Rapid and Definitive Simulation of Next Generation Electronics

Science in the Age of Experience

May 25, 2016
Simulia
Boston, MA
Electronics Will Soon Be Everywhere
Why Should You Care?

Future Growth of MCAE

- Test Replacement
- Expand the User Base
- Simulate the Real World
- Technology Growth

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THE INTERNET OF THINGS
An Explosion of connected possibility

Year
1992 0.5 BILLION
2003 1,000,000
2009 IoT INCEPTION
2012 8.7 BILLION
2013 11.2 BILLION
2015 18.2 BILLION
2016 22.9 BILLION
2017 28.4 BILLION
2018 34.8 BILLION
2019 42.1 BILLION
2020 50.1 BILLION

Billions of devices
0 10 20 30 40 50

"Technology Growth"
Most OEMs in the Automotive and Aviation communities **hate** environmental testing

- It takes too long
- It costs too much
- It is too late in the process
- Suppliers rarely fail
- Failures are not always relevant
- It stymies innovation and modification (no one wants to retest)
Test Durations Example: Automotive OEM

Temperature Cycling

And this manufacturer is considering extending test time to 5000 hours!
Total Global Engineering Population (+20M)

- How to Fill the Gap?
  - 'Easier to Use' Tools with more definitive ‘Calls to Action’
  - Application-Specific MCAE

Engineers who could make use of simulation: ~9M

The “Gap”:
- Engineers using CAE today: ~2M
- Engineers who don’t use CAE tools (+7M)

~750K* using MCAE today
Right Tools: Application-Specific CAE Apps

- CAE Software that is geared towards a particular technology, market, or solving a particular problem

- User-control is limited
  - Greatly simplifies user interface
  - Typically parametric (accelerates model development)
  - Often includes application-specific libraries

- Allows product teams to perform expert-level CAE analysis
  - Democratization
Technology companies are increasingly frustrated with ‘representations’ of their products.

‘Single-Point-of-Fail’ requires models that include 1000s of interconnections and parts.
The One Tool that Rules Them All?
Sherlock Automated Design Analysis™

A powerful Abaqus pre and post-processor for the mechanical and reliability modeling of electronic components, boards, assemblies, and products
What is Sherlock?

- Physics of Failure-based design reliability analysis tool
- Predicts product failure early in design process, quickly and accurately
- Electronics-focused – used across all industries
Sherlock Worldwide

- First released in 2011
- Over 120 Companies and 350 users worldwide
- Specified for automotive and avionics supply chain in 2015
- Implemented in all major technology verticals, including Telecom/Enterprise, Automotive, Aerospace, and Medical Devices
How Does Sherlock Provide Value?

**Design**
- Evaluate design-reliability tradeoffs, even for off-the-shelf technology

**Mechanical**
- Rapidly produce intelligent 3D models
- Turn stress (thermal/mechanical) into prediction

**Reliability**

**Testing**
- Design relevant test conditions
- Confirm test success, before test

**Manufacture**
- Quantitatively evaluate risk post-assembly
‘Voice of the Customer’

- “Greater Insight, Earlier in New Product Development”
- “Eliminates Test Failures Due To Design”
- “Release Rev1, not Rev3”
- “Quantitative Tradeoff Analysis; No More Opinioneering”
- “Ensures More Rapid Acceptance Of Newer, More Ground-Breaking Technologies”
How Does Sherlock Work?
Phase 1: Data Input
- Parses standard EDA files (schematic, layout, parts list) automatically
- Uses embedded libraries (part, package, materials, solder, laminate)
- Can build box-level finite element analysis model in minutes

Phase 2: Sherlock Analysis
- Produces holistic analysis critical to develop reliable products
- Easy to assign and create standard structures and conditions
- Assessment options include: Thermal Cycling, Mechanical Shock, Natural Frequency, Harmonic Vibration, Random Vibration, Bending, Integrated Circuit Wearout, Thermal Derating, Failure Rate, Conductive Anodic Filament, High Fidelity PCB Model

Phase 3: Report & Recommend
- Presents results in multiple formats: Tabular / Histogram / Life curve / Overlay
- Easy-to-locate commands
- Industry terminology (parts list, stackup, pick & place, etc.)
Create simple (test) or very complex (field) environments
Import Standard Electronic Design Files (Gerber/ODB)
Embedded / Fully Populated Libraries (Local and Global)
Parts/Package/Laminates/Materials/Solder
FEA 3D Modeling

ICT and Shock/Vibration Analysis

• Fully 3D elements for the PCB, components and mount points
  • Increase simulation accuracy
  • More reliable meshing algorithm
  • Increased analysis flexibility
    • Leads, heat-sinks, sub-assemblies, chassis analysis

FEA Engine

• Multi-core and 64 bit support
• Faster analysis
• Accurate properties of the printed circuit board (fiber-reinforced laminate composite) is critical
  – Sherlock allows the user to select the level of detail necessary to accurately capture mechanical response
• De-featuring resolves circular features
• Automatic feature recognition with material properties
• Generates python script

Trace-Via Modeling
• System Level Integration
  − Attach one or more sub-assemblies to a motherboard/backplane
  − Supports edge connections or mezzanine attached with standoffs
  − Put it all together and model all of your electronics and the housing in a single analysis
Mode 1: Sherlock manages Abaqus

Mode 2: Export model from Sherlock to Abaqus (python script) and then import Abaqus results into Sherlock for reliability analysis
• Transparent to the user
• Sherlock forms the input deck and runs the simulation with Abaqus
• Sherlock automatically post processes results and generates reliability metrics
Model generated by Sherlock and modified and run in Abaqus

Mechanical parts added, mesh changed, etc..
Mode 2
Thermal Cycling Fatigue

- Cumulative Damage Index (CDI)
- Time to failure
- Thermal profile and Flowtherm results
Vibration/Shock/Bending

- Loading
- Mounting
- Direction
• Multi-Axis Shock and Vibration Loads
• Specify load direction and/or PCB orientation
• Specify uni-axial or tri-axial harmonic profiles
Board-to-Board Connector Fretting Analysis

- Stick (< 2.5 μm)
- Stick-Slip (5 – 10μm)
- Slip (> 10 μm)
- Only software tool that provides a complete life curve
Fully Validated

- Wirebonds
- QFN
- BGA
- Chip Resistors
Organizations Expand Simulation

- $50B/year oilfield services company limited FEA simulation to mechanical systems
  - However, a strategic focus was to aggressively integrate technology (e.g., IoT) for market differentiation

- Just two (2) licenses of Sherlock resulted in a ‘substantial’ increase in usage of Abaqus tokens
What Happens with Sherlock? Case Study #2

Organizations Replace Testing

- American Auto Manufacturer begin utilizing Sherlock+Simulation in parallel with its current testing plan
  - Over the course of 12 months, Sherlock identified 4 designs that would have failed power-temperature cycling (PTC)
  - Avoiding PTC test failures saved over $1.3M

- ROI was so high, American Auto Manufacturer will require Sherlock+Simulation to its supply chain
  - Finding problems in test is TOO LATE
Engineering Organizations Enter the 21st century

- $800M/year embedded system company resisted finite element analysis (FEA)
  - Too expensive, too slow, requires too much expertise, does not provide a definitive answer

- After one (1) year with Sherlock, purchased their first Abaqus license
  - Evaluating purchase of 2nd Abaqus seat in 2017
What Happens with Sherlock? Case Study #4

Organizations Migrate to Real-World Simulation

- Electronic component companies are increasingly concerned with trace/via failure due to geometry shrinkage
  - Requires migration to Sherlock trace/via modeling tool

- Increases model size by order of magnitude (from hundreds of thousands of elements to millions of elements)
  - Requires increased number of tokens to complete simulation in a reasonable period of time
Conclusion

- Sherlock is a ground-breaking tool for the MCAE community
- Only MCAE tool designed specifically for electronics
- Provides definitive calls to action
- Drives organization to increase their commitment to simulation
- Expands model size and complexity at the request of the user