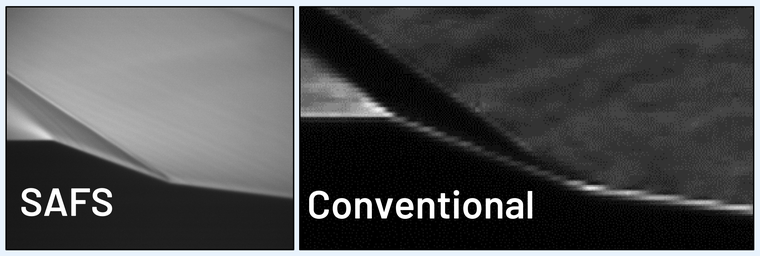
National Aeronautics and Space Administration

Self-Aligned Focusing Schlieren (SAFS) Flow Visualization Technique

A compact, low-cost, easy-to-use flow visualization tool

Challenge

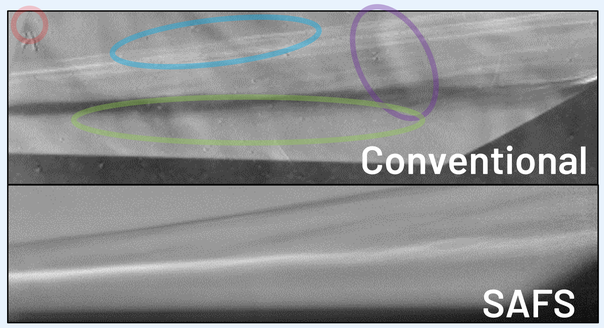
- Understand how fluid flow interacts with bodies of interest
  - Simple wind tunnel models: Further understanding of fundamental physics
  - Aircraft/spacecraft: Measure flow field to evaluate full vehicle designs
- Requires non-intrusive, off-body measurement
  - Sensitive, compact, inexpensive, easy to align and adjust, quick setup time



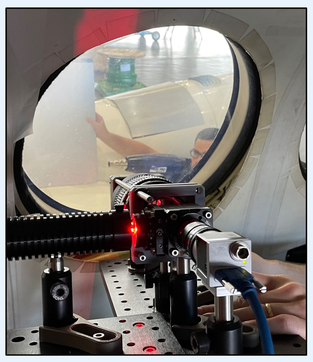
Comparison of SAFS (left) and conventional schlieren (right) images, cone-flare at Mach 3, with Mach waves from model's 3D printed layer lines visible in SAFS images

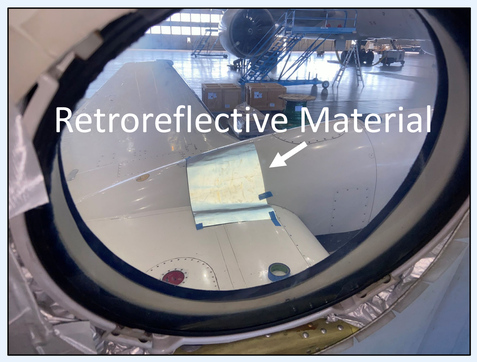
Expected Impacts

- CFD: High-quality flow visualization images for CFD simulation comparison/validation
- Researcher: Focusing schlieren now available as a tool for any researcher regardless of experience
- Flight testing: Simple flow visualization tool for flight testing and aircraft integration
- Big picture: May replace many existing conventional schlieren systems

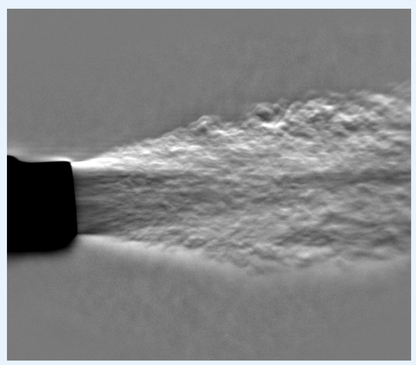


Comparison of conventional schlieren (top) and SAFS (bottom), demonstrating elimination of window defects, path integration, HVAC thermals, and window boundary layers





SAFS installed inside Beechcraft B200 King Air, with curved retroreflective material on engine cowling



Heat gun flow at propeller tip vortex position, demonstrating SAFS feasibility

Solution

- SAFS system significantly reduces complexity of traditional focusing schlieren systems
  - Uses only one source/cutoff grid instead of two
  - Manipulates polarization of light for maximum light intensity throughput and window glare elimination

Results

- Compact, with quick setup time (on the order of minutes)
- Insensitive to vibration
- Requires only single-sided optical access
- High-quality windows not needed
- Narrow depth-of-focus isolates only relevant flow features
- Resolution and sensitivity comparable to conventional schlieren
- Uses polarized light to eliminate window glare
- Non-orthogonal imaging for limited optical access facilities
- High-speed imaging possible (> 1 MHz)

Ongoing Work

- Quantify sensitivity of system
- Develop software to aid in preliminary system design
- Implement system in supersonic flight vehicle (AFRC F-15)
- Aid other researchers in their own design applications

Partners and/or Participants

- NASA Transformational Tools and Technologies Project
- NASA Advanced Air Transport Technology Project
- NASA Flight Demonstrations and Capabilities Project
- NASA Revolutionary Vertical Lift Technology Project

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