U.S. Air Force Research Laboratory's Need for Flow Physics and Control with Applications Involving Aero-Optics and Weapon Bay Cavities

23 Aug 09

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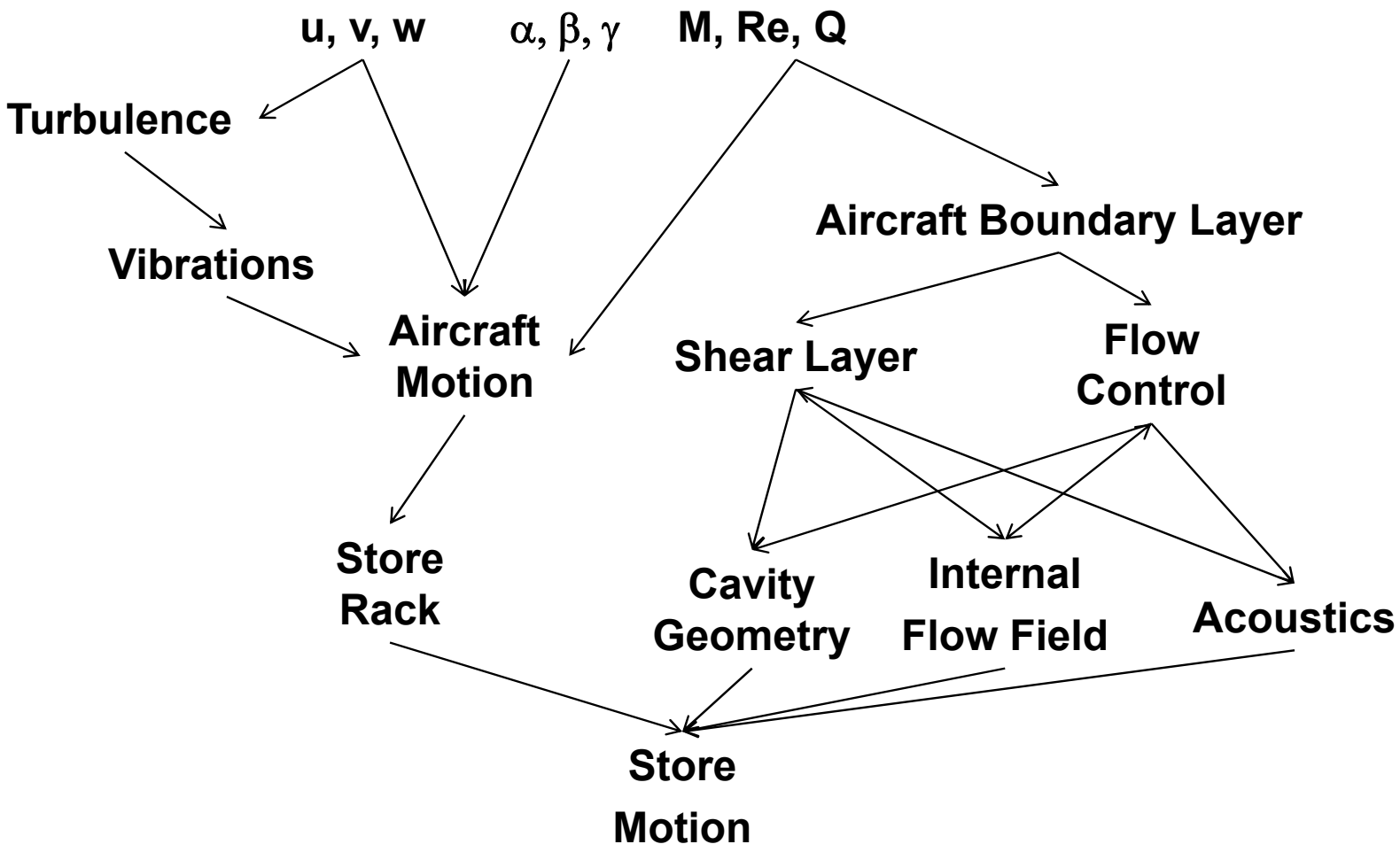
When the Calculations say it should work sometime the Physics doesn't listen

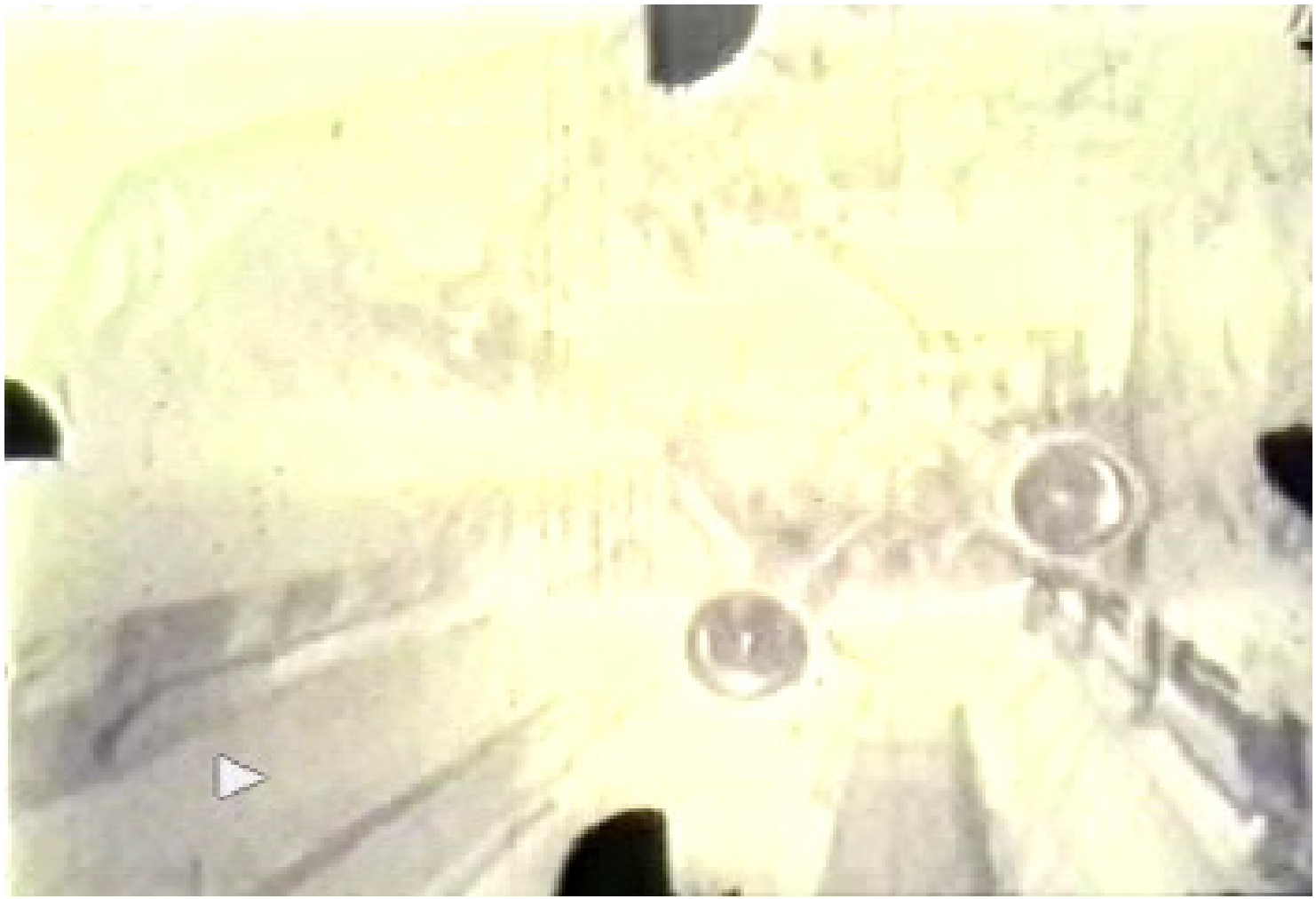
Click to play animation

filename: 03Movie Clip Public2.wmv

Internal Store Motion Interaction



Inside a Weapons Bay



Click to play animation

filename: 03bomb-bay.mpg

Consequence

- Store Motion
  - Deploys Properly
  - Becomes unstable in flight
  - Strike aircraft
- Flow Physics
  - Damage to Aircraft, Equipment and Store
    - Mainly from Acoustic levels

Flow Control

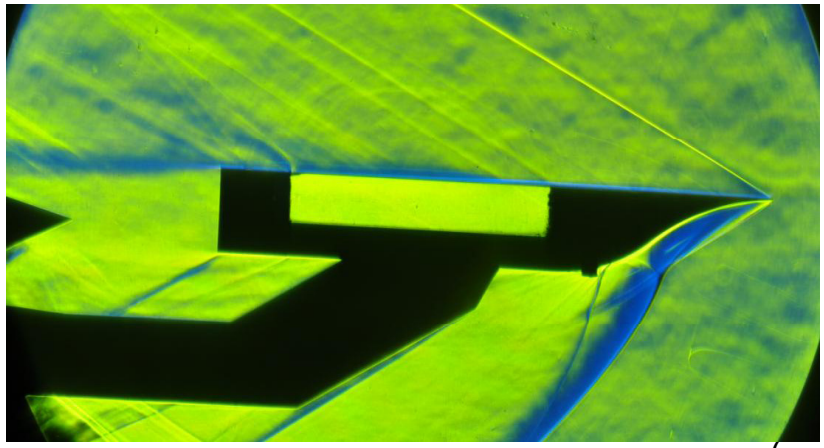
- Geometry Modification
  - Fences, Spoilers, Rod-in-Cross Flow
- Open Loop Control
  - Pulsed Blowing, Suction, Plasma
- Closed Loop Control
  - Feedback Flow Control with Pulsed Blowing

- You name it, it has been tried
  - The shot gun approach

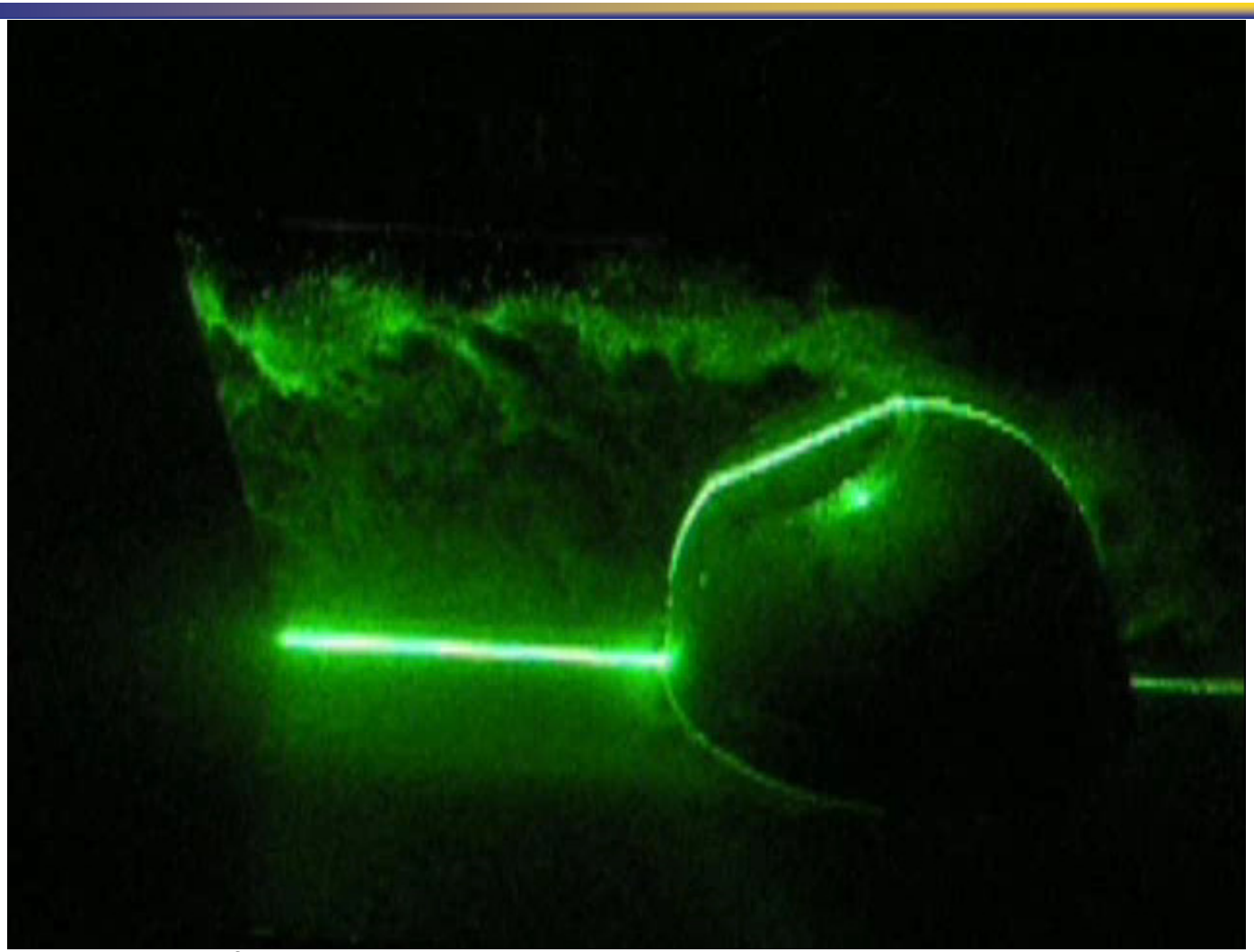
Flow Physics

- **Trisonic Gasdynamic Facility**
  - PIV
    - Seeding Methods
      - CO_2
      - ViCount Fluid
  - Optic Nozzle Blocks
  - Seedless PIV
  - PSP

- **Advance Diagnostic Development Inside a Cavity (ADDICT)**
  - Examine how flow control effects the flow physics at 10% scales cavity



Near Field Aero Optics Flow Control



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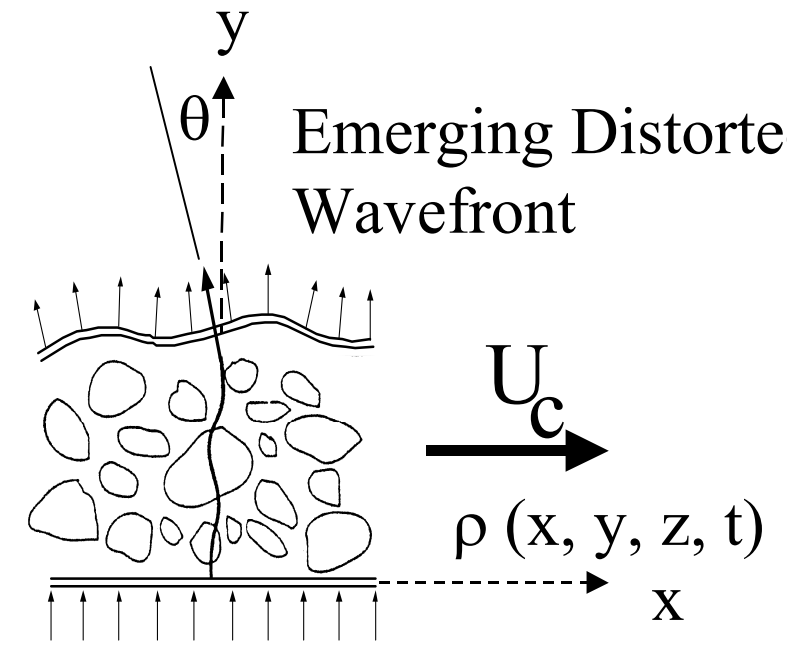
Background on Aero Optics



Optical Path Length

$$OPL = \int_{y_1}^{y_2} n(x_o, y)dy$$

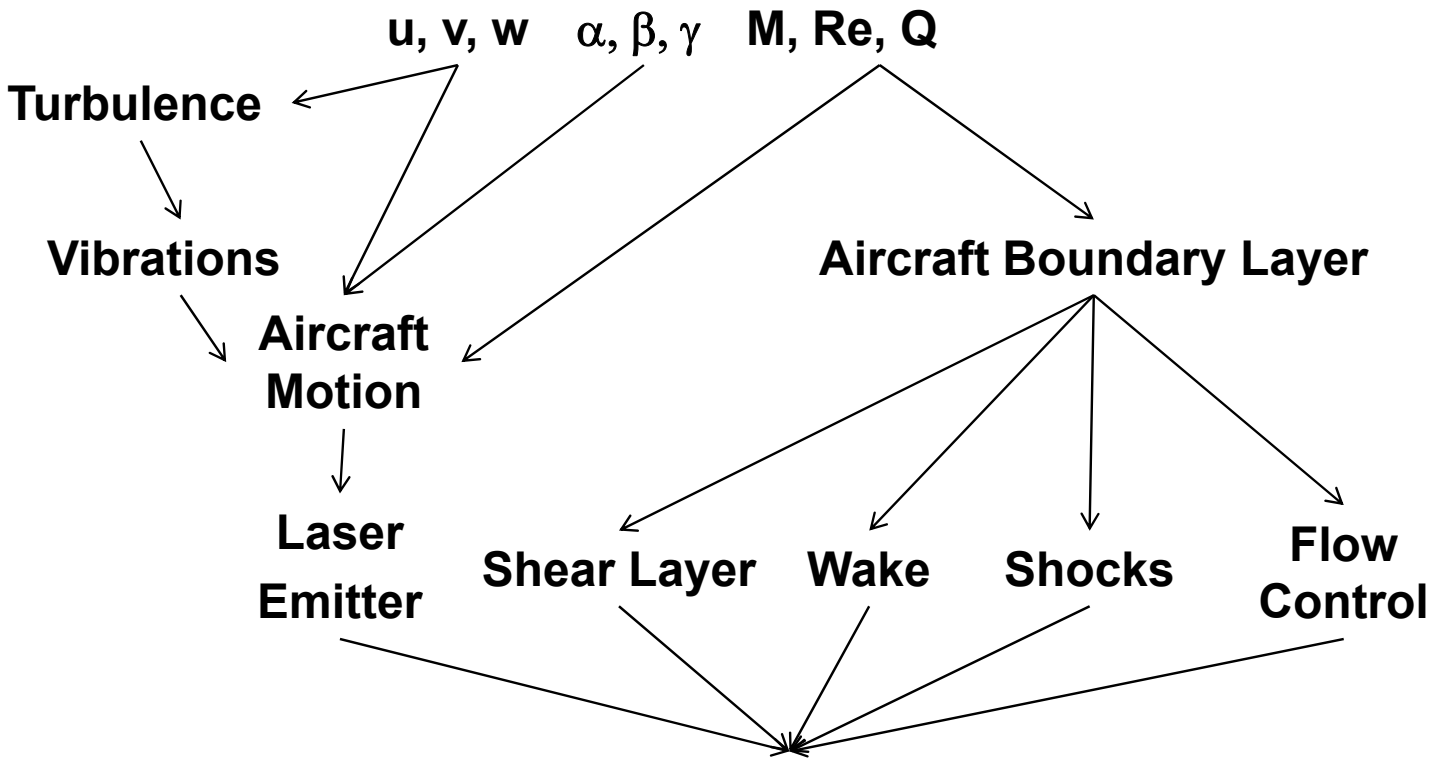
Integration of index over path length

Optical Path Difference

$$OPD(x_o) = OPL(x_o) - \overline{OPL}$$

The difference between mean and instantaneous OPL

Aero-Optic Interactions

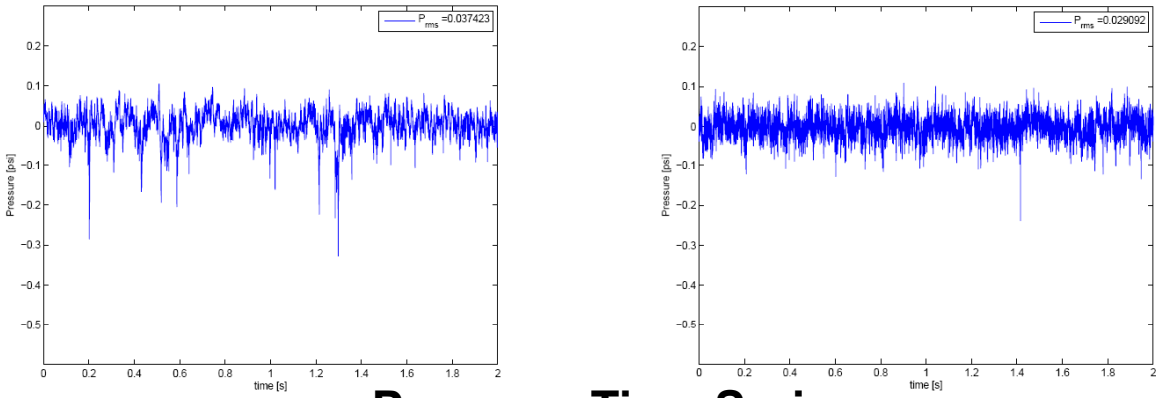


Reduce Density Fluctuations to Increase Energy on Target

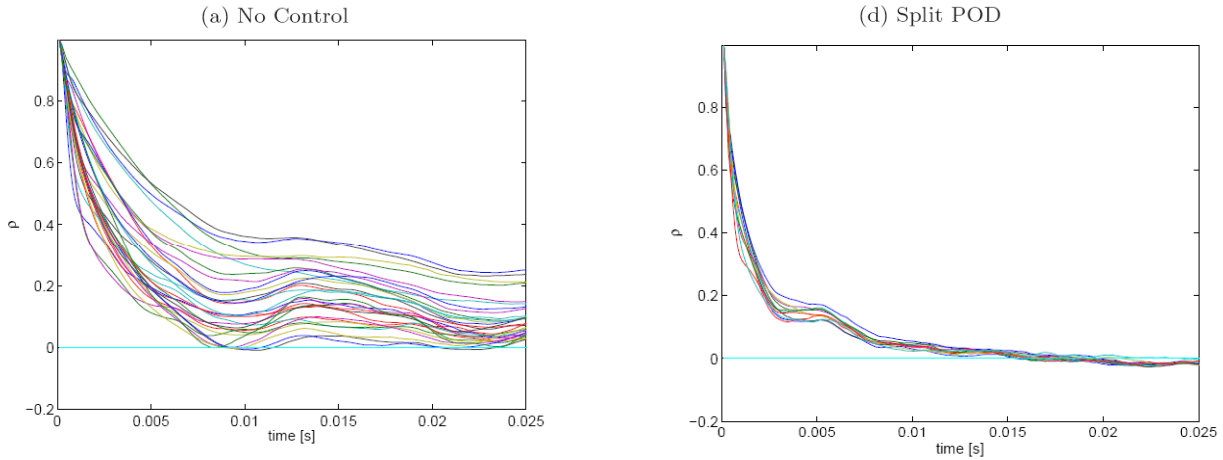
Flow Control for Aero-Optics

- Used Shot Gun Approach for Flow Control
  - Pulse Blow, Pins, Combustions, etc.
- One of the best but not yet completely proven methods
  - Closed Loop Control using Split POD.
    - Split POD was developed by Chris Camphouse
    - Separate baseline from control flow field properties to produce proper actuation characteristics for Closed Loop Flow Control
    - Provides Flow Physics Knowledge to the Flow Control Device

Closed Loop Flow Control for Near Field Aero-Optics



Pressure Time Series



Pressure Autocorrelation

Conclusions

- To develop New Flow Control Techniques
  - Knowledge of the Flow Physics with and without control
  - How does Flow Control Effect Flow Physics
    - What Works to Optimize the Design?
  - Energy or Work Efficiency of the Control Technique
    - Cost - Risk - Benefit Analysis
  - Supportability, e.g. (size of equipment, computational power, power supply)
    - Allows Designer to include Flow Control in Plans