THE POWER OF EVENT SIMULATION

Dynamic simulation gives analysts more powerful and practical tools for understanding product behavior.
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A new approach to accuracy
Dynamic simulation helps CAE analysts better understand how products are likely to behave in their actual operating environments. Refining products through iterative simulation is vital for discovering critical issues earlier in the development cycle and improving speed to market.

One challenge analysts often run up against is dealing with models that are very large, very complex or involve highly nonlinear systems. In these cases, implicit methods of finite element analysis (FEA) require enormous amounts of computing power and memory.

Explicit simulation uses an altogether different approach, one that sidesteps these issues and helps make extremely sophisticated simulation techniques more practical and accessible.

Simulation without a solver
The power of explicit simulation is that it has no solver. Implicit analysis sets up a giant system of algebraic equations and solves it, which is both time-consuming and computing-intensive. Explicit simulation, however, obtains accelerations with a diagonal mass matrix, “explicitly” integrating velocities and displacements. In other words, it never forms a matrix.

Instead, explicit simulation solves for acceleration using the force vector. It forms all of the internal and external forces applied to the mesh and solves for accelerations, then calculates velocities from known accelerations in each time step, updating displacements from known velocities accordingly through each successive time step.
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The explicit approach to dynamic simulation has important implications:

• **Handling extremely large models.** Because explicit simulation dispenses with tangent stiffness matrices, it can solve extremely large models with millions of elements in the mesh on a conventional laptop. No need for terabytes of computing power; 16GB RAM works just fine.

• **Simulating nonlinear material behavior.** Explicit simulation works like a black box; the application computes the strain in the elements of the model and feeds that to a material model to compute the strain. No second derivatives are required for tangent stiffness matrices, representing nonlinear material behavior becomes much simpler.

• **Solving large deformation contact problems.** Explicit simulation can easily model two bodies impacting each other, automatically tracking all surfaces and understanding how the relationships between these surfaces changes. Models can be torn apart and new surfaces created on the fly. Objects can be eroded according to predefined deletion criteria.

• **Automatic time step determination.** One unusual aspect of this method is that the solver selects the time step automatically according to a stability limit. As a result, solutions may involve thousands or tens of thousands of steps, which the solver monitors as it integrates problems to completion.
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**Back to the beginning**
Explicit simulation originated with the Manhattan Project. In fact, it was the first computational mechanics method ever performed with an actual computer.

In 1947, mathematician and physicist John von Neumann, who had been leading the effort to perform one-dimensional spherical calculations by hand for this secret project, co-opted the first computer, the ENIAC, to solve equations doing 40 floating point operations per second. (That’s down slightly from three billion flops, which today is routine!)

In the 1950s and 60s, the only people using these types of calculations were assembly language programmers who toggled code in by hand. By 1962, the team at Sandia National Laboratories employed FORTRAN to perform the first one-dimensional finite difference calculations and coined the term “explicit dynamics.”

From that point onward, the pace of innovation only accelerated. The first 2D calculations appeared in 1965, followed by 3D explicit dynamics in the early 1970s. By 1990, the technique was commercialized alongside other well-known innovations from Intel, Microsoft and others. The result was a new world of product design that quickly delivered breakthroughs for consumer products, ground vehicles, aircraft and civil structures, to name only a few.

**Dynamic simulation makes it easier to handle very large models and replicate nonlinear behavior.**
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Virtually unlimited applications
Today, explicit simulation is available through several commercially available software applications. To varying degrees, these tools package very sophisticated simulation techniques in a way that makes them useful to analysts who are designing products in any number of industries—not just those who specialize in this field.

Examples of how explicit simulation can be used to improve product design are numerous. Some examples include:

- **Fasteners.** In a couple of minutes, designers can import part geometry, select the correct material, set up the push/pull of the test and generate a force deflection curve that shows how many pounds of force the buckle can withstand before it breaks.

- **Snap-fit parts.** Simulate traditional impact testing to understand the stresses on both sides of a clamshell-style, snap-fit case when it’s dropped and see whether the tabs break off.

- **Safety equipment.** Understand the impact velocity of a quarter-inch steel sphere on a pair of military-grade safety goggles, and see how snap-fit parts react at the moment of impact.

- **Consumer electronics.** For a snap-fit assembly of a consumer electronics part, simulation lets you gauge how much force it takes to pop the housing in its socket and see if it will break.
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The idea behind explicit simulation software is to make these kinds of workflows very simple and straightforward for analysts to use in an everyday context. Pick the material, select the type of simulation and run it. More advanced applications might include:

• **Impact simulation testing.** For a plastic router with three snap-fit parts, explicit simulation lets you see how it reacts to being hit with a hammer. In the example, the mesh has 189,000 elements. As the head of the hammer impacts the product, cracks in the heat sink holes appear, fractures grow and broken pieces fall and hit other pieces. Contact tracking occurs automatically, and surfaces do not need to be set up in advance.

• **Long-duration events.** Widely applicable for tennis rackets, golf clubs and other athletic equipment, long-duration simulations let you explore how a product reacts to an object arriving from a specific distance at a certain velocity and angle of attack. The example shows a net designed to capture drones returning to a base in mountainous terrain where landing strips are unavailable. The net has 17,000 truss elements and leg beams that bend.

• **Additive manufacturing.** 3D printing is already rewriting the rules for product design. Explicit simulation can be used to test these parts too. Compression testing a small, intricate lattice, for example, is a highly contact dominated problem that explicit simulation can address easily.
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The range of possibilities for explicit simulation is impressive. Equally remarkable is how relatively simple it is to use these powerful simulation capabilities to solve familiar challenges in product design—without the need to be an FEA expert.

Learn more now
To explore more information about simulation, visit our resource center at