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ARIANE 4 PAYLOAD FAIRING SEPARATION ASSESMENT

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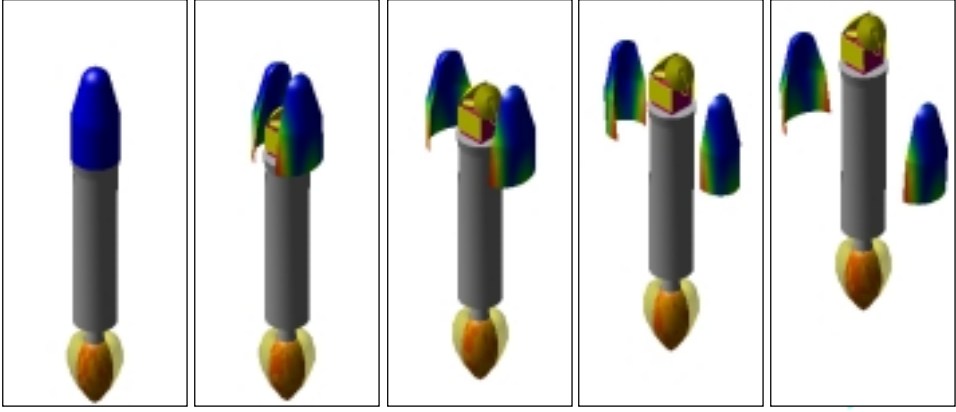
MDI France
58 Rue Pottier
F - 78150 LE CHESNAY
EMail : info@mdi.fr
Tel. : <33> 01 39 66 04 00
Fax : <33> 01 39 66 94 74





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ARIANE 4 payload fairing separation




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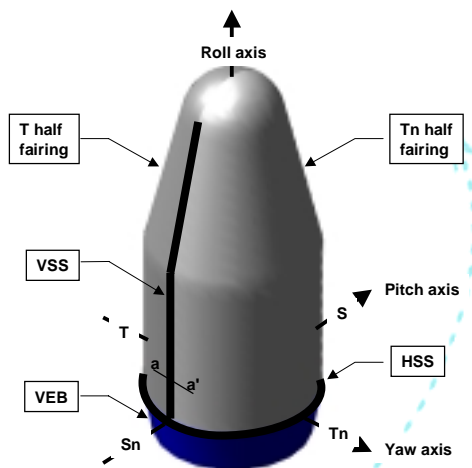
Introduction / objectives

- 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



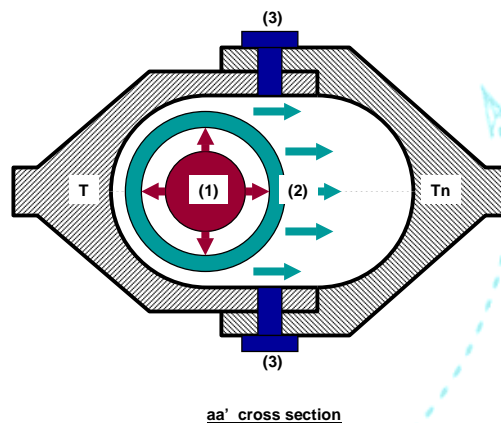
Separation system description (...)

- VEB : vehicle equipments 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



Separation system description

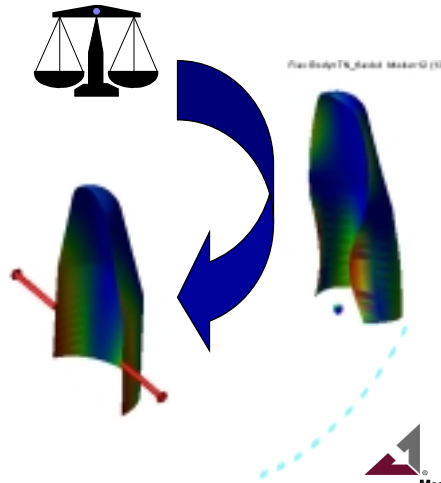
- VSS pyrotechnic system :
 - ◆ ignition : cord explosion (1)
 - ◆ vessel expanding in cavity (2)
 - ◆ pressure ramping
 - ◆ shear loading of rivets untill resistance limit (3)
 - ◆ separation pulse



aa' cross section

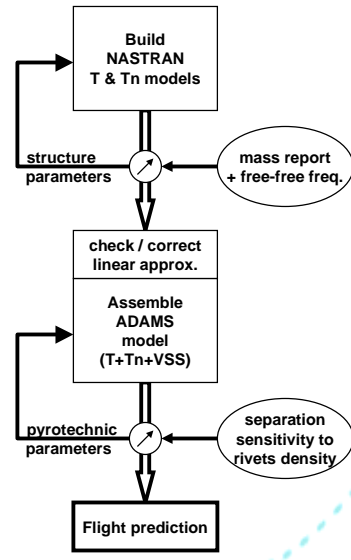
Available measurements

- 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



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



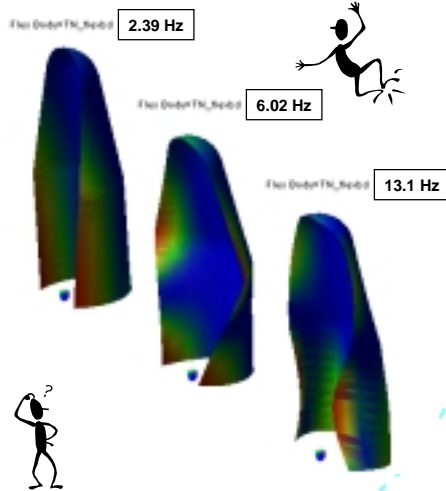
Nastran model correlation

- 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 %

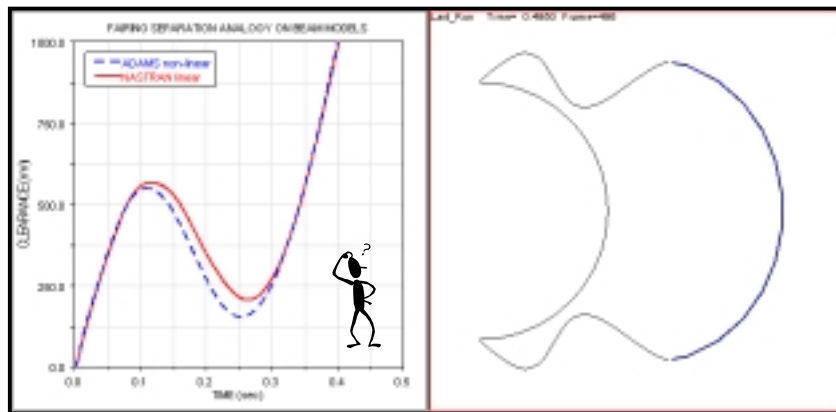
- Deflection under static loads showed unpredicted non-linearity (composite material behavior ?) :

- ◆ Nastran non-linear -380 / +380
- ◆ measurements -395 / +300



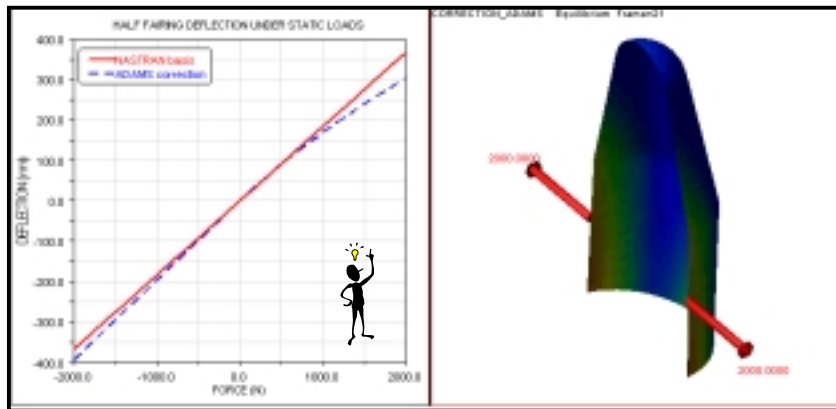
Linear approximation effects

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



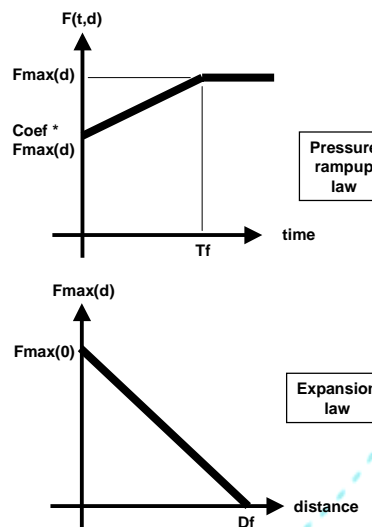
Adams non-linear correction

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



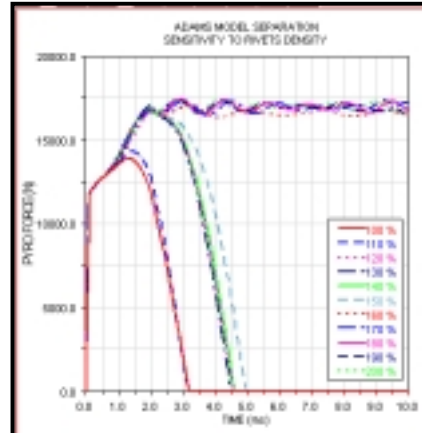
Pyrotechnics model

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



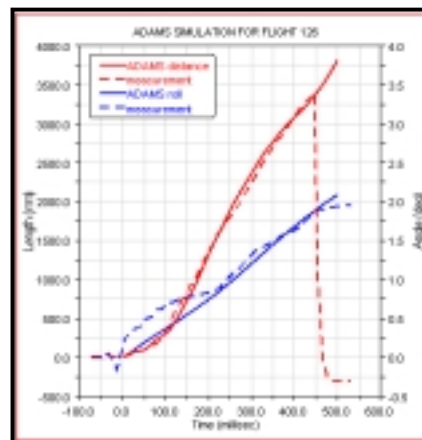
Adams model correlation

- 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 ...

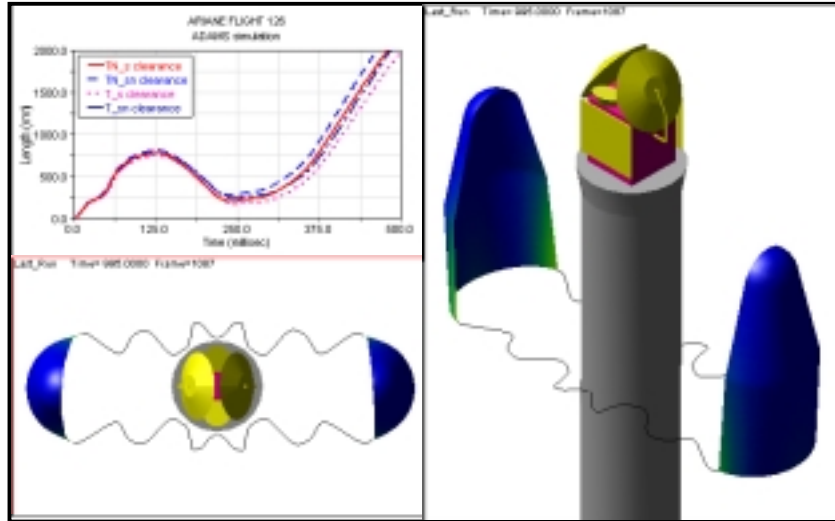


Simulation of flight 126 (...)

- 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 ...



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
 - ◆ powerful 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

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