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SCIENTIFIC COMPANY
A Teledyne Technologies Company
Formerly Rockwell Science Center

Integral Textile Composites: Design and Modeling Tools

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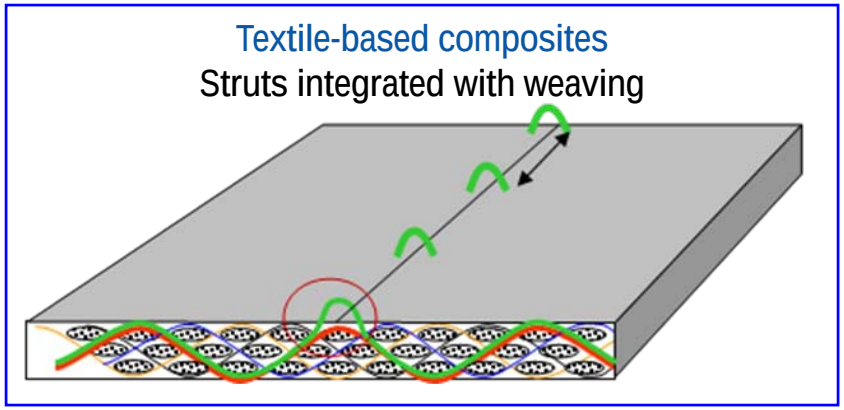
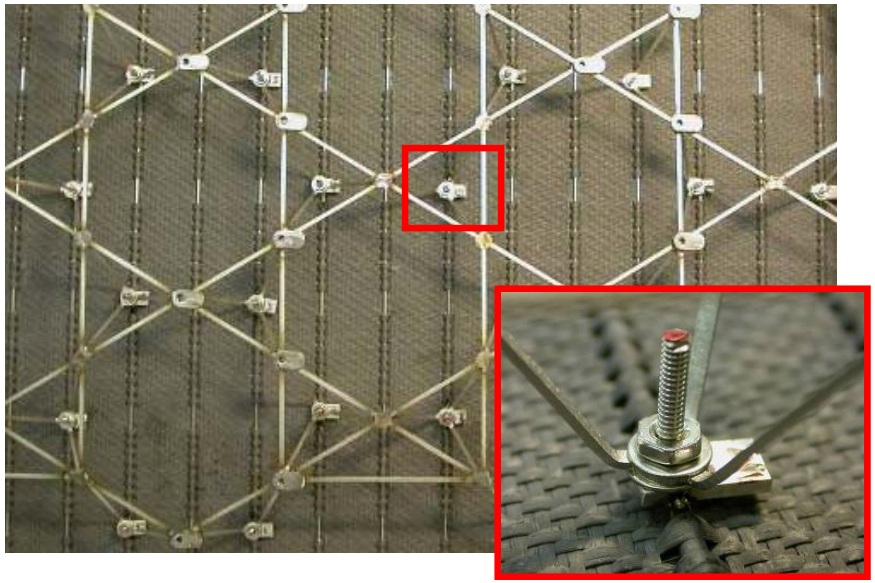
Textile Based Composite Technologies

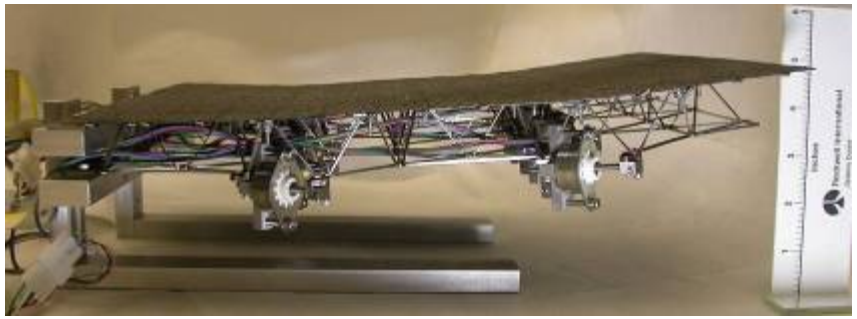
- Textile woven 3D fiber architecture provides high strength in 3D
  - No delamination risk
- Compliance can be tailored to meet the actuation requirements
- Attachments for the backing structure and actuation system are integrally woven into the preform
  - High strength bond
  - No perforation of flow surface
- Both polymer matrix and ceramic matrix composites can be fabricated
  - Ceramic composites provide improved impact and erosion resistance.

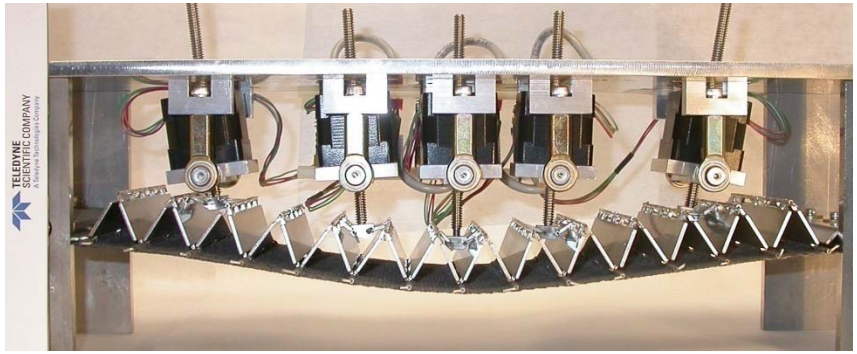


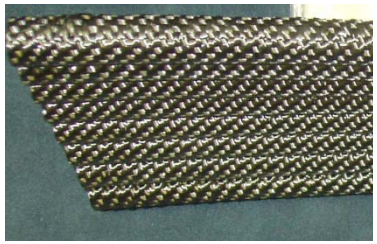


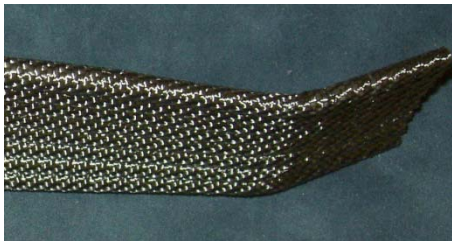
Complex Ceramic Matrix Composites

- Ceramic Matrix Composites offer high toughness and damage resistance
  - Leading edge applications
- Significant deformation possible with thin CMC skins with high fatigue resistance
- Weaving of complex shapes possible
  - Integrated attachments
  - Double curved structures
  - Airfoil shapes
- Strength not feasible with tape layup structures



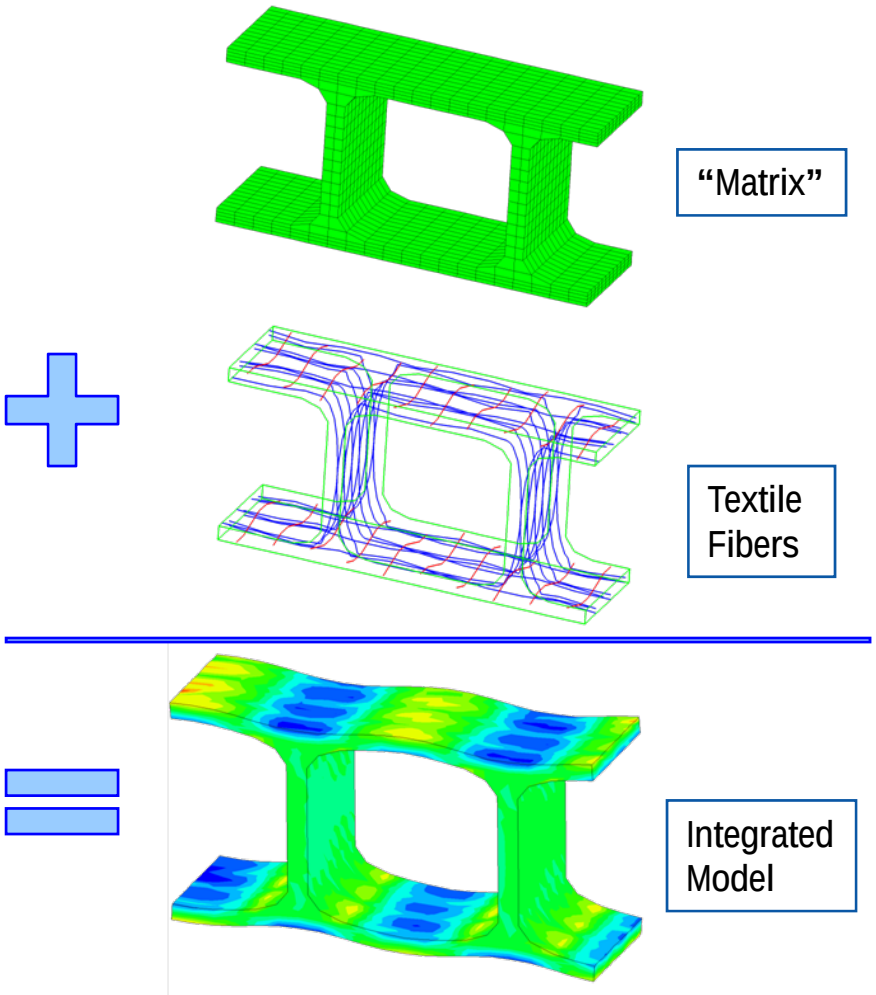






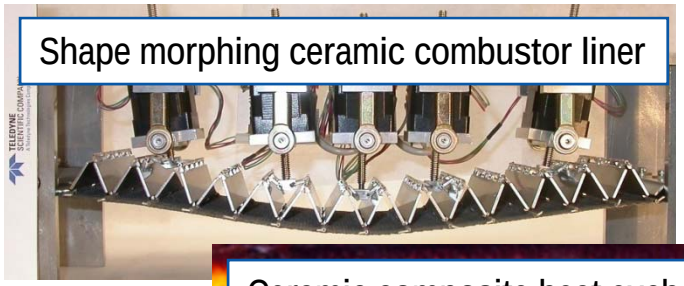
Modeling of Composite Materials

- *Binary Model* – The Simulation Tool for Fiber Reinforced Composites
  - Exact knowledge of localized conditions on a fiber tow scale
  - No periodicity assumption
  - Multi-scales: structural + fiber tow
  - Effects of fiber tow topology
  - Nonlinearity
- Failure analyses at single tow level (tows fail as discrete entities)
- Computational efficiency permits large component models on standard PC hardware
- Applicable to polymer & ceramic composites

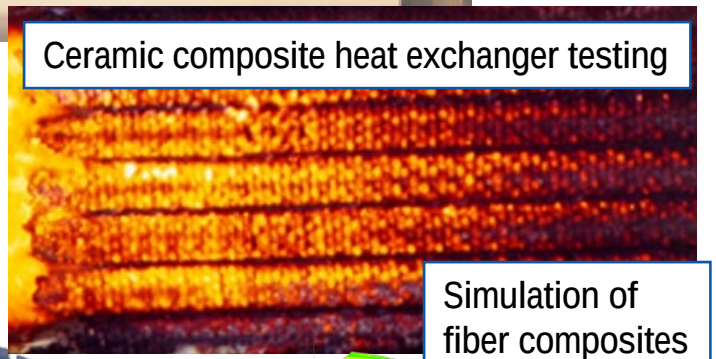


Teledyne Scientific Company

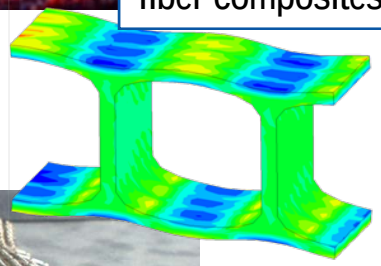
- Formerly Rockwell International Science Center
- 30 yrs of history in basic research, contract R&D, full prototype development & testing
- Fully equipped on-site shop and analytical lab for design, fabrication, testing & QA
- Extensive experience in materials and process selection and multifunctional structure design
- Close cooperation with other Teledyne units for integrated solutions



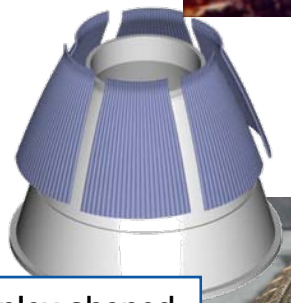
Shape morphing ceramic combustor liner

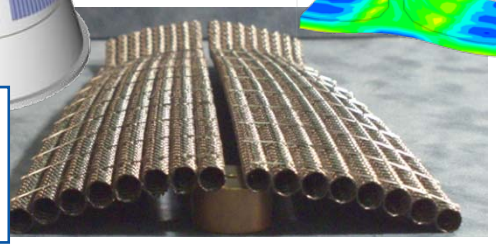


Ceramic composite heat exchanger testing



Simulation of fiber composites





Complex shaped integrally woven fiber composites

High Fidelity Multidisciplinary Tool Development for Helicopter Quieting

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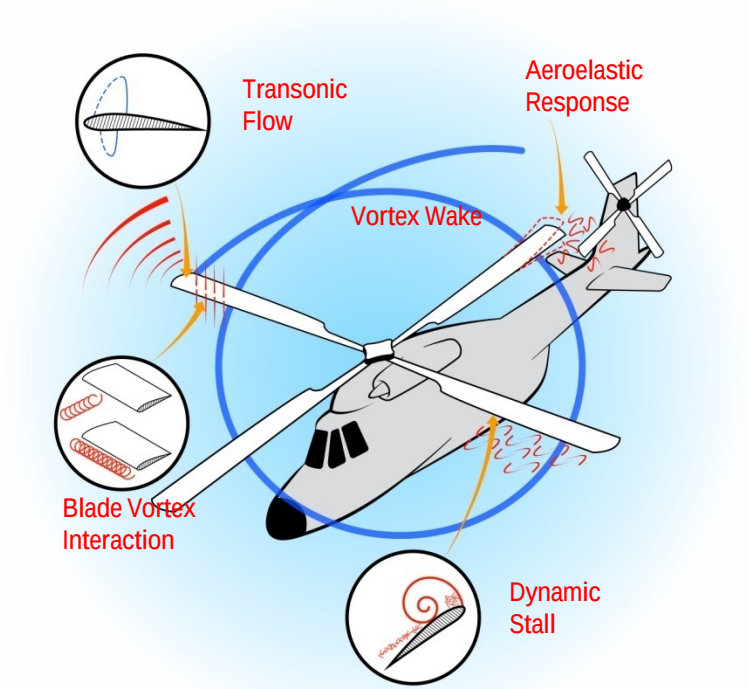
Teledyne Scientific Company

Team Members: R. Jain, Z. J. Wang, H. Saberi, T. Lund and T.H.Shih

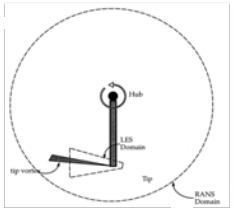
Hypercomp, ISU, ART, CU and OAI

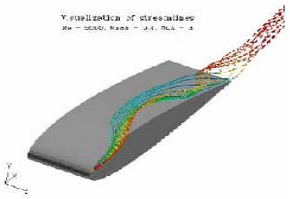
TSC Technical Approach



Advanced Hybrid RANS/LES enabling high fidelity simulation of complex flowfield

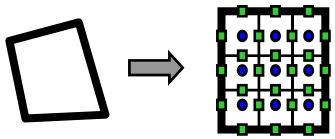
- DES, PRNS and nonlinear $\kappa-\varepsilon$ models
- Zonal LES/RANS approach



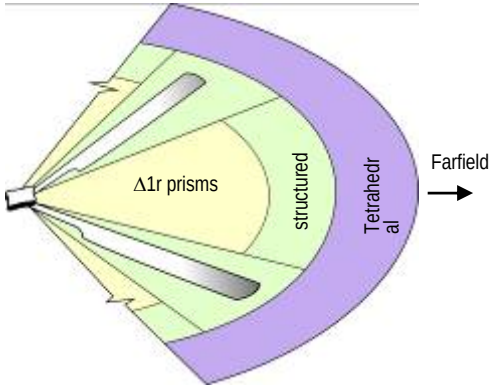


State-of-the-Art Numerical Discretization offering accurate solution in affordable time frame

- WIND-US unstructured solver can simulate complex geometry with minimum number of mesh points
- Spectral difference approach can capture diverse length scales with minimum CPU time
- Parallel computing



Extra unknowns are introduced to fit high-order polynomials within each cell.

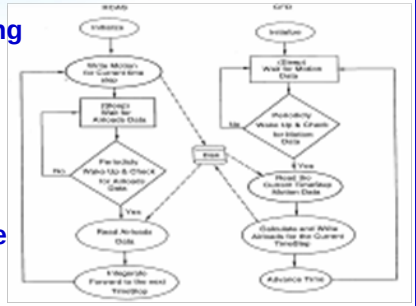


WIND-US CFD/RCAS coupling providing a breakthrough in prediction accuracy for rotorcraft aeromechanics characteristics

- Loose coupling

WIND-US acoustics interface

- PSU-WOPWOP



WIND-US/RCAS Based Helicopter Rotor Simulation Tool

Spectral Difference

Multigrid

2nd Order in Time

Moving Grid

Grid Deformation

CSD Interface

Scalable (parallel efficiency)

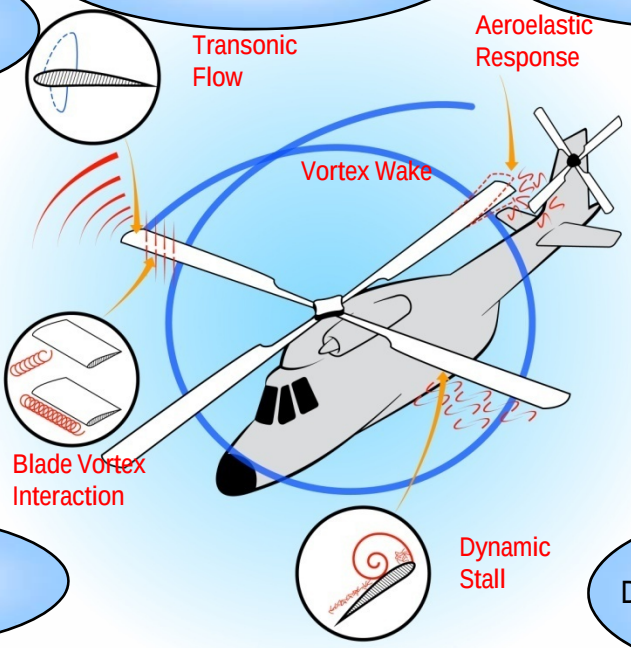
Free wake modeling

Spalart-Allmaras

DES, PRNS, Zonal RANS/LES

Nonlinear $\kappa-\varepsilon$

Acoustics Interface



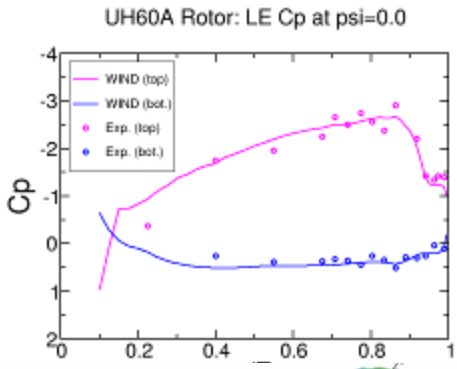
RCAS

PSU-WOPWOP

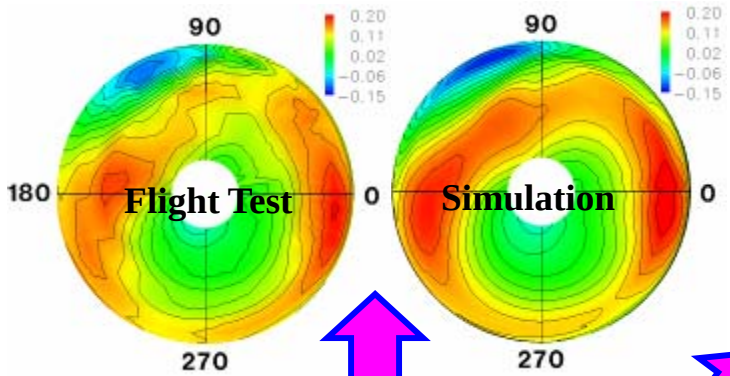
Ready for Morphing Blades

Simulation of Rotor Flows

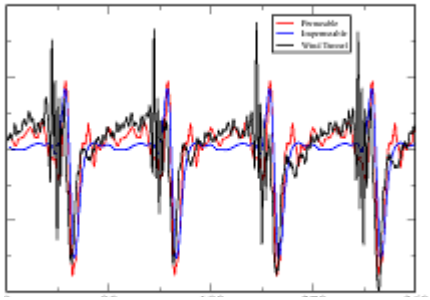
Rotor Performance

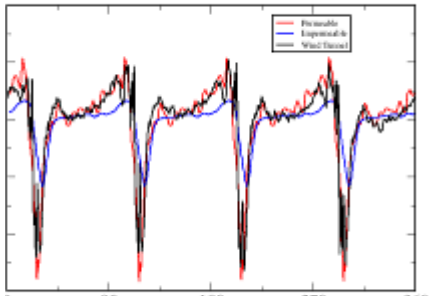


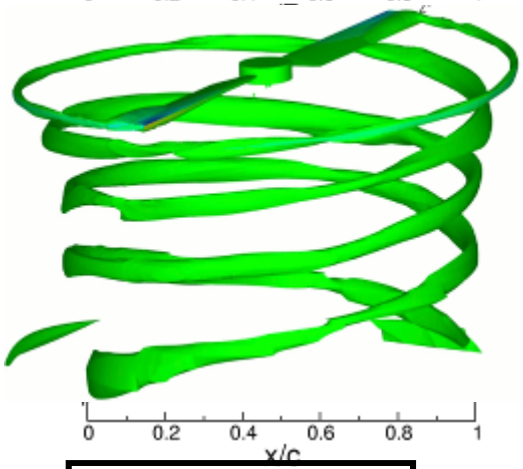
Rotor Disc Loading



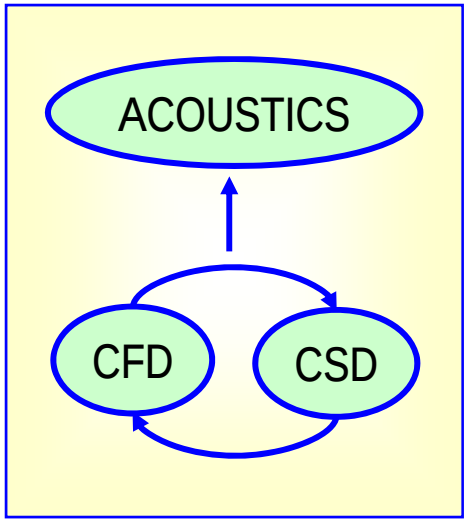
Far-field Acoustics







Wake Capturing



Blade Dynamics: Controls & Deformation Motions

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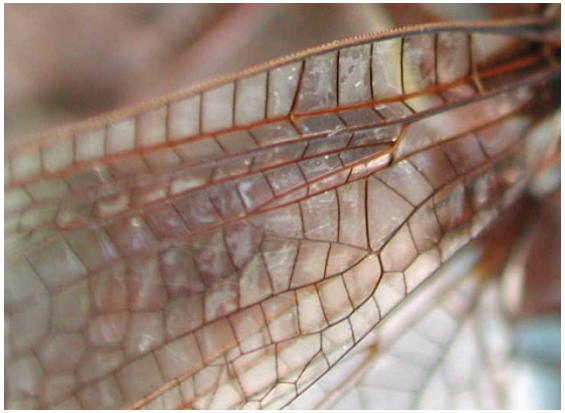
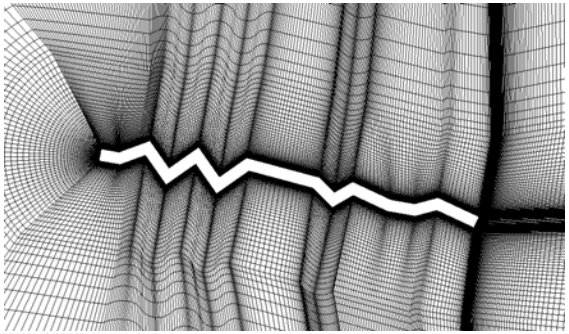
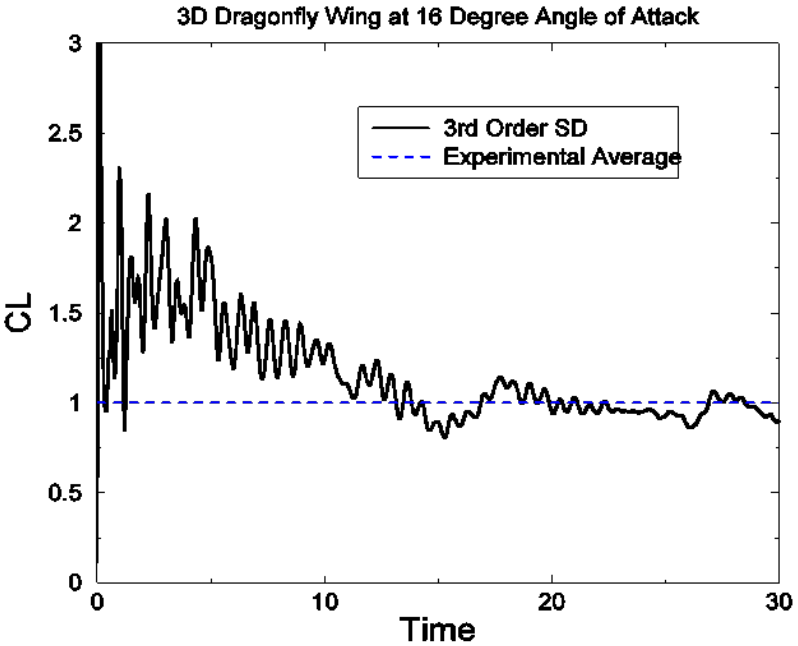
Flow over Corrugated Dragonfly Airfoil – SD Approach

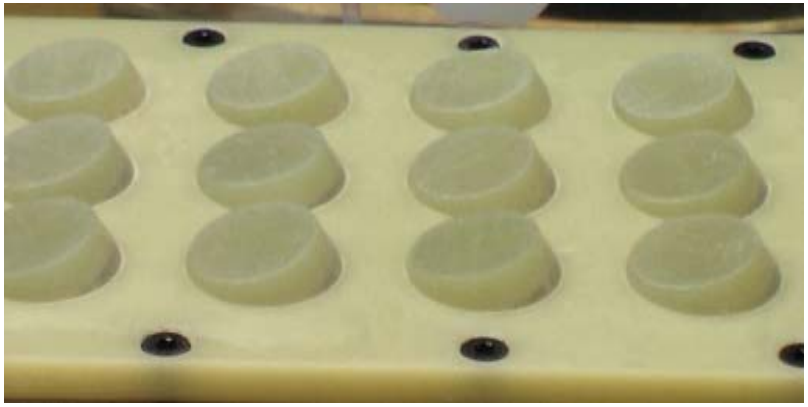
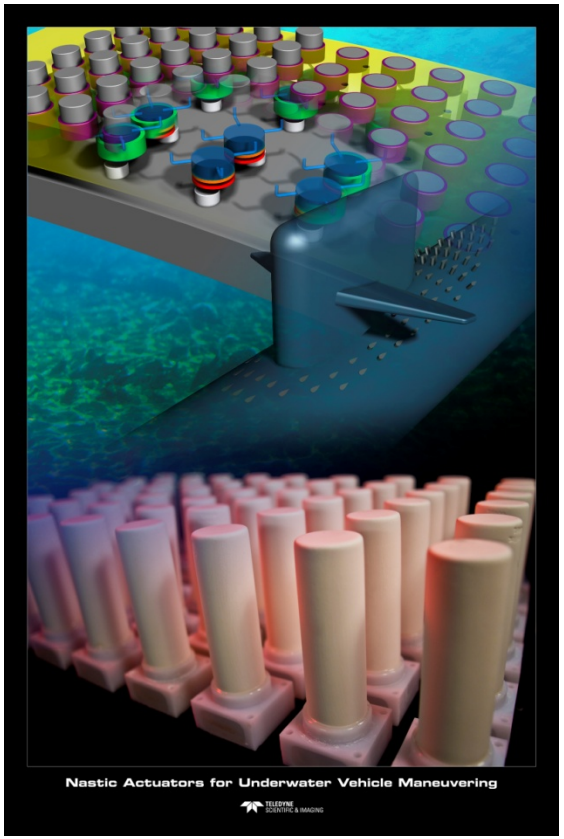
- Flow conditions: Re = 34,000, AOA = 16 deg. (stall regime)
- Computational mesh
  - 3D: 46,400 cells (1.25M DOFs, 3rd order SD)







Morphing with Nastic Actuation



Dynamic Bumps