Powering Innovation That Drives Human Advancement

Electronics Reliability & RadHard - Ansys Solution Overview

Electronics Reliability & Radiation Hardening Solutions Overview

Package / System	Printed Circuit Board (PCB)	Device / Assembly	Radiation Hardening
Package Warpage Modeling	Shock and Vibration Reliability	Enhanced Solder Fatigue	Rad Hard Design Workflow – SEE & TID
BGA Solder Reflow	Electronics Lifetime & Reliability	Remaining Useful Life	Surface Charging Risk Assessment
Solder Reflow	Mechanical Reliability	Vibration of Electrical Assembly	Internal Charging of Bulk Material
Solder Joint Fatigue	Thermal Impact		Radiation Hardening
			Dielectric Breakdown of Solar Cells
			Arc Formation in High Voltage Systems

Electronics Reliability & RadHard – Solution-Product Matrix

Learn more about Ansys products at: https://www.ansys.com/products

Solution Areas

Solution Areas	Ansys Discovery™	Ansys optiSLang®	Ansys Systems Tool Kit® (STK®)	Ansys Twin Builder®	Ansys EMC Plus™	Ansys Icepak®	Ansys Fluent®	Ansys Granta MI Enterprise™	Ansys Thermal Desktop™	Ansys Mechanical™	Ansys Sherlock™	Ansys LS-DYNA®	High Performance Computing
Package / System				●			●			●	●	●	●
Printed Circuit Board (PCB)	●							●	●	●	●		
Device / Assembly				●		●			●	●	●		●
Radiation Hardening		●	●		●								

/ Increased Collaboration; Faster Innovation; Customized Workflows; Optimization; Cloud & HPC

Package Level

Package Warpage Modeling

Challenge

- Comprehending warpage in new package architectures is crucial for optimum SMT assembly yields.
- Ability to rank package designs and material combinations based on warpage helps customers reduce costly and time-consuming DOEs.

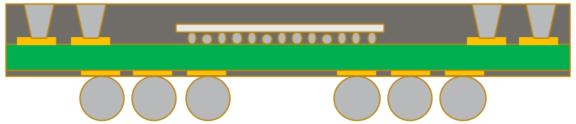
Solution

- **optiSLang** Metamodel analysis run on Mechanical models efficiently determines the important parameters influencing package warpage.
- Derived **ROM** can be used for new package warpage predictions.

Benefits

- Reduce number of package prototypes built for testing.

Package Architecture

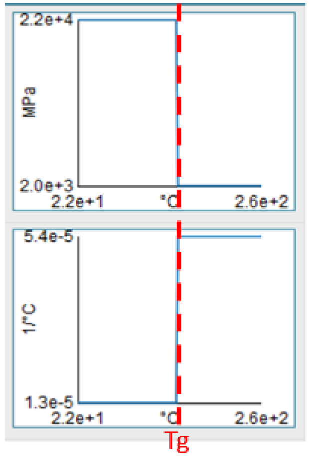


Reference: Model for Prediction of Package-on-Package Warpage and the Effect of Process and Material Parameters, Pradeep Lall et al., ECTC 2013

Material Properties

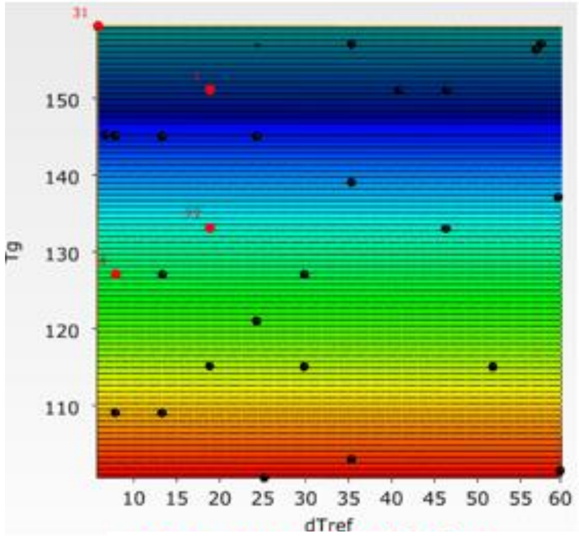
Young's modulus

CTE



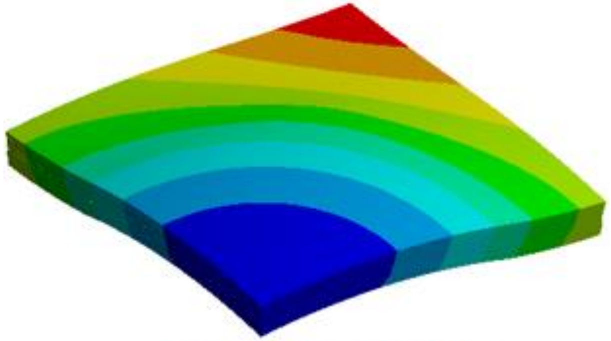
Temperature

Parametric Sensitivity in Ansys optiSLang



250C warpage obj. fcn.

Quarter-Symmetric Warpage Model



250C warpage: 82 um

Applicable Products: Ansys Mechanical™, Ansys optiSLang®, Ansys Twin Builder®

BGA Solder Reflow

Challenge

- **Predict soldering defects** occurring in different package configurations.
- **Efficient modeling of reflow process** for packages having up to tens of thousands of solder joints.

Solution

- **Particle-based method** (ISPG) to capture molten solder evolution governed by surface tension and contact angle at various interfaces.
- **Fluid-structure coupling** in one solver leads to unparalleled scaling reducing weeks of simulation time with coupling solvers to a day.

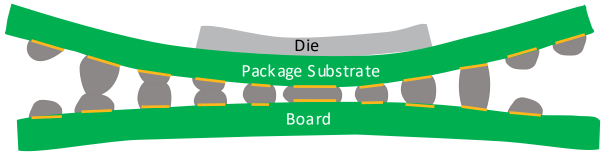
Benefits

- **Improve** soldering process with guidance from simulation.
- **Reduce** prototyping cost for different packages.

Incompressible Smoothed Particle Galerkin Method (ISPG)

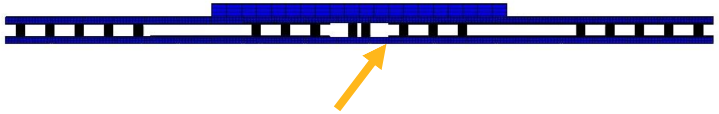
Assembly Defects

FCBGA Package
Concave (-) Warpage



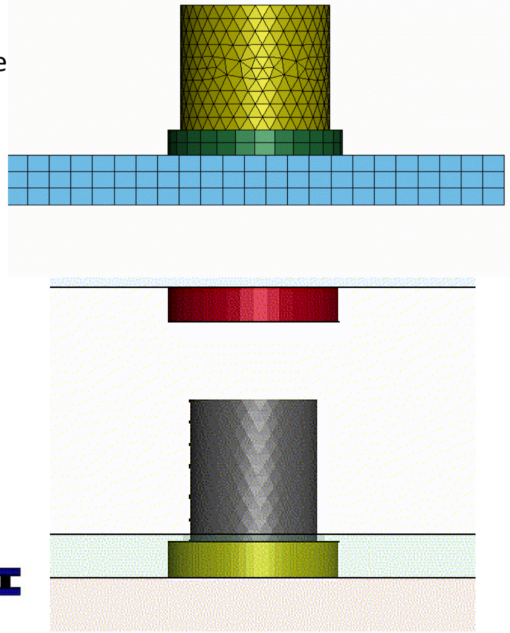
PCB Convex (+)
Warpage

ISPG with Adaptive remeshing for large BGA models.



BGA Solder Reflow

One Solder Ball Scenario



Reference: Recent trends of package warpage and measurement metrologies, W. K. Loh et al., ICEP 2016.

Applicable Products: Ansys LS-DYNA®

Solder Reflow

Challenge

- **Reduce** manufacturing-related/induced failures.
- Use **predictive tools** for faster detection of failure modes.
- **Efficiency** of electrical contacts depends on the reflow soldering process.
- Efficient board layout design.

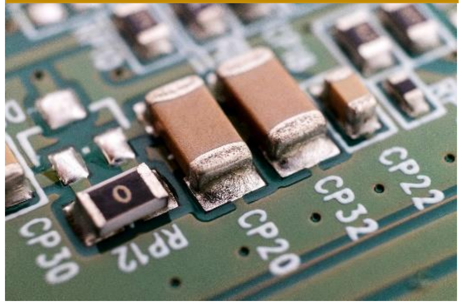
Solution

- **Robust** multiphase workflow accounting for surface tension effects.
- **Solidification** and **melting** of solder, and advanced property modeling capabilities to simulate this phenomenon.

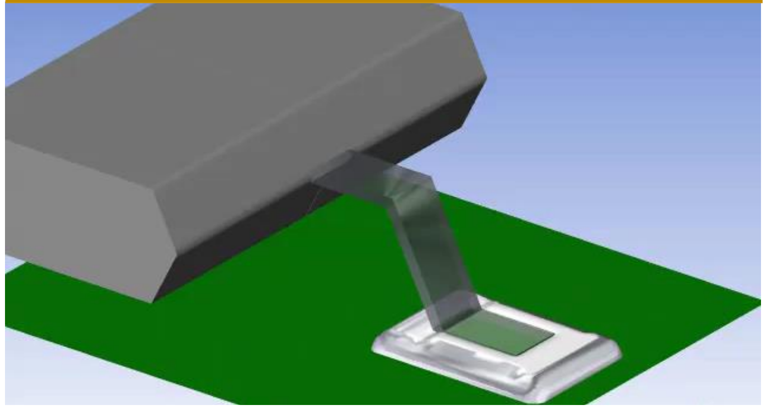
Benefits

- **Identify sustainable materials** that meet adhesion properties.
- Drive operational **efficiency.**
- **Ensure** uniform settling of die with proper wetting.
- **Ensure** permanent solder joints, avoid defects.

Reflow Soldering Process



Reflow Soldering Process with Solidification



Tombstone Defect in Soldering Process

Reflow Soldering Process with Surface Tension

Applicable Products: Ansys Fluent®, High Performance Computing (HPC)

Solder Joint Fatigue

Challenge

- Reduce **thermal cycling physical testing costs** while guaranteeing product compliance to standards such as JEDEC.
- **Predict failure rates** based on physical implementation of multi-die packages.

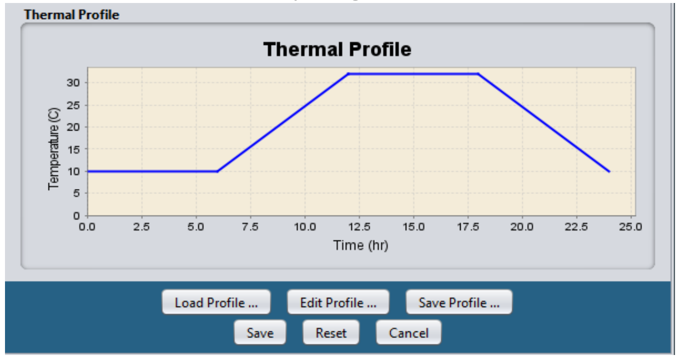
Solution

- **Quick Solder Joint Fatigue (SJF) life predictions (TTF)** based on simple analytical models for initial screening.
- Thorough SJF predictions through **automated thermal cycling simulations** including **all geometric features and nonlinear material properties**.

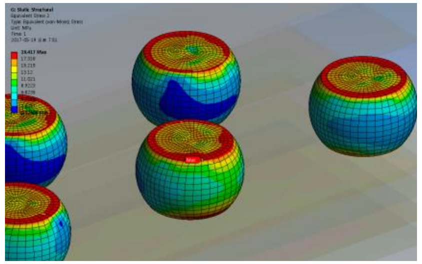
Benefits

- Thermal cycling **testing costs reduction,** upon discarding non reliable multi-die package designs.

Thermal Cycling Profile



Detailed Solder Ball model in Mechanical



Nonlinear Plastic Work Output

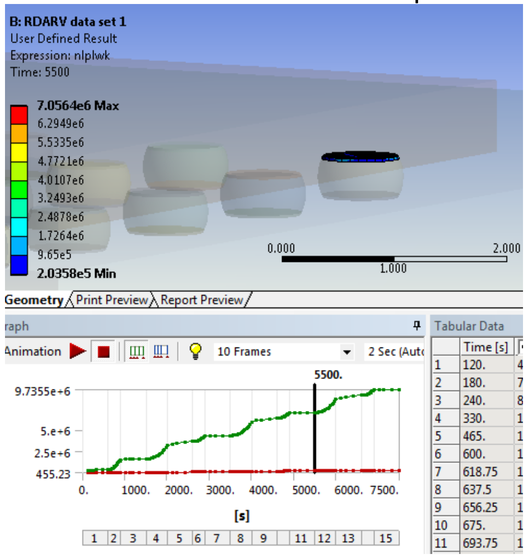


Table of Reliability Results

RefDes	Package	Part Type	Model	Side	Material	Solder	Max dT (C)	Max TSF	Damage	TTF (ye...	Score
R158	1206	RESISTOR	CC	BOT	ALUMINA	SAC305	145.0	1.50	2.5E0	2.04	0.0
C11	1210	CAPACITOR	CC	TOP	BARIUMTITAN...	SAC305	145.0	1.50	1.2E0	4.10	0.0
C12	1210	CAPACITOR	CC	TOP	BARIUMTITAN...	SAC305	145.0	1.50	1.2E0	4.10	0.0
C13	1210	CAPACITOR	CC	TOP	BARIUMTITAN...	SAC305	145.0	1.50	1.2E0	4.10	0.0
C14	1210	CAPACITOR	CC	TOP	BARIUMTITAN...	SAC305	145.0	1.50	1.2E0	4.10	0.0
C15	1210	CAPACITOR	CC	TOP	BARIUMTITAN...	SAC305	145.0	1.50	1.2E0	4.10	0.0
C16	1210	CAPACITOR	CC	TOP	BARIUMTITAN...	SAC305	145.0	1.50	1.2E0	4.10	0.0
C17	1210	CAPACITOR	CC	TOP	BARIUMTITAN...	SAC305	145.0	1.50	1.2E0	4.10	0.0
C18	1210	CAPACITOR	CC	TOP	BARIUMTITAN...	SAC305	145.0	1.50	1.2E0	4.10	0.0
C19	1210	CAPACITOR	CC	TOP	BARIUMTITAN...	SAC305	145.0	1.50	1.2E0	4.10	0.0
C20	1210	CAPACITOR	CC	TOP	BARIUMTITAN...	SAC305	145.0	1.50	1.2E0	4.10	0.0
C21	ADS_CPC...	CAPACITOR	ThruHole	TOP	BARIUMTITAN...	SAC305	145.0	1.50	8.1E-1	6.18	0.0
C22	ADS_CPC...	CAPACITOR	ThruHole	TOP	BARIUMTITAN...	SAC305	145.0	1.50	8.1E-1	6.18	0.0
C23	ADS_CPC...	CAPACITOR	ThruHole	TOP	BARIUMTITAN...	SAC305	145.0	1.50	8.1E-1	6.18	0.0
C24	ADS_CPC...	CAPACITOR	ThruHole	TOP	BARIUMTITAN...	SAC305	145.0	1.50	8.1E-1	6.18	0.0
C25	ADS_CPC...	CAPACITOR	ThruHole	TOP	BARIUMTITAN...	SAC305	145.0	1.50	8.1E-1	6.18	0.0
J1	ADS_WAL...	JACK	ThruHole	TOP	COPPER	SAC305	145.0	1.50	6.9E-1	7.26	0.0
U5	QFP-80 (M...	IC	Leaded	TOP	EPOXYENCAP...	SAC305	145.0	1.50	3.5E-1	14.33	6.8
U6	QFP-80 (M...	IC	Leaded	TOP	EPOXYENCAP...	SAC305	145.0	1.50	3.5E-1	14.33	6.8
C26	CAP-ALUM...	CAPACITOR	Leaded	TOP	EPOXYENCAP...	SAC305	145.0	1.50	1.5E-1	34.01	10.0
C27	CAP-ALUM...	CAPACITOR	Leaded	TOP	EPOXYENCAP...	SAC305	145.0	1.50	1.5E-1	34.01	10.0
C28	CAP-ALUM...	CAPACITOR	Leaded	TOP	EPOXYENCAP...	SAC305	145.0	1.50	1.5E-1	34.01	10.0
C29	CAP-ALUM...	CAPACITOR	Leaded	TOP	EPOXYENCAP...	SAC305	145.0	1.50	1.5E-1	34.01	10.0
C30	CAP-ALUM...	CAPACITOR	Leaded	TOP	EPOXYENCAP...	SAC305	145.0	1.50	1.5E-1	34.01	10.0
U3	QFJ-68 (M...	IC	Leaded	TOP	EPOXYENCAP...	SAC305	145.0	1.50	9.2E-2	>50	10.0
U4	QFJ-68 (M...	IC	Leaded	TOP	EPOXYENCAP...	SAC305	145.0	1.50	9.2E-2	>50	10.0

Solder Joint Fatigue App

Tabular Data

	Cycles	Plastic Work Difference	Cycles to Crack Initiation	Rate of Crack Propagation	No. of Propagation cycles to Failure
1	2-1	701.35	722730.129687	1.58488806291e-09	283931.723969
2	3-2	652.3	806932.194312	1.47618544881e-09	304839.747854
3	4-3	503.7	1195351.67099	1.14580575948e-09	392736.723722

Applicable Products: Ansys Sherlock™, Ansys Mechanical™

Package Level – Solution-Product Matrix

Learn more about Ansys products at: https://www.ansys.com/products

Applications	Ansys Twin Builder®	Ansys Fluent®	Ansys Mechanical™	Ansys Sherlock™	Ansys LS-DYNA®	High Performance Computing
Package Warpage Modeling	●		●	●		
BGA Solder Reflow					●	
Solder Reflow		●				●
Solder Joint Fatigue			●	●		

/ Increased Collaboration; Faster Innovation; Customized Workflows; Optimization; Cloud & HPC

Board Level

Shock and Vibration Reliability

Challenge

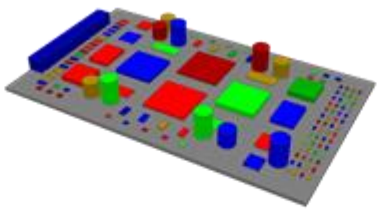
- **Reduce** physical testing of devices for shock and vibration reliability that is both expensive and time-consuming.
- **Simulation-driven testing** of parts that provides component-level failure prediction.

Solution

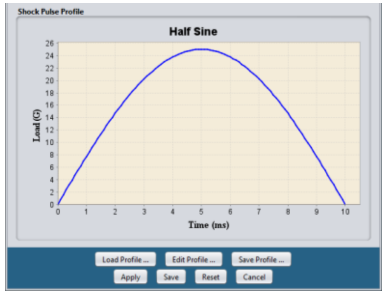
- Different Mechanical Shock, Harmonic Vibe, and Random Vibe scenarios can be run.
- Generate color-coded risk levels along with TTF curves for each component and system.

Benefits

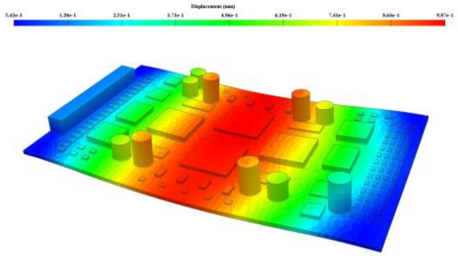
- **Large reduction** in pre-processing and post-processing times for complex electronics assemblies with thousands of parts.
- Use **industry accepted reliability** prediction tool to reduce physical testing.



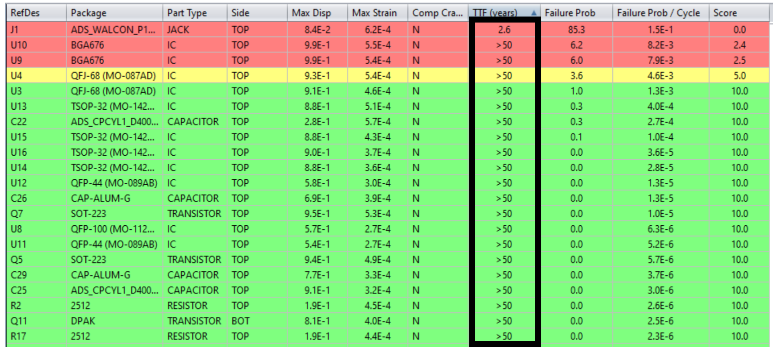
Generated 3D Model



Sample Shock Profile

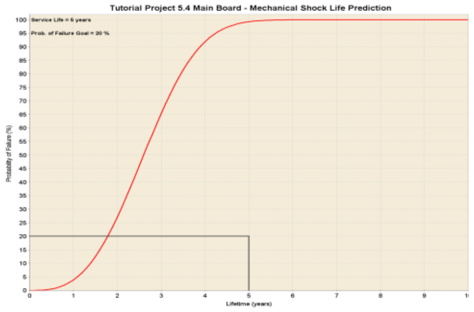


Displacement Plot



RefDes	Package	Part Type	Side	Max Disp	Max Strain	Comp Cra...	TTF (years)	Failure Prob	Failure Prob / Cycle	Score
J1	ADS_WALCON_P1...	JACK	TOP	8.4E-2	6.2E-4	N	2.6	85.3	1.5E-1	0.0
U10	BGA676	IC	TOP	9.9E-1	5.5E-4	N	>50	6.2	8.2E-3	2.4
U9	BGA676	IC	TOP	9.9E-1	5.4E-4	N	>50	6.0	7.9E-3	2.5
U4	QFJ-68 (MO-087AD)	IC	TOP	9.3E-1	5.4E-4	N	>50	3.6	4.6E-3	5.0
U3	QFJ-68 (MO-087AD)	IC	TOP	9.1E-1	4.6E-4	N	>50	1.0	1.3E-3	10.0
U13	TSOP-32 (MO-142...	IC	TOP	8.8E-1	5.1E-4	N	>50	0.3	4.0E-4	10.0
C22	ADS_CPCYL1_D400...	CAPACITOR	TOP	2.8E-1	5.7E-4	N	>50	0.3	2.7E-4	10.0
U15	TSOP-32 (MO-142...	IC	TOP	8.8E-1	4.3E-4	N	>50	0.1	1.0E-4	10.0
U16	TSOP-32 (MO-142...	IC	TOP	9.0E-1	3.7E-4	N	>50	0.0	3.6E-5	10.0
U14	TSOP-32 (MO-142...	IC	TOP	8.8E-1	3.6E-4	N	>50	0.0	2.8E-5	10.0
U12	QFP-44 (MO-089AB)	IC	TOP	5.8E-1	3.0E-4	N	>50	0.0	1.3E-5	10.0
C26	CAP-ALUM-G	CAPACITOR	TOP	6.9E-1	3.9E-4	N	>50	0.0	1.3E-5	10.0
Q7	SOT-223	TRANSISTOR	TOP	9.5E-1	5.3E-4	N	>50	0.0	1.0E-5	10.0
U8	QFP-100 (MO-112...	IC	TOP	5.7E-1	2.7E-4	N	>50	0.0	6.3E-6	10.0
U11	QFP-44 (MO-089AB)	IC	TOP	5.4E-1	2.7E-4	N	>50	0.0	5.2E-6	10.0
Q5	SOT-223	TRANSISTOR	TOP	9.4E-1	4.9E-4	N	>50	0.0	5.7E-6	10.0
C29	CAP-ALUM-G	CAPACITOR	TOP	7.7E-1	3.3E-4	N	>50	0.0	3.7E-6	10.0
C25	ADS_CPCYL1_D400...	CAPACITOR	TOP	9.1E-1	3.2E-4	N	>50	0.0	3.0E-6	10.0
R2	2512	RESISTOR	TOP	1.9E-1	4.5E-4	N	>50	0.0	2.6E-6	10.0
Q11	DPAK	TRANSISTOR	BOT	8.1E-1	4.0E-4	N	>50	0.0	2.5E-6	10.0
R17	2512	RESISTOR	TOP	1.9E-1	4.4E-4	N	>50	0.0	2.3E-6	10.0

Table of Reliability Results



Life Prediction Curve

Applicable Products: Ansys Sherlock™

Electronics Lifetime & Reliability

Challenge

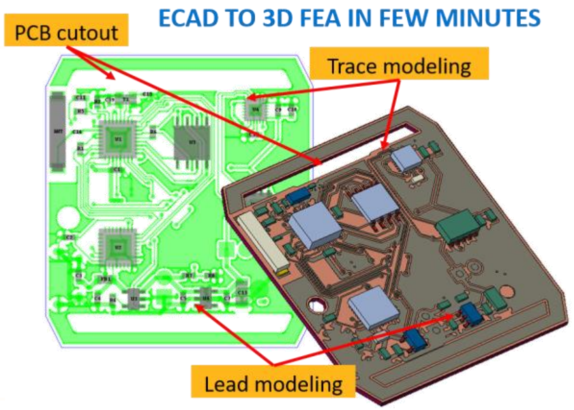
- PCB reliability.
- **Reduce** design cycle.
- **Standards compliance**: IPC-TR-579, IPC 9704, SAE J3168, MIL, JESD-22 etc.

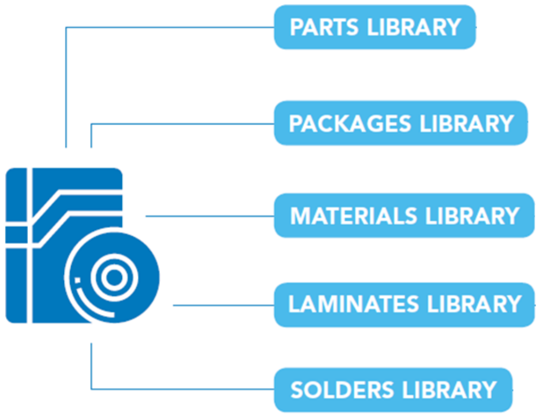
Solution

- **Faster Pre-processing:** 2D ECAD to 3D MCAD conversion at a click of a button.
- Exhaustive and expandable electronics components, materials and laminates **library.**
- **Complete life curves** for Electronics.

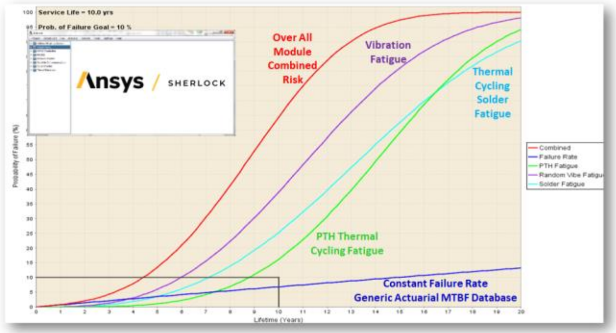
Benefits

- **20-50%** time reduction in PCB reliability prediction at Component, Board and System level.
- **Optimized** component selection and placement for target PCB reliability.
- **Meet regulations** at reduced cost by reducing physical prototypes by **~50%.**

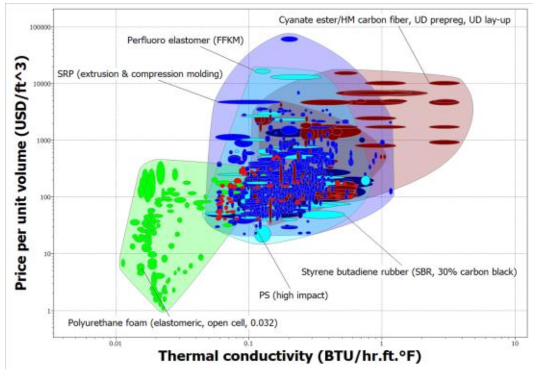




Reliability prediction via Life Curve



Materials Selection



Standards Compliance

Applicable Products: Ansys Sherlock™, Ansys Granta MI Enterprise™

Mechanical Reliability

Challenge

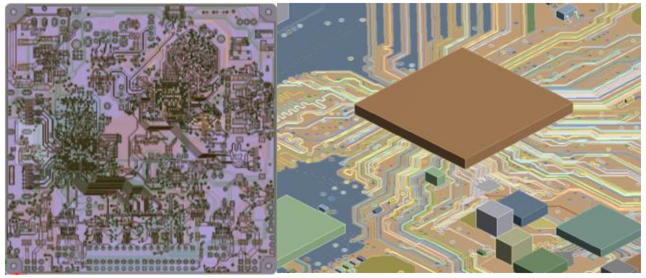
- Evaluate electronics reliability with quantitative **life estimates.**
- Comply with IPXX , MIL-STD 810 and JEDEC **standards.**
- Optimize on material selection, manufacturing and assembling processes for **best performance vs cost.**

Solution

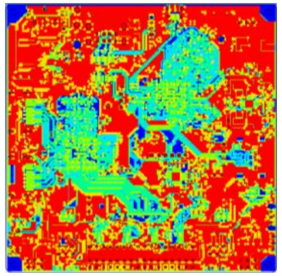
- **Model** electronic components to different levels of fidelity (true solder shape, trace modeling, test setup).
- **Seamless Workflow**: Designers and simulation engineers.
- **Variability**: Material, Manufacturing and assembling.

Benefits

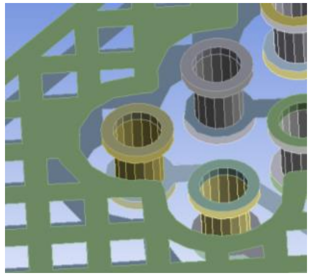
- **Reduce** number of test prototypes built.
- **Shorten** development cycles by reducing number of parts that go through long reliability testing processes.
- **Provide** insight into the failure mechanisms that may be hard to investigate in testing.



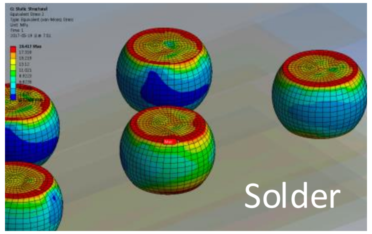
Accurate Trace modeling



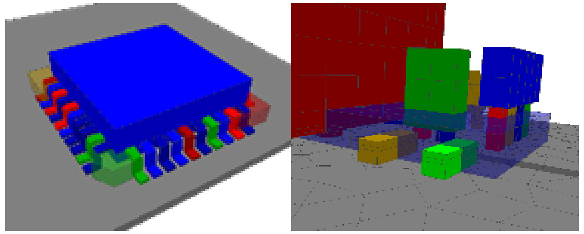
Trace Mapping



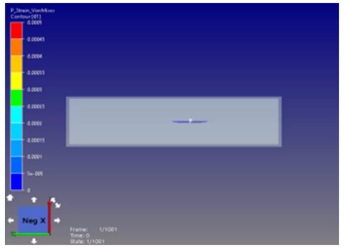
Reinforcements



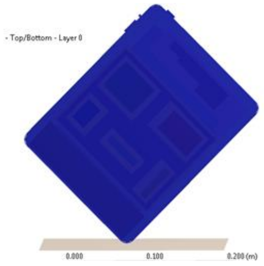
Detailed Assembly Modeling



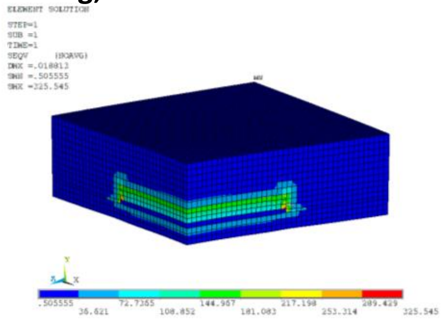
Coatings, Potting, Underfill



Tumble Test



Drop Test



Moisture Ingress

Applicable Products: Ansys Discovery™, Ansys Mechanical™, Ansys Sherlock™

Satellite Thermal Evaluation and Design

Challenge

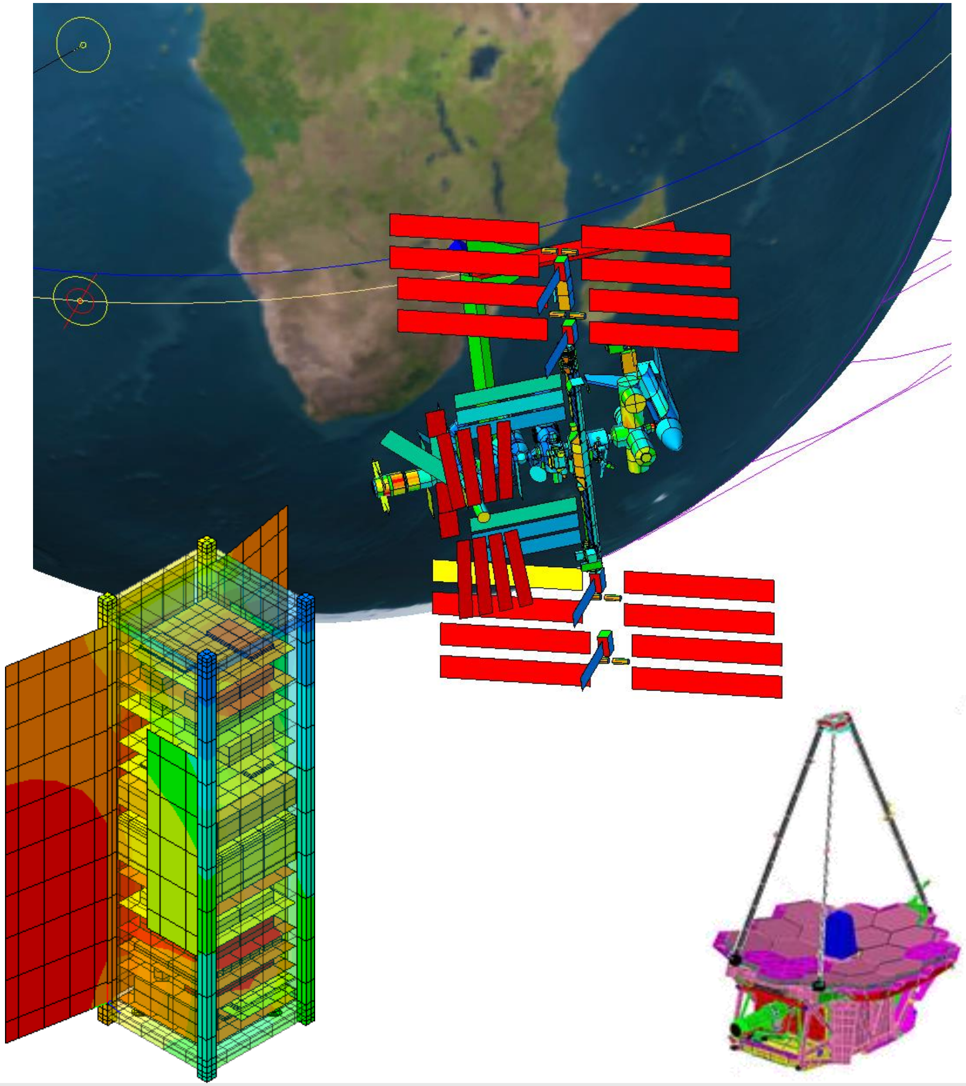
- Design a **thermal control system** to ensure all components of the satellite remain within design temperature limits.
- Account for **interdependencies** of the subsystems.
- Account for the **environmental heat loads** including shadowing and reflections.
- Perform many simulations of orbits to determine the **time-based** behavior.

Solution

- Simulation of the satellite from design to test including **thermovac testing**, **launch pad integration**, **ascent**, and **on-orbit**.
- Efficient **radiative heat exchange** for the entire system including environmental heat loads with **built-in orbit definition** and articulating subsystems such as solar panels.
- Fast simulation of thermal control devices including thermostatic **heaters**, **thermoelectric coolers**, **multi-layer insulation**, **heat pipes**, and **pumped fluid loops**.

Benefits

- Ensure the flight hardware remains within its design limits from launch pad to end-of-service.
- Evaluate the degradation of surface properties with easy and quick substitution of property values.
- Model the satellite using the modeling techniques that suit the needs of the simulation with any combination of lumped parameters, finite difference, and finite element.



Applicable Products: Ansys Thermal Desktop™

Board Level – Solution-Product Matrix

Learn more about Ansys products at: https://www.ansys.com/products

Applications	Ansys Discovery™	Ansys Granta MI Enterprise™	Ansys Thermal Desktop™	Ansys Mechanical™	Ansys Sherlock™
Shock and Vibration Reliability					●
Electronics Lifetime & Reliability		●			●
Mechanical Reliability	●			●	●
Satellite Thermal Evaluation and Design			●		

/ Increased Collaboration; Faster Innovation; Customized Workflows; Optimization; Cloud & HPC

Device or Module Level

Solder Fatigue in Satellites under Realistic Conditions

Challenge

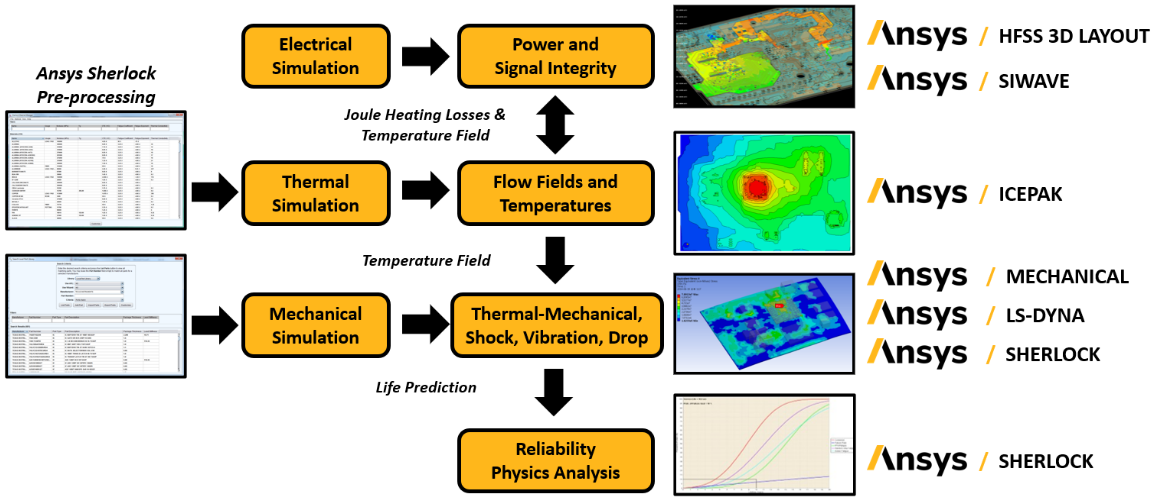
- **Solder Joint Fatigue:** The primary causes of failure in electronics of satellites are thermal - mechanical stresses, in addition to vibration, humidity, dust, and radiation.
- **Cooling and Temperature:** The cooling concept and temperature distribution greatly affect product reliability.
- **Prediction Models:** Accurate simulations are essential for developing reliable electronic equipment.

Solution

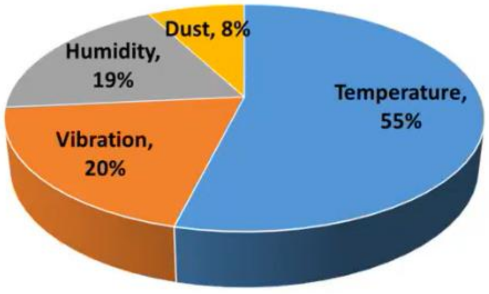
- **Automated Simulation Models:** Use Ansys Sherlock’s libraries and preprocessing capabilities.
- **Accurate Cooling Simulation:** Run electronics cooling simulations.
- **Precise Lifetime Predictions:** Utilize temperature fields, mechanical loads, humidity, and radiation.

Benefits

- **Optimal Performance:** Early-stage optimization ensures maximum durability and reliability under harsh space conditions.
- **Time Savings:** Significant time saved in developing accurate simulation models for predicting solder joint fatigue, reducing the need for extensive trial-and-error.
- **Reduced Testing:** Elimination of costly retesting by fulfilling the stringent space requirements on the first attempt.

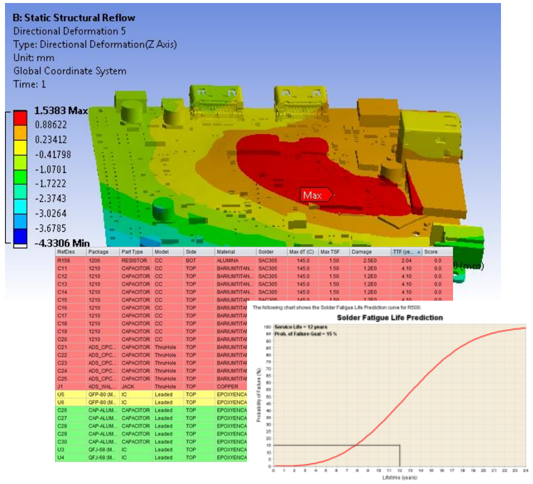


Cause of Failures in Electronics



Steinberg D.S. Vibration analysis for electronic equipment. John Wiley & Sons, 2000.

Simulation Outputs



Applicable Products: Ansys Icepak®, Ansys Sherlock™

Satellite Remaining Useful Life (RUL) with Digital Twins

Challenge

- To ensure mission success, Predictive Health Monitoring strategies are needed to determine the Remaining Useful Life (RUL) of electronic components and systems as they are subjected to thermal cycling loads and other environmental conditions.

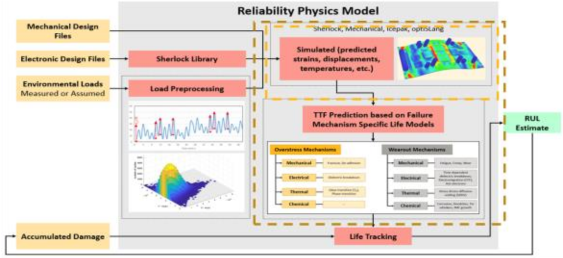
Solution

- Apply a reliability physics approach based on the likely failure mechanisms for the components, subassemblies, and assemblies, given the actual storage and use environment history to remaining useful life (RUL).
- Ansys Thermal Desktop for on-orbit and other assembly/system thermal effects.
- Ansys Sherlock for reliability predictions given Thermal Cycling, Vibration, and others.
- Ansys TwinBuilder and PyAnsys for System-Level Modeling and Workflow Automation.

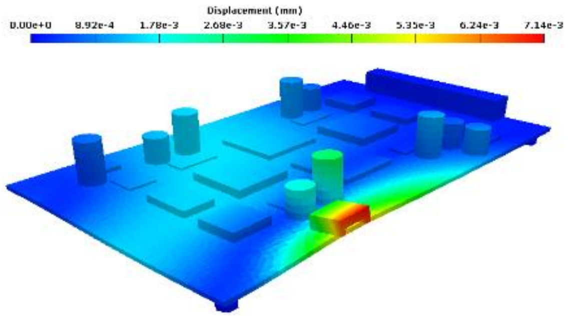
Benefits

- Ability to predict the RUL of electronic components and systems throughout a given mission in near real-time.
- Cost savings due to the ability to better define maintenance schedules.
- Improved safety for piloted missions due to near real time updates on product health.

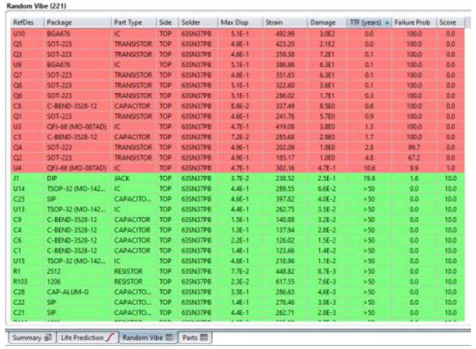
Workflow



PCB Warpage



Reliability Report



Applicable Products: Ansys Sherlock™, Ansys Thermal Desktop™, Ansys Twin Builder®

Vibration of Electrical Assembly

Challenge

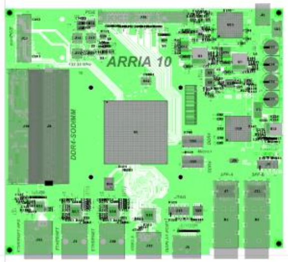
- **Validate structural reliability & life** of entire electronic assembly (PCB + mount/enclosure) by **virtual random vibration** test.
- **Reduce** lengthy and expense physical tests.

Solution

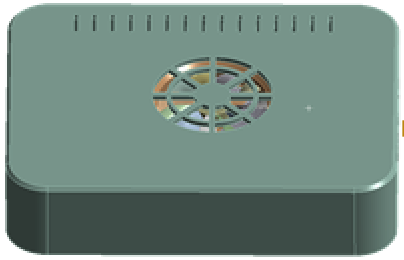
- **Single platform**: easy-to-use, integrated workflow to import PCB layout, direct export to high-fidelity structural solver to combine with enclosure and model random vibration.
- **Fidelity & performance:** electronics reliability modeling built for automotive specifics, with vast material and component library.

Benefits

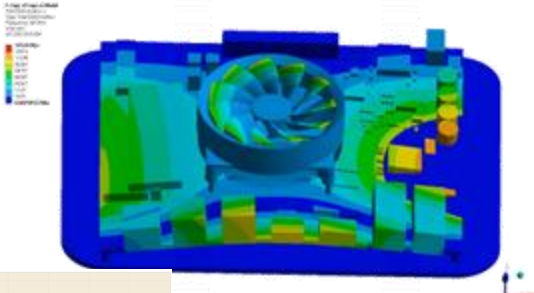
- **Enabled non-FEA experts** with high-quality reliability analysis.
- Reliability results provides **quantifiable metrics** to show system **exceeds specifications.**
- **Fast feedback** allows for more **innovative designs.**



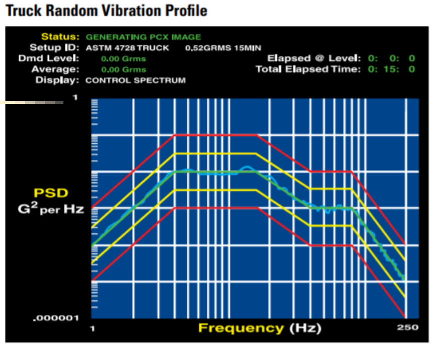
PCB MCAD generated by ECAD Import



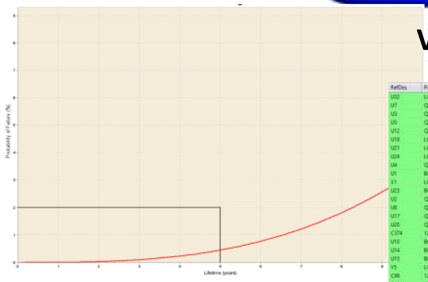
PCB + Enclosure MCAD



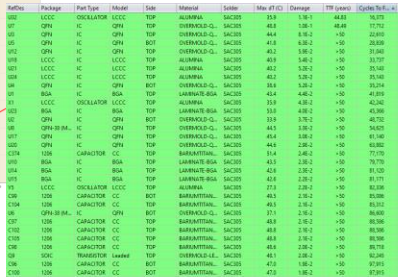
Vibration Results



Applied PSD Loads



Reliability Curve



Reliability Results

Applicable Products: Ansys Mechanical™, Ansys Sherlock™, High Performance Computing (HPC)

Device or Module Level – Solution-Product Matrix

Learn more about Ansys products at: https://www.ansys.com/products

Applications	Ansys Twin Builder®	Ansys Icepak®	Ansys Thermal Desktop™	Ansys Mechanical™	Ansys Sherlock™	High Performance Computing
Solder Fatigue in Satellites under Realistic Conditions		●			●	
Satellite Remaining Useful Life (RUL) with Digital Twins	●		●		●	
Vibration of Electrical Assembly				●	●	●

/ Increased Collaboration; Faster Innovation; Customized Workflows; Optimization; Cloud & HPC

Rad Hard Design

Rad Hard Design Workflow – SEE & TID

SEE: Single Event Effects
TID: Total Ionizing Dose
TCAD: Technology CAD
ARM: Ansys Reliability Module
ROM: Reduced Order Model

Challenge

Electronics are susceptible to natural occurrence of radiation (e.g., solar energetic particles, ultraviolet radiation, etc.) and man-made radiation resulting in:

- Degradation of microelectronics, noise on images, circuit damage, system shutdowns, power system failure.
- Qualification time for rad hard designs take several years due to long cycle times in development and testing.

Solution

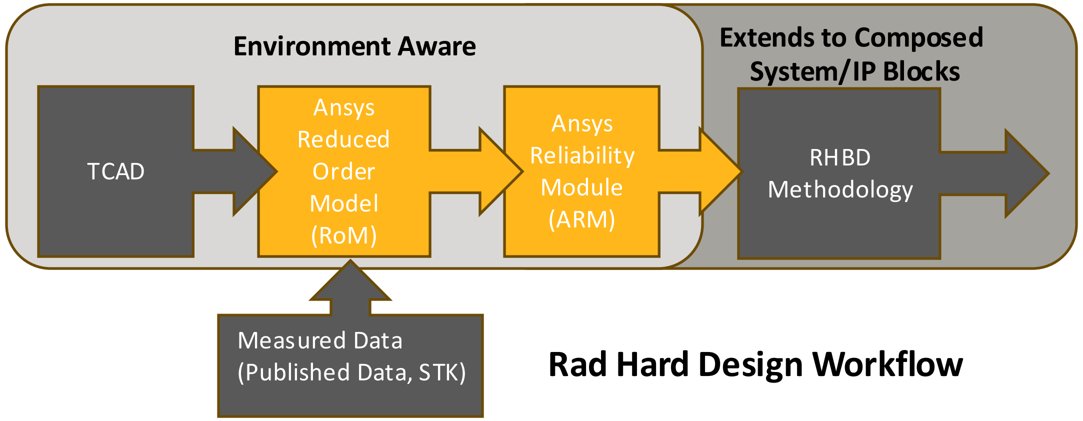
An integrated workflow for RHBD (Rad Hard by Design) process leveraging the power of TCAD, Simulation and Modeling.

- TCAD – Synopsys.
- Simulation & Modeling – Ansys optiSLang and Ansys Reliability Module.

Benefits

- Identified robust radiation solutions.
- Enabled higher performance electronics to be used in radiation environments.
- Reduced time to market and qualification.

Solar radiation impact on satellites and space vehicles



Rad Hard Design Workflow

Applicable Products: Ansys optiSLang®

Surface Charging Risk Assessment

Challenge

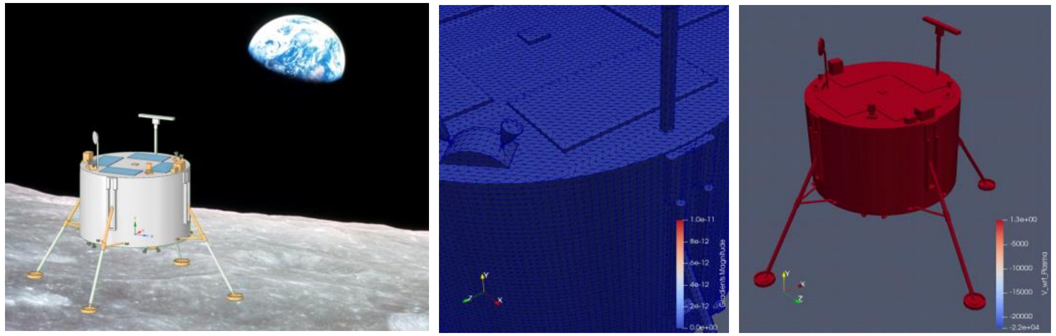
- Electrostatic discharge risks increase plasma environment in space or dusty environments (LEO, GEO, Auroral, Lunar, and interplanetary) including triboelectrification due to moon dust or due to precipitation.
- Concerns with arcing in solar cells, degradation of material performance.
- Disruption in communication.

Solution

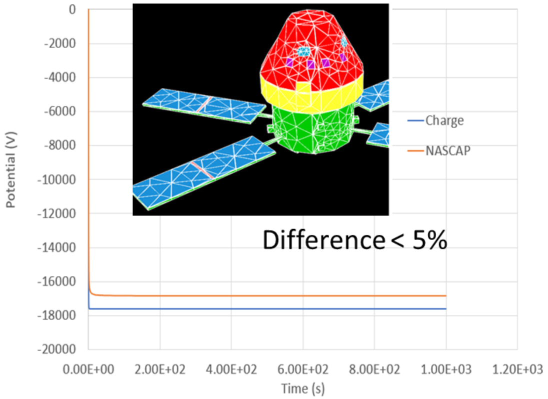
- Ansys Charge Plus uses numerous material properties to track the balance of charge between the surface and environment of the spacecraft or space bodies.
- PIC solver coupled with BEM makes it possible to analyze state of low-energy, low-density plasma surrounding the spacecraft – analyzing charge and distribution of surrounding plasma state.
- Surface charging using FEM – Full wave electromagnetic field to calculate fields in 3D to analyze risk of arcing in the plasma.

Benefits

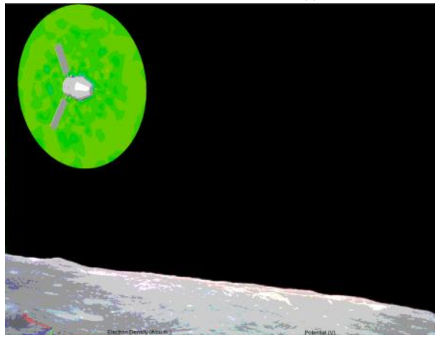
- Accurate results within 5% in the GEO environment –benchmarking with NASCAP.
- Adaptive meshing allows for optimal cell count.
- Obtaining plasma environments from STK and computes the coupled surface and internal charging.



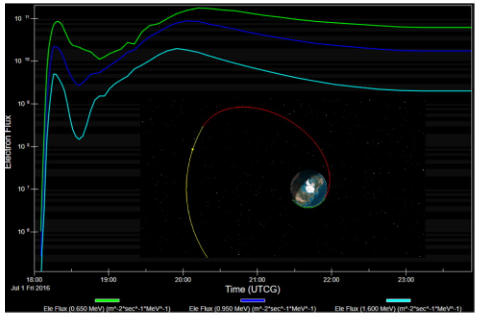
Surface Charging in Lunar



Comparison of Charge Plus and NASCAP surface charges



Surface Charging with 3D Fields



Integration with Ansys STK-SEET

Applicable Products: Ansys Systems Tool Kit® (STK®) - SEET, Ansys Charge Plus™

Internal Charging of Bulk Material

Challenge

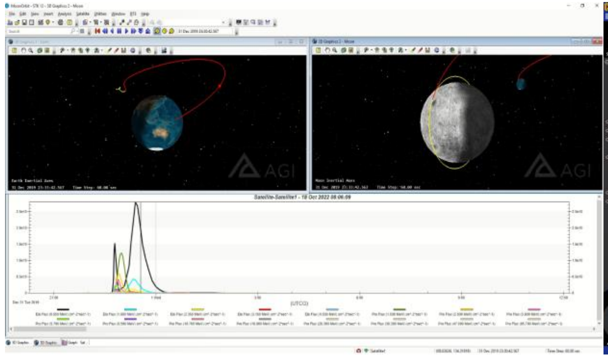
- High energy particles can penetrate deep in materials, currents can be induced on conductors, and dielectrics can build E-fields strong enough for electrostatic discharge (ESD) – all affecting sensor operation and robustness.
- Internal charging of solar panels and cables under extreme conditions, such as GEO or X-ray photons.

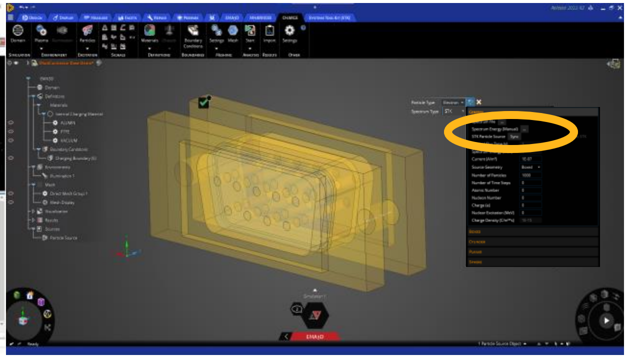
Solution

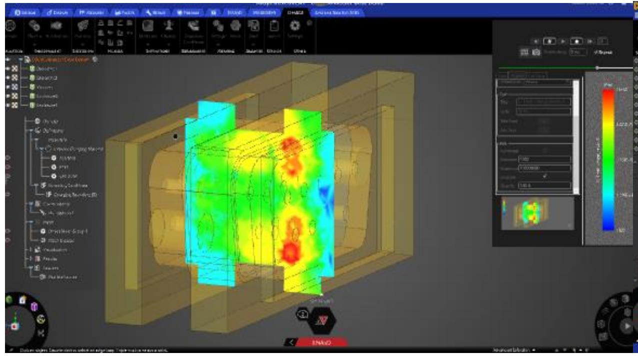
- Co-simulation of radiation transport and full-wave, 3D electromagnetics.
- Monte Carlo particle physics transport modeling coupled with Time Domain FEM electromagnetic solver.
- Model ESD and extent of damage to understand EM radiation and carbonization of material.
- Stochastic-tree damage modeling.

Benefits

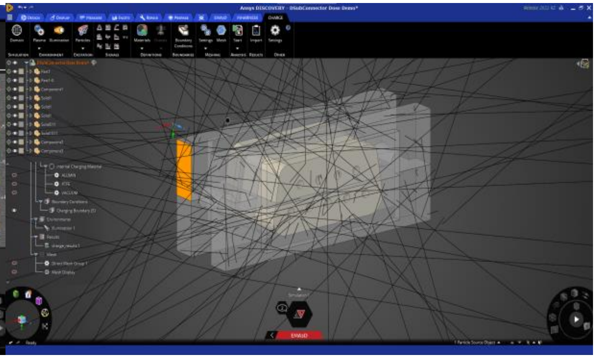
- Integrated workflow starting from ephemeris file for mission: time domain of charging simulation used to parse Ansys STK spectrum automatically.
- Automatic sync between Ansys STK Space Environment and Effects Tool (STK-SEET) and Ansys Charge Plus.







Internal charging of connector



Internal charging in GEO – Electron tracks

Applicable Products: Ansys Systems Tool Kit® (STK®), Ansys Charge Plus™

Radiation Hardening

Challenge

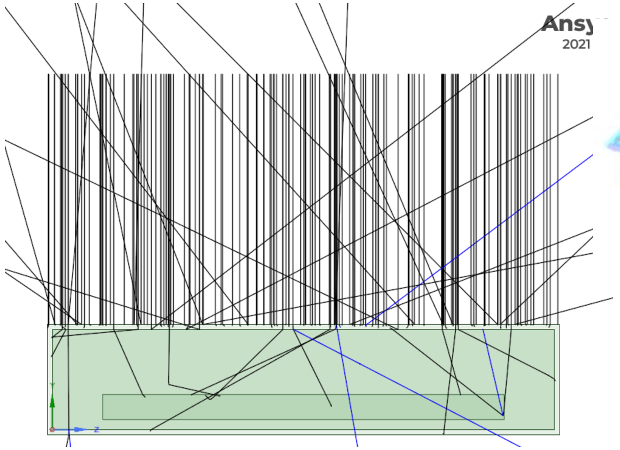
- Space radiation from protons, electrons, and ions pose significant risk to the functionality and longevity of electronics causing both to intermittently malfunction and result in permanent damage.
- Understanding the threats of radiation is critical: Single Event Effects (SEE), Total Ionizing Dose (TID), Electromagnetic Interference (EMI), thermal effects, and solar particle events.

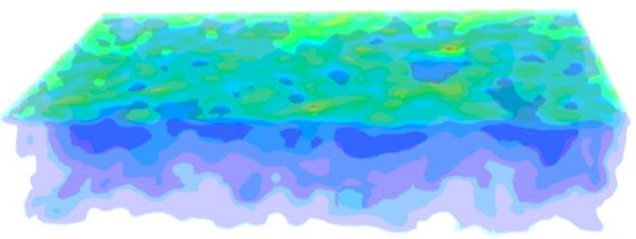
Solution

- Charge Plus uses Monte Carlo 3D particle transport and the FEM to track particle fluences during simulations, and use fields as feedback to the transport problem.
- Charge Plus evaluates the amount of radiation penetration into the interior of different metal thicknesses.

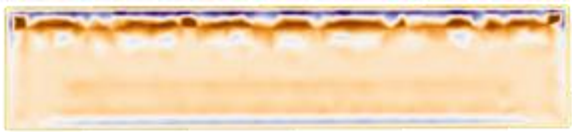
Benefits

- Design the metal thickness to balance the weight of the aircraft with the impact of radiation hardening.



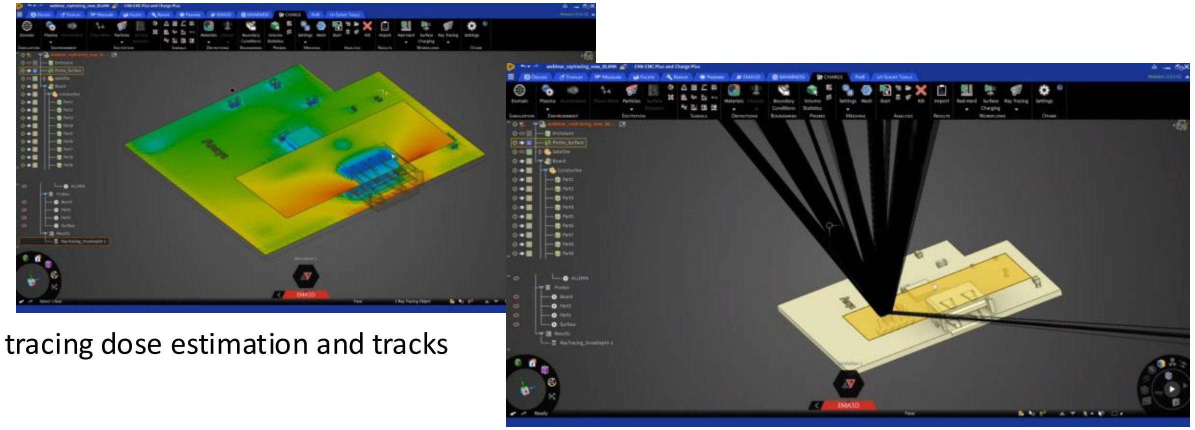


Flux density



Charge density

E-Fields



Ray tracing dose estimation and tracks

Applicable Products: Ansys Charge Plus™

Dielectric Breakdown of Solar Cells

Challenge

Dielectric breakdown occurs when an insulating material (dielectric) within the solar cell becomes conductive due to a high electric field, leading to a failure in insulation.

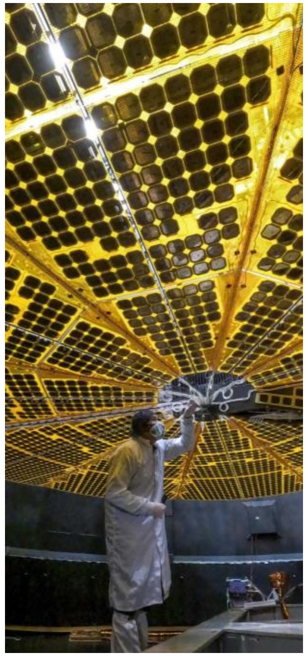
- Localized heating, increased leakage currents, and ultimately, a reduction in the efficiency and lifespan of the solar cell.
- Scope for testing is limited by sample size and equipment issues.

Solution

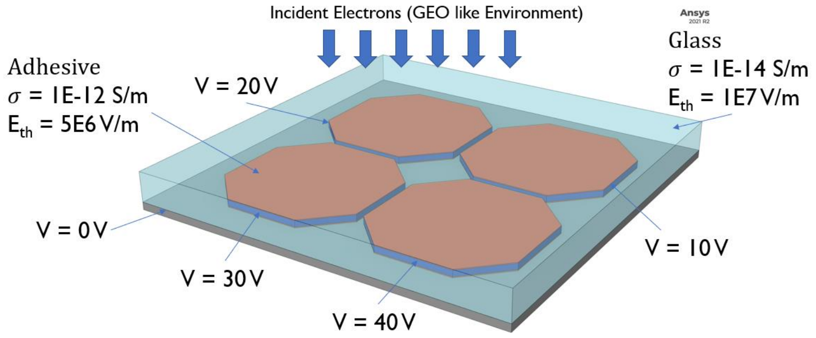
- Ansys Charge Plus is based on transport modeling coupled with an electromagnetic solver.
- Ansys Charge Plus tracks the arcing paths within materials and model the current waveforms from the generated arc and the resulting conductivity changes.

Benefits

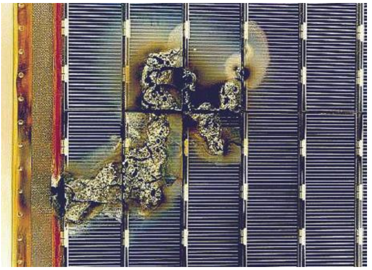
- Understand the effects of cosmic radiation, voltage on dielectrics.
- Assess risk and damage when electric fields exceed breakdown strength of a material.
- Mitigate potential issues through material selection, material thickness or circuit design.



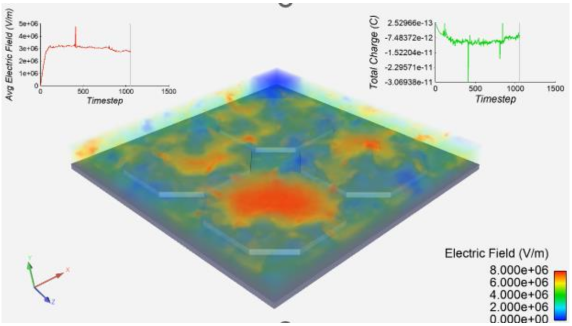
Solar cell for space



Charging analysis in GEO like environment



Solar cell damage



Dielectric breakdown in a solar cell

Applicable Products: Ansys Charge Plus™

Arc Formation in High Voltage Systems

Challenge

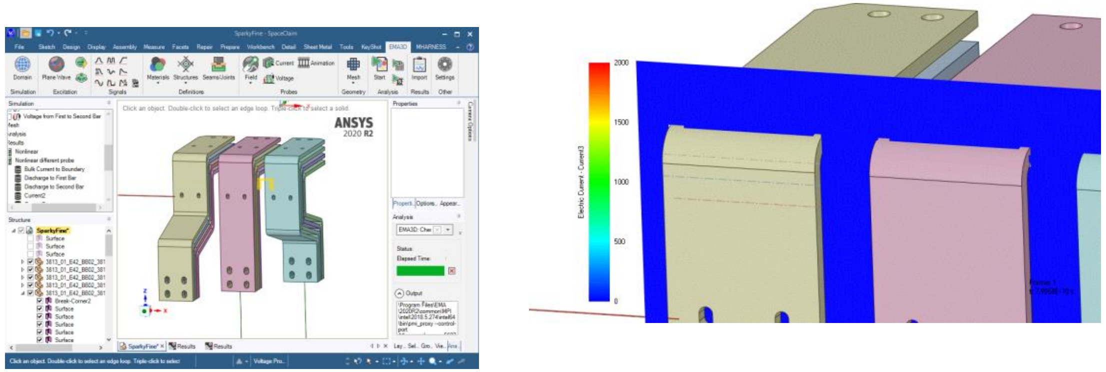
- Risk management of arc discharge locations in high voltage systems and voltage estimation during discharge.
- Prediction of discharge voltage in changes in atmospheric pressure and humidity.
- Prediction of secondary discharge occurrence.

Solution

- Air breakdown calculation module is implemented in Finite-Difference Time-Domain (FDTD) technology based on conservation of charge carrier density, energy, and momentum of airborne particles.
- A method for defining multiple arc regions and predicting the location of arc initiation.

Benefits

- Reduce defect risk by designing for arc discharge.
- Reduction of development cost by risk management of arc discharge.



Arc discharge between bus bars

Air discharge and breakdown voltage of high voltage circuit breakers

Applicable Products: Ansys Charge Plus™

Powering Innovation That Drives Human Advancement

Ansys

Rad Hard Design – Solution-Product Matrix

Learn more about Ansys products at: https://www.ansys.com/products

Applications	Ansys optiSLang®	Ansys Systems Tool Kit® (STK®)	Ansys EMC Plus™
Rad Hard Design Workflow – SEE & TID	●		
Surface Charging Risk Assessment		●	●
Internal Charging of Bulk Material		●	●
Radiation Hardening			●
Dielectric Breakdown of Solar Cells			●
Arc Formation in High Voltage Systems			●

/ Increased Collaboration; Faster Innovation; Customized Workflows; Optimization; Cloud & HPC

Ansys