# SLOWD

## Sloshing Wing Dynamics

## Advancing Aeronautics: Collaborating for Smarter Wing Design

A consortium of industry beneficiaries and academic researchers is coming together with a common purpose – to achieve the following objectives:

**Exploring Dynamic Wing Behavior:**
Launch an experimental campaign to uncover how modern airliner wings (200+ passengers) respond to dynamic loads while carrying fuel. The outcome database of measurements serves as a benchmark for the project's numerical and analytical methods.

**Revolutionizing Numerical Techniques:**
State-of-the-art numerical techniques aiding the design of the experimental campaign and constructing a sophisticated digital twin of the setup.

**Unveiling Efficient Models:**
Evaluate various reduced-order and analytical models, designed to simplify intricate numerical frameworks.

**Integrating Disciplines for Optimal Design:**
Models generated are seamlessly integrated into a holistic design framework.

**"Become a part of this visionary aviation initiative, where collective expertise shapes the next era of wing design."**

## SLOWD Results

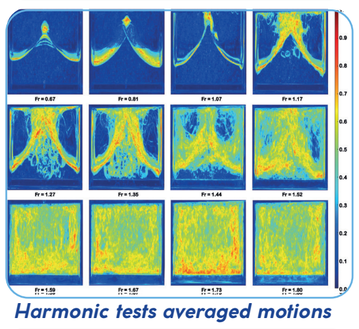
### WP2 Experimental Testing

**Vertical Sloshing in Flexible Structures: Experimental Testing and Achievements**

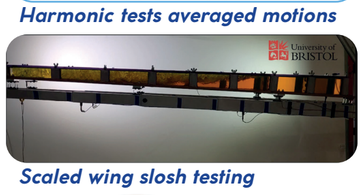
Developed various test rigs for exploring vertical sloshing.

**Main Findings**

- One DOF transient response rigs: Identified turbulent, lateral sloshing, and low-motion phases.
- One DOF harmonic rigs: Frequency and amplitude affect damping levels.
- Scaled (3m long) wing model: Realistic 3D multi-DOF test case for scaling.



*Harmonic tests averaged motions*




*Scaled wing slosh testing*

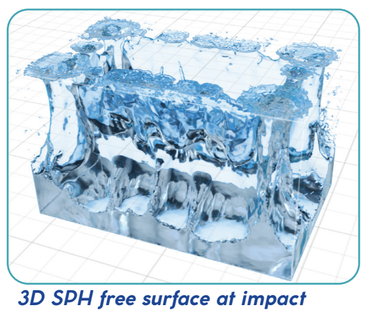
### WP3 Fluid Dynamics

**Advancing Aircraft Fuel Slosh Modeling**

SLOWD advances aircraft fuel slosh modeling for improved design and safety

**Main Achievements**

- Use SPH models and VOF code for slosh-induced load simulation.
- Accurate modeling of 2D and 3D slosh cases.
- Develop scaling laws for aircraft design.



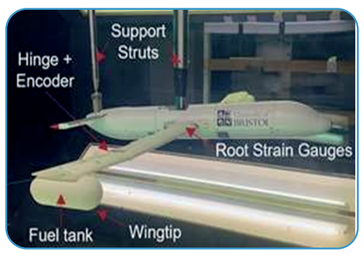
*3D SPH free surface at impact*

### WP4 Structural Dynamics

**Advancing Structural Dynamics Modeling**

**Main Achievements**

- Enabled support for high and low fidelity FSI analyses.
- Shared MiniWoT FE model and experimental data with SLOWD partners.
- Gained insights and calibrated models for nonlinear damping in dry structures.
- Proposed ad hoc models to capture nonlinear effects in aerodynamics and dry damping.
- Described amplitude and frequency characteristics arising from geometric nonlinearity.
- Contributed to FSI coupling understanding and SPH/ROM model development.




### WP5 Fluid/Structure Coupling

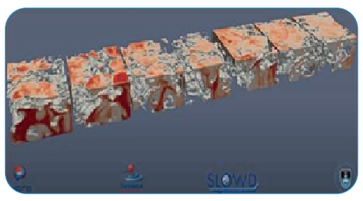
**Advancing Sloshing Simulation**

**Main Achievements**

- Created new software capability for high-performance sloshing simulation.
- Studied fluid slosh effects at varying Froude numbers and baffle setups.

**Key Findings**

- Achieved coupled FSI simulation with commercial closed-source solutions.
- Importance of high-fidelity CFD for sloshing dynamics.
- Baffled regions' impact on damping behavior.
- SPH and VoF suitable for different sloshing scenarios.



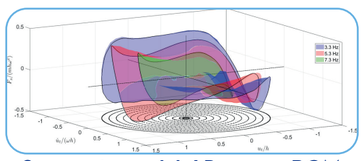

*FSI simulation of Airbus ProtoSpace data using Elemental*

### WP6 ROM and Analytical Models

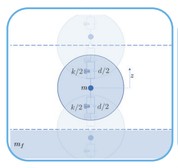
**Fuel Sloshing Reduced-Order Models (ROM)**

**Main Achievements**

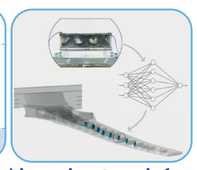
- Accurate sloshing behavior reproduction in diverse applications.
- Pressure ROM computes tank wall pressures precisely & faster than detailed CFD.
- LFD applied successfully to different tank shapes for small perturbations.
- Bouncing ball models, NN-based ROMs, and surrogate models predict sloshing-induced responses.
- Integrated ROMs demonstrate load alleviation in gust response analyses.



*Surrogate model / Pressure ROM*



*Bouncing Ball*



*Neural network for sloshing aeroelastic wing modeling*

### WP7 Integration into Design

**Software Integration: Streamlining Success**

**Main Achievements**

- Comprehensive software managing project structure and configuration data.

Key Functions

- System coordination made easy.
- Flexible configuration options.
- Seamless communication with other work packages.
- Efficient simulation restart.
- Impressive results plotting.

## SLOWD Team

AIRBUS · ArianeGroup · Airbus Defence & Space · easn · University of Cape Town · University of Bristol · Sapienza Università di Roma · Universidad Politécnica de Madrid · UKRI Science and Technology Facilities Council · Consiglio Nazionale delle Ricerche

Connect with SLOWD

https://slowd-project.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815044