A Study Concerning Precision of LS-DYNA Results

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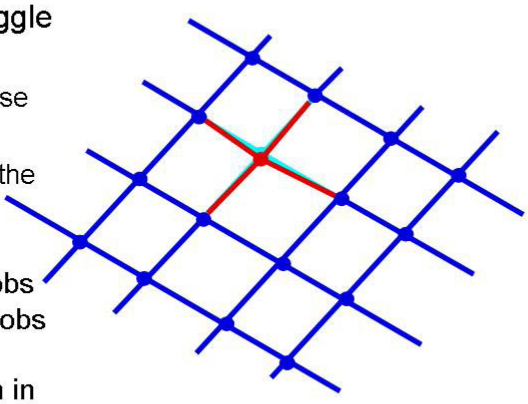
Some initial observations

- Crash calculations are difficult!
- Variations are unavoidable in the simulation process.
  - Different versions of LS-DYNA
  - Switching hardware platforms
- Changes over 20 years of crash simulation
  - Initially, even on expensive hardware, many approximations were introduced to make simulations practical
  - Today, with low-cost hardware customers have the option of relaxing these approximations to see if the quality of their results will improve.

Quick overview of methods

- Initial work in 2001 – "jiggle plot" internal IBM study
  - Introduce numerical noise into the model
  - Randomly move 1% of the nodes by 1 micron
- Run 10 single precision jobs
- Run 10 double precision jobs
- Plot and quantify variation in solutions due to nodal jiggle



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2005 single precision / double precision comparisons

- LS-DYNA 970_r5434 (single and double precision)
- Move 0.1% of the nodes by 0.001 microns
- Run on IBM POWER4 AIX systems

- NCAC Neon model
  - 280,000 elements – 80 msec
  - Node A: transmission hump
  - Node B: C-pillar
- “Side Impact” - customer input deck
  - 1M+ elements – 80 msec
  - Nodes “J” and “K”

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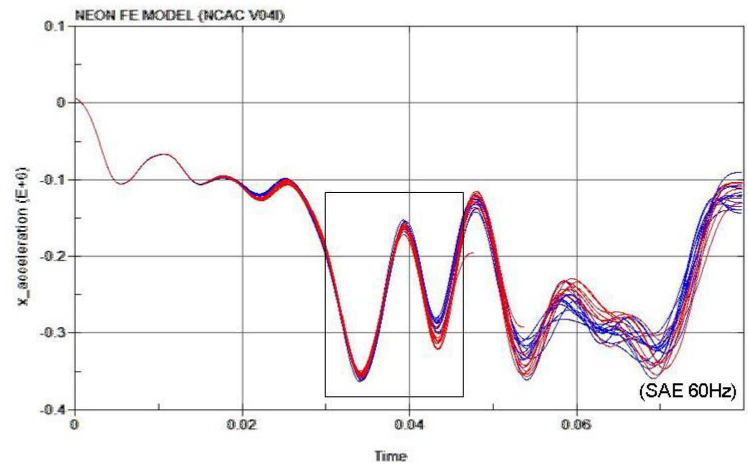
Neon (node A)



Single Precision Double Precision

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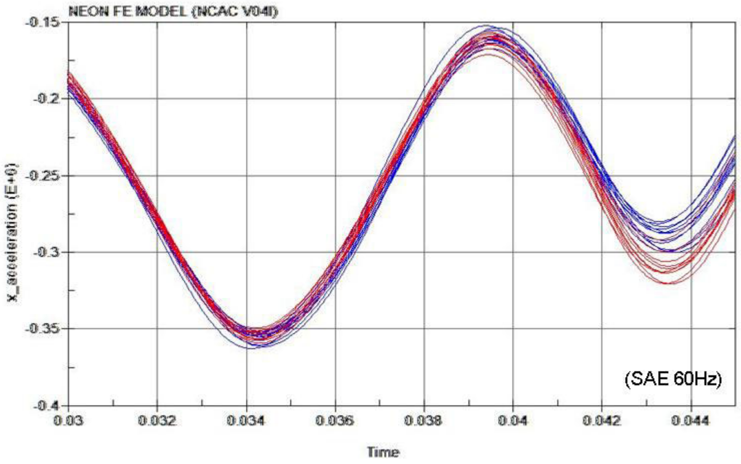
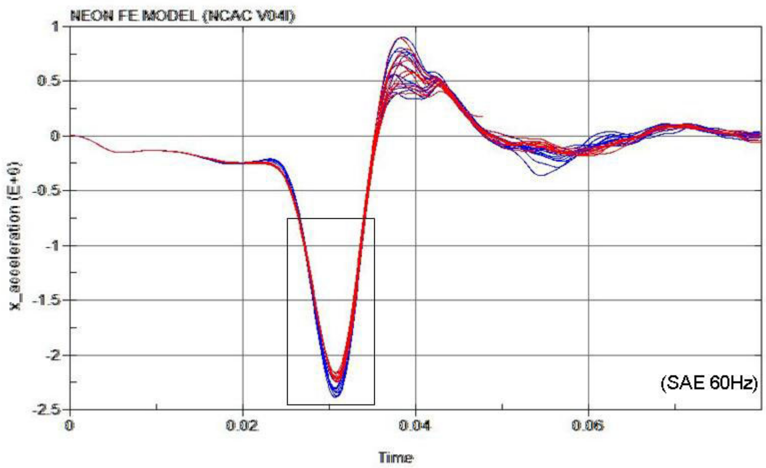
Neon (node A – peak detail)



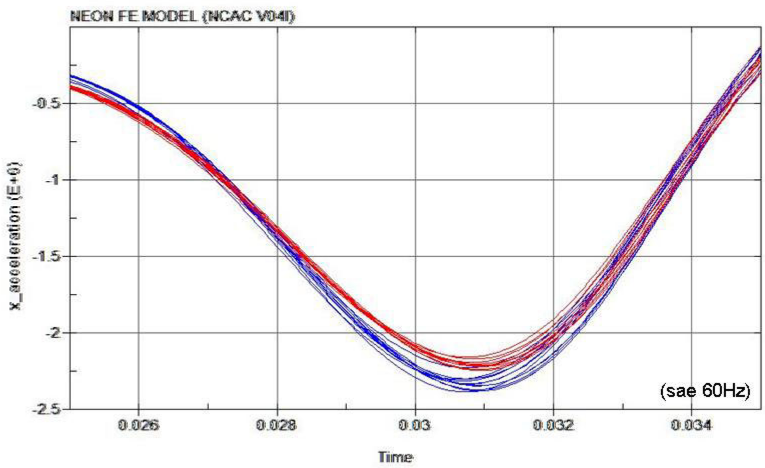
Single Precision Double Precision 6

Neon (node B)



Single Precision Double Precision 7

Neon (node B – peak detail)



Single Precision Double Precision

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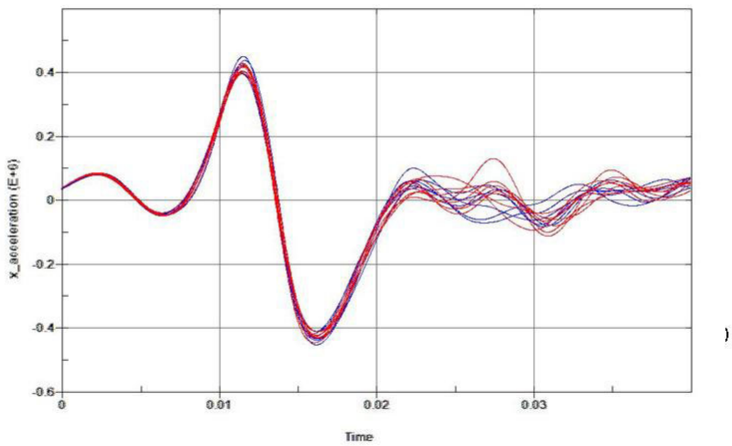
Side Impact (node J, x accel)



Single Precision Double Precision

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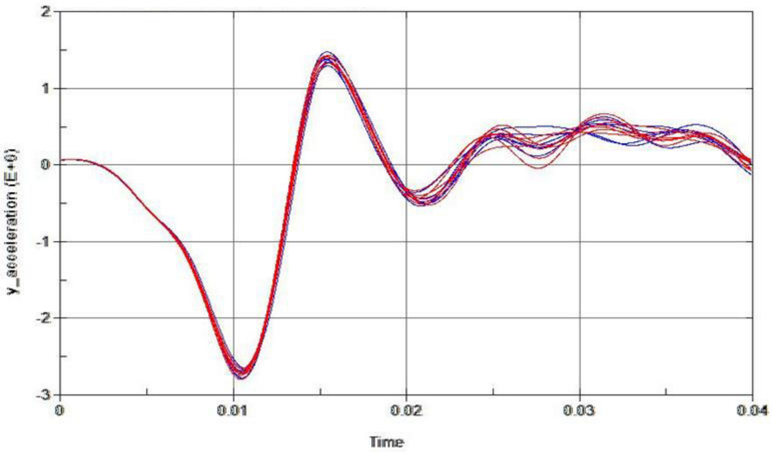
Side Impact (node J, y accel)



Single Precision Double Precision

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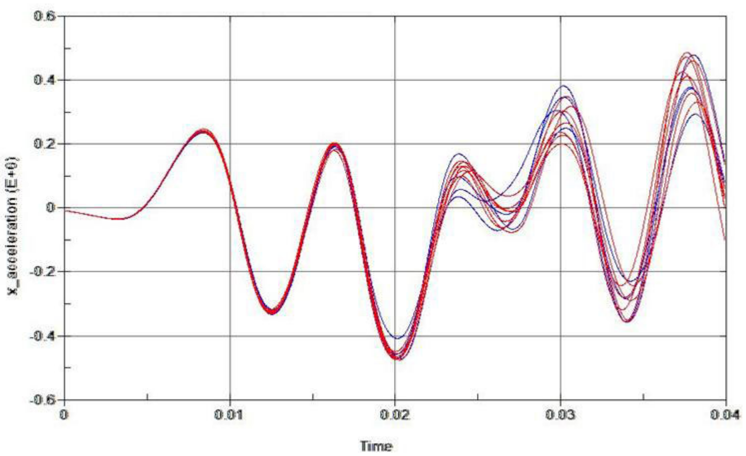
Side Impact (node K, x accel)



Single Precision Double Precision

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Some additional observations

- Double precision curves show less variation, especially early in the simulation
- Long-term effects are controlled by buckling modes of major structural elements – which behave similarly between single and double precision.
- Double precision may become more important
  - better suited for simulations with more time steps (pedestrian, durability, …)
  - smaller element size requires smaller time steps
  - helpful in complex models (tire rolling, material rupture, foam crush, automatic meshing

Some additional observations (continued)

- Additional studies
  - Same binary = different results (Xeon and Opteron, running IA-32 binary)
  - Compiler selection (Portland Group and Intel are two choices in the commodity processor arena)
- Customers have different strategies for dealing with numerical differences
  - address only when absolutely required
  - eliminate hardware or software variability
  - run local QA tests to build confidence in new hardware and new versions of LS-DYNA