. "Even before the Columbia Project came on the horizon, the NAS team at Ames, along with other Agency high-end computing experts, toiled with the task force to define what it would take to bring the nation's and NASA's supercomputing resources on par with even our minimum current requirements," recalls Brooks.

Upon arrival at NASA, each new Altix system was up and running in less than a day, and new nodes were made available to scientists in as little as 48 hours.

"What we proposed," he says, "was a relatively modest investment to stay vital in high-end computing." The idea: NASA would purchase 15 Teraflops (trillion operations per second) of computing power over three years. Brooks and his counterparts continued to sell their concept through the spring.

Meanwhile, the Agency considered more ambitious approaches. Particularly intriguing was the notion of building a world-class supercomputer by November. One idea was to link thousands of dual-processor commodity servers into a sprawling cluster, but NASA quickly dismissed that approach. "We're trying to solve some of the toughest scientific problems in the world," says Jim Taft, task lead for the NAS Division's Terascale Applications Group. "We needed a system designed to efficiently execute the algorithms used in NASA's premier science codes, rather than one that would merely do well on artificial benchmarks."

Brooks and his team instead pointed to Kalpana, an Intel® Itanium® 2-based, 512-processor SGI® Altix® 3000 system in use at NASA Ames since November 2003 and named to honor Kalpana Chawla, a NASA scientist lost in the Columbia accident. In less than six months, Taft says, the Kalpana system - the first 512-processor Linux® system ever to operate under a single Linux kernel - had revolutionized the rate of scientific discovery at NASA for a number of disciplines. On NASA's previous supercomputers, simulations showing five years worth of changes in ocean temperatures and sea levels were taking 12 months to model. But on the SGI® Altix® system, scientists could simulate decades of ocean circulation in just days, while producing simulations in greater detail than ever before. And the time required to assess flight characteristics of an aircraft design, which involves thousands of complex calculations, dropped from years to a single day. "That kind of leap is incredible," says Taft. "What took a year on the best computing technology previously available, we could now accomplish in days on the Altix system."

NASA scientists began to imagine what an SGI® supercomputer built from 20 nodes, each with the power of Kalpana, could offer. "We could easily do all the benchmarking anyone could want," Taft says, "but we're more interested in a system capable of doing useful science." The entire NASA team envisioned the science that would be possible on such a system: detailed hurricane predictions, global warming studies, electronic wind tunnel simulations, galaxy formation and supernova analysis, and experiments leading to safer space exploration.

Thirty Days to Yes: So the race was on. Once SGI and Intel determined they could meet a November installation deadline, Brooks and his team at NASA began a 30-day dash to change the agency's operating plan and seek approval from NASA administrators, the Office of Management and Budget, Congress, and the White House.

Another crucial challenge was to prove NASA could pull it off without spending another dime over its approved budget. "Once Congress saw how we could acquire four times the computing resources for the same money," says Brooks, "it was hard to refuse."

In just 30 days, NASA received the green light on Project Columbia. "People both inside and outside the agency were inspired," says Brooks. In light of Return to Flight initiatives following the loss of the Columbia shuttle and crew, the need was increasingly urgent. Lawmakers also took note of the impact the new supercomputer would have on other national science projects "The Columbia Accident Investigation Board spent three months conducting analysis to seek the root cause of the accident. If they had this new system then, it would have been possible to do this in a matter of days."

'40 Days and 40 Nights: Back in Chippewa Falls, SGI's Dick Harkness and his team of 200 were ready. While NASA briefed Congress and the Office of Management and Budget on the Columbia concept, SGI's manufacturing facility prepared workers to adapt to new processes. "Manufacturing flows were completely transformed to accommodate faster, more efficient builds. SGI's factory personnel worked "40 days and 40 nights" to meet production demands, says Harkness. Assembly and QA of 512-processor Altix systems - until then a rare and involved event - quickly became a streamlined and easily repeatable manufacturing process.

Another challenge for SGI: Squeezing more than 10,000 processors into NASA's supercomputing room in Mountain View, Calif., meant Columbia had to incorporate eight 512-processor nodes made new high-density, high-bandwidth version of the SGI Altix 3000 system.

"There simply wasn't room on the floor for 20 traditional Altix nodes," says Bill Thigpen, NASA's Columbia project manager. "We needed eight nodes to be half the size of the original Altix 3000 systems for us to get all the hardware in the room."

For SGI, that spelled a challenge, since the Bx2 hadn't even achieved engineering release when Columbia plans were cemented. Indeed, based on typical parts delivery schedules, SGI only was to receive raw Bx2 parts by the time the finished systems were due at NASA. But SGI's engineering and manufacturing group joined forces to deliver eight Altix Bx2 systems weeks ahead of schedule.

The team met an even greater challenge, accelerating by four months the delivery of optional water-cooled doors—the first ever to be offered from other than a Cray product—that allow the denser Bx2 nodes to avoid overheating as they operate amid 12 air-cooled Altix nodes. "The water-cooled doors were crucial to this installation," recalls Thigpen. "This wouldn't have worked without them."

When installation was completed Oct. 12, Columbia became the world's most advanced Linux supercomputer.

Some Kind of Record: The 19 new Altix nodes joined the Kalpana system at NASA Ames beginning in late June, and with them came a 440-terabyte SGI® InfiniteStorage solution to help NASA store and manage terabytes of new data generated every day.

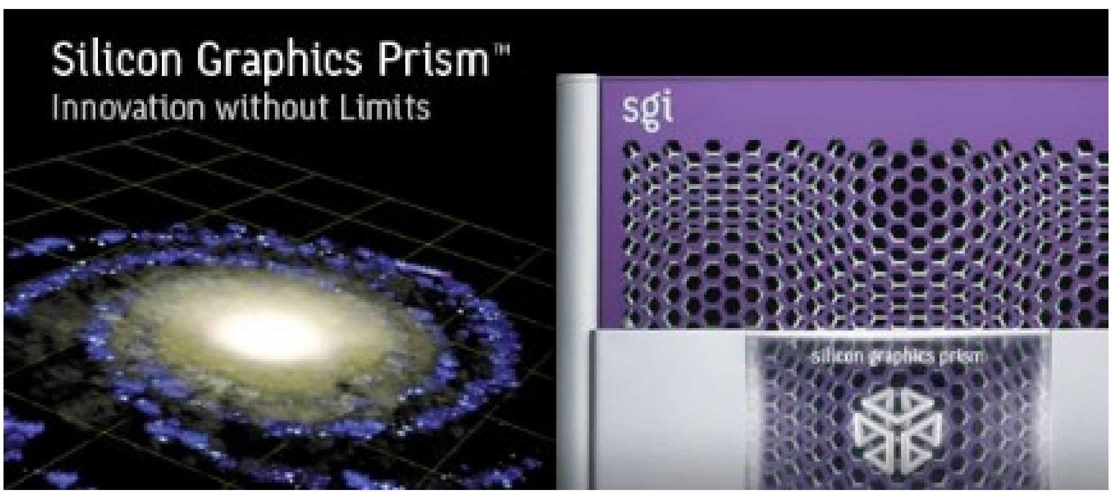
For those on site, the rally continued, says Bill Thigpen, NASA's Columbia project manager. "Here we were, pulling out old systems and installing new ones, replumbing our water cooling system, and literally reconfiguring the floor on the fly, and meanwhile we had a large community of users who needed access to our systems every day."

According to NASA, the installation of the Altix nodes themselves was surprisingly easy. "It's phenomenal how quickly this combined team was bringing the nodes up and providing them to users to do real science," says Thigpen. "We had people from throughout NASA and several universities using the first installations within a week of having them hit the floor."

Jim Taft agrees. "In some cases, a new Altix was in production in as little as 48 hours. This is starkly different from implementations of architectures not based on the SGI architecture, which can take many months to bring to a reliable state and ready for science."

Japan's 5,120-processor Earth Simulator, for instance, wasn't fully usable for more than four years after inception of the project. "Imagine what you've lost in that time," says Taft, "not only in productivity, but in processor obsolescence as well. You're generations behind the curve before you even get started."

For those who drove the Columbia effort, however, the achievement symbolizes much more than mere Teraflops, or even supercomputing superiority. "This effort created a powerful national resource," notes SGI CEO Bob Bishop. "This is a story about opportunity and drive and a willingness to stand up to the seemingly impossible - and make it happen. With the building of this great system completed, the work that will be performed will literally make our world and our universe safer for mankind. What could be more important than that?"



http://www.sgi.com/products/visualization/prism/index.html

What Is Deep Computing?

Informational excerpts http://www-1.ibm.com/servers/deepcomputing/

Deep computing provides the ability to analyze and develop solutions to very complex and difficult problems. These problems are being made tractable by the emerging capabilities in very large scale computing, data management and communications. Combining these capabilities with advances in algorithms, analytic methods, modeling and simulation, visualization, data management and software infrastructures is enabling valuable scientific, engineering, and business opportunities. Using an integrated, multi-disciplinary approach, Deep Computing builds on IBM's experience with Deep Blue in exploring large, complex state spaces typical of many difficult problems.

It harnesses the similarities in disparate businesses and organizations, which have a common need to stretch the boundaries of computing while minimizing risk.

When demands are for intense computation, visualization, or manipulation and management of massive amounts of data, deep computing delivers powerful solutions to challenging and complex problems, enabling businesses and researchers to get results faster and realize a competitive advantage. It has the power that enables trillions of calculations to occur within a second, and achieves the peak performance and productivity needed to run increasingly complex scientific and commercial applications.

Anywhere there is a complex process that needs to run more efficiently, Deep Computing optimization applications can help. Whether it's delivery of power from a utility to a new world of customers in the era of deregulation; or package distribution, routing and delivery; or how digital data is distributed in the era of a fully networked world; or increasing the effectiveness of advertising campaigns; or better financial management through portfolio optimization -- in fact, better overall management by optimizing entire companies -- Deep Computing will be the key to replacing intuition and guesswork with effective solutions.

FOR SOUTHWEST AIRLINES, having a team of six to eight people sequestered for three to four weeks to produce a monthly "crew pairing" was no longer good enough. Especially since rapidly shifting market dynamics and new aircraft deliveries were demanding new schedules almost faster than they could be produced. Enter a team of experts from IBM Research, Global Services, Travel and Transportation Industry Solutions, RS/6000, and business partners from Sabre Decision Technologies. Drawing on their experience making Crew Pairing Optimization Systems (CPOS) work for other airlines, the IBM team was able to deliver a solution that now can generate daily, weekend, and transition pairing solutions in a fraction of the time they used to take. Additionally, aircraft downtime has been reduced, as have flight costs and crew work hours. But the most important benefit, according to Al Davis, vice president of special projects for Southwest, has been "improving the quality of life for airline crews and schedulers."

So how'd the IBM team perform the magic? First, using the domain knowledge built up over years of working with airline customers, the team was able to identify key elements of the problem and identify where efficiency increases were most needed. Then, IBM researchers with expertise in mathematical algorithms looked for novel ways of optimizing solutions to the problem -- no easy task, given the quadrillion possible permutations involved. As published in a 1998 paper entitled "Column Generation and the Airline Crew Pairing Problem," the researchers used something known as the so-called "Volume Algorithm" as well as other innovations to reach very good solutions to these large problems.

By running the solutions on the super-fast RS/6000 397 and 595 servers, Southwest has not only reduced the time to solve these problems from three to four weeks to a few days, but the airline also can now "fine-tune" solutions, instead of accepting the first solution found because of time constraints.

Informational Announcement

On September 29, 2004, IBM announced that an IBM BlueGene/L supercomputer. Using the industry-standard LINPACK benchmark, the IBM Blue Gene/L system attained a sustained performance of 36.01 Teraflops. The milestone was attained during internal testing at IBM's production facility in Rochester, Minnesota

The largest planned Blue Gene/L machine, which is scheduled for delivery to Lawrence Livermore National Laboratory (LLNL) in California in early 2005, will occupy 64 full racks, with a peak performance of 360 teraflops. The Advanced Super Computing (ASC) Program of the National Nuclear Security Administration (NNSA) is a primary collaborator on the Blue Gene project. LLNL is operated for the NNSA by the University of California

eta/VPG version 3.0 Delivers the Best of the Windows and Unix Modeling Features to LS-DYNA Users © 2004

By: Tim Palmer,Director of Business Development, ETA Software

As complexity and scope of finite element simulations continues to keep pace with the growth in computing capacity, users are faced with the difficulty of dealing with immense amounts of graphical data.

In 1996, at the initial release of LS-DYNA PC, most users would have never imagined that models approaching 1,000,000 elements would be routinely run on a Windows-based PC within 10 years. In fact, most engineers were just trying to deal with the idea of running simulations of any size on the PC. The fact that this is occurring on a daily basis is an encouraging situation for those needing the type of data that only LS-DYNA can provide, for the most complex engineering problems.

To keep pace with this mushrooming capability and data handling need – as well as the ever-growing complexity of the simulations, ETA and LSTC have continually enhanced the capabilities of the eta/FEMB software. While this has been a very effective tool for building and post-processing the large amounts of data available from an LS-DYNA analysis, users are constantly pushing the limits of FEMB's capability.

Earlier this year, at the 8th LS-DYNA User Conference, in Dearborn, Michigan, ETA announced that it would develop and deploy a new generation of software tools for LS-DYNA PC users, under the eta/VPG product line. This new product will be bundled and deployed with LS-DYNA PC, offering an upgrade to users for model construction and post-processing, while the FEMB software is gradually phased-out.

The eta/VPG software will be available to LS-DYNA PC users beginning December 1, 2004. Current FEMB PC version 28 users will find that their current license will also be valid for the initial release of eta/VPG 3.0. This allows them to download and tryout VPG side-by-side with their current modeling environment, without disrupting their current projects, and enabling a smooth transition between software tools.

The VPG product has, for several years, been a toolset that provides LS-DYNA users the ability to create complex system level models for durability, NVH and of course, impact analysis. This product has enabled LS-DYNA to reach into the more non-traditional areas of product development, and enabled a system level simulation to replace many of the outdated analysis methodologies.

While, eta/VPG was focused on these specialized modeling and simulation requirements, it still retained all of the meshing tools and model construction features which were found in the more general FEMB software.

"We've realized for several years now, that our products (FEMB and VPG) would eventually merge into a single toolset for LS-DYNA users", comments Abe Keisoglou, ETA President. "These software products have been instrumental in the continued penetration of LS-DYNA into new and niche markets, such as vehicle system durability. VPG has opened up LS-DYNA capabilities to a previously unaddressed segment of the CAE community."

VPG version 3.0 is a cross-platform software, delivering the advanced modeling tools found on earlier versions of eta/VPG for the UNIX/LINUX platforms, with the ease of use and GUI advantages of the Windows environment.

LS-DYNA PC users will notice that the features available to them have been greatly enhanced. Users can now access all of the eta/VPG functions such as RADIOSS, PAM-CRASH, and even ADAMS model import capability. This allows user to import and re-use the data in these types of models within you LS-DYNA analysis.

To address the increasing size of models and the difficulties in manipulating this large amount of data, VPG incorporates a new graphics engine. This allows users to more easily move/rotate, shade and modify their model.

The graphics performance improvements will also be noticed in the post processing menus. This portion of the VPG software has been totally re-written, keeping many of the features found in PostGL, but wrapping them in a new user interface and adding an integrated graphing module. “Users will no longer have to open a separate application when graphing data”, says Wing Lee, who heads ETA’s software development team, “ They can now easily plot their model data in a window on their animation results. This capability is a major enhancement to the post processing capability of VPG.”

The tire and suspension modeling tools that have been critical links in the development of vehicle system models are now available for use by all LS-DYNA PC users. Tire models are increasingly important for simulations such as rollover, where the tire and roadway interaction is a key boundary condition prior to the rollover event.

With CAE and CAD becoming more and more integrated, the need for direct CAD interfaces has become essential. VPG 3.0 allows users to directly import native CAD files from the major CAD software vendors, including CATIA v4 and v5, Unigraphics 18 and NX, and Pro/E. These CAD interfaces all require additional licensing options, which may be supplied by LS-DYNA distributors.

Along with this new software are a completely revised set of manuals and tutorials. These provide the LS-DYNA PC user the necessary documentation to use these advanced tools more easily.

“We understand that users may need additional support when there are so many new features available. We have created three updated tutorials to demonstrate the range of capabilities to users. ETA is also offering 1-day training classes at our offices in Troy, MI, and at distributor locations worldwide”, comments Abe Keisoglou. “We are committed to supporting our users, since they are also a great source for new functionality requirements.”

An exciting new feature available in the VPG 3.0 deployment is the addition of a stand-alone 3D Player. This player can be distributed freely to any person who has a computer, and the need to view the results of a simulation. The 3D Player allows users to load a file generated from the VPG Post Processor, and interactively manipulate the model while displaying the deformation or stress results in an animation. “We like to call it a mini-post processor”, says Lee. “The 3D Player allows customers to view the result without installing a complete FE modeling application on their computer. It provides the right balance of features and simplicity, to accommodate the occasional user.”

The 3D Player is also available as a Microsoft PowerPoint plug-in, enabling you to embed interactive LS-DYNA results animations into your presentations.

With user productivity in mind, ETA has delivered a new software for LS-DYNA PC users. This opens a new set of opportunities for all LS-DYNA PC users, giving them access to many new tools, interfaces and enhanced modeling capabilities.

Database for technical papers updated
By: Uli Franz

Papers of 8th International Conference have been added to www.dynalook.com .

The site presents papers from European and International LS-DYNA User Conferences. Additionally it provides previous issues of the FEA Newsletter and a few papers provided by users.

In total more than 460 papers are now available. The papers are accessable via the search functionality and can be downloaded at no charge. For example, a searching for the word 'dummy' leads to 60 papers and 55 papers provide information about 'rubber'.

Feel free to stop by and visit and search. An additional site under re-design with Table of Contents from the Conferences is **www.feapublications.com**

Additional Informational Sites to visit:

LS-DYNA Portal - www.lsdyna-portal.com
Top Crunch – www.topcrunch.org

Asia Pacific News – China
Marsha Victory, LSTC Global Business Administrator

LSTC's China Business Unit (CBU) has again been successful during November bringing LS-DYNA to the China market.

Jason Wang, of Livermore Software Technology Corporation, traveled to China, achieving the goal of bringing MPP information and LS-DYNA applications to the forefront of software being used.

Jason discussed LS-DYNA MPP at the ANSYS Chongqing Auto CAE seminar, Nov.8, in Chongqing City. At the MSC.Software conference, Thursday, Nov. 4, in Guilin, Jason presented The Current and Future Developments of LS-DYNA. Both had an excellent turnout of engineers, Professors and students interested in LS-DYNA MPP.

We are pleased to announce the posting of the following publication to our China Site "Drop Testing":

"Simulation and Verification of the Drop Test of 3C Products"
Hsing-Ling Wang –Chinese Air Force Academy
Shia-Chung Chen –Chung-Yuan Christian University
Lei-Ti Huang - Chung-Yuan Christian University
Ying Chieh Wang - Chung-Yuan Christian University

www.droptesting.cn

At this time we would like to announce that we are updating our China websites. Their formal announcement will be the January edition of the FEA Information News. While we are under construction, please feel free to send us your ideas – these specialized informational sites are for you. We will be adding publications specific to each application from universities and industry in China. Please send your ideas for our China Community Sites contact: mv@feainformation.com - All Universities teaching LS-DYNA are listed at no fee.

Sites:
www.ls-dyna.cn **www.droptesting.cn** -
www.crashanalysis.cn **www.metalformingsimulation.cn**

www.ls-dyna.cn

Contact your local distributor for your 30-day demonstration license of LS-DYNA

ANSYS Inc. China - http://www.ansys.com.cn

MSC.Software – China - http://www.mscsoftware.com.cn

or fill in our 30-day free demonstration form on our website www.ls-dyna.cn under the link "Demo Request" at the top of the page

Hardware
&
Computing and Communication Products
(Listed in Alphabetical Order)

AMD

www.amd.com

FUJITSU

www.fujitsu.com

hp invent

www.hp.com

IBM

www-1.bim.com/servers/deepcomputing

intel

www.intel.com

NEC

www.nec.com

sgi

www.sgi.com

Software Distributors

Alphabetical order by Country

Australia	Leading Engineering Analysis Providers www.leapaust.au
Canada	Metal Forming Analysis Corporation www.mfac.com
China	ANSYS China www.ansys.cn
China	MSC. Software – China www.mscsoftware.com.cn
Germany	CAD-FEM www.cadfem.de
Germany	Dyna*More* www.dynamore.de
India	GissETA www.gisseta.com
India	Altair Engineering India www.altair.com
Italy	Altair Engineering Italy www.altairtorino.it
Italy	Numerica SRL www.numerica-srl.it
Japan	Fujitsu Limited www.fujitsu.com
Japan	The Japan Research Institute www.jri.co.jp
Korea	Korean Simulation Technlogies www.kostech.co.kr
Korea	Theme Engineering www.lsdyna.co.kr

Software Distributors

Alphabetical order by Country

Russia	State Unitary Enterprise www.ls-dynarussia.com
Sweden	Engineering Research AB www.erab.se
Taiwan	Flotrend www.flotrend.com.tw
Turkey	FIGES www.figes.com.tr
USA	Altair Western Region www.altair.com
USA	Engineering Technology Associates www.eta.com
USA	Dynamax www.dynamax-inc.com
USA	Livermore Software Technology Corp. www.lstc.com
USA	ANSYS Inc. www.ansys.com
UK	Oasys, LTC www.arup.com/dyna/

Consulting Services
Alphabetical Order By Country

Australia Manly, NSW www.leapaust.com.au	**Leading Engineering Analysis Providers** Greg Horner info@leapaust.com.au 02 8966 7888
Canada Kingston, Ontario www.mfac.com	**Metal Forming Analysis Corporation** Chris Galbraith galb@mfac.com (613) 547-5395
India Bangalore www.altair.com	**Altair Engineering India** Nelson Dias info-in@altair.com 91 (0)80 2658-8540
Italy Torino www.altairtorino.it	**Altair Engineering Italy** sales@altairtorino.it
Italy Firenze www.numerica-srl.it	**Numerica SRL** info@numerica-srl.it 39 055 432010
UK Solihull, West Midlands www.arup.com	**ARUP** Brian Walker brian.walker@arup.com 44 (0) 121 213 3317
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Alphabetical Order By Counrty

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Italy	**Professor Gennaro Monacelli**	**Prode – Elasis & Univ. of Napoli, Frederico II**
Russia	**Dr. Alexey I. Borovkov**	**St. Petersburg State Tech. University**
USA	**Dr. Ted Belytschko**	**Northwestern University**
USA	**Dr. David Benson**	**University of California – San Diego**
USA	**Dr. Bhavin V. Mehta**	**Ohio University**
USA	**Dr. Taylan Altan**	**The Ohio State U – ERC/NSM**
USA	**Prof. Ala Tabiei**	**University of Cincinati**
USA	**Tony Taylor**	**Irvin Aerospace Inc.**

Informational Websites

FEA Informational websites	**www.feainformation.com**
TopCrunch – Benchmarks	**www.topcrunch.org**
LS-DYNA Examples (more than 100 Examples)	**www.dynaexamples.com**
LS-DYNA Conference Site	**www.ls-dynaconferences.com**
LS-DYNA Publications to Download On Line	**www.dynalook.com**
LS-DYNA Publications Index	**www.feapublications.com**
LS-DYNA Forum	**http://portal.ecadfem.com/Forum.1372.0.html**
LS-DYNA CADFEM Portal	**http://www.lsdyna-portal.com**

www.feainformation.com

Previous FEA Information Site News
Archived on the Weekly News Page

Oct		
11	**Oasys**	**Fluid Structure Course**
	HP	**HP workstation c8000**
	Kostech	**Distributor in Korea**
18	**Intel**	**Intel® E7221 chipset**
	Fujitsu	**PRIMERGY BX300 Server**
	DYNAmore	**Distributor in Germany**
25	**AMD**	**The #1 Windows®-Compatible 64-bit PC Processor**
	NEC	**SX Series Model "SX-8"**
	Altair – Italy	**Distributr in Italy**

EVENTS

2005	
May 25-26	**5th European LS-DYNA Conference** - The ICC, Birmingham UK
July 25-27	**8th U.S. National Congress on Computational Mechanics,** Austin, TX
2006	
June	**9th International LS-DYNA Users Conference** - Deerborn, MI
July	**Seventh WCCM** - Los Angeles, CA

Due to the size of this publication it is archived on line
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STRUCTURAL ANALYSIS IN THE FREQUENCY DOMAIN & UNDERSTANDING IMPACT DATA

Ala (Al) Tabiei, PhD And Martin Lambrecht

INTRODUCTION

When performing a dynamic analysis of a structure, often the primary interest of the analyst is to determine how the structure will respond over time to a given set of conditions (loads, motion, impact with another structure, etc.). The word "dynamic" itself implies that something changes in time, i.e. is different at time t_0 and at time t_1 with $t_0<t_1$. Dynamic finite element codes, for example, compute the parameters of interest to the analyst by looking at a structure at different point in time, and by providing an output of some form that indicates how the structure changes as time progresses. The time domain is a natural choice for many (if not most) types of analysis; not only from a mathematical point of view but also because of its familiarity everyone can easily grasp the idea of changes that occur in time. However, it is often very useful if not even necessary to look at a structure from the point of view of the frequency domain. Information that can be obtained this way includes but is not limited to, the vibrational frequencies of a structure and the amount of measurement noise present in a given time domain dataset. The frequency domain is a somewhat less intuitive concept than the time domain, and it indicates "how often" an even occurs as opposed to the time domain, which gives information about when an event takes place. To perform a frequency domain analysis of a structure, most of the time it is necessary to take time domain data and transform it mathematically to the frequency domain. This can be accomplished by using the Fourier Transform (FT), which provides information about the frequency content of a measurement i.e. the strength of the measure at various frequencies.

The main objective of this presentation is to give a basic overview of frequency domain structural analysis. After some background, concept are introduced the rationale behind the use of the Fourier transform will be presented. In particular the fast Fourier transform FFT will be discussed, and its use for transforming digitally measured data from the time domain to the frequency domain will be illustrated. Next, the basics of filter measurement noise from a signal without affecting data that corresponds to the natural frequency or frequencies of the system being measure. Of course, before a filter can be designed knowledge of the signals frequency content obtained from the Fourier Transform is necessary. Several examples will be sued to illustrate the mathematical concepts bring presented and to reinforce the points that are most important for applications.

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Simulation of Under Water Explosion using MSC.DYTRAN

Peiran Ding
Arjaan Buijk
MSC.Software Corporation
2300 Traverwood Drive
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This paper describes the numerical simulation of a cylinder submerged under water subjected to explosion using MSC.Dytran.

The cylinder is modeled using a Lagrangian mesh. Multiple Euler domains are used to the air inside the cylinder, the surrounding air, water and the explosive. Since the model includes air, water and explosive, a multi-material Euler solver is required. A fast general coupling is used to simulate the interaction between the Lagrangian mesh and Euler mesh. When by the impact of the shock wave and subsequent gas bubble, the cylindrical structure deforms, fails and water flow into the cylinder.

Introduction:

When a submerged structure subjected to UNDerwater Explosion (UNDEX) loading, it is important to predict structural response to the shock wave. Furthermore, in the case of the explosion occurring close to the structure, a high velocity water jet penetrating the gas bubble occurs. This water jet is extremely efficient in producing damage.

Test and Analysis Correlation of Foam Impact onto Space Shuttle Wing Leading Edge RCC Panel 8

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Abstract

Soon after the Columbia Accident Investigation Board (CAIB) began their study of the space shuttle Columbia accident, "physics-based" analyses using LS-DYNA were applied to characterize the expected damage to the Reinforced Carbon-Carbon (RCC) leading edge from high-speed foam impacts. Forensic evidence quickly led CAIB investigators to concentrate on the left wing leading edge RCC panels. This paper will concentrate on the test of the left-wing RCC panel 8 conducted at Southwest Research Institute (SwRI) and the correlation with an LS-DYNA analysis. The successful correlation of the LS-DYNA model has resulted in the use of LS-DYNA as a predictive tool for characterizing the threshold of damage for impacts of various debris such as foam, ice, and ablators onto the RCC leading edge for shuttle return-to-flight.

Introduction

During the Columbia Accident Investigation Board (CAIB) investigation, various teams from industry, academia, national laboratories, and NASA were requested by Johnson Space Center (JSC) Orbiter Engineering to apply "physics-based" analyses to characterize the expected damage to the shuttle thermal protection system (TPS) tile and Reinforced Carbon-Carbon (RCC) material, for high-speed foam impacts. The forensic evidence from the Columbia debris eventually led investigators to conclude that the breach to the shuttle TPS was caused by a large piece of External Tank (ET) foam that impacted and penetrated the lower portion of a left-wing leading edge RCC panel. The precise location of the impact was narrowed down to the left-wing RCC panel 8. Consequently, the CAIB sanctioned a foam impact test onto RCC panel 8 in July 2003 at Southwest Research Institute (SwRI) in San Antonio, Texas. In the test, a 1.67-lb. block of foam was shot from a large compressed-air gun and impacted panel 8 at a velocity of 777 ft/s at an angle of incidence of 25.1 degrees in an attempt to simulate the scenario observed approximately 82 seconds into Columbia's flight. The impact resulted in a large 16-in. x 16-in. hole in panel 8.

Chapter 11 recommendation 3.3-2 of the CAIB report [1] requests that NASA initiate a program to improve the impact resistance of the wing leading edge. The second part of the recommendation is to …"determine the actual impact resistance of current materials and the effect of likely debris strikes." For Return-to-Flight, a team consisting of personnel from NASA Glenn Research Center, NASA Langley Research Center, and Boeing Philadelphia was given the following task: to develop a validated finite element model of the shuttle wing leading edge capable of accurately predicting the threshold of damage from debris including foam, ice, and ablators for a variety of impact conditions. Since the CAIB report was released, the team has been developing LS-DYNA models of the RCC leading edge panels, conducting detailed materials characterization tests to obtain dynamic material property data, and correlating the LS-DYNA models with data obtained from impacts tests onto RCC panels. Other documents that have been authored by the team can be found in References 2- 5.

To begin validating LS-DYNA predictions, test and analysis correlations were performed for selected full-scale RCC panel impact tests. In particular, the correlation study for the panel 8 impact test at SwRI, which produced the most damage to date, will be described in this report.

Experimental Program

Description of Test

A foam impact test onto RCC panel 8 was conducted in July 2003 at SwRI in San Antonio, Texas. In the test, a 1.67-lb. block of foam with a cross-section of 11.5 x 5.5 inches was shot from a large compressed-air gun and impacted panel 8 at a velocity of 777 ft/s at an angle of incidence of 25.1 degrees. The primary purpose of the test was to determine if a piece of foam traveling at the estimated velocity of the foam that struck Columbia's wing could breach an RCC leading edge panel.

The pre-test setup of panels 5 through 10 with T-seals between panels is shown on the test-rig at SwRI in Figure 1. The end of the gun barrel can also be seen in the figure. The gun barrel was rotated (clocking angle) such that the front edge of the foam would align with the RCC panel to produce as much contact surface as possible. High-speed picture and photogrammetry data were captured as well as time history data from strain-gages and accelerometers.

Summary of Test Results

The most obvious result from the test was the large 16-in x 16-in hole in panel 8 that is illustrated in Figures 2 – 3. Also, the RCC fragments from the hole that were created by the foam impact were collected and are illustrated in Figure 4. The ruler at the right side of the figure measures 12 inches in length.

In addition to high-speed photographic data, photogrammetric measurements were made of the panel behind the area of the foam impact. Strain gages, accelerometers, and load cell transducers were used on the test article to obtain time histories of the impact event. Photogrammetric and strain gage data will be used in the report to compare with the LS-DYNA simulations.

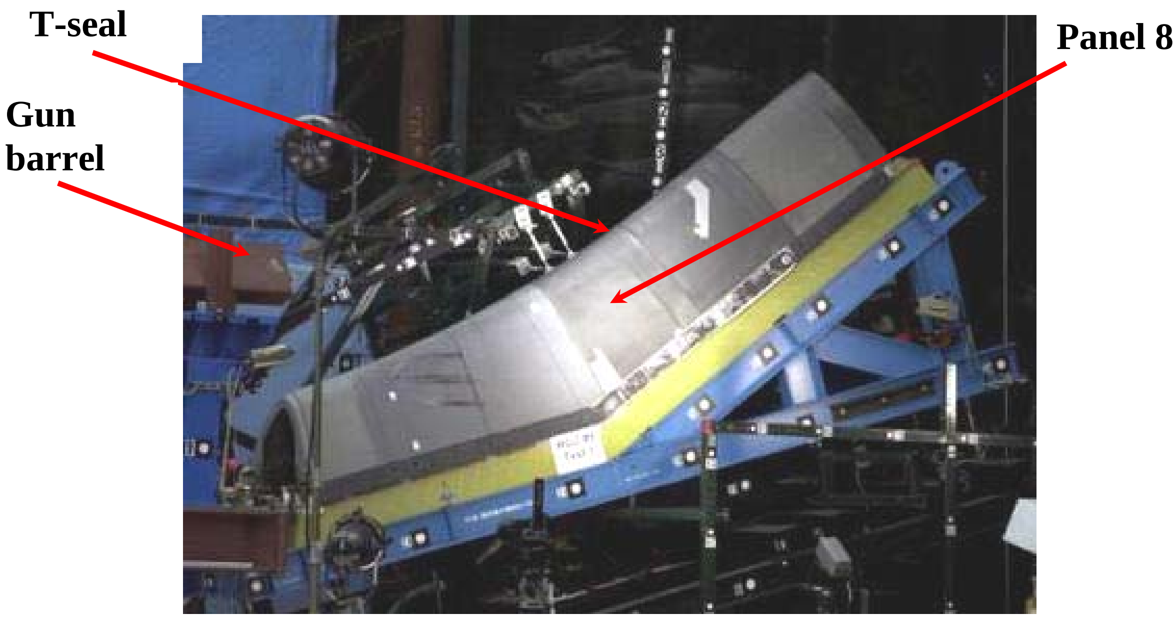


Figure 1. Pre-test set up at SwRI with panels 5 through 10 and associated T-seals on test-rig.

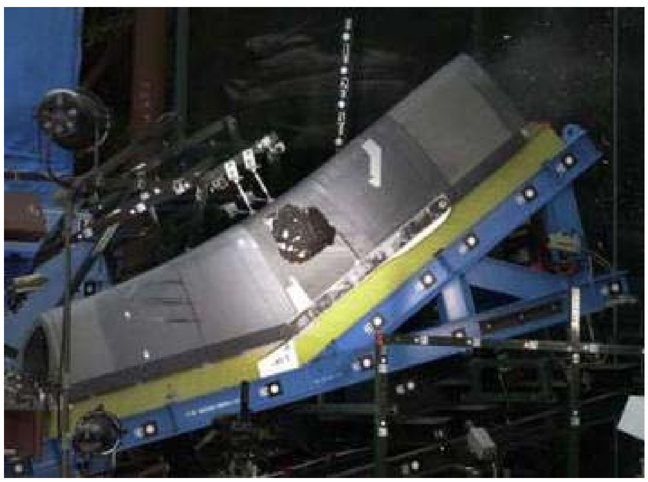


Figure 2. Post-test photo illustrating the large hole in RCC panel 8.

Figure 3. Close-up photograph of the damage to RCC panel 8.

Figure 4. The major RCC fragments from the impact test.

Finite Element Simulation

The units used in the LS-DYNA model for length, mass, and time were inch, pound/g, and seconds. In these units, the acceleration of gravity, g, is 386.4 in/s^2. The main shuttle Orbiter coordinate system was also used. For this example, the outer mold line (OML) surfaces of the RCC panel plus flanges and ribs were obtained from solid models and meshed using quadrilateral shell elements by Boeing and Glenn Research Center (GRC). The foam debris velocity was primarily along the global Orbiter X-axis with a resultant velocity of 9,300 in/s (775 ft/s) used in the model.

Before the test at SwRI, pre-test LS-DYNA models were constructed by Boeing Philadelphia to assess the likely damage. However, no failure criterion was used in the initial pre-test predictions. For the model described in this paper, Mat58 (MAT LAMINATED COMPOSITE FABRIC) [6] with failure was used as the material model for the RCC. The RCC material parameters required for Mat58 are discussed in Reference 3 and are based on available RCC material data. There is a wide variation in the RCC material properties for as-fabricated material. Panels that have been flown exhibit some mass loss, which further degrades the RCC material strength. In addition, the material is considerably stronger in compression as compared to tension. The RCC material properties for the LS-DYNA model were chosen to be average as-fabricated values. The failure strain for the model was approximately 0.006. The RCC material is a “tough” brittle material with a typical panel of 19-plies of fabric laid up in alternating 0/90 layers. The thickness of the 19-ply RCC material is nominally 0.233 inches and the density of RCC is approximately 100 lb/ft^3. The manufacturing process to make RCC from Rayon cloth is a complex multistage process [7]. The material is laid up and then heated without oxygen to drive out all volatile materials except the carbon. In a final process silica is added into the furnace to produce SiC-rich material in the outer two layers through a diffusion process. The failure model in the LS-DYNA Mat 58 material is a cumulative damage model [8].

The foam model for the projectile was the Mat 83 MAT_FU_CHANG_FOAM model [6]. Strain rate effects were found to be important in the foam material at the velocities in question. High strain-rate data for the Fu-Chang model was generated in a specially configured and instrumented 14-ft. bungee-assisted drop tower at the Impact Dynamics Research Facility at NASA Langley that can achieve strain rates of over 400/s. The high strain-rate data were directly input into the Fu-Chang model. The Poisson ratio of the foam is assumed to be zero. The weight density of the foam for this simulation was calculated from the weight and size of the foam block used in the test at SwRI and was found to be approximately 2.0 lb/ft^3.

An exploded view of the LS-DYNA model is shown in Figure 5. The model consists of a single panel 8 with a foam projectile and neglected the adjacent RCC panels and the T-seals that fill the gaps between RCC panels. There were a total of 25 designated parts in the LS-DYNA model. The model used 59,360 shell elements to represent the RCC panel and 11,636 solid elements to represent the foam projectile. The shells make use of lamination theory and are modeled to have the actual number of plies for each area (part) modeled. The nominal size of the RCC shell elements was chosen to be approximately 0.2 inch on a side. From LS-DYNA parametric studies performed on the RCC Panel 6 impact test conducted in June 2003 at SwRI, the boundary conditions removed from the area of the impact do not significantly affect the damage. Thus, whether the panel is held in place or is completely unrestrained, the predicted damage was about the same. In this panel 8 model, the bolt holes in the flanges were filled with a rigid material that was completely restrained.

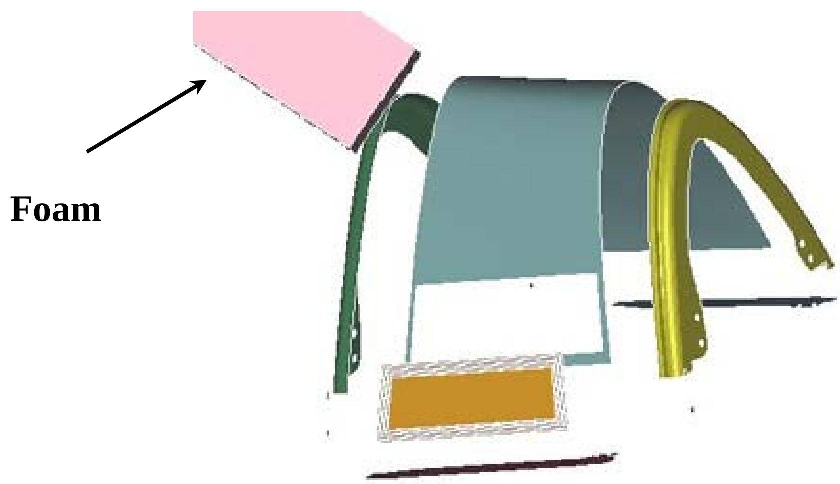


Figure 5. Exploded view of parts of the LS-DYNA model including foam, left and right ribs, front and back flanges or spars, main panel, and front lower doubler region.

Test and Analysis Correlation

Structural Deformation and Failure

The deformed model at approximately 6 ms after impact is shown in Figure 6. The “picture panel” area (in red) at the bottom of the panel is a doubler region with ply drop-offs forming the “frame.” The damage did not extend into the doubler region. Qualitatively, the damage shown in Figure 6 correlated quite well with the size and shape of the actual hole observed post-test (see Figure 3). The RCC debris that was collected post-test is illustrated in Figure 7 from the back side of the panel with the photogrammetric targets. In Figure 8, damage progression is shown at 5 ms after foam impact. The broken pieces in the simulation show a remarkable similarity to the actual pieces collected and shown in Figure 7. Failure of a brittle material is chaotic and depends on local imperfections, residual strains, and thicknesses of the material. The simulation assumes

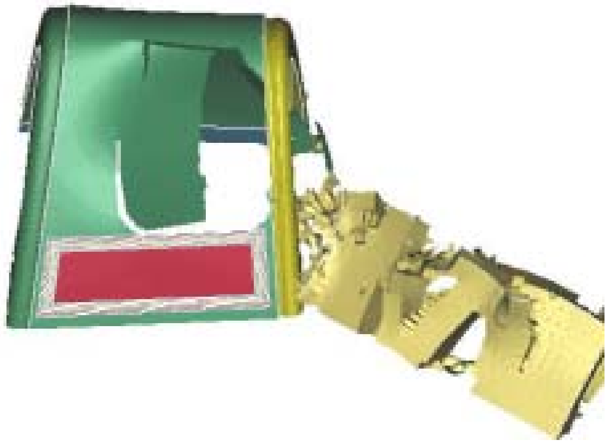


Figure 6. LS-DYNA model showing foam and panel breaking apart 6 ms after impact.

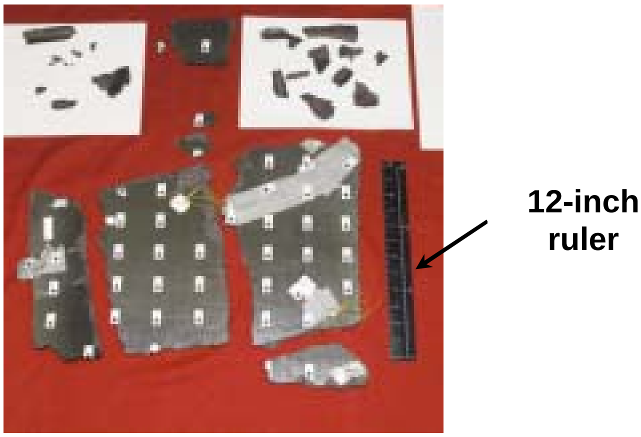
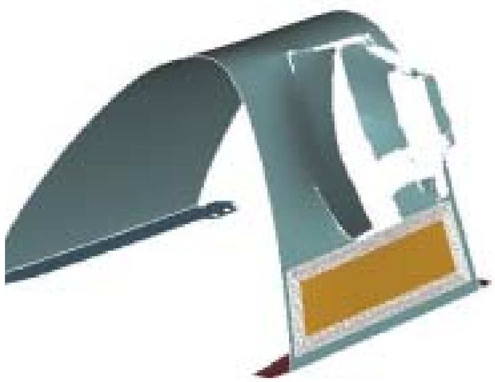


Figure 7. Panel debris showing photogrammetric targets on the back side. The black ruler on the right is 12 inches long.



Panel 8. LS-DYNA model, with panel ribs and foam removed for clarity, showing RCC debris pattern at 5 ms after foam impact.

a perfect orthotropic RCC material without imperfections and cannot be expected to accurately predict the actual shapes and sizes of the debris.

Photogrammetric test and analysis correlation

The displacements of targets on the backside of panel 8 were captured by high-speed video cameras. This photogrammetric data were analyzed in the region outlined by the square in Figure 9. Since the local axis system shown in Figure 9 did not align with the model axes, the photogrammetric data were processed to obtain a resultant displacement at each point for a given time. The resultant displacement is a scalar quantity independent of the coordinate frame. The experimental resultant panel displacements for the points at various times were then plotted as contour plots and compared with the LS-DYNA predicted resultant displacement contours. A typical comparison of test with analysis is shown in Figure 10 for a time of 1.8 ms after foam impact. The panel began to break up around 2.0 ms after foam impact.

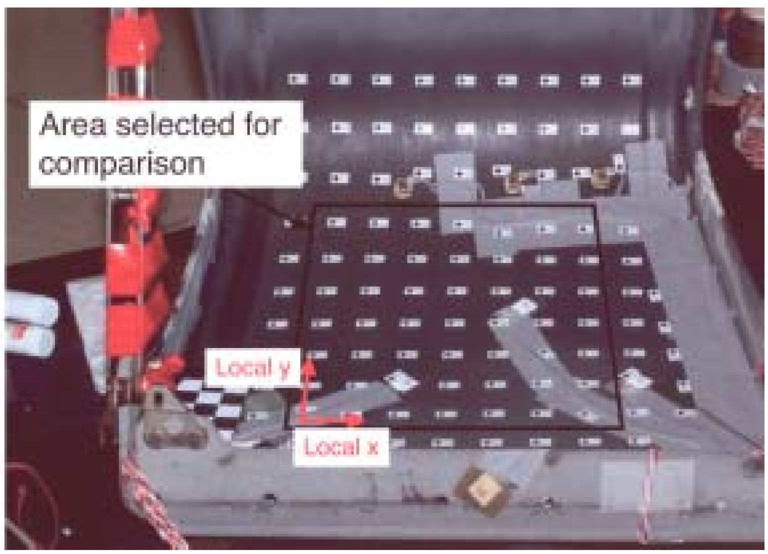


Figure 9. Photogrammetric targets on the back of Panel 8 in the SwRI test.

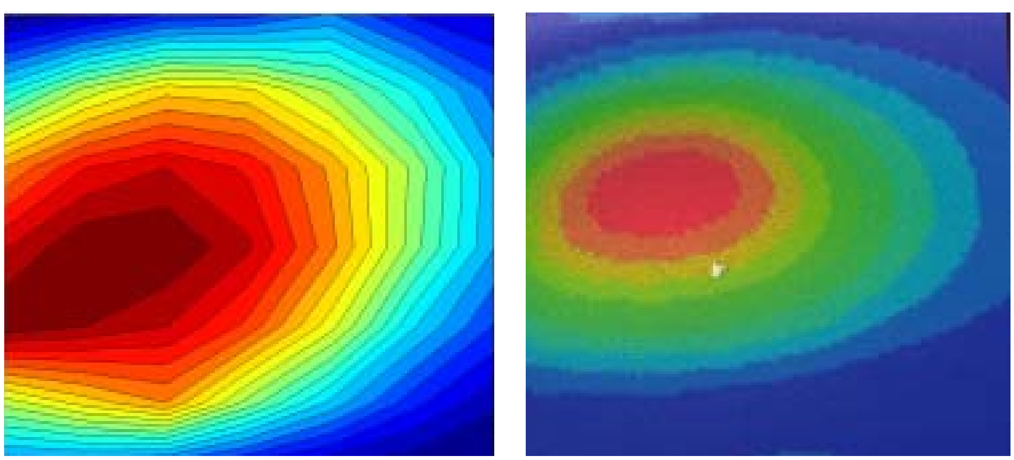


Figure 10. Measured (left) and predicted (right) deflection pattern at 1.8 ms after foam impact. The maximum deflection contour for both plots is 1.2 inches.

Strain gage test and analysis correlation

A large number of strain gages were placed on the panels, ribs, and flanges for the impact test onto panel 8. The test-analysis correlation presented in this paper will concentrate on the five strain-gage rosettes on panel 8 near the foam contact region. The test data were processed to determine the local-x, or longitudinal strains, and the local-y, or lateral strains (see coordinate system in Figure 9). The five positions of interest of the strain-gage rosettes are shown in Figure 11 and are labeled from 1 to 5. The five elements in the finite element model that best corresponded to the experimental location are shown in Figure 12 labeled with the shell element number. The experimental strains are compared with the predicted strains on the inside (inner or 19th ply) of the selected shell element. The comparisons are shown in Figures 13 through 17.

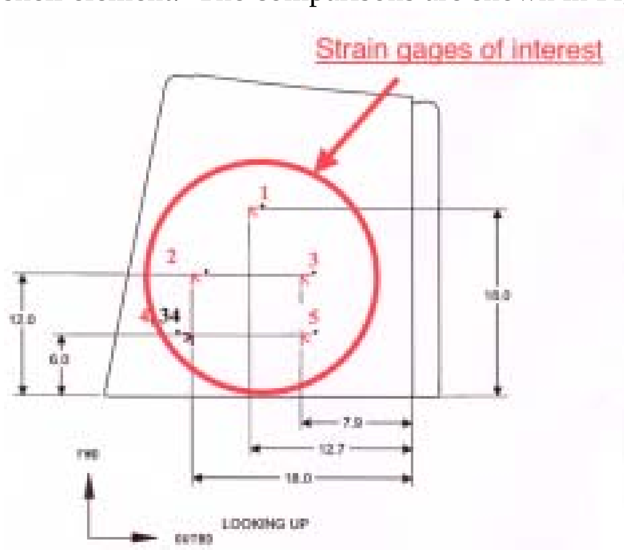


Figure 11. Strain gage locations in test drawing. The strain gages were on the inside of the panel.

Figure 12. Locations of five elements that best correspond to the strain-gage locations 1 through 5 (see Figure 11).

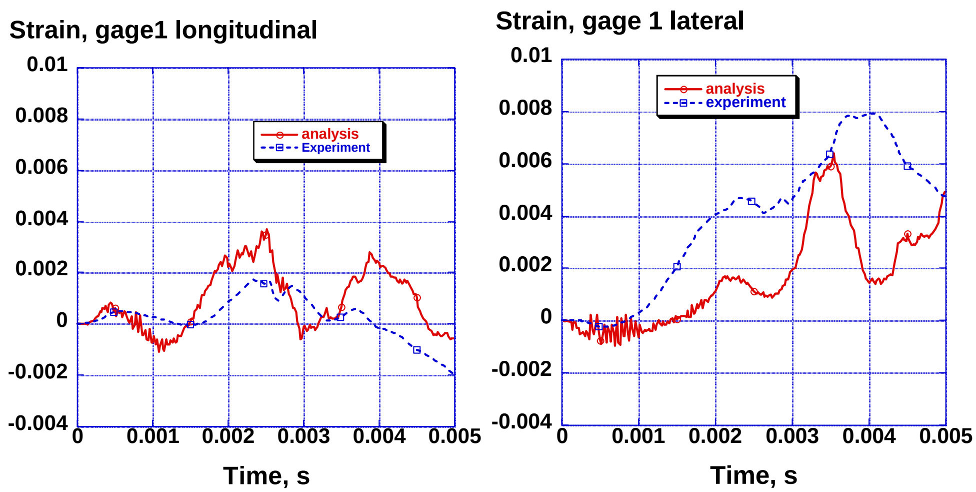


Figure 13. Strain comparisons for gage 1 location.

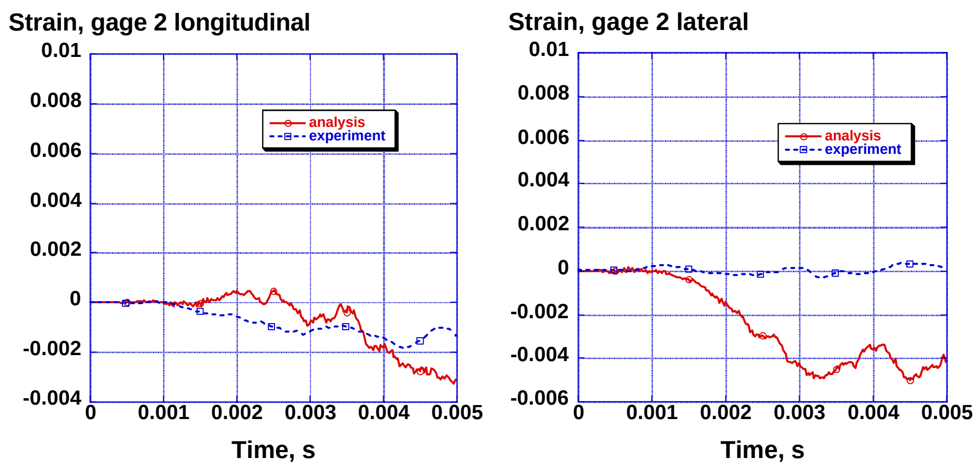


Figure 14. Strain comparisons for gage 2 location.

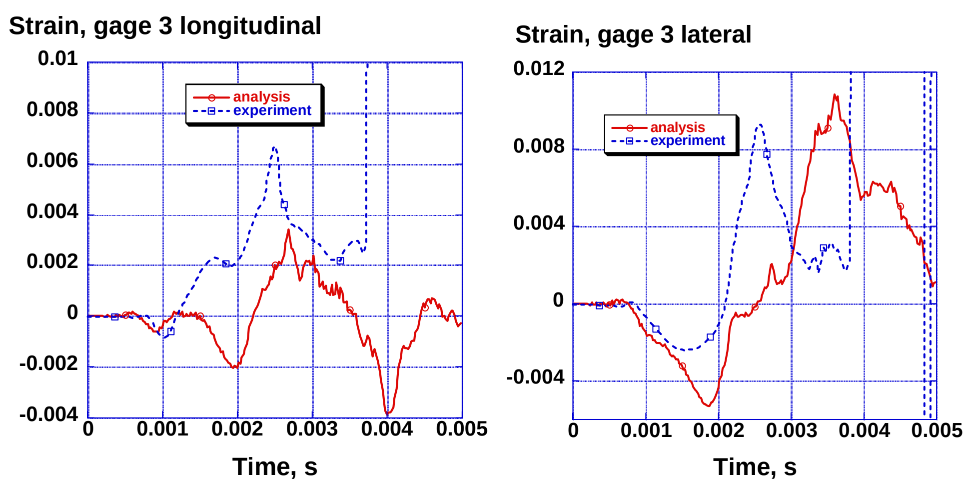


Figure 15. Strain comparisons for gage 3 location.

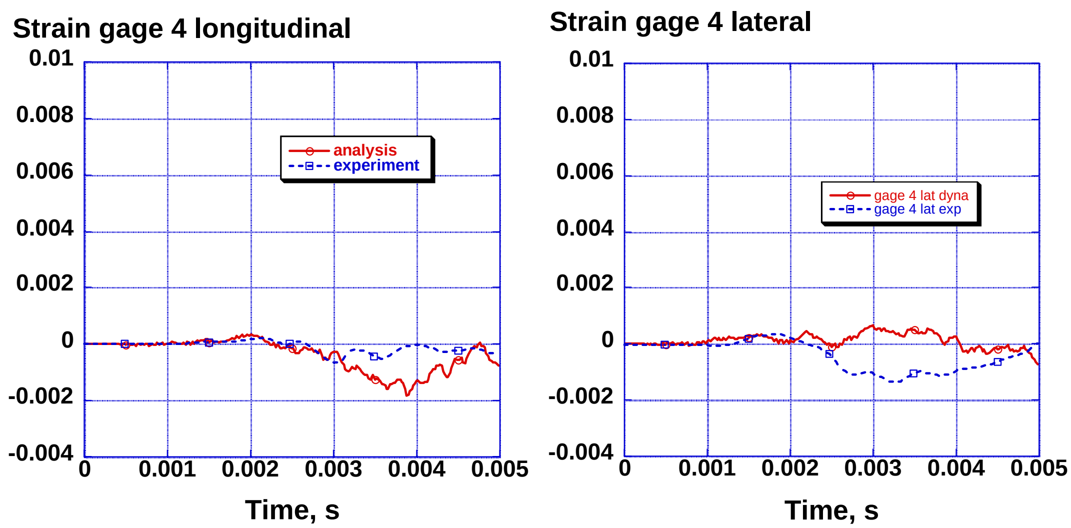


Figure 16. Strain comparisons for gage 4 location.

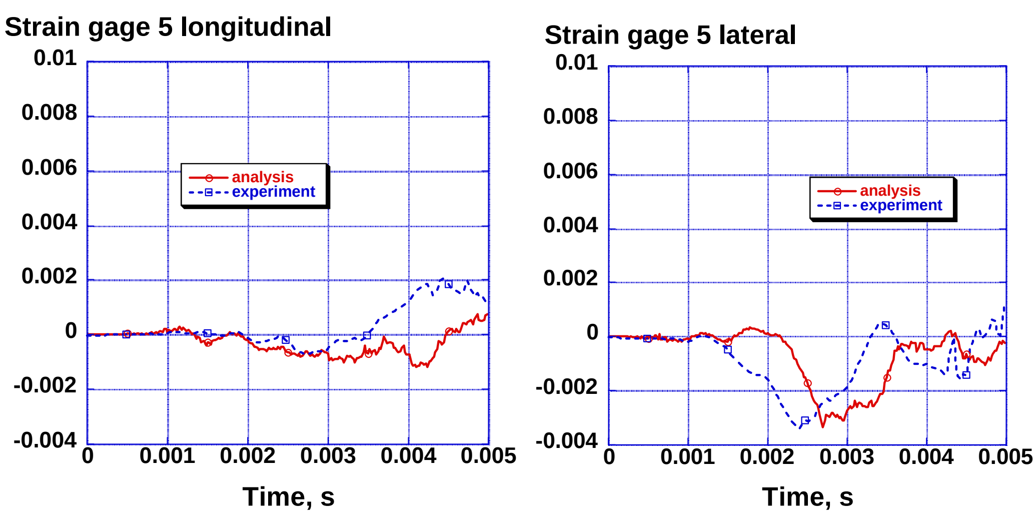


Figure 17. Strain comparisons for gage 5 location.

Discussion of Results

The amount of damage, including the resulting 16-in. square hole produced in panel 8 and the approximate shape of RCC debris, predicted by LS-DYNA correlate well with the experiment. Considering the brittle nature of the RCC material, the high speed of the impact, and the complexities of modeling the foam, the high level of agreement obtained is remarkable.

The resultant displacement data predicted by LS-DYNA was consistent with the experimental data and produced contours that approximated the overall pattern of deflection for each time interval. Since the experimental photogrammetric method has not been completely validated against a standard, the data should only be considered as qualitative.

The experimental strain data also correlate reasonably well the experimental data. There are many details that must be considered when comparing dynamic destructive stain data. First, the strain is likely to have high gradients from region to region. Consider that the strain gages are bonded onto the SiC outer layer. The SiC material is filled with micro-cracks and the underlying RCC material is quite porous. The exact location of the cracks in the RCC does not correspond to the location of the cracks in the model. Thus, overall, the agreement is considered quite good.

Concluding Remarks

LS-DYNA was used to simulate the damage to the left-wing RCC panel 8 that occurred during an impact test in which a 1.67 lb. block of foam impacted the panel at 777 ft/s. The test was conducted at SwRI in June 2003 during the Columbia accident investigation. The LS-DYNA Fu-Chang foam model with rate-effects was used to characterize the foam material properties, and the MAT_LAMINATED_COMPOSITE_FABRIC with a cumulative damage failure model was used to characterize the complex RCC material. The LS-DYNA model results correlated well with the test both qualitatively and quantitatively. As a result, LS-DYNA "physics based" models are being used as predictive tools for characterizing the threshold of damage for impacts of various debris such as foam, ice, and ablators onto the RCC leading edge for shuttle return-to-flight.

Acknowledgements

The authors wish to thank the CAIB and their staff, the astronaut core including Charles Camarda; Glenn Miller, Justin Kerr, and Ronald Baccus at JSC; Darwin Moon at Boeing Houston; Josh Schatz at Boeing, Philadelphia; Karen Jackson of the U. S. Army Research Laboratory at NASA Langley; Philip Kopfinger at Lockheed Martin; Stephen Richardson at NASA Marshall; Sotiris Kellas of Veridian; Nelson Seabolt and Robin Hardy at NASA Langley; and the many, many other unnamed individuals who toiled long hours during the Columbia accident investigation to make this effort possible.

References

1. Gehman, H. W., et al, "Columbia Accident Investigation Board," Report Volume 1, U. S. Government Printing Office, Washington, DC, August 2003.

2. Carney, K.; Melis, M.; Fasanella, E.; Lyle, K; and Gabrys, J.: "Material Modeling of Space Shuttle Leading Edge and External Tank Materials for Use in the Columbia Accident Investigation." Proceedings of 8th International LS-DYNA User's Conference, Dearborn, MI, May 2-4, 2004.

3. Melis, M.; Carney, K.; Gabrys, J.; Fasanella, E.; and Lyle, K.: "A Summery of the Space Shuttle Columbia Tragedy and the Use of LS-DYNA in the Accident Investigation and Return to Flight Efforts." Proceedings of 8th International LS-DYNA User's Conference, Dearborn, MI, May 2-4, 2004.

4. Gabrys, J.; Schatz, J.; Carney, K.; Melis, M.; Fasanella, E.; and Lyle, K.: "The Use of LS-DYNA in the Columbia Accident Investigation." Proceedings of 8th International LS-DYNA User's Conference, Dearborn, MI, May 2-4, 2004.

5. Lyle, K.; Fasanella, E.; Melis, M.; Carney, K.; and Gabrys, J.: "Application of Non-Deterministic Methods to Assess Modelling Uncertainties for Reinforced Carbon-Carbon Debis Impacts." Proceedings of 8th International LS-DYNA User's Conference, Dearborn, MI, May 2-4, 2004.

6. Anon., "LS-DYNA Keyword User's Manual Volume I and II – Version 960," Livermore Software Technology Company, Livermore, CA, March 2001.

7. Gordon, M. P., "Leading Edge Structural Subsystem and Reinforced Carbon-Carbon Reference Manual." Boeing Document KL0-98-088, October 1998.

8. A. Matzenmiller, A.; Lubliner, I. J.; and R.L. Taylor, R. L.: "A constitutive model for anisotropic damage in fiber-composites." *Journal of Mechanics and Materials*, Vol. 20, pp. 125-152, 1995.