Rapid Jitter Analysis of an Evolving Optical Design

Raymond Amador
David Hiley
DRS Sensors and Targeting Systems

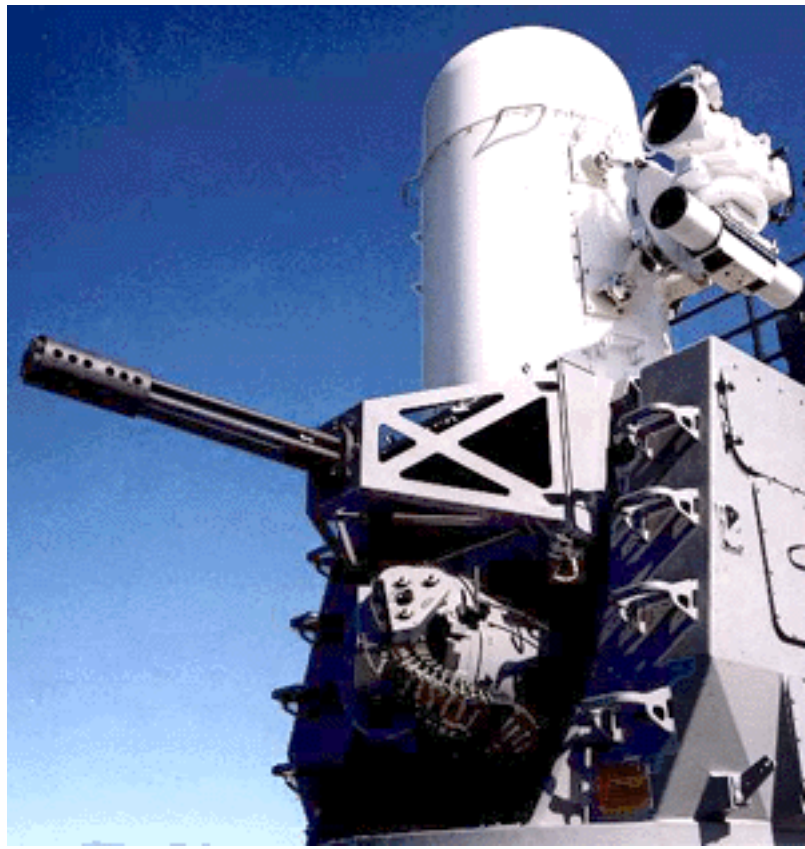
David Bremmer
MSC.Software Corporation

Presentation 2004-63

Introduction

Electro-optical design for Phalanx

- Navy “Last chance” ship defense
  - Multi sensor inputs
  - 4500 rounds/min. blast/vibration
  - Optical jitter response
  - Micro-radian pointing requirements
- VPD
  - “Prove” design before expensive build
  - Simulate optical performance
    - Based upon structural behaviour



Problem Description

VPD Goal: Enable reduction of Jitter

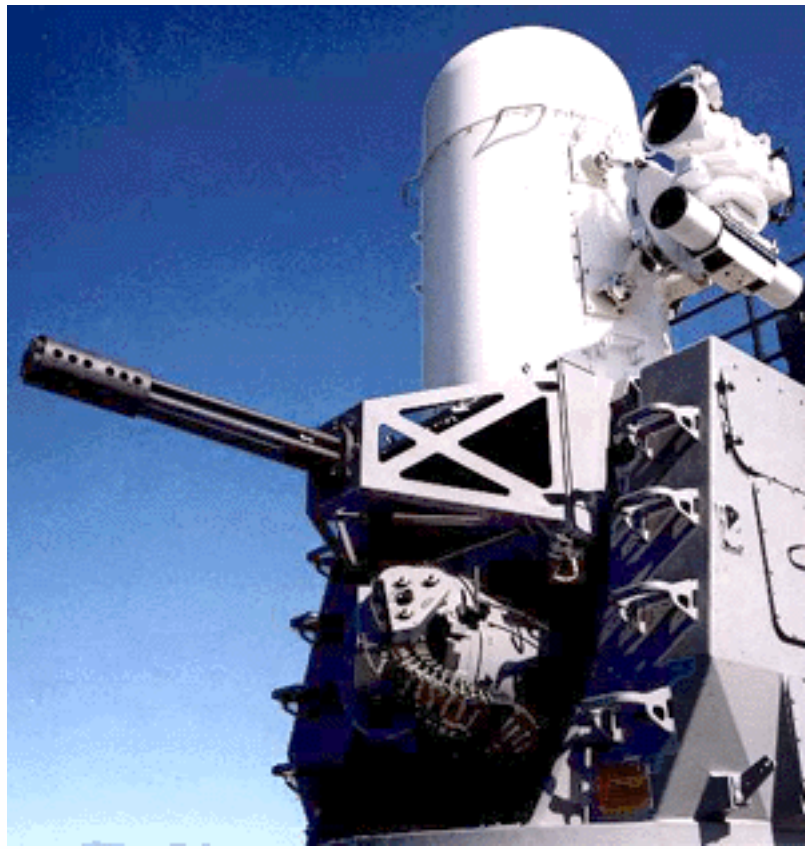
- Optical Jitter
  - Apparent Azimuth/Elevation excursions

High frequency structural vibration

- Housing response drives optical

Model optical element displacements

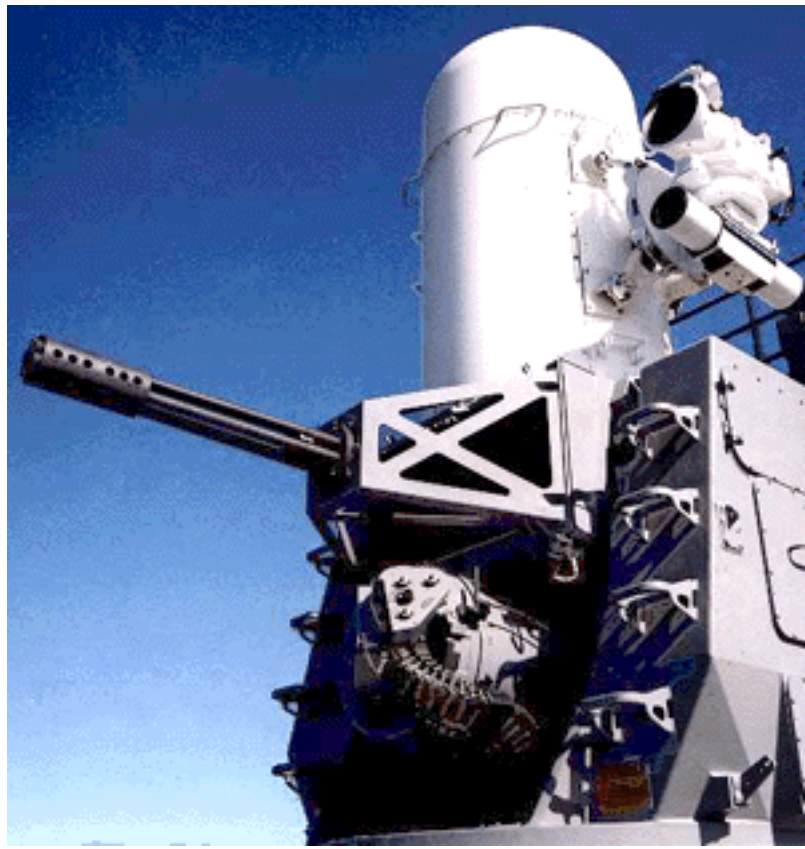
- Coupling of optics/ structure
  - Optical sensitivity coefficients
  - Error budget established for each optical element



Modeling and Analysis

Support Rapid Design Evolution

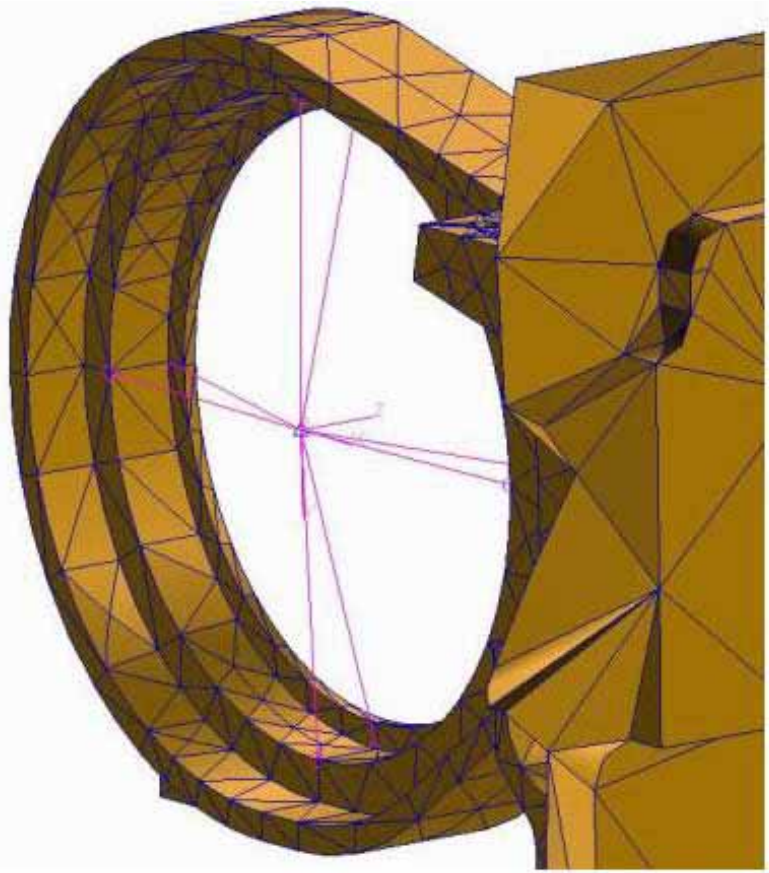
- Pro-E Geometry Source
  - Conditioned by CAD user for analysis
- CAE Tools
  - MSC.Patran – build FEM
  - MSC.Nastran – Solve
  - MSC.Random – Post Process
- Report Optical Jitter, Frequencies
- Guide structural design update



Typical Optical Element

Lumped Mass Model

- Rigid Body RBE2 MPC
  - Secondary structure mounting
- Lumped mass at optical centroid
  - Track displacement, rotations



Main Optical Lens

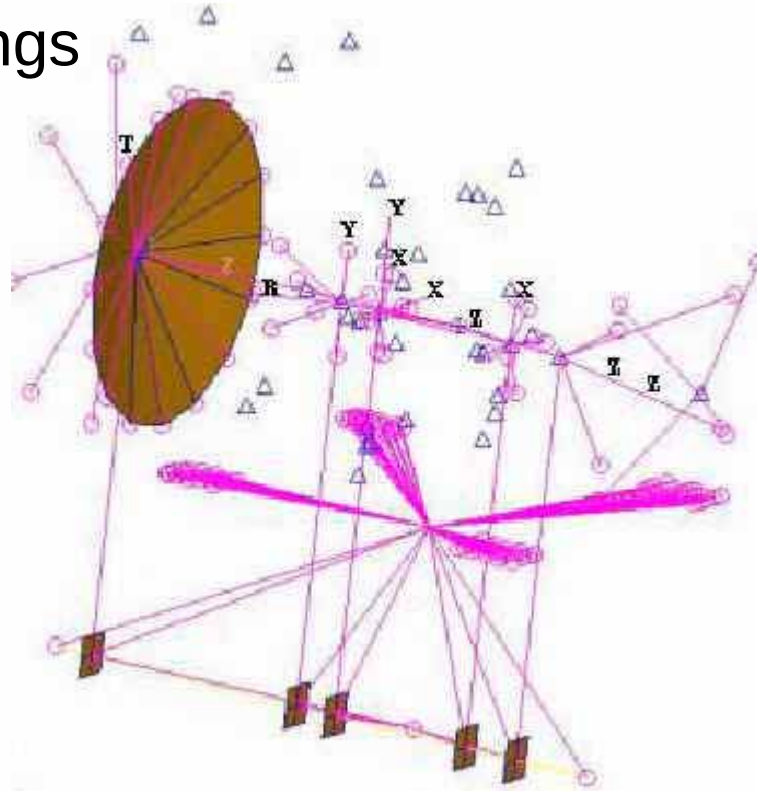
Lumped Mass Model

- Rigid Body RBE2 MPC with springs
  - Zero length springs: R, theta, Z
- Local Cylindrical Coordinates
- Lumped mass at optical centroid
  - Mass offset vector
  - Track displacement, rotations

“Skeleton” Model

Behaviour of Optics, Masses, Mountings

- Housing Connections
  - Rigid Body MPCs, Springs
- Optical Axis Elements
- Additional Lumped Masses
- Driver Node and RBE2 MPC
- Explicit MPCs
  - Relative Motion
  - Jitter
- Motion Visualization Elements



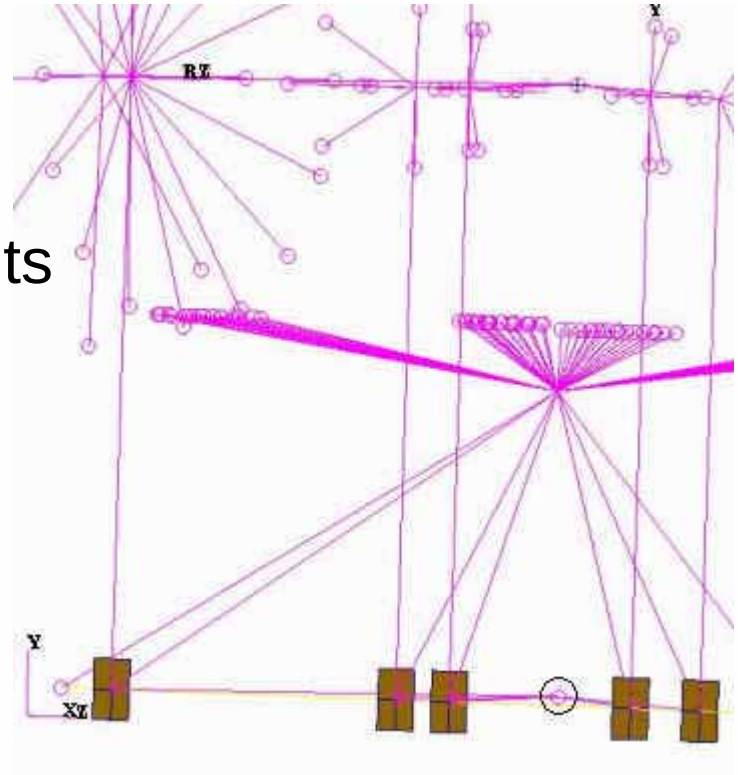
Motion and Jitter Tracking

Relative Motion Nodes/Elements

- Explicit MPCs subtract driver motion

Free Nodes Record Jitter Components

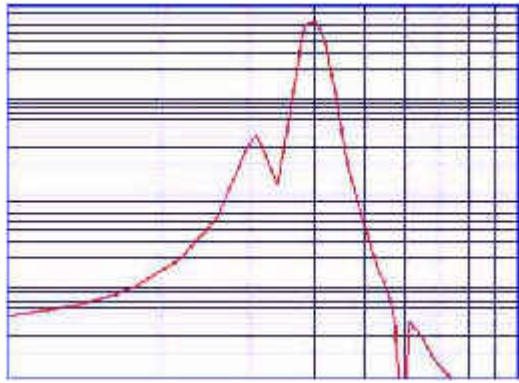
- Explicit MPCs with optical coefficients



Post Processing

Natural Frequencies and Mode Shapes

- MSC.Nastran Soln 103 Results
- Explore flexibilities by animating modes
- Special visualization elements show optics motion



Line-of-sight Jitter computation

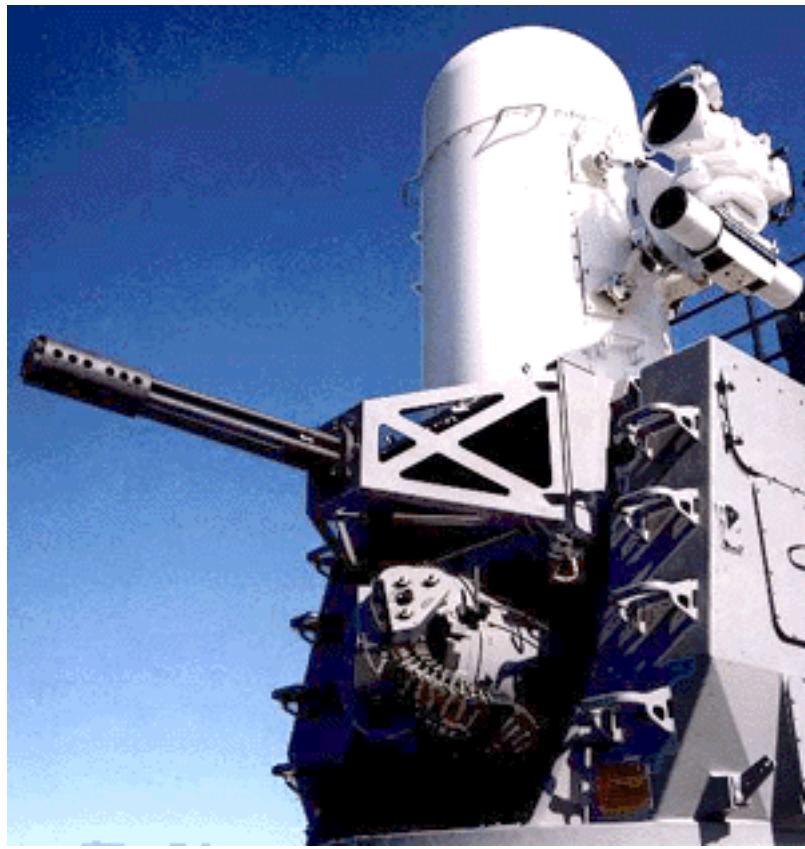
- MSC.Nastran Soln 111 Frequency Response
- MSC.Random automates the process
- Report individual optical contributions +total
- RMS Azimuth/Elevation reported in Micro-radians

DRS SENSORS & TARGETING SYSTEMS, INC.

Process Automation and Standard Practices

Goal: cut time, assure quality

- CAD design best practices
  - Build immunity to personnel change
  - Geometry suitable for analysis
    - Different idealizations per design phase
    - Enhance to facilitate FEA automation
      - Vertices at “skeleton” connection points
      - Guide curves for “skeleton” construction

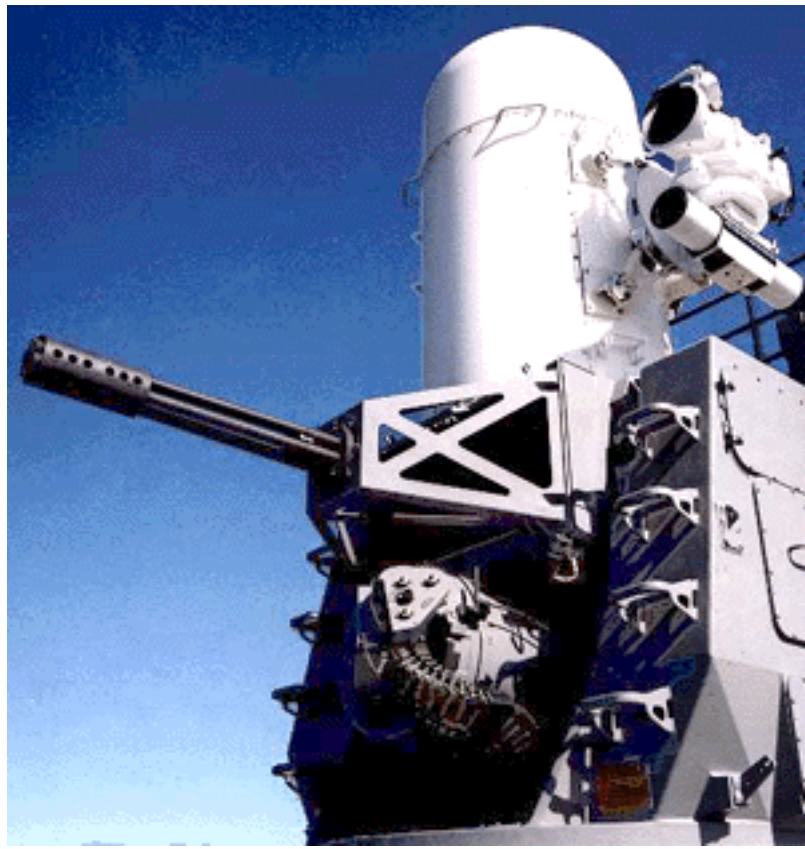


DRS SENSORS & TARGETING SYSTEMS, INC.

DRS TECHNOLOGIES

Process Automation and Standard Practices

- FEA model best practices
  - Build immunity to personnel change
  - Standard use of tools / constructions
    - Optical element modeling
    - Explicit MPCs to compute Jitter
    - MSC.Random results, reports
  - Idealize differently per design phase
    - Shell element models precede solid
  - Adopt MSC.RD as early phase tool
  - Create automation application
    - MSC.Patran is programmable
    - Special vertical app to build “skeleton”



Conclusions / Recommendations

DRS TECHNOLOGIES

- Simulation in optical system design
  - Integral and essential
  - Must supply rapid feedback/ guidance
  - Must coordinate CAD/ CAE
  - Best practices for success
- Improvements
  - Save significant time, cost
  - Immunity to personnel change
  - Better VPD maturity = better designs