BOUNDARY-LAYER TRANSITION DETECTION MEASUREMENTS IN THE UNITARY PLAN WIND TUNNEL

by

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OBJECTIVES

- Evaluate four measurement techniques
  - Very thin hot film gauges
  - Liquid crystals
  - Infrared photography
  - Optical interferometry
- Perform evaluations under as close to identical conditions as possible
- Assess ease of use as well as accuracy in anticipation of applying to wind tunnel testing

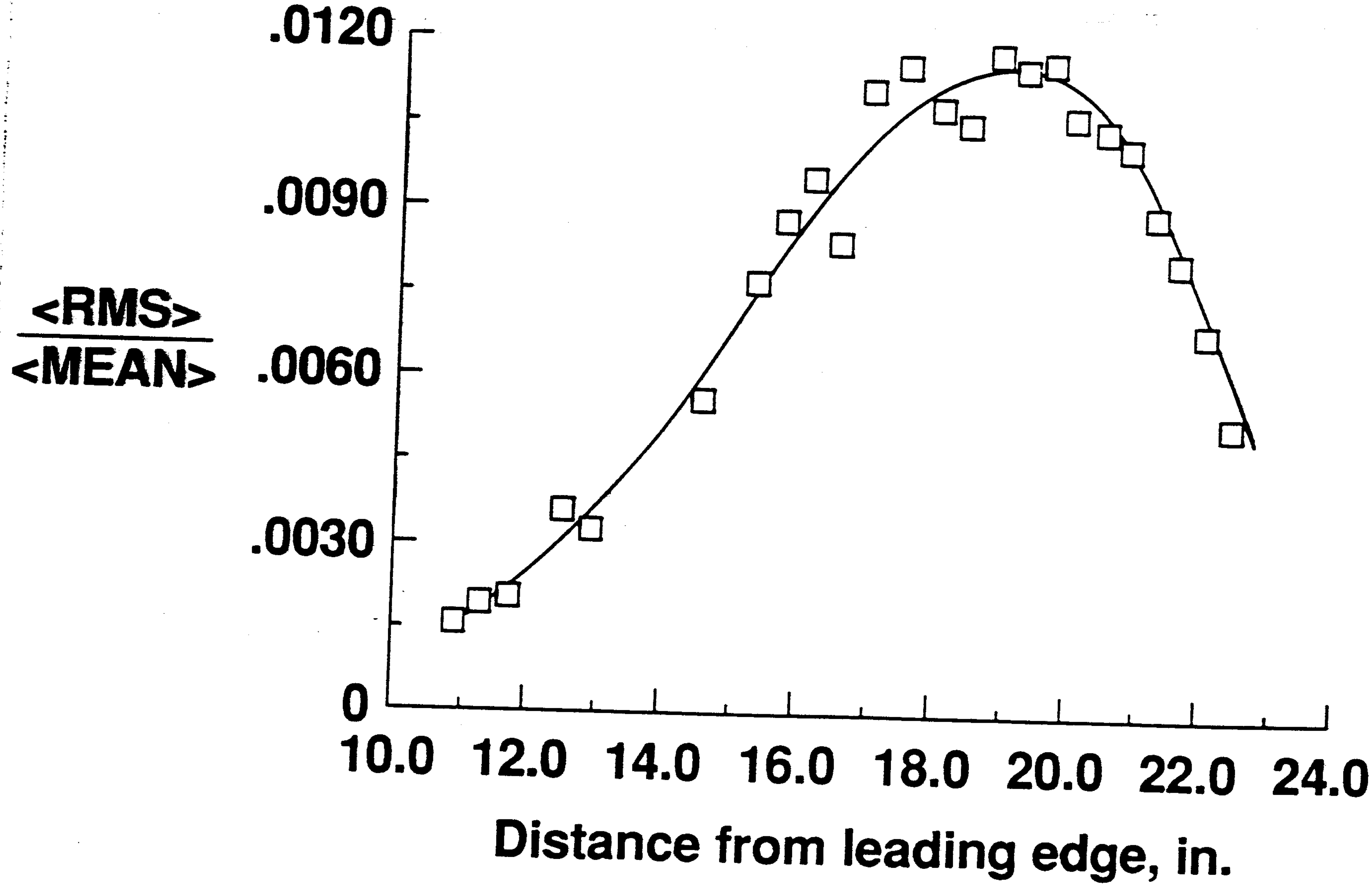
TECHNIQUES INVOLVED

- Very thin film gauges developed by Charlie Johnson (FIMD), Debbie Carraway (IRD), Sang Tran (FD), and Jim Bartlett (FD)
- Liquid crystals—Cliff Obara(Lockheed)
- Infrared optical photography—Bob Wright (IRD)
- Optical interferometer developed by Spectron Development Laboratories, Bob Hall (AAD) was NASA monitor

Note: Tunnel personnel include Pete Covell and Floyd Wilcox (AAD)

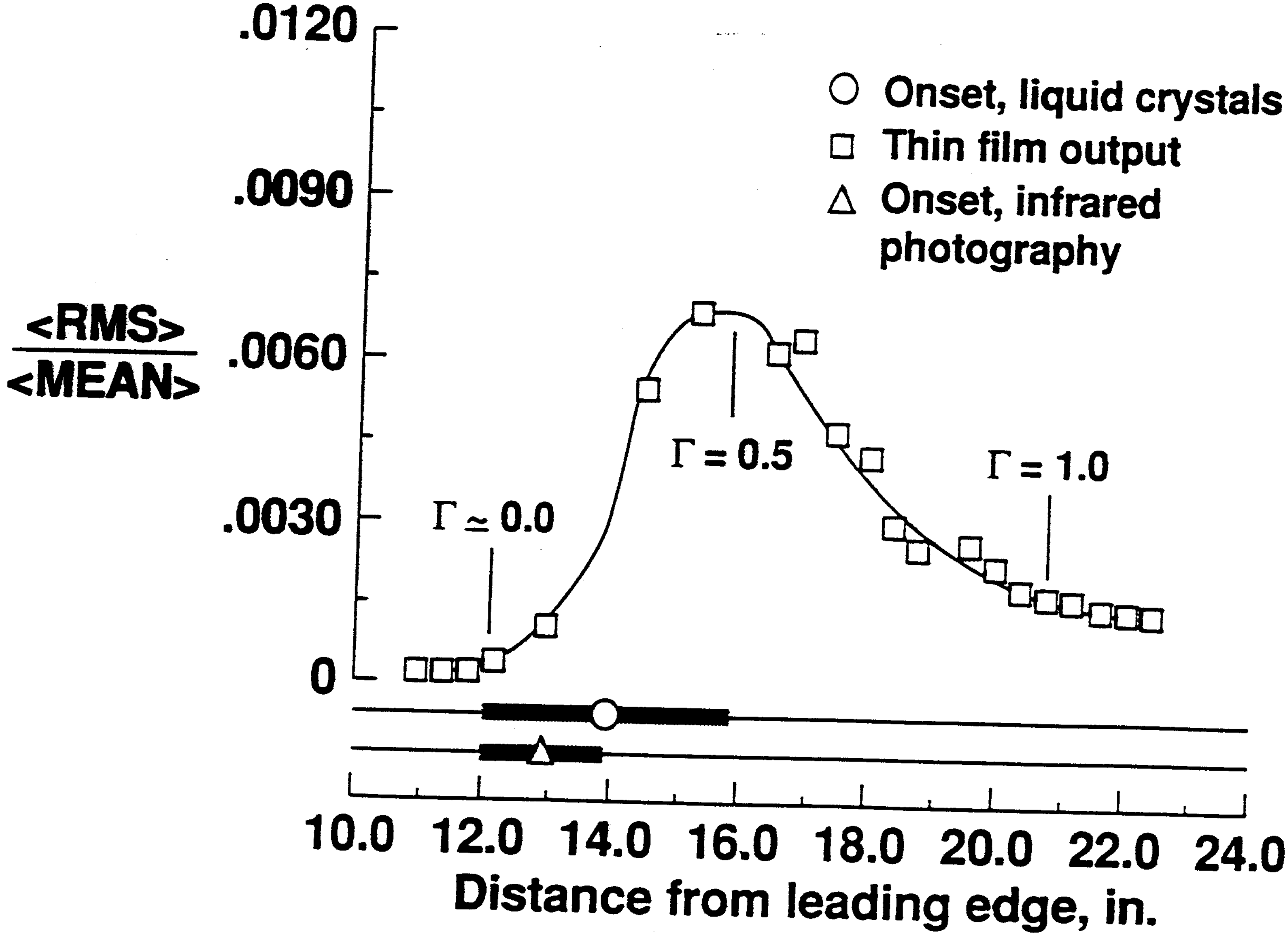
TYPICAL THIN FILM DATA

$M_\infty = 1.5$, $R/ft = 3.0 \times 10^6$

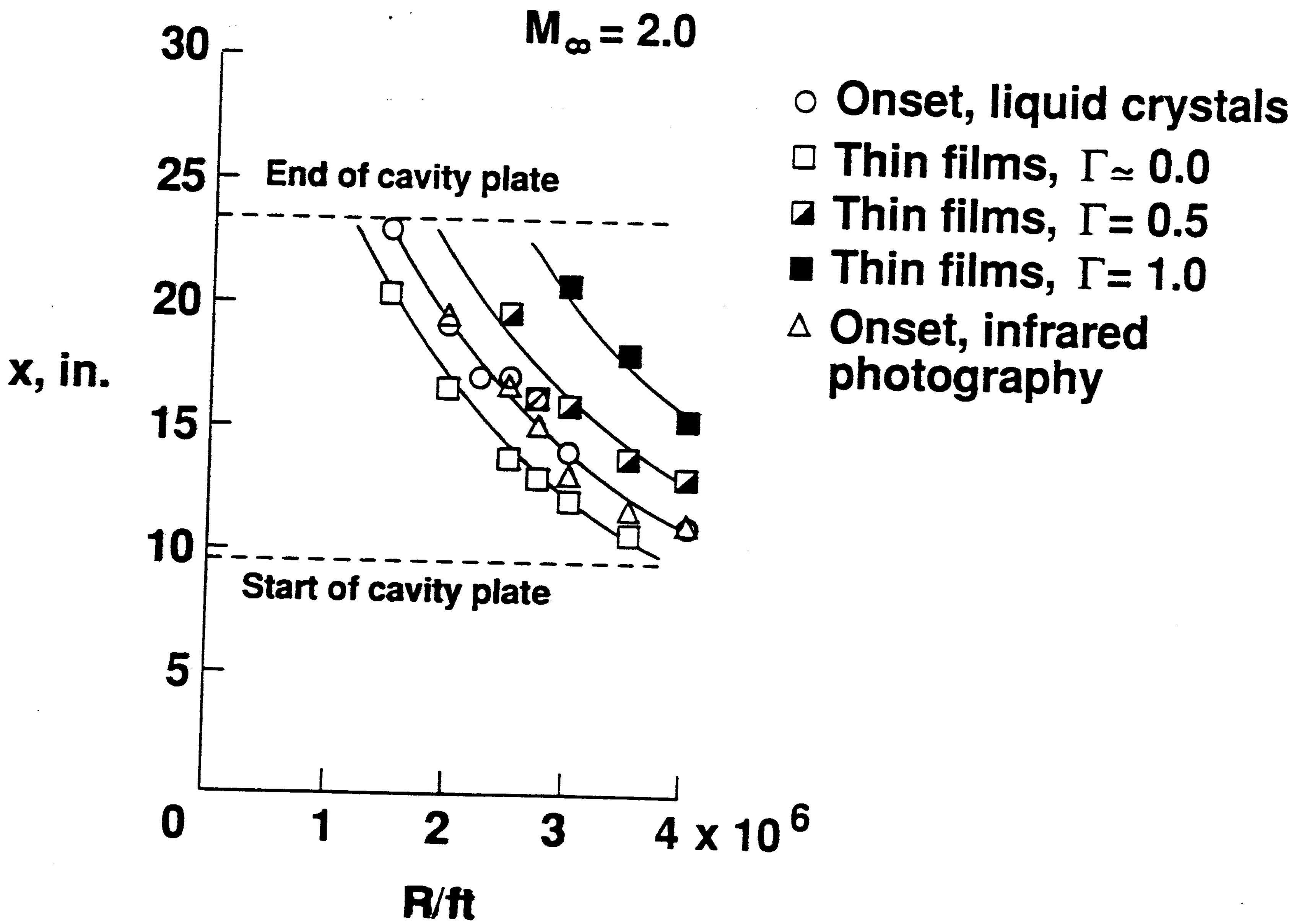


COMPARISON OF THIN FILM OUTPUT TO ONSET DETERMINED BY OTHER TECHNIQUES

$M_\infty = 2.0$, $R/ft = 3.0 \times 10^6$



COMPARISON SUMMARY



SUMMARY

Very thin hot film gauges

- **Data acquisition took 3 to 5 minutes for information along line of gauges**
- **Most quantitative indicator of techniques studied for determining state of boundary layer**
- **Worked well at all test conditions**
- **A challenge in present application to apply to model**

SUMMARY
Liquid crystals in shear sensitive mode

- Data acquisition fast. Image contained data for entire surface at one instant.
- Time response sufficient to reflect tunnel and transition unsteadiness
- Worked well in zero-pressure gradient environment
- Simple to apply. Lasts for multiple flow conditions.
- Detected onset of transition before intermittency factor reached 0.5

SUMMARY
Infrared photography

- Data aquisition fast. Image again contained data for entire surface at one instant.
- Old camera (temperature resolution of 0.5 R) required an insulated plate insert to detect a turbulent wedge or natural transition.
- New camera (temperature resolution of 0.1 R) could see turbulent wedge on painted metal. Required insulated plate to detect natural transition.
- Detected onset of transition before intermittency factor reached 0.5.

GENERAL CONCLUSIONS

- Techniques that can be used to take surface pictures are invaluable -- liquid crystals, infrared photography, and thin films (future).
- Techniques should yield real-time information on boundary-layer state. Unexpected turbulent wedges can disturb desired flow field.

WHAT HAS EFFORT PRODUCED?

Papers Prepared

- Hall, Obara, Carraway, Johnson, Wright, Covell and Azzazy, "Comparisons of Boundary-Layer Transition Measurement Techniques in the Langley Unitary Plan Wind Tunnel," AIAA-89-2205.
- Johnson and Carraway, "A Transition Detection Study at Mach 1.5, 2.0, and 2.5 Using a Micro-Thin Hot-Film System," ICIASF 89, West Germany.

Other Contributions

- Covell's grit sizing evaluation
- Continuing interest in infrared and liquid crystals techniques at Unitary Plan Wind Tunnel
- Increased exposure for Langley capabilities