Multiphysics Numerical Simulation

Application of Multiphysics Numerical Simulations to assess the effects of aircraft systems intrinsic hazards to its physical system installation

FISHING FOR EXPERIENCE

AIRBUS

Barkin Bulut, Humphrey Ochieng, Rebeca Sebastian, Riddhi Desai, Tehsinraza Mulla, Torej Siddiki

Aim

- Ensuring the safety of the aircraft system after exposure to intrinsic threat events, like **tire bursts**, is crucial, as they could potentially affect **hydraulic rigid pipes** and electrical harnesses within the wheel well.
- The aim of the project was to conduct a dynamic simulation to assess the impact of a main landing gear tire burst on the hydraulic rigid pipes of the A320 aircraft.
- The importance of dynamic analysis over the previously employed conservative quasi-static methods by Airbus is highlighted.

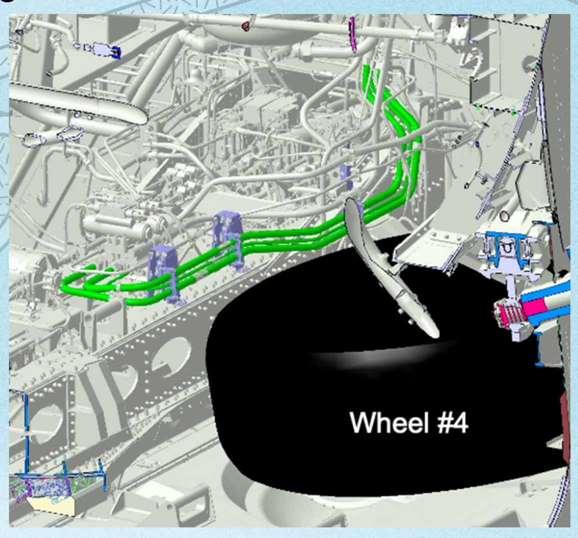

Figure 1: Wheel well of A320 Aircraft

Approach

- Tire blowout complexity limits the experimental research.
- The project aims to study numerically the response of hydraulic pipes to aircraft tire blowout pressure.
- A **Finite Element (FE)** model was established for hydraulic pipe numerical simulation.
- **Empirical blast function** and **equivalent static pressure** defined the tire blowout load.
- Static and Dynamic analysis results were compared.
- **ANSYS student software** was employed for the simulations.

Method

- Dynamic analysis is crucial given the transient nature of the tire burst.
- Two methods are available: Explicit and Implicit dynamic analysis.
- **Explicit dynamic analysis** was chosen due to the short duration of shock loading.
- **ANSYS Explicit Dynamics solver** was utilized for the analysis.
- An empirical blast function from literature was employed for load calculation in dynamic analysis.
- In static analysis, an equivalent static pressure was calculated and applied.

$$P(r,t) = \frac{p_0}{1559.5} \cdot \left(\frac{913.27}{\left[1+\left(\frac{r+0.131}{0.315}\right)^2\right] . \left[1+\left(\frac{t-4.952}{2.579}\right)^2\right]} - 62.7 \right)$$

$$P_s = \frac{1}{\Delta t} \int p(t)dt$$

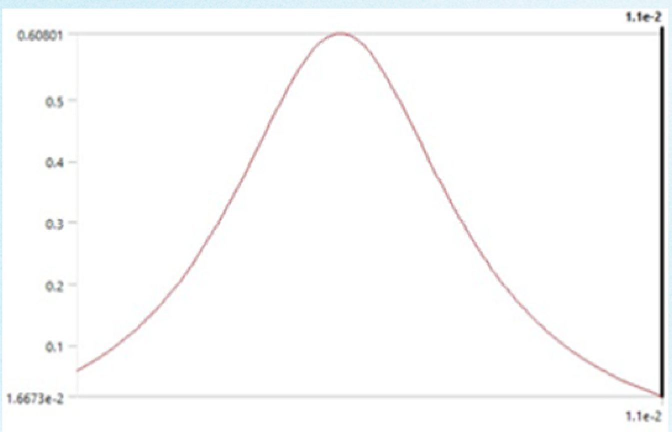

Figure 2: Emperical blast function in time domain

where, *P(r,t): Empirical blast function in kPa*
r: Distance between tire surface and target point on the hydraulic pipe in metres
t: Time of tire blowout in milliseconds
p0: Initial tire inflation pressure in kPa
Ps: Equivalent static pressure in kPa

Considerations

- Tire-to-pipe distance: **0.1667 meters.**
- Blowout event duration: **11 milliseconds**.
- Uniform meshing applied to reduce critical time step in explicit analysis.
- Three hydraulic pipes, fixed with clamp blocks at both ends were analyzed.
- Hydraulic pressure varied: **1000 psi, 2000 psi, and 3000 psi.**
- Blast pressure considered: **22.6 bar.**

Results

Pipe Internal Pressure (psi)	Static Total Deformation (mm)	Dynamic Total Deformation (mm)	Static Equivalent Stress (Mpa)	Dynamic Equivalent Stress (Mpa)
1000	0.103	0.193	86.49	60.68
2000	0.209	0.205	179.74	119.07
3000	0.322	0.299	267.44	183.49

Table 1: Comparison of static and dynamic analyses

Static Analysis | Dynamic Analysis

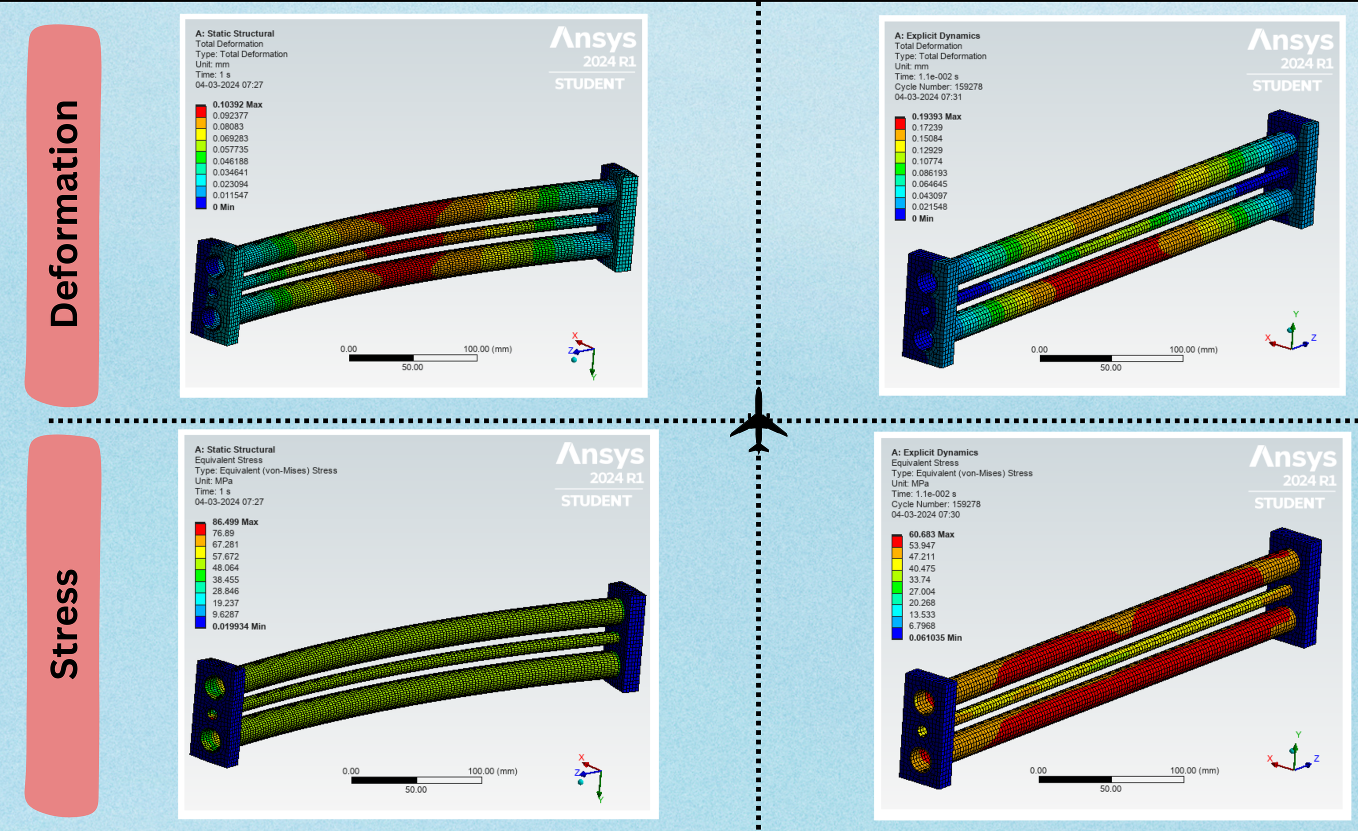

Figure 3: 1000 psi pipe internal pressure

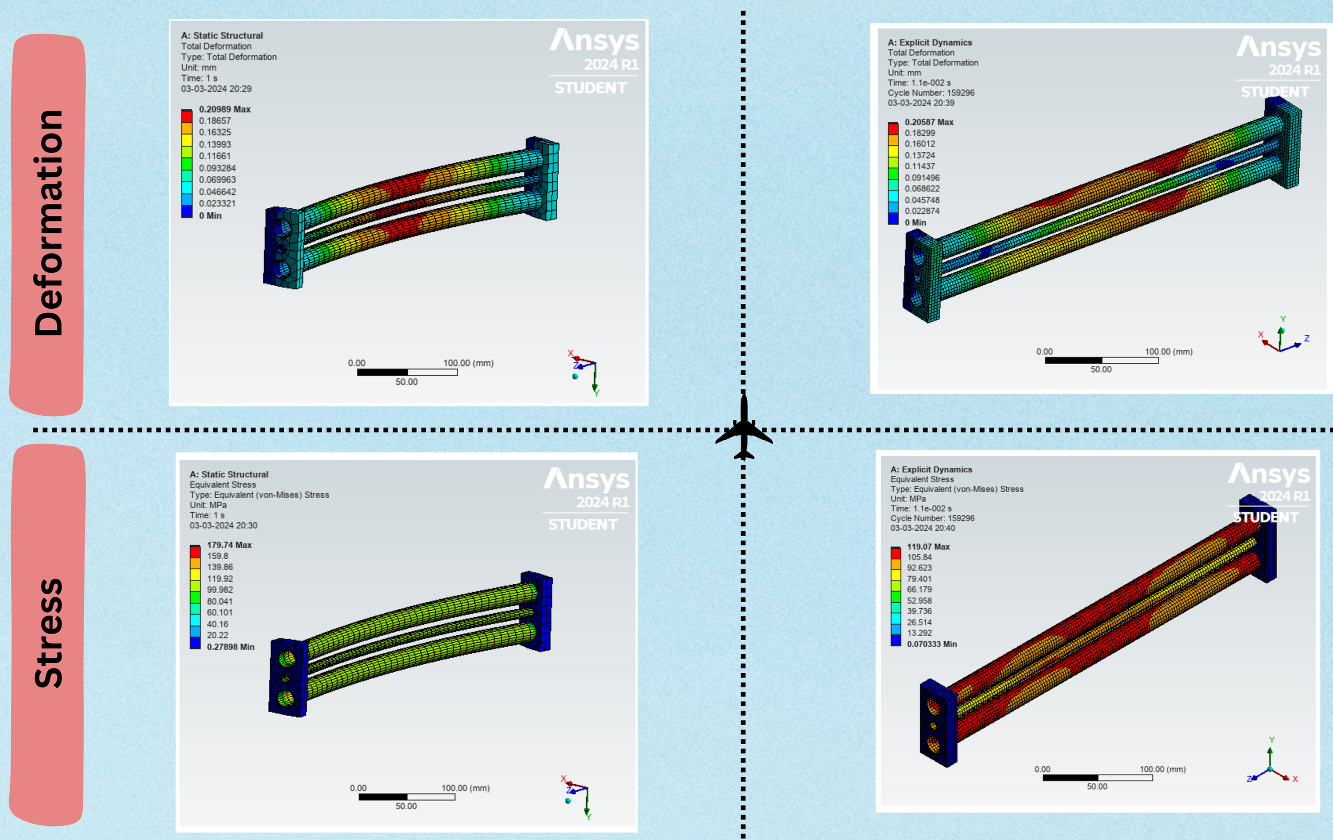

Figure 4: 2000 psi pipe internal pressure

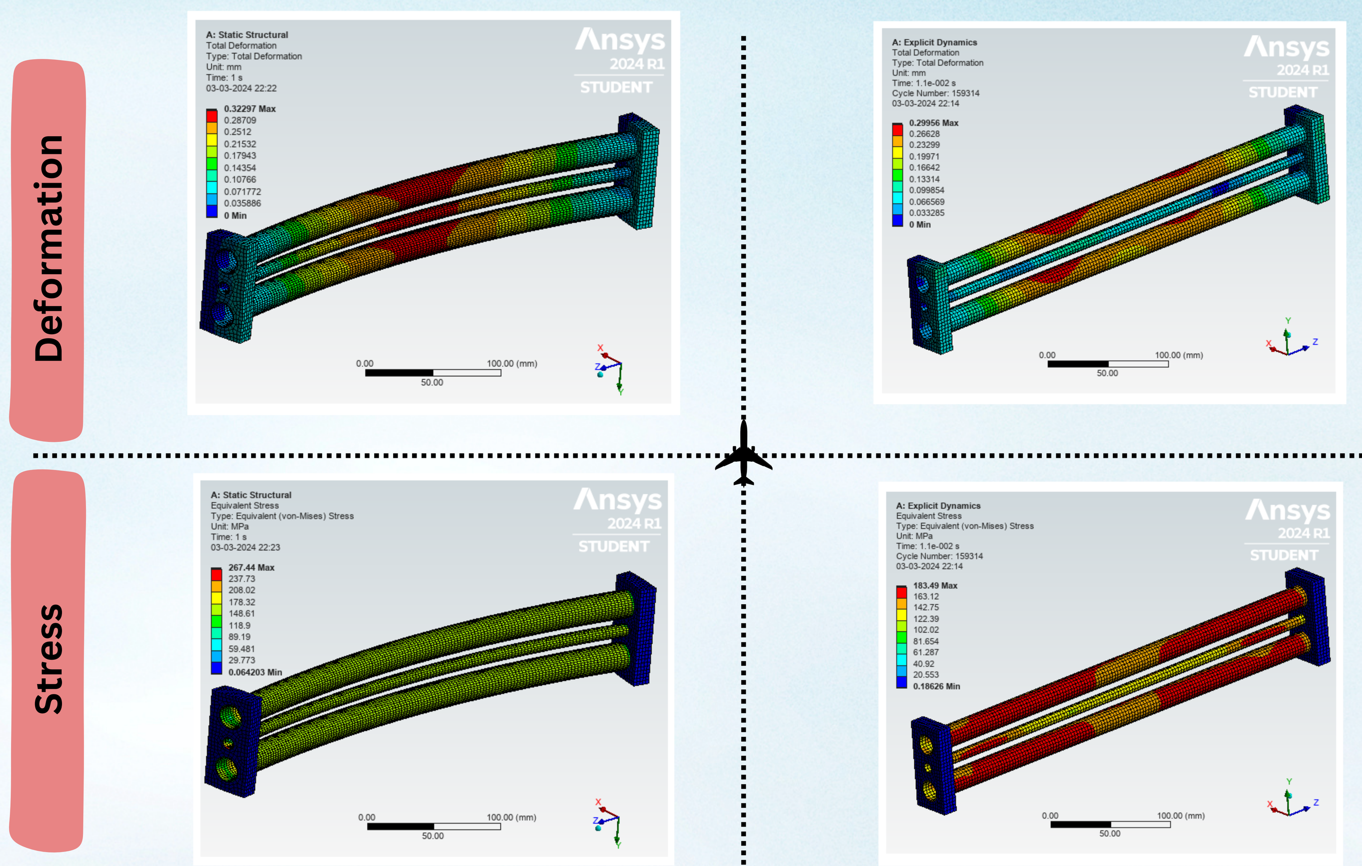

Figure 5: 3000 psi pipe internal pressure

Key findings

- Maximum stresses experienced during static loading exceeded those observed under dynamic loading.
- Stress concentration was more prominent at the **ends of the pipes**.
- Total deformation was slightly higher under static loading compared to dynamic loading.
- A notable difference in **stress distribution pattern** was observed between static and dynamic analyses.
- Despite variations, stresses remained below the yield strength of all the materials, **indicating the safety of the pipes.**

Limitations

- Analysis constrained by **limited computational power** and resources.
- **Student license** of ANSYS limited meshing and parameter fine-tuning.
- Hourglass effect was mitigated with relevant damping coefficients.
- Extensive literature studies are necessary due to the complex nature of tire burst phenomena.
- Hydraulic pipe assembly was simplified due to resource constraints.
- Specific regions of middle pipe showed stress spikes under static loading, requiring further investigation.
- **Validation of results** with existing literature data is crucial for accuracy and reliability.