Electronic Systems Qualification by Analysis

William Villers, Director of Engineering, TEN TECH LLC, 2014 CAE Symposium
TODAY’S PRESENTATION AGENDA

Introduction to TEN TECH LLC
• Company Profile
• Business Organization
• Areas of Expertise

Electronic Systems & Harsh Environments
• Air, Sea and Land Electronics Systems
• Source of Thermal & Mechanical Loads
• Analysis of Harsh Environments

ATR Chassis Analysis Example
• Radar System Random Vibration Analysis
• Single Board Computer Thermal Cycling
• Shock Response & Electronics Cooling
INTRODUCTIONS
INTRODUCTIONS: WILLIAM VILLERS

Co-founder & Director of TEN TECH LLC
• Manage Technical Aspects of the Company
• Project Management & Customer Relations
• Analysis Team Management
• Executive Decisions Authority

Seasoned Aerospace & Defense Professional
• MSME & ABD Doctor of Engineering, MIT France
• Over 20 years of Industry Experience in Europe & US
  • Engineering & Engineering Management
  • Eurocopter, Aerospatiale
  • CAE Technical Consultant at SDRC/EDS/UGS
INTRODUCTIONS: TEN TECH LLC

Design, Test & Analysis Services Provider
• Offices in Culver City, CA and Billerica, MA
• Primary Focus on Aerospace & Defense

Trusted Industry Specialists
• Seasoned Aerospace Engineers
• Proven Technology & Processes

Certified Woman-Owned Small Business
• Registered Government Contractor
  • Certified WOSB, SBA 8(m)
  • Cage Code & Active DD2345
TEN TECH LLC’S AREAS OF ANALYSIS EXPERTISE

• Stress & Deflection
• Shock & Vibration
• Fatigue Life Prediction
• Thermal Analysis
• Electronics Cooling
• Fluid Dynamics
• Aerodynamics
• Kinematics
• Vibro-Acoustic
• Aeroelasticity

- Naval 19%
- Energy 2%
- Medical 1%
- Parks & Rides 3%
- Spacecraft 3%
- Consumer Products 2%
- Defense Electronics 69%
- Transportation 1%
- Stress 5%
- Training 4%
- Thermal & CFD 19%
- Vibro-Acoustics 1%
- Shock & Vibration 70%
- Test Plan 1%

19% Thermal & CFD
1% Vibro-Acoustics

69% Defense Electronics
70% Shock & Vibration

2% Consumer Products
2% Medical
3% Parks & Rides
3% Spacecraft
1% Stress
4% Training
SIEMENS PLM SOFTWARE PRODUCTS AT TEN TECH LLC

NX As Core CAE Product
- Strong Geometry Simplification Toolset: Synchronous Modeling
  Often Used to Prepare Geometry for Other Solvers
- Tight CAD/CAE Integration: Large Assembly FEM
- Extensive Solver Support: NASTRAN, …

NX NASTRAN As Primary Solver
- Strong Aerospace Heritage & Acceptance
- Decades of NASTRAN Experience
  - Started with MSC NASTRAN v65

JT2Go for Model Review
- Lightweight FEM & Results Communication
- MS Office Integration
Rugged Electronics Systems, Mechanical and Thermal Loads

ELECTRONICS & HARSH ENVIRONMENTS
AIR, SEA AND LAND RUGGED ELECTRONICS
HARSH ENVIRONMENT: SOURCES OF THERMAL & MECHANICAL LOADS

- Transportation
- Take-off & Maneuvering Loads
- Engine Structural or Acoustic Loads
- Engine/Motor Thrust Transients
- Pogo & Solid Motor Pressure Oscillations
- Turbulence & Aerodynamics
- Payload Release Loads
- Pyrotechnic-Induced Loads
- Electronics Operations & Heat Dissipation
- Thermo-mechanical Effects
- Flight & Onboard Equipment Operations
- Impact & Explosions
- Sun, Wind Gust, Icing
HARSH ENVIRONMENTS IN TERMS OF ANALYSIS

Quasi-Static & Low Frequency Acceleration

Sinusoidal Vibration
  Propellers
  Gunfire

Broadband Random Vibration
  Transportation
  Engine & Propeller vibration
  Aerodynamic pressure oscillations
  Vibro-Acoustics

Shock Transient
  Stage Separation, Engine Shutoff
  Payload Release
  Explosive Environments

Thermal Cycling & CTE Mismatch
  Board & System-Level

Thermal Management
  Fan Sizing and Placement
  Dust Filters Selection
  Components Junction Temperatures
  Airflow Path Optimization

Environmental Heating
  Altitude Considerations
  Solar Radiation
  Storage Extremes
TYPICAL ELECTRONICS EQUIPMENT ENVIRONMENTAL GUIDELINES

Mechanical
• Shock & Crash
• Random Vibration
• Sine-on-Random
• Explosion & Blast

Thermal
• Temperature & Altitude
• ECS & Fans Failure

Thermo-Mechanical
• Thermal Stress
• Interface Gapping
NX & NX NASTRAN Shock, Vibration and Thermal Analysis

ATR CHASSIS ANALYSIS EXAMPLES
ER 3.1: The chassis shall operate during exposure to vibration profiles specified with MIL-STD-810G Method 514.6 Annex D. Note this standard specifies for each axis or equivalently scaled times and levels. (Assume UH-1, 2-bladed helicopter)
AIR TRANSPORT RACK (ATR) SYSTEM EXAMPLE

ATR Chassis & Payloads

Wedge-Lock

Backplane

Payloads
HELCOPTER RADAR SYSTEM RANDOM VIBRATION ANALYSIS

Complete ATR Chassis 3D CAD Model
- Brazed Aluminum Plates Design
- STEP File of Fully Populated Assembly

System-Level NASTRAN Model
- Parts Simplified with Synchronous Modeling
- NX AFEM from CAD Product Structure
- NX NASTRAN Glue Joints for Brazed Joints
- NX Automated Bolt Creation

Sine-on-Random Vibration Analysis
- NX NASTRAN SOL103/111
- MAYA SATK
- Fatigue Life Estimates
  - Structural Members
  - Solder Joint Fatigue
SINGLE BOARD COMPUTER THERMAL CYCLING ANALYSIS

CTE Mismatch Analysis
- Warping of PCB
- Gapping of Thermal Pads
- Stress Concentration on Components
- Low Cycle Fatigue Issues

Thermo-Mechanical Solution
- NX NASTRAN Non-Linear SOL106
- Boundary Condition Sequence
SHOCK RESPONSE AND ELECTRONICS COOLING WITH A SINGLE MODEL

Neutral Format 3D CAD Model
- Simplified with NX Synchronous Modeling
- System Meshed as an AFEM

Shock Response Spectrum
- NX NASTRAN SOL103

NX/Flow Thermal Analysis
- Reuse of Structural FEM
- Payloads Max Temperature
- Fan Selection, Sizing & Operating Point
- High Altitude Operation
- Thermal Inertia Evaluation
- Input to downstream ESS Test
Summary, Q&A

CLOSING REMARKS
SUMMARY

Analysis of Electronics Systems is Complicated
• Large Models, Complex Geometry
• Numerous Requirements Across Multiple Disciplines
• Many Potential Failure Modes
• System-Level and Component-Level Analysis

NX CAE Well Suited For Our High-End Needs
• Strong Integrated Multi-physics Environment
• Excellent Model Abstraction Functionality
• Advanced Meshing Functionality
• High Performance Solver Technology