*fea*INFORMATION

The 10ᵗʰ International
LS-DYNA® Users Conference
June 8-10, 2008
Dearborn, Michigan USA
www.ls-dynaconferences.com

HP & Intel
The 11th Asia Pacific/Japan
CAE Seminar Series

FEA Information Announcements

10th Int'l LS-DYNA[®] Users Conference Starting June 8th

FEA Information will be Booth # 101

PDF 512KB – Conference Seminar Schedule

In The News:

New participant: Structure Technology

**Course Training: Advanced Training "Using LS-DYNA for Air Bag Simulation".
Instructor: Isheng Yeh, Ph.D.
Friday, June 13 and Saturday, June 14**

**Mysteries behind the Coefficient of Thermal Expansion (CTE) Revealed
Art Shapiro (LSTC)**

ROI – Toronto – Annual Open House BBQ

Sincerely, *Will be at the Conference
*Art Shapiro, Editor art@feainformation.com
*Marsha Victory – President – mv@feainformation.com
Anthony Giaccana – Business Manager – agiac99@aol.com
*Wayne Mindle – Graphics – wlm@lstc.com
Trent Eggleston – Consultant/Systems Admin - feaanswer@aol.com

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Advanced Training "Using LS-DYNA for Air Bag Simulation".
Instructor: Isheng Yeh, Ph.D.
Friday, June 13 and Saturday, June 14
Respond to cathie@lstc.com to register, or for further information

Dear LS-DYNA User,

In conjunction with the 10th International LS-DYNA Users Conference (June 8-10) and the Advanced Seminars on June 11 and 12, LSTC has been asked to provide this specialized instruction on **Friday, June 13** and **Saturday, June 14**.

This is an advanced training; <u>attendees must have experience</u> using LS-DYNA with Air Bag Simulation.

Outline of Topics to be covered:
  (1) Introduction: safety regulation, airbag design countermeasure
  (2) Airbag folding, DAB, PAB and CAB
  (3) Modeling of tether, deployment door and tear seam
  (4) ALE for deployment simulation: ***airbag-related*** theory, input and application
  (5) Corpuscular method for deployment simulation: theory, input and application

The cost for this two-day course is $600; continental breakfast and lunch is provided both days.   Space is reserved by purchase order, check or credit card. Payment information will be sent upon request.

Training will take place at LSTC-Michigan office: 1740 West Big Beaver, Suite 100, Troy, MI 48184

Class will start at 9 a.m. and end at 4:30 p.m. each day. Participants are also invited to a Welcome Dinner on Friday, June 13 (no additional cost).

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LSTC Michigan
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Mysteries behind the Coefficient of Thermal Expansion (CTE) Revealed
Art Shapiro (LSTC)

Which calculation is correct?

Your job is to calculate the final length of a 1 meter long metal rod heated from 20C to 1020C. The coefficient of thermal expansion is $\alpha = 5.e-04$ m/mC.

You use the formula $\dfrac{L - L_0}{L_0} = \alpha(T - T_0)$

And calculate $L = 1 + (1)(5.e - 04)(1020 - 20) = 1 + 0.5 = 1.5 \ m$

In checking your work, a colleague uses the thermodynamic definition for the coefficient of thermal expansion

$$\alpha = \frac{1}{L}\left(\frac{\partial L}{\partial T}\right)_P \quad \text{or} \quad \frac{dL}{L} = \alpha dT$$

Integrating $\quad \displaystyle\int_1^L \frac{dL}{L} = 5.e - 04 \int_{20}^{1020} dT$

He gets $\quad \ln(L) - \ln(1) = (5.e - 04)(1020 - 100) = 0.5$

$L = \exp[\ln(1) + 0.5] = 1.65 \ m$

There is a large difference between the two answers. Which one is correct?

Both are correct plus 1 other is also correct
The difference is related to the definition of the CTE – there are 3. When using a CTE from a reference publication, you must determine how the CTE is defined. The 3 definitions for CTE are:

1. Tangent CTE using current length $\qquad \alpha_t = \dfrac{1}{L}\left(\dfrac{\partial L}{\partial T}\right)_P \qquad$ (eq. 1)

2. Tangent CTE using reference length $\qquad \alpha_{t,r} = \dfrac{1}{L_r}\left(\dfrac{\partial L}{\partial T}\right)_P \qquad$ (eq. 2)

3. Secant (or, mean) CTE $\qquad \alpha_s = \dfrac{L - L_r}{L_r(T - T_r)} \qquad$ (eq. 3)

Mysteries behind the Coefficient of Thermal Expansion (CTE) Revealed
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These are shown graphically in figure 1. The thermodynamic defined coefficient, α_t, is the slope of the tangent to the curve at a specific temperature, T. The secant coefficient, α_s, is the slope of the line between two points on the curve. One point is taken as the reference state (T_r, L_r). The subscript, r, means reference state. The thermal strain is zero at the reference temperature, T_r , and reference length, L_r. The reference temperature is usually 20C.

Figure 1: Shown is the graphical representation of the tangent, α_t, and secant, α_s, coefficient of thermal expansion.
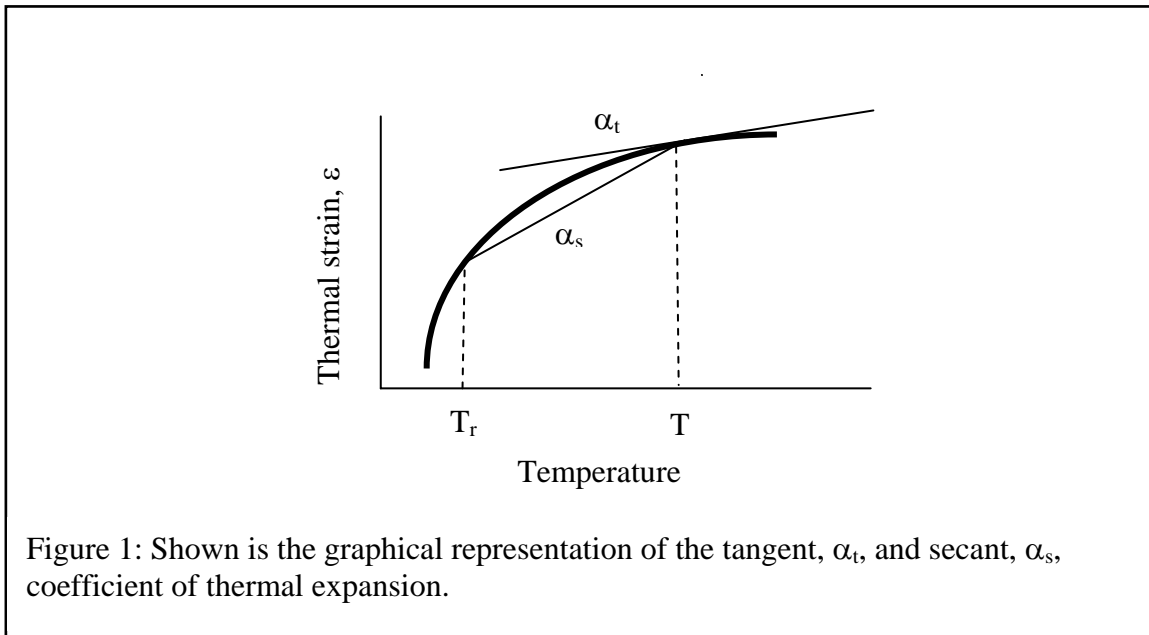
The CTEs can also be interpreted as representing the:

- "natural (logarithmic)" strain $\bar{\varepsilon} = \dfrac{dL}{L} = \alpha_t dT$ using eq. 1.

- "engineering (linear)" strain $\varepsilon = \dfrac{L - L_r}{L_r} = \alpha_s (T - T_r)$ using eq. 3.

Integrating $\displaystyle\int_{L_r}^{L} \dfrac{dL}{L}$, we obtain the logarithmic strain $\bar{\varepsilon} = \ln\left(\dfrac{L}{L_r}\right)$.

This can also be expressed as $\bar{\varepsilon} = \ln\left(1 + \dfrac{L - L_r}{L_r}\right) = \ln(1 + \varepsilon)$

If $\alpha_s (T - T_r) \ll 1$, then $\bar{\varepsilon} \cong \varepsilon$. CTE values for metals and alloys are in the range of 10×10^{-6} to 30×10^{-6} /K. The difference in the thermal strain calculation if you use a tangent or secant CTE for reasonable temperature changes is very small for metals. However, using the correct CTE definition becomes more important for plastics with a typical CTE around 1×10^{-4} K.

Mysteries behind the Coefficient of Thermal Expansion (CTE) Revealed
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The tangent coefficient of thermal expansion (default CTE definition in LS-DYNA)

The tangent coefficient of thermal expansion, $\alpha_t = \frac{1}{L}\left(\frac{\partial L}{\partial T}\right)_P$, is a very convenient value to use in an explicit finite element code. An explicit analysis is an incremental method where calculations are based on the instantaneous properties of the material. A reference state (e.g., reference temperature, reference length) is not required. The same tangent CTE values are applicable for heating an object up from room temperature or, cooling it down from an elevated temperature (e.g., hot stamping, casting). This is not true for secant CTEs which have different values for heating and cooling because the secant CTE is a function of a strain free reference state. The secant CTE values depend on whether the strain free reference state is at room temperature or at the elevated temperature.
A thermodynamic relation defines the tangent CTE. It is therefore compatible with thermodynamic defined equations of state. This makes solid-solid and liquid-solid volume changes during phase transition easy to calculate.

A main difficulty is finding values for tangent CTEs. They are much less reported in the literature than secant values. However, they can be easily calculated. An excellent source for CTE values is the reference book, <u>Thermophysical Properties of Matter, Thermal Expansion</u>, Vol. 12., ed. Y.S. Touloukin. Thermal expansion data is presented as polynomial curve fits, such as:

$$\frac{L - L_{293}}{L_{293}} = a + bT + cT^2 + dT^3 \tag{eq. 4}$$

To obtain the tangent CTE, we can simply take the derivative of this polynomial, dL/dT, and then divide by the current length, L, at a specific temperature, T.

The tangent coefficient of thermal expansion using a reference length

The tangent coefficient of thermal expansion using a reference length, $\alpha_{t,r} = \frac{1}{L_r}\left(\frac{\partial L}{\partial T}\right)_P$, is presented as tabulated data in the reference book, <u>Thermophysical Properties of Matter, Thermal Expansion</u>, Vol. 12., ed. Y.S. Touloukin. I'm not aware of any FE codes that use this definition. However, this definition gets confused with the tangent coefficient, α_t, in the literature. You will find the statement in the literature that, "if the CTE is not a function of temperature, then the tangent CTE equals the secant CTE". This is only true for $\alpha_{t,r}$ and not for α_t.

Integrating eq. 2
$$\int_{L_r}^{L} \frac{dL}{L_r} = \int_{T_r}^{T} \alpha_{t,r} dT \tag{eq. 5}$$

We obtain
$$\frac{L - L_r}{L_r} = \int_{Tr}^{T} \alpha_{t,r} dT \tag{eq. 6}$$

Equation 3 can be written as
$$\frac{L - L_r}{L_r} = \alpha_s (T - T_r) \tag{eq. 7}$$

Then, equating equations 6 and 7 we obtain: $\alpha_s = \frac{1}{(T - T_r)}\int_{T_r}^{T} \alpha_{t,r} dT \tag{eq. 8}$

We can see from equation 8 that if $\alpha_{t,r}$ is not a function of temperature, then $\alpha_s = \alpha_{t,r}$. Equation 8 also shows that α_s is the mean value of $\alpha_{t,r}$ over the temperature interval.

The secant coefficient of thermal expansion (optional CTE definition for MAT_106 in LS-DYNA)

Another definition for the coefficient of expansion exists which is called the secant value, α_s. These are easily obtained in the laboratory and I'm sure many of you performed this experiment in a college physics lab. Take a rod at room temperature (i.e. reference temperature), T_r, and measure its length, L_r. Then uniformly (usually by an electric current) heat the rod and measure its new length, L, (or, change in length) and temperature, T. Then,

$$\alpha_s = \frac{L - L_r}{L_r (T - T_r)} \tag{eq. 9}$$

Note that a reference temperature, T_r, must be specified when using the secant value of thermal expansion. α_s is also referred to as the "mean" or "effective" coefficient of thermal expansion. Historically, the specification of α_s as a function of temperature allowed modeling the nonlinear influence of temperature on thermal strain in linear finite element codes. This specification carried over to many of the current nonlinear codes. For linear and nonlinear incremental material analysis, the increment in thermal strain can be calculated by

$$\Delta \varepsilon = \frac{\Delta L}{L_r} = \alpha_{s,T+\Delta T}(T + \Delta T - T_r) - \alpha_{s,T}(T - T_r) \tag{eq. 10}$$

This is an exact calculation and therefore is not dependent on the incremental time step size. This expression is used in implicit finite element calculations.

The main disadvantage in using α_s is the requirement of a reference state. If the part initial temperature is different from the material reference state temperature, then the α_s values are no longer valid. They must be adjusted to account for the new strain free condition at the part initial temperature.

Mysteries behind the Coefficient of Thermal Expansion (CTE) Revealed
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How do you adjust α_s values at a new reference state?

If the part initial temperature state (P_1), is different from the material reference temperature state (P_0), then the α_s values must be modified. The subscript RM means 'reference material', and the subscript RP means 'reference part'. Figure 2 graphically depicts the computational method.
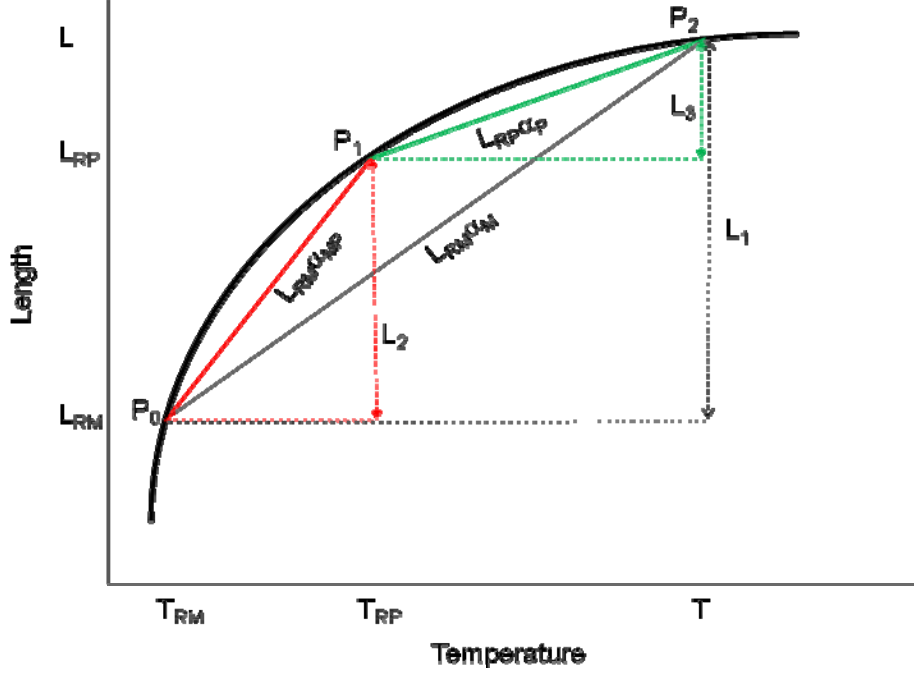

Figure 2: This figure shows graphically the parameters used in eq. 11 to shift the CTE reference state.

(T_{RM}, L_{RM}) is the material reference state at point P_0. This is the reference state for the material data. α_M is the secant CTE at the temperature, T. α_{MP} is the secant CTE at the temperature T_{RP}. α_M and α_{MP} are obtained from the literature.

(T_{RP}, L_{RP}) is the part reference state at point P_1. This is the initial temperature for the part at which the thermal strain is 0. We want to calculate α_P.
$L_{RM}\alpha_M$ is slope of the line from point P_0 to P_2.
$L_{RM}\alpha_{MP}$ is the slope of the line from point P_0 to P_1.
$L_{RP}\alpha_P$ is the slope of the line from point P_1 to P_2.

$$L_1 = L - L_{RM} = L_{RM}\alpha_M\left(T - T_{RM}\right)$$

$$L_2 = L_{RP} - L_{RM} = L_{RM}\alpha_{MP}\left(T_{RP} - T_{RM}\right)$$

$$L_3 = L - L_{RP} = L_{RP}\alpha_P\left(T - T_{RP}\right)$$

$$L_3 = L_1 - L_2$$

$$\alpha_P = \left(\frac{L_{RM}}{L_{RP}}\right)\frac{\alpha_M\left(T - T_{RM}\right) - \alpha_{MP}\left(T_{RP} - T_{RM}\right)}{\left(T - T_{RP}\right)} \qquad \text{(eq. 11)}$$

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Mysteries behind the Coefficient of Thermal Expansion (CTE) Revealed
Art Shapiro (LSTC)

How do you calculate α_t from α_s?

The secant lines can be used to approximate the tangent. The slope of a secant line (e.g., α_p in figure 2) approaches the slope of the tangent line as the secants' 2nd point (i.e., P_2) approaches the 1st point (i.e., P_1). The problem of finding the tangent line to a graph was one of the main problems that originated calculus. In calculus this problem is solved using Newton's difference quotient.

$$f'(a) = \lim_{h \to 0} \frac{f(a+h) - f(a)}{h}$$

This equation is similar to eq. 11. Also, by observation, the secant α_P in figure 2 appears to represent the slope of the tangent to the curve at the point $(T+T_{RP})/2$. The input to most FE codes is by piecewise linear data tables. If we have 2 data pairs (α_{s1}, T_1) and (α_{s2}, T_2), we can calculate α_t at the midpoint temperature $(T1+T2)/2$ using eq. 11. Remember that this calculation is approximate and becomes more accurate in the limit as $\lim(T-T_{RP}) \to 0$.

How do you calculate α_s from α_t?

We can use equation (1) to calculate the thermal strain, $\varepsilon - \frac{dL}{L} - \int_{T_r}^{T} \alpha_t \, dT - \alpha_t \, (T - T_r)$ for the case α_t = constant. The input to most FE codes is by piecewise linear data tables in which the tangent coefficient of thermal expansion is considered constant over the temperature increment. For example, $\alpha_{t,1}$ is constant between T_r and T_1, $\alpha_{t,2}$ is constant between T_1 and T_2, etc. Then

$$\varepsilon_1 = \alpha_{t,1}(T_1 - T_r)$$
$$\varepsilon_2 = \varepsilon_1 + \alpha_{t,2}(T_2 - T_1)$$
$$\varepsilon_3 = \varepsilon_2 + \alpha_{t,3}(T_3 - T_2)$$

Secant values of the coefficient of thermal expansion can then be calculated from:

$$\alpha_{s,1} = \varepsilon_1 / (T_1 - T_r)$$
$$\alpha_{s,2} = \varepsilon_2 / (T_2 - T_r)$$
$$\alpha_{s,3} = \varepsilon_3 / (T_3 - T_r)$$

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Mysteries behind the Coefficient of Thermal Expansion (CTE) Revealed
Art Shapiro (LSTC)

CTE Data for Aluminum

Temperature [K]	Length [m]	α_{tan} [μm/m K]	α_{tan_r} [μm/m K]	α_{sec} [μm/m K]
293	1.000000	23.59	23.59	23.59
300	1.000165	23.63	23.64	23.61
325	1.000759	23.84	23.86	23.72
350	1.001359	24.08	24.11	23.84
375	1.001965	24.35	24.40	23.97
400	1.002579	24.65	24.71	24.10
425	1.00321	24.98	25.06	24.25
450	1.003833	25.34	25.44	24.41
475	1.004474	25.73	25.85	24.58
500	1.005126	26.15	26.29	24.76
525	1.005789	26.61	26.76	24.95
550	1.006465	27.09	27.26	25.15
575	1.007153	27.60	27.80	25.37
600	1.007855	28.14	28.36	25.59
625	1.008572	28.71	28.95	25.82
650	1.009304	29.31	29.58	26.06
675	1.010052	29.94	30.24	26.31
700	1.010817	30.60	30.93	26.58
725	1.011599	31.28	31.65	26.85
750	1.012400	32.00	32.40	27.13
775	1.013220	32.74	33.18	27.43
800	1.014060	33.52	33.99	27.73

HP & Intel Present:

The 11th Asia Pacific/Japan CAE Seminar Series

- July 14: Shanghai, China
- July 16: Seoul, Korea
- July 18: Tokyo, Japan
- July 22: Bangalore, India

This one day event is **THE premier CAE event** for customers in multiple industries such as **aerospace, automotive, semiconductor, consumer electronics, defense and security**. It brings together over 20 leading CAE application developers, industry speakers, and 200+ engineers to discuss current CAE trends. Keynote speakers include Dr. J. S. Hurley, Sr. Manager Distributed Computing, Networked Systems Technology, The Boeing Company, Knute Christensen, Worldwide HPC Solutions Marketing Manager, Hewlett-Packard and George Chaltas, Sr. Engineering Manager, Intel.

Registration for this event is now open but seating is limited, so encourage your customers to register today!

For details or to register contact Christine Fronczak at christine.fronczak@hp.com

10th International LS-DYNA Users Conference
June 8 –1oth in Dearborn, Michigan

Exhibitor Booth 303 HP

Exibhitor Booth 202 Intel

Yahoo Group Yammerings

Note: LS-DYNA Yahoo Group is neither owned nor operated by LSTC, and LSTC has no control over the content.

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The LS-DYNA Yahoo Group archive contains a wealth of information that can be helpful to any LS-DYNA user. We suggest you review the archives when you are seeking help on any topic related to LS-DYNA. NOTE: Questions and responses may have been edited for clarity & brevity.

This installment of "Yahoo Yammerings" features several questions and responses from the past month of postings to the LS-DYNA Yahoo Group:

- CPU Estimate and Flushing the I/O Buffer?
- Mesh Size Sensitivity and MAT159?
- Hardening Law for MAT037?

CPU Estimate and Flushing the I/O Buffer?

I have 2 questions:

1. Why is the estimated total CPU and clocktime, at the beginning of the run zero.
2. When contact occurs, I get the message, "flushing in the i/o buffer", and the simulation just keeps going. What does "flushing in the i/o buffer"?

Reply by Jim Kennedy: The initial estimate of the termination time is an *estimate*, and is affected by the initialization operations for the process (e.g., element and contact calculations) which control the time step once the simulation proceeds. Values of termination time obtained after several time steps, using sense switch 2 (SW2) are more accurate. Be advised that the estimates of termination time can change significantly during a simulation; in particular, when the controlling time step drops due to extreme deformation or when the contact become more complex.

Please see the IFLUSH variable on page 8.103 of the LS-DYNA Version 971 User's Manual for an explanation of "flushing in the i/o buffer."

Mesh Size Sensitivity and MAT159?

I modeled two masonry shear walls with the same conditions but different solid element sizes and I obtained results. I read in the evaluation report for MAT159 (PUBLICATION NO: FHWA-HRT-05-063) that the results of simulations, with this material model, are independent of solid mesh size when including damage. Why do I obtain two different results?

Reply by Akram Abu-Odeh: The material model developer (Yvonne Murray) did not claim that the results of simulations will be independent of mesh size. The regularization

implemented in the material model has to do with fracture energy (area under softening curve) being independent of the element size. So, when you do mesh sensitivity analyses you will converge to an answer rather than having damage localized in few elements. Please read the section on "Demonstration of Mesh Size Sensitivity" on page 33; see Figures 33 to 39 which tells the story at a glance.

Hardening Law for MAT037?

I would like to know about different hardening laws for sheet metal forming simulation. I also would like to know what hardening law is used in the Mat_037 model. I read that for accurate spring back simulation, kinematic hardening should be used.

Reply by Jim Kennedy:

MAT_037 (MAT_TRANSVERSELY_ANISOTROPIC_ELASTIC_PLASTIC) uses an anisotropic hardening parameter R, which is the ratio of the in-plane plastic strain rate to the out-of-plane plastic strain rate.

MAT_125 (MAT_KINEMATIC_HARDENING_TRASVERSELY_ANISOTROPIC) uses a combination of Yoshida non-linear kinematic hardening along with the hardening for MAT_037 (please see pages MAT_476 to MAT_479 in the LS-DYNA Version 971 User's Manual).

Two selected presentations with hardening discussions:

Campana, F., Cortese, L, and Placidi, F., "FEM Evaluation of Springback After Sheet Metal Forming: Application to High Strength Steels of Combined Isotropic-Kinematic Hardening Model," 1st International Conference on Super High Strength Steels, Rome, Italy, November, 2005.
http://www.msm.cam.ac.uk/phase-trans/2005/LINK/130.pdf

Arwisaon, C., "Numerical Simulation of Sheet Metal Forming for High Strength Steels," Licentiate Thesis, Division of Manufacturing Systems Engineering, Lulea University of Technology, Lulea, Sweden, August, 2005.
http://epubl.ltu.se/1402-1757/2005/08/LTU-LIC-0508-SE.pdf
LS-DYNA Yahoo Groups

You can subscribe to the group by sending an email request to LS-DYNA-subscribe@yahoogroups.com or by visiting the Yahoo Groups web site http://groups.yahoo.com

Generally, the quickest/best responses are to those questions posed with the most specifics. General questions such as "How do I use XXX feature?" either go unanswered, or are answered by Jim Kennedy with links to appropriate references in the growing LS-DYNA related literature, e.g. see the archive of LS-DYNA Conference proceedings at www.dynalook.com

FEA Information Inc Participants Booth Numbers

ANSYS -   Booth 106

APTEK —   Booth 309

ARUP -   Booth 201

BETA CAE SYSTEMS SA -   Booth 403

ETA   -   Booth 100

Detroit Engineered Products - Booth 208

ESI -   Booth 305

FEA Information - Booth 101

FUJITSU - Booth 306

HP -   Booth 303

Intel -   Booth 202

JRI -   Booth 103

MICROSOFT -   Booth 301

MSCS.SOFTWARE — Booth 308

NEC -   Booth 207

PANASAS -   Booth 204

SGI -   Booth 200

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TOP CRUNCH Participant Submission – April - May 2008

SGI – Vendor/Submitter   Page 1 of 2

Computer/Interconnect	Processor	#Nodes x #Processors per Node x #Cores Per Processor = Total #CPU	Time (sec)	Benchmark Problem
Altix XE1200/Windows CCS/Voltaire Infiniband DDR	Intel Xeon 5160 DC 3.0GHz (Woodcrest)	4 x 2 x 2 = **16**	1001	neon_refined_revised
Altix XE1200/Windows CCS/Voltaire Infiniband DDR	Intel Xeon 5160 DC 3.0GHz (Woodcrest)	1 x 2 x 2 = **4**	3070	neon_refined_revised
Altix XE1200/Windows CCS/Voltaire Infiniband DDR	Intel Xeon 5160 DC 3.0GHz (Woodcrest)	1 x 1 x 2 = **2**	4757	neon_refined_revised
Altix XE1200/Windows CCS/Voltaire Infiniband DDR	Intel Xeon 5160 DC 3.0GHz (Woodcrest)	1 x 1 x 1 = **1**	8729	neon_refined_revised
Altix ICE8200EX/Mellanox ConnectX IB HCA DDR Fabric OFED v1.3	Intel Xeon E5472 3.00GHz	1 x 2 x 4 = **8**	1462	neon_refined_revised
Altix ICE8200EX/Mellanox ConnectX IB HCA DDR Fabric OFED v1.3	Intel Xeon E5472 3.00GHz	32 x 2 x 4 = **256**	90	neon_refined_revised
Altix ICE8200EX/Mellanox ConnectX IB HCA DDR Fabric OFED v1.3	Intel Xeon E5472 3.00GHz	16 x 2 x 4 = **128**	121	neon_refined_revised
Altix ICE8200EX/Mellanox ConnectX IB HCA DDR Fabric OFED v1.3	Intel Xeon E5472 3.00GHz	8 x 2 x 4 = **64**	230	neon_refined_revised
Altix ICE8200EX/Mellanox ConnectX IB HCA DDR Fabric OFED v1.3	Intel Xeon E5472 3.00GHz	4 x 2 x 4 = **32**	433	neon_refined_revised
Altix ICE8200EX/Mellanox ConnectX IB HCA DDR Fabric OFED v1.3	Intel Xeon E5472 3.00GHz	128 x 2 x 4 = **1024**	568	3 Vehicle Collision
Altix ICE8200EX/Mellanox ConnectX IB HCA DDR Fabric OFED v1.3	Intel Xeon E5472 3.00GHz	64 x 2 x 4 = **512**	640	3 Vehicle Collision
Altix ICE8200EX/Mellanox ConnectX IB HCA DDR Fabric OFED v1.3	Intel Xeon E5472 3.00GHz	2 x 2 x 4 = **16**	807	neon_refined_revised
Altix ICE8200EX/Mellanox ConnectX IB HCA DDR Fabric OFED v1.3	Intel Xeon E5472 3.00GHz	1 x 2 x 4 = **8**	21667	3 Vehicle Collision

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SGI – Vendor/Submitter   Page 2 of 2

Computer/Interconnect	Processor	#Nodes x #Processors per Node x #Cores Per Processor = Total #CPU	Time (sec)	Benchmark Problem
Altix ICE8200EX/Mellanox ConnectX IB HCA DDR Fabric OFED v1.3	Intel Xeon E5472 3.00GHz	32 x 2 x 4 = **256**	948	3 Vehicle Collision
Altix ICE8200EX/Mellanox ConnectX IB HCA DDR Fabric OFED v1.3	Intel Xeon E5472 3.00GHz	16 x 2 x 4 = **128**	1729	3 Vehicle Collision
Altix ICE8200EX/Mellanox ConnectX IB HCA DDR Fabric OFED v1.3	Intel Xeon E5472 3.00GHz	8 x 2 x 4 = **64**	3076	3 Vehicle Collision
Altix ICE8200EX/Mellanox ConnectX IB HCA DDR Fabric OFED v1.3	Intel Xeon E5472 3.00GHz	4 x 2 x 4 = **32**	5589	3 Vehicle Collision
Altix ICE8200EX/Mellanox ConnectX IB HCA DDR Fabric OFED v1.3	Intel Xeon E5472 3.00GHz	2 x 2 x 4 = **16**	11292	3 Vehicle Collision

Visit The SGI Booth # 200
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Shell Strain

Comments regarding these notes can be directed to jday@lstc.com

Preface

Whereas through-thickness strain of shells is always computed, change of thickness is NOT calculated by default. ISTUPD in *CONTROL_SHELL controls only whether the shell thickness is updated in accordance with the through-thickness strain. By setting ISTUPD to 1, change of shell thickness is activated. Shell thinning may be important in applications where shell stretching is prominent -- this is NOT the case in the majority of impact simulations while it IS important in metal forming applications. In crash analysis, we recommend ISTUPD be left as zero (no through thickness strain) for several reasons. One, it's cheaper. Two, shell thinning is not an important effect. Lastly, dynamic simulations may be less stable with shell thinning turned on.

[Version 971 update: A new parameter PSSTUPD in *CONTROL_SHELL identifies which parts are affected by the ISTUPD parameter. This allows some parts to include shell thinning and others not. Also, a new thinning option, invoked by setting ISTUPD=4, is available for isotropic, elasto-plastic materials. This new option should be more stable than ISTUPD=1 since elastic strains are neglected in the thickness update.]

Shells are, by definition, plane stress elements. Whereas two of the three principal STRESS directions are in the plane of the shell, that's not always the case when dealing with the 'actual' principal STRAIN directions. By 'actual', I mean the principal strain directions calculated taking into account all 6 components of strain.

To write the strain tensor to the d3plot and/or elout databases, you MUST set the strain output flag STRFLG to 1 in the LS-DYNA input deck using *DATABASE_EXTENT_BINARY.

There are two approaches that LS-Prepost uses for calculating principal strains in shells.

- The 'global' method takes into account all 6 components of strain. The following LS-Prepost buttons utilize this method:

Vector > Prin. strain

Fcomp > Strain > L-surf max-prin strain (while in "Global" mode)

History > Element > Lower surface principal strain (while in "Global" mode)

- The 'local' method gives you the in-plane principal strains. The two in-plane principal strains are computed by LS-Prepost by first transforming the six global components of strain to the local element system. Then, using ONLY the three in-plane components of local strain, one of which is the in-plane shear strain, the two in-plane principal strains are derived.

 Visualization of principal shell strains by LS-Prepost

- In LS-Prepost, you can create vector plots of in-plane principal strain using Vector > P. Inplane strain.

- To create fringe plots of in-plane principal strain, use Fcomp > FLD > lower eps1 or, equivalently, Fcomp > Strain > L-surf max-prin strain (while in "Local" mode).

- To create history plots of in-plane principal strain, use History > Element > Lower surface principal strain (while in "Local" mode) or, equivalently, use the following sequence of steps,

Range > Avg: None

Fcomp > FLD > lower eps

History > Scalar > Lower surface eps1

- Keys to understanding the strain output:
  1. Use Setting to select the thru-thickness location before plotting In-plane strain vectors via the Vector button.
  2. The in-plane principal strains are labeled as max principal and min principal in Fcomp > Strain and History > Element when "Local" is toggled on. Through-thickness strain appears as 2nd principal. This convention is somewhat confusing since it does NOT necessarily meet the condition 2nd prin strain > min principal strain and < max principal strain.

Notice

Maximum in-plane (tensoral) shear strain is gamma/2 = (eps1 - eps2)/2. (Tensoral shear strain is half the engineering shear strain.) You can get a time history of

maximum in-plane shear strain by plotting histories of eps1 and eps2 on the same plot and then using the "Oper" button to subtract the eps2 curve from the eps1 curve. Then use "Scale" to scale the ordinate value by 0.5.

Be aware that the strain values stored in the databases correspond to the upper and lower integration points, not the actual upper and lower surfaces of the shell (unless you've placed integration points on the surface by way of *INTEGRATION_SHELL or have specified that Lobatto integration be used via *CONTROL_SHELL). Alternately, LS-Prepost can use resultant forces and moments to calculate stress on the surface of a shell (assuming linear elasticity). To invoke this feature, choose one of the last six components listed under Fcomp > Result.

A final note -- it is not proper to extrapolate principal strains from integration points to the surface; extrapolation is only appropriate for the six components of the strain tensor. You can plot the six components in either the global coordinate system (default for d3plot data) or the element local coordinate system (default for elout data; also available from d3plot data by selecting "Local" in the postprocessor). The advantage of working with strains in the local element system is that you're dealing directly with in-plane strains.

Strains from Fcomp > Infin are calculated by LS-Prepost using nodal displacements and thus are only an approximation. The greater the displacements, the worse the approximation. Furthermore, strains acquired in this manner would not take into account any variation of strain through the thickness of the shell. In constrast, the tensoral strains stored in d3plot and elout when STRFLG=1 are calculated directly by LS-DYNA and are thus accurate for large displacements and give the variation of strain through the shell thickness.

Participant LS-DYNA® Resource Page (alpha order)
Fully QA'd by Livermore Software Technology Corporation

SMP and MPP Hardware and OS

FUJITSU

FUJITSU Prime Power	SUN OS 5.8
FUJITSU VPP	Unix_System_V

HP

HP PA-8X00	HP-UX 11.11. and above
HP IA-64	HP-UX 11.22 and above
HP Opteron	Linux CP4000/XC
HP Alpha	True 64

INTEL

INTEL IA32	Linux, Windows
INTEL IA64	Linux
INTEL Xeon EMT64	Linux, Windows 64

NEC

NEX SX6	Super-UX

SGI

SGI Mips	IRIX 6.5X
SGI IA64	SUSE 9 w/Propack 4 Red Hat w/ Propak 3

Participant LS-DYNA® Resource Page (alpha order)
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MPP and Interconnect MPI

FUJITSU

	O/S	HPC Interconnect	MPI Software
FUJITSU Prime Power	SUN OS 5.8		
FUJITSU VPP	Unix_System_V		

HP

	O/S	HPC Interconnect	MPI Software
HP PA8000	HPUX		
HPIA64	HPUX		
HP Alpha	True 64		

INTEL

	O/S	HPC Interconnect	MPI Software
INTEL IA32	Linux, Windows	InfiniBand (Voltaire), MyriCom	LAM/MPI, MPICH, HP MPI, SCALI
INTEL IA64	Linux		LAM/MPI, MPICH, HP MPI
INTEL Xeon EMT 64	Linux	InfiniBand(Topspin, Voltaire), MyriCom, PathScale InfiniPath	LAM/NPI, MPICH, HP MPI, INTEL MPI, SCALI

NEC

	O/S	HPC Interconnect	MPI Software
NEX SX6	Super-UX		

SGI

SGI Mips	IRIX 6.5 X	NUMAlink	MPT
SGI IA 64	SUSE 9 w/Propack 4 RedHat w/Propack 3	Numalink, InfiniBand(Voltaire)	MPT, Intel MPI, MPICH

LS-DYNA® Resource Page - Participant Software

Interfacing or Embedding LS-DYNA - Each software program can interface to all, or a very specific and limited segment of the other software program. The following list are software programs interfacing to or having the LS-DYNA solver embedded within their product. For complete information on the software products visit the corporate website.

ANSYS - ANSYS/LS-DYNA
ANSYS/LS-DYNA

Built upon the successful ANSYS interface, ANSYS/LS-DYNA is an integrated pre and postprocessor for the worlds most respected explicit dynamics solver, LS-DYNA. The combination makes it possible to solve combined explicit/implicit simulations in a very efficient manner, as well as perform extensive coupled simulations in Robust Design by using mature structural, thermal, electromagnetic and CFD technologies.

AI*Environment:

A high end pre and post processor for LS-DYNA, AI*Environment is a powerful tool for advanced modeling of complex structures found in automotive, aerospace, electronic and medical fields. Solid, Shell, Beam, Fluid and Electromagnetic meshing and mesh editing tools are included under a single interface, making AI*Environement highly capable, yet easy to use for advanced modeling needs.

ETA — DYNAFORM

Includes a complete CAD interface capable of importing, modeling and analyzing, any die design. Available for PC, LINUX and UNIX, DYNAFORM couples affordable software with today's high-end, low-cost hardware for a complete and affordable metal forming solution.

ETA — VPG

Streamlined CAE software package provides an event-based simulation solution of nonlinear, dynamic problems. eta/VPG's single software package overcomes the limitations of existing CAE analysis methods. It is designed to analyze the behavior of mechanical and structural systems as simple as linkages, and as complex as full vehicles.

MSC.Software - MSC.Dytran LS-DYNA

Tightly-integrated solution that combines MSC.Dytran's advanced fluid-structure interaction capabilities with LS-DYNA's high-performance structural DMP within a common simulation environment. Innovative explicit nonlinear technology enables extreme, short-duration dynamic events to be simulated for a variety of industrial and commercial applications on UNIX, Linux, and Windows platforms. Joint solution can also be used in conjunction with a full suite of Virtual Product Development tools via a flexible, cost-effective MSC.MasterKey License System.

MSC.Software - MSC.Nastran/SOL 700

The MSC.NastranTM Explicit Nonlinear product module (SOL 700) provides MSC.Nastran users the ability access the explicit nonlinear structural simulation capabilities of the MSC.Dytran LS-DYNA solver using the MSC.Nastran Bulk Data input format. This product module offers unprecedented capabilities to analyze a variety of problems involving short duration, highly

dynamic events with severe geometric and material nonlinearities.

MSC.Nastran

Explicit Nonlinear will allow users to work within one common modeling environment using the same Bulk Data interface. NVH, linear, and nonlinear models can be used for explicit applications such as crash, crush, and drop test simulations. This reduces the time required to build additional models for another analysis programs, lowers risk due to information transfer or translation issues, and eliminates the need for additional software training.

MSC.Software — Gateway for LS-DYNA

Gateway for LS-DYNA provides you with the ability to access basic LS-DYNA simulation capabilities in a fully integrated and generative way. Accessed via a specific Crash workbench on the GPS workspace, the application enhances CATIA V5 to allow finite element analysis models to be output to LS-DYNA and then results to be displayed back in CATIA. Gateway for LS-DYNA supports explicit nonlinear analysis such as crash, drop test, and rigid wall analysis.

Oasys software for LS-DYNA

Oasys software is custom-written for 100% compatibility with LS-DYNA. Oasys PRIMER offers model creation, editing and error removal, together with many specialist functions for rapid generation of error-free models. Oasys also offers post-processing software for in-depth analysis of results and automatic report generation.

EASi-CRASH DYNA

EASi-CRASH DYNA is the first fully integrated environment for crashworthiness and occupant safety simulations with LS-DYNA, and covers the complete CAE-process from model building and dataset preparation to result evaluation and design comparisons.

EASi-CRASH DYNA can be used for concept crash, FE crash and coupled rigid body/FE crash simulations in conjunction with MADYMO.
Full capability to handle IGES, CATIA V4, CATIA V5, UG and NASTRAN files.

APTEK

The MMCD is a graphics-based and menu-driven program that interfaces with the LS-DYNA library of material models and the LS-OPT optimization code. The core of the MMCD is the driver, which calculates the stress-strain behavior of material models driven by combinations of strain increments and stress boundary conditions, i.e. pure shear stress, and combinations of uniaxial, biaxial, and triaxial compression and tension. MMCD input and output is accessed via pre- and post-processors; graphical user interfaces (GUIs) for easily selecting the material model parameters and load histories, and for plotting the output in both two (stress-strain curves) and three (yield surfaces) dimensions. The pre-processor, driver, and post-processor are combined into a web downloadable software package that operates seamlessly as a single code.

FEA Information Participants –
Company name takes you directly to Website

OASYS Ltd: Markets engineering software products. Consulting engineers, planners and project managers working in all areas of the built environment.

JRI Solutions Ltd.: Specializing in Research & Consulting; System Consulting, Frontier Business, System Integration and Science Consulting.

Hewelett Packard: Personal computing, mobile computing, network management, 3-D graphics and information storage.

ANSYS Inc.: Develops, markets, supports and delivers collaborative analysis optimization software tools.

SGI: Silicon Graphics, Inc., is a leader in high-performance computing, visualization, and storage.

MSC.Software: Information technology software and services provider.. Products & services used to enhance & automate the product design/manufacturing process.

NEC: A history of more than 100 years of leadership/innovation in the core high-technology sectors of communications, computers/electronic components

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INTEL: For more than three decades, Intel Corporation has developed technology enabling the computer and Internet revolution that has changed the world.

Engineering Technology Associates, Inc.: Provides engineering & IT services & has created the streamlined simulation software packages DYNAFORM and VPG

ESI Group: A software editor for the numerical simulation of prototype and manufacturing process engineering in applied mechanics.

Microsoft: For customers solving complex computational problems, Microsoft Windows Compute Cluster Server 2003 accelerates time-to-insight.

BETA CAE Systems S.A.: Specialized in the development of state of the art CAE pre- and post-processing software systems.

FEA Information Participants —
Company name takes you directly to Website

Detroit Engineered Products: A Michigan based engineering consulting and software products firm specializing in the area of Product Development products and solutions.

APTEK: Among the software developed APTEK develops and licenses an interactive program for driving LS-DYNA material models - the Mixed Mode Constitutive Driver (MMCD).

PANASAS: High performing Parallel Storage for scalable Linux clusters. Delivering exceptional scaling in capacity and performance for High Performance Computing (HPC) organizations.

Intelligent Light: A a world leader in the development and delivery of software for computational fluid dynamics (CFD) users. We help the world's best engineering and research organizations maximize the productivity and impact of their CFD capabilities

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LS-DYNA® Software Distributors - Alphabetical order by Country

Australia	**Leading Engineering Analysis Providers**
Canada	**Metal Forming Analysis Corporation**
China	**Arup**
Germany	**CAD-FEM**
Germany	**DynaMore**
India	**Oasys, Ltd.**
Italy	**DynaMore**
Japan	**The Japan Research Institute**
Japan	**ITOCHU Techno-Solutions Corporation**
Korea	**Theme Engineering**
Russia	**State Unitary Enterprise - STRELA**
Sweden	**Engineering Research AB**
Taiwan	**Flotrend Corporation**
USA	**Engineering Technology Associates, Inc.**
USA	**Dynamax**
USA	**Livermore Software Technology Corp.**
UK	**ARUP**

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Educational & Contributing Participants
Alphabetical Order By Country

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Italy	Professor Gennaro Monacelli	Prode – Elasis & Univ. of Napoli, Frederico II
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USA	Dr. Ala Tabiei	University of Cincinnati

Informational Websites
The LSTC LS-DYNA Support site: www.dynasupport.com

LS-DYNA Support Site	FEA Informationwebsites
LS-DYNA Examples (more than 100 Examples)	LS-DYNA Conference Site
TopCrunch – Benchmarks	LS-DYNA Publications to Download On Line
LS-DYNA Publications	LSTC LS-PrePost Tutorials
CADFEM GmbH Portal	LS-OPT Support Site

ROI Engineering Inc. www.roieng.com
Annual Toronto Summer OPEN HOUSE, BBQ & More
Thursday June 5th, 2008   9:00 am - 4:30 pm

Morning:

1. An Exciting Announcement about Simutech Group & ROI Engineering

2. Simulation Process Management and Knowledge Optimization

    ROI Engineering (ROIE), as your preferred partner for simulation solutions, continually strives to help corporations maximize their investment in the ANSYS Suite of Simulation products. To that end, ROIE is committed to investigating and understanding new products and technologies that meet the ever changing business environment of manufacturers.

    One such product, that has been recently introduced by ANSYS Inc., is Engineering Knowledge Manager (ANSYS EKM), a solution designed and developed to address the challenges associated with working within a collaborative engineering environment.

BBQ Lunch – From Simply BBQ

Afternoon:

    ANSYS Multiphysics: A presentation on the advanced capabilities of ANSYS Multiphysics with discussions / demos on structural, thermal, electromagnetic and fluid interactions. Small Demos and group discussions.

    RSVP to Olyana.Bortnyk@roieng.com

LSTC Training Classes in California & Michigan

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Advanced Impact	Aug 5-8	
Advanced Option	June 23-24	Dec 15-16
ALE/Eulerian & FSI	July 16 - 18	
Blast & Penetration	Aug 18-19	
Composite Materials	June 25-26	
Concrete & Geomaterial Modeling	Sept 25-26	
Contact	Aug 14-15	Sept 16-17
Heat Transfer & Thermal-Stress		
Implicit	Aug 12-13	
Intro to LS-DYNA	May 06-09 July 22-25 Nov 11-14	June 17-20 Sept 09-12 Dec 09-12
Intro to LS-OPT	Sept 09-14	
Material Modeling Using User Defined Options	June 30-July01	
Mesh Free Methods (SPH & EFG)		

The "1ˢᵗ International Conference on Hot Sheet Metal Forming of High performance Steel, October 22-24, 2008, Kassel, Germany"

The ongoing demand towards the application of high-performance steel and, beyond that, towards steel parts with tailored properties leads inevitably to a demand for improved metal forming technologies. Among these technologies hot sheet metal forming is gaining increasing importance. The technological reason for that can be seen in the ability not only to improve formability at elevated temperatures but especially in the potential of simultaneous control of complex micro structures during thermo-mechanical processing. This of course involves challenges in terms of tailored properties through optimisation of varying microstructure over the overall part geometry. As the first in a series of international conferences, to be alternatively held in Kassel and in Luleå, will highlight these multiple aspects from a scientific as well as from an industrial viewpoint

Website   Conference Invitation - pdf

Conference Secretary Contact Information

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The Finite Element Method: Linear Static and Dynamic Finite Element Analysis (Paperback) – T.R. Hughes	Concepts and Applications of Finite Element Analysis, 4th Edition	Finite Element Books Listed On Amazon.com

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Keynote Speakers, Sponsors and Exhibitors
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Toyota Motor Corporation

Mr. Nand K. Kochhar
Executive Technical Leader,
CAE
Ford Motor Company

Dr. Ted Belytschko
Walter P. Murphy Professor
Northwestern University

Dr. Chuan-Tao Wang
Chief Die Engineer
GM Technical Fellow
Global Die Center
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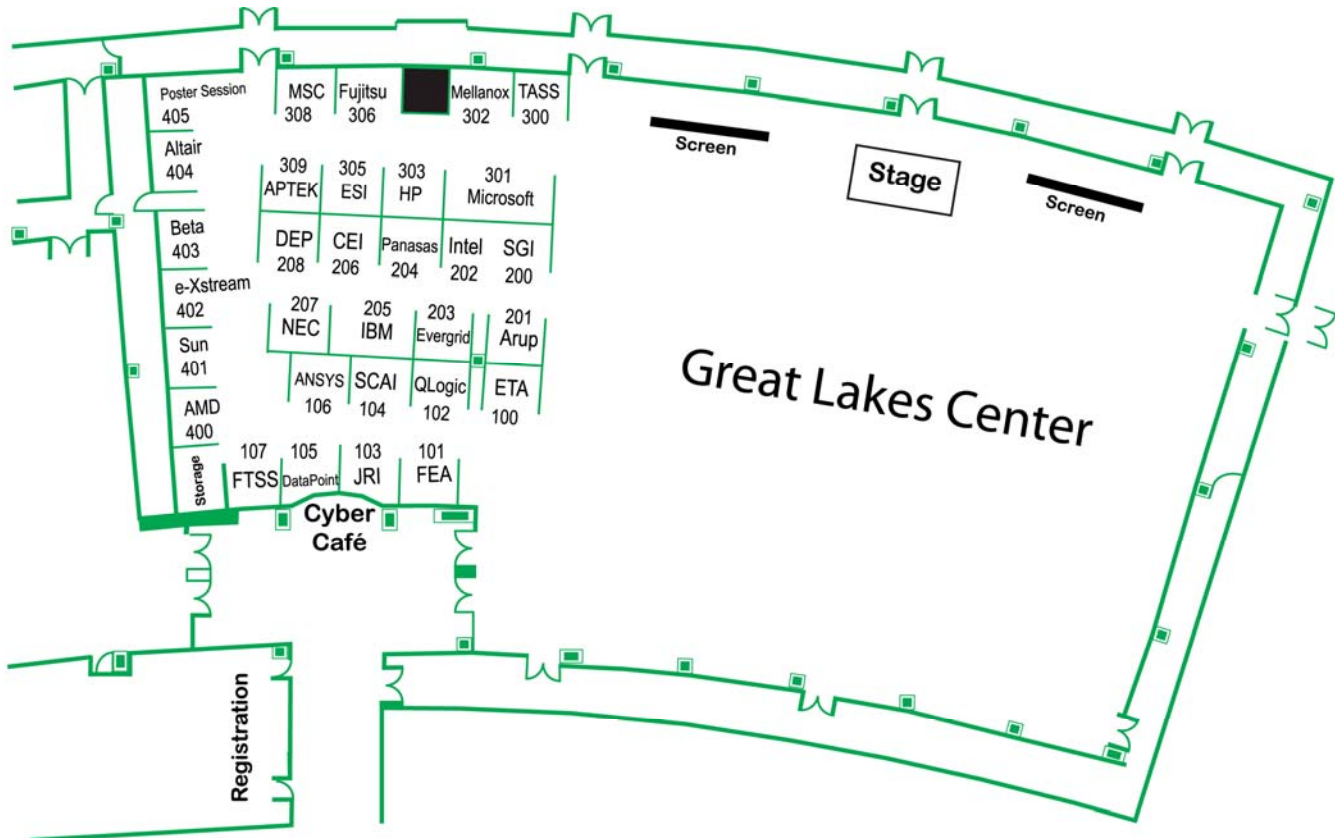Engineering Technology Associates, Inc.
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Exhibit Area Map
10th International LS-DYNA® Users Conference

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