ARIANE 4
PAYLOAD FAIRING
SEPARATION ASSESMENT

R. LAGIER (Arianespace)
T. BERNARD (MDI France)
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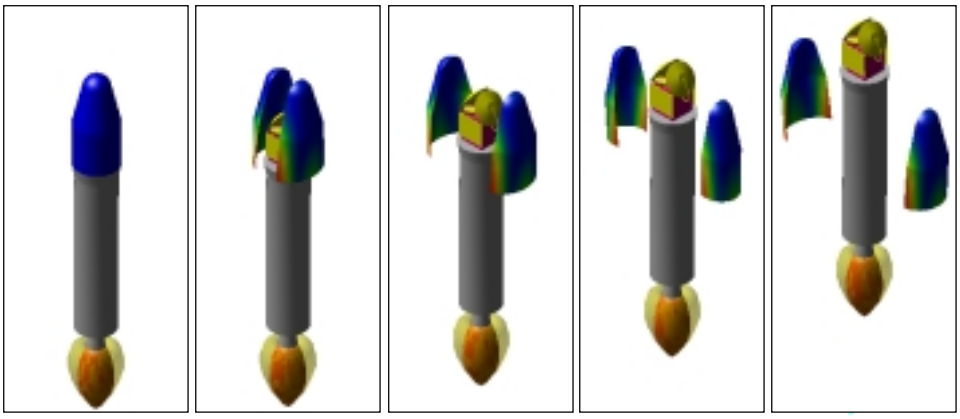
MDI France
58 Rue Pottier
F - 78150 LE CHESNAY
EMail : info@mdi.fr
Tel. : <33> 01 39 66 04 00
Fax : <33> 01 39 66 94 74

Mechanical Dynamics

Agenda

ARIANE 4 payload fairing separation



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Summary

- Introduction / objectives
- Separation system description
- Available measurements
- Simulation methodology
- Nastran model correlation
- Linear approximation effects
- Adams non-linear correction
- Pyrotechnics model
- Adams model correlation
- Simulation of flight 126
- Conclusion / perspectives

Introduction / objectives

- Background of existing non-linear FEA based models :
  - complex modeling : many assumptions on component physics
  - CPU expensive : limited use for sensitivity studies
- Setup an **efficient simulation methodology** for ARIANE 4 payload fairing separation :
  - ease of modeling to take in account all components physics
  - extended parametrization (components physics, system configurations)
  - CPU costless to allow extensive use of DOE / optimization
  - good correlation / predictivity
- Quite short delay starting from scratch in May 2000 : 1 month for modeling, 1 month for investigations

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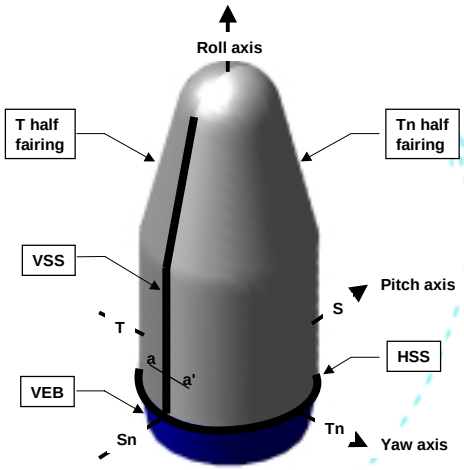
Separation system description (…)

- VEB : vehicle equipements bay
- 2 half fairing structures (T & Tn)
- HSS : horizontal separation system
- VSS : vertical separation system
- Separation sequence :
  - 2G constant acceleration of VEB
  - ignition of HSS to untie fairing from VEB / payload assembly
  - ignition of VSS to separate the 2 half fairing => focus of the assesment



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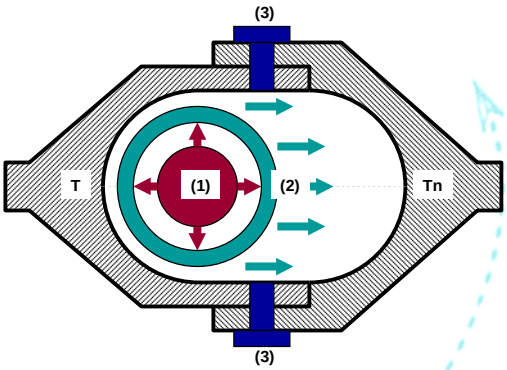
Separation system description

- VSS pyrotechnic system :
  - ignition : cord explosion (1)
  - vessel expanding in cavity (2)
  - pressure ramping
  - shear loading of rivets untill resistance limit (3)
  - separation pulse



aa' cross section

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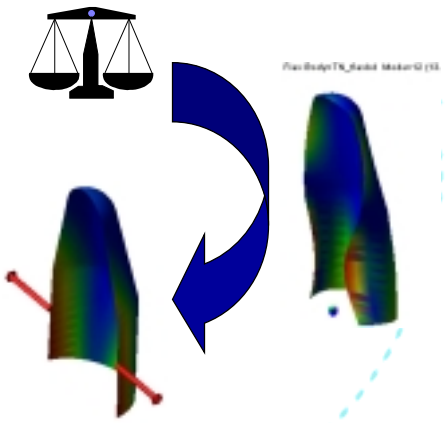
Available measurements

- Ground measurements :
  - mass, inertia, CoG position
  - free-free frequencies
  - deflection under opening / closing static loads
  - separation sensitivity (100, 150, 200 % rivets density)
- Flight measurements :
  - radial displacement
  - pitch, roll angular velocities



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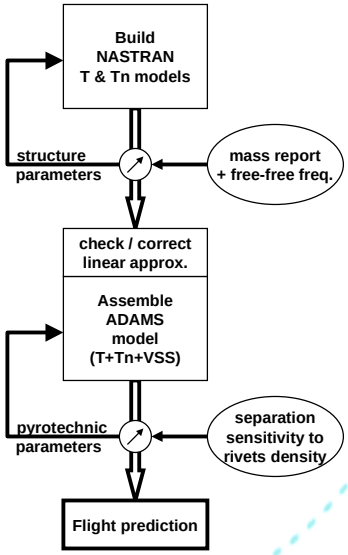
Simulation methodology

- Build Nastran models of 2 half fairings :
  - correlate mass report
  - correlate free-free frequencies
  - correlate static deflection
- Assemble Adams model of fairing together with VSS rivets and pyrotechnic cord :
  - check (and correct if possible) linear approximation effects
  - identify pyrotechnic pulse parameters to correlate separation sensitivity to rivets density
  - correlate flight measurements



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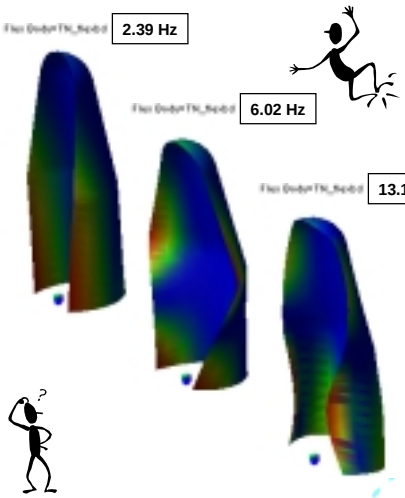
Nastran model correlation

- Use Adams DOE for Nastran model parameters tuning to correlate measured mass and frequencies :
  - mass, inertia and CoG position correlated within 0.1 %
  - first 6 free-free frequencies correlated within 5 %
- Deflection under static loads showed unpredicted non-linearity (composite material behavior ?) :
  - Nastran non-linear -380 / +380
  - measurements -395 / +300



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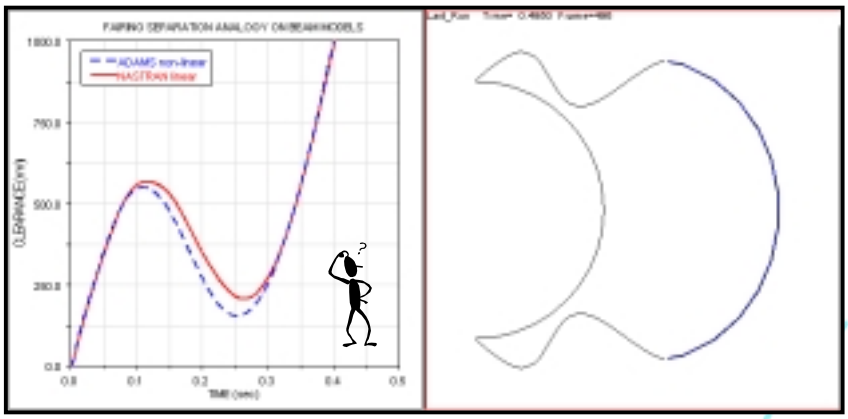
Linear approximation effects

- Estimate the effects of linear approximation by comparing Adams beams w.r.t. Nastran equivalent flexible body :



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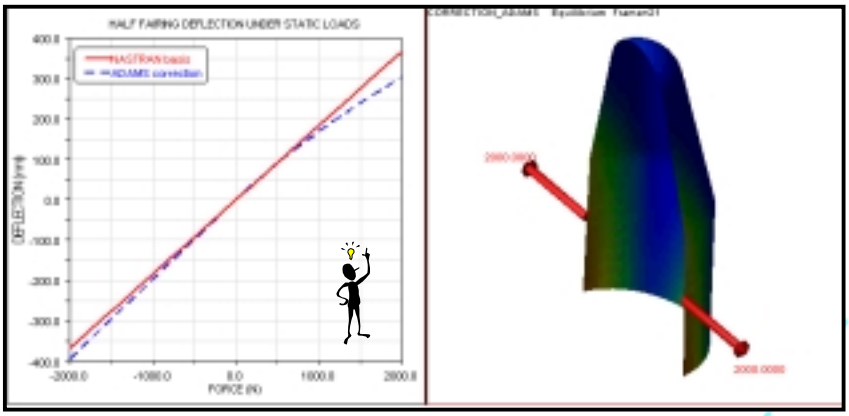
Adams non-linear correction

- Use new Adams modal loads to add non-linear correction :
  ML(7) = IF(Q(7) : 0 , 0 , - DK * Q(7))



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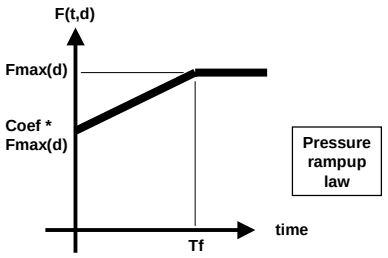
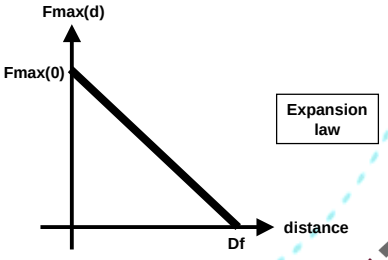
Pyrotechnics model

- Function-of-time-only pyro force is not sufficient to reproduce separation sensitivity to rivets density …
- How to guess a realistic parametric pyro law ?





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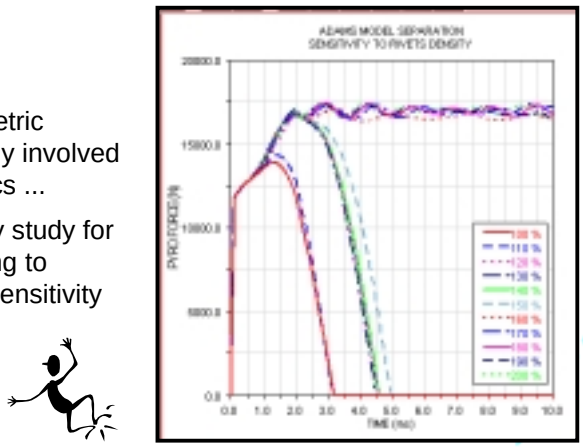
Adams model correlation

- Only the first 3 symmetric modes are significantly involved in separation dynamics ...
- Use Adams sensitivity study for pyro parameters tuning to correlate separation sensitivity to rivets density …



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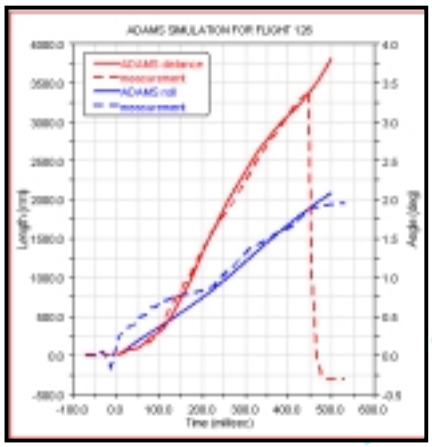
Simulation of flight 126 (…)

- Flight 126 - Ariane 4 on January 2000 : successfull injection of GALAXY 10-R satellite
- Use of Adams optimization to guess pyrotechnic levels (S / Sn balance) out of flight 126 measurements …



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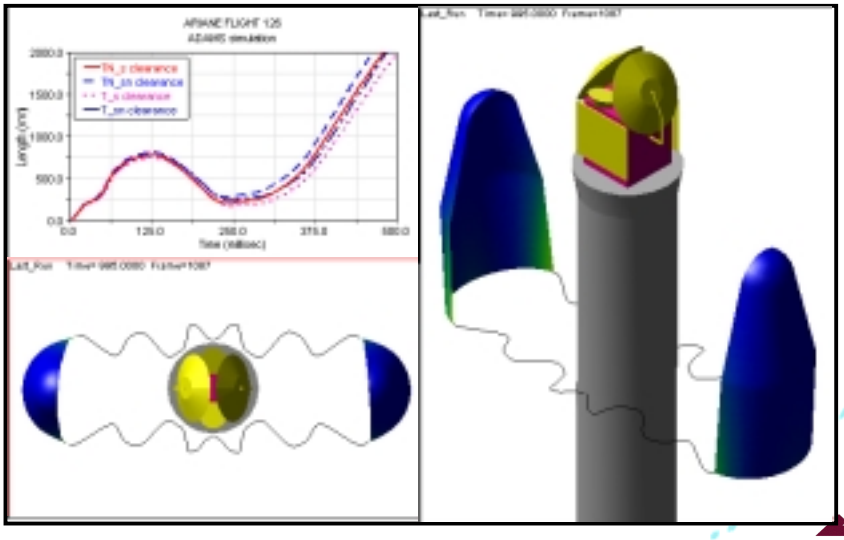
Simulation of flight 126



Conclusion / perspectives (…)

- Adams with modal flexibility was the good choice to setup an efficient simulation methodology for fairing separation studies :
  - sensitivity / DOE / optimization to correlate parametric components
  - powerfull environment to take in account any component physics
  - modal loads to add non-linear correction
  - 1 mn CPU / simulation
- ARIANE 4 payload fairing separation :
  - better understanding of rivet / pyrotechnic coupling
  - limited number of significant modes
  - collision clearance (safety margin) prediction

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Conclusion / perspectives

- Payload fairing separation :
  - validated tool and methodology to specify components tolerance requirements (VSS S / Sn balance)
  - easy extend to other configurations (ARIANE 5, etc ...)
  - ability to investigate non conformances consequences
- Use of Adams modal flexibility :
  - a successfull step in the domain of non-linear structures behavior

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