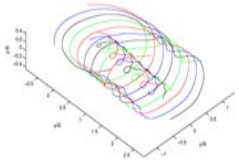
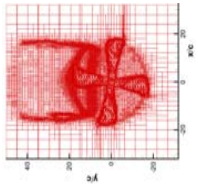
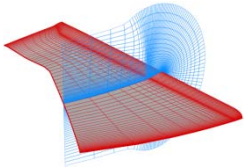
Hybrid Unsteady Simulation for Helicopters - HUSH Overview

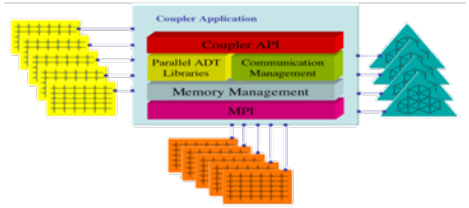






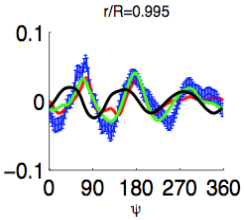
Hybrid CFD solvers

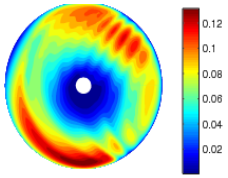
Comprehensive Rotor Modeling

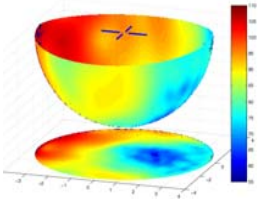


Coupling library

- **Airloads**
- **Structural loads**
- **Performance**
- **Acoustics**



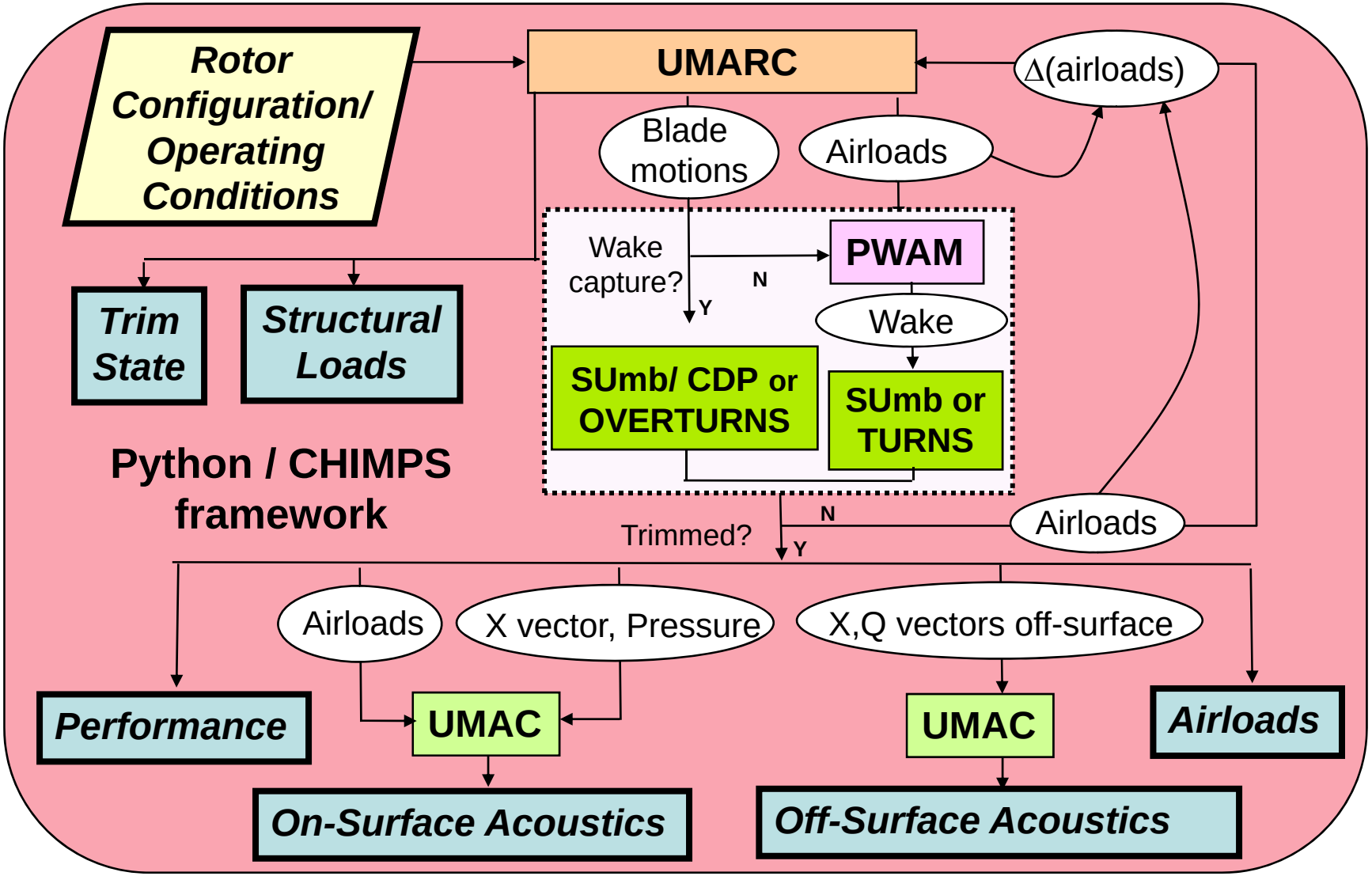




Acoustics module	Grid generation utilities	Data processing utilities

March 3, 2009

Coupling Procedure w/ Acoustics "HUSH"

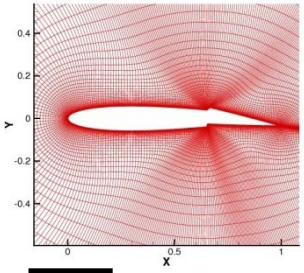


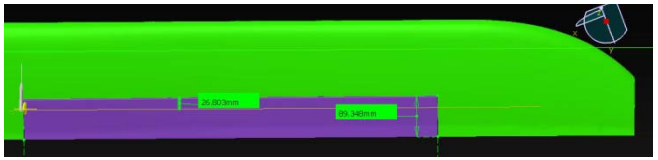
Scope of HQP

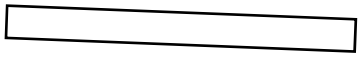
- **5 rotor configurations**
  - **14 flight conditions**
- **Extensive validation with test data**
- **Articulated rotors**
  - **UH-60A (including high speed and stall)**
  - **DNW model test rotor**
- **Hingeless rotors**
  - **HART II model rotor – 40% BO-105**
- **Bearingless rotors**
  - **MDART (pre-production MD900)**
  - **SMART (MDART with TEFs)**
    - **True *PRE*diction of structural loads, performance and acoustics!**

Modeling SMART Rotor with Flaps

- **Specifically, for SMART rotor with flaps**
  - **Loose-coupling to UMARC**
    - **Re-trim / get new deformations (aeroelastic coupling)**
  - **Modify HUSH for unsteady trailing-edge (integral) flaps**
    - **Mesh deformations in vicinity of flap**
    - **Investigate "gap averaging"**
  - **Make sure adequate gap juncture resolution**
  - **Understand effects due to trailing-edge flap**
    - **Trim, blade deformations, structural loads and vibration**
    - **Physics of airloads, performance, wake and acoustics**





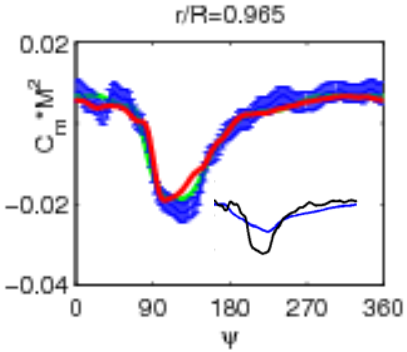


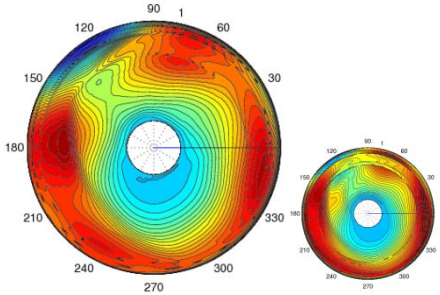
Predict as much ahead of time!

Examine PREdictions to make sure they are reasonable and robust

Technical Conclusions

- **UH-60A rotor**
  - CFD captures 3-D transonic, unsteady moving shocks
  - Improved pitching moment prediction – improved torsion response
  - Improved prediction of the negative lift peak, stall, pitch link loads
- **DNW model rotor**
  - Better acoustics prediction using off-surface methodology
- **HART II rotor**
  - Good agreement for higher harmonics of normal forces
  - Good agreement for BVISPL – confidence in wake modeling
  - Not so good agreement for OASPL – suspect pitch link stiffness
- **SMART rotor**
  - Presence of strong 3-D aerodynamic effects around flaps
  - 2-D aerodynamics insufficient to capture exact flow details





Useful to have multiple tools available, python framework

Summary

- **Three Years Ago**
  - **Only preliminary CFD with full structural coupling simulation validation for small number of conditions but …**
  - ***… Industry became interested in evaluating possibility of CFD capabilities for improving rotor aeromechanical design***
- **One Year Ago: Significant Validation of CFD/CSD/Acoustics**
  - **It appears that new more first-principles based CFD, structural coupling *and acoustics* prediction capabilities are becoming mature enough such that …**
  - ***… Industry can use it to more effectively examine novel rotor configurations for reduced in-plane acoustics w/o performance penalties***
- **The Future *is* the Present**
  - **CFD becomes *more efficient, robust, accurate* with more extensive validation testing and applications to novel rotorcraft configurations and continuing improvement in the size and speed of computer simulations so that …**
  - ***… Industry becomes confident in CFD results as a major tool in rotorcraft design (performance, structural loads, vibration, noise)!***