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**ON THE PREDICTION OF
SEPARATION BUBBLES
USING A MODIFIED
CHEN-THYSON MODEL**

by

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Monterey, CA**

**End-Stage Transition Workshop
Syracuse University
16-18 August 1993**

OUTLINE

BACKGROUND

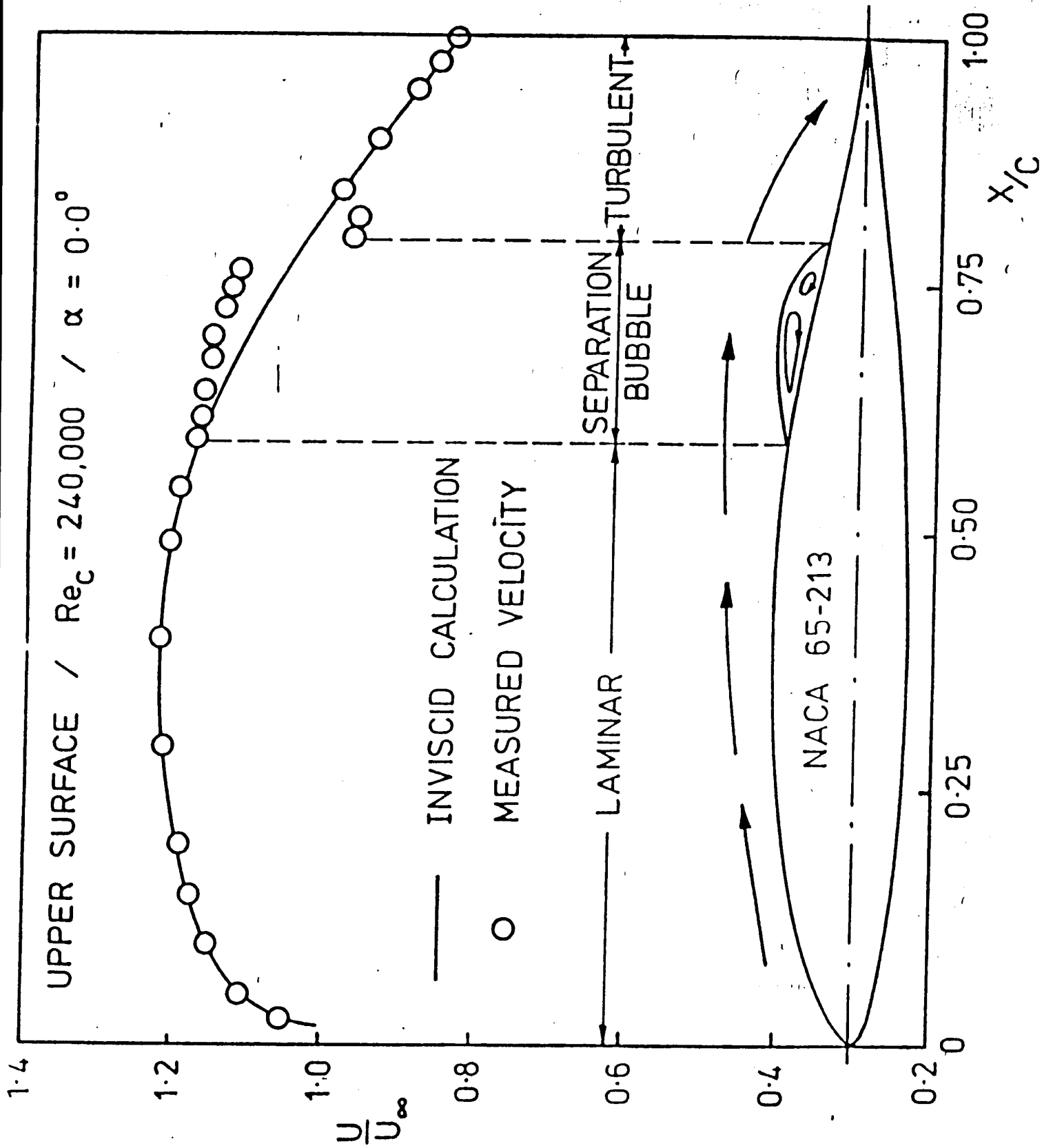
**ANALYSIS OF NACA 65-213
SEPARATION BUBBLE USING
CEBECI'S VISCOUS-INVISCID
INTERACTION METHOD**

**ANALYSIS OF NACA 0012
SEPARATION BUBBLE USING
NAVIER-STOKES METHOD**

**COMPARISON WITH
EXPERIMENT**

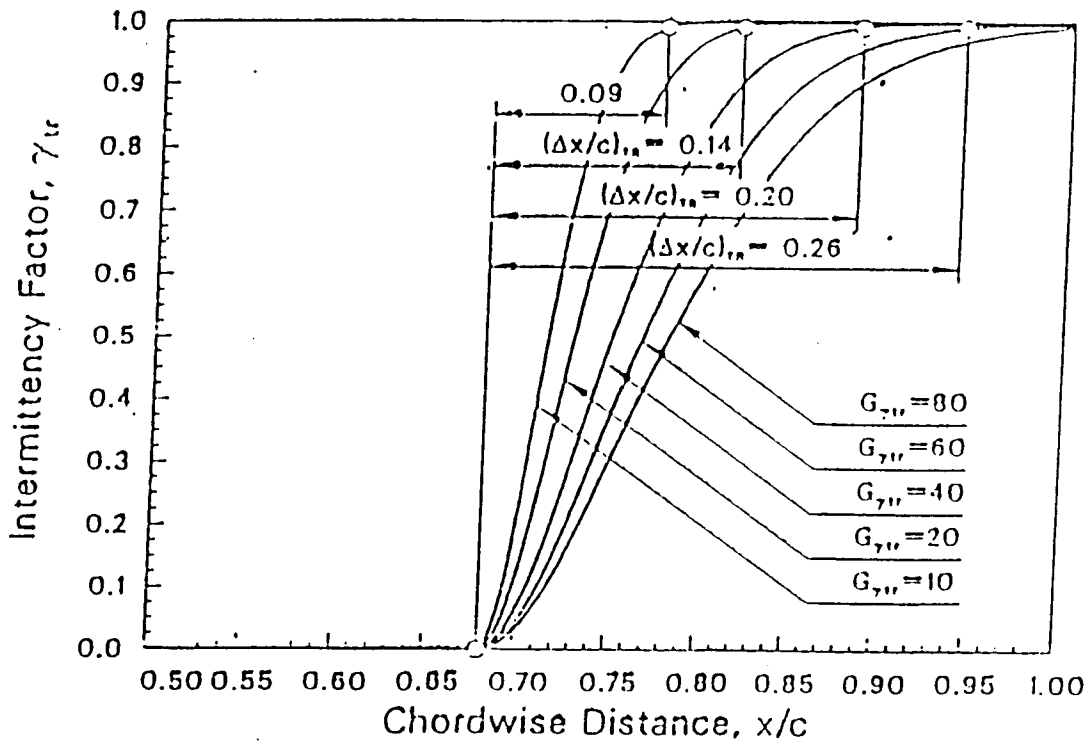
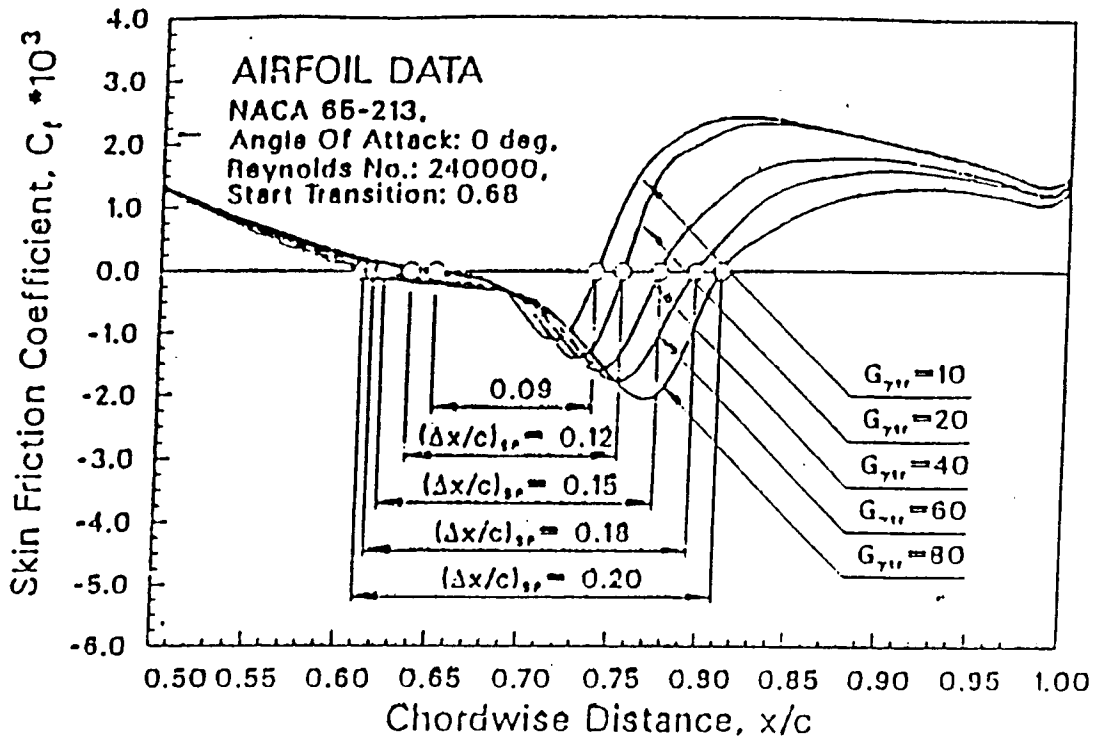
SUMMARY

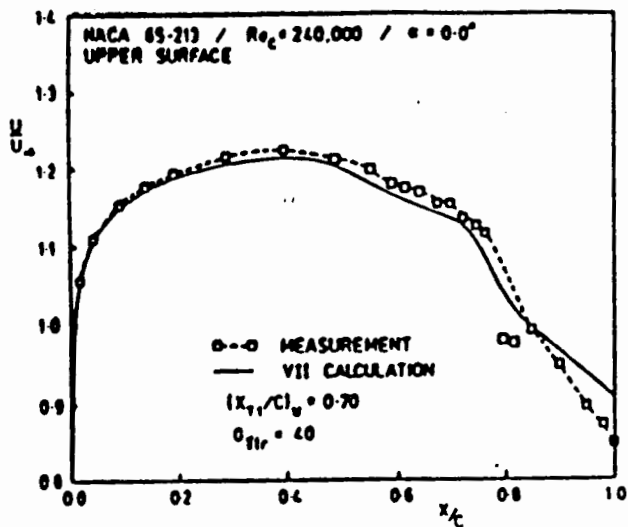
**ANALYSIS
OF
NACA 65-213 AIRFOIL
USING
VISCIOUS-INVISCID INTERACTION
METHOD**



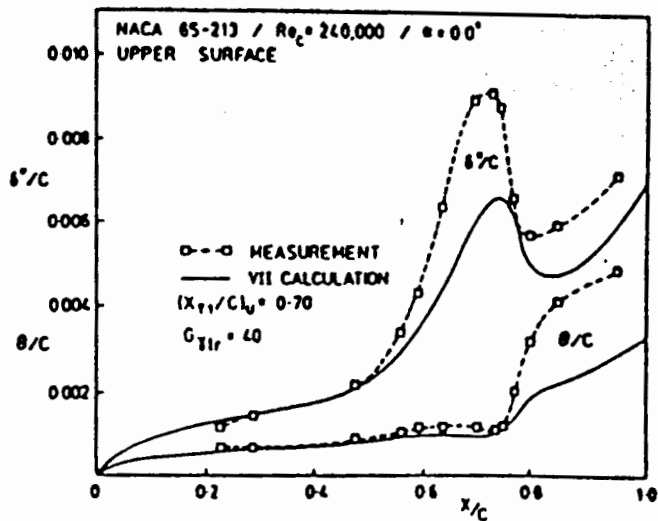
Chen and Thyson

$$\gamma_{\pi} = 1 - \exp \left[- \frac{u_e^3}{G_{\gamma_{\pi}} v^2} R_{x_{\pi}}^{-1.34} (x - x_{\pi}) \int_{x_{\pi}}^x \frac{d\xi}{u_e} \right]$$

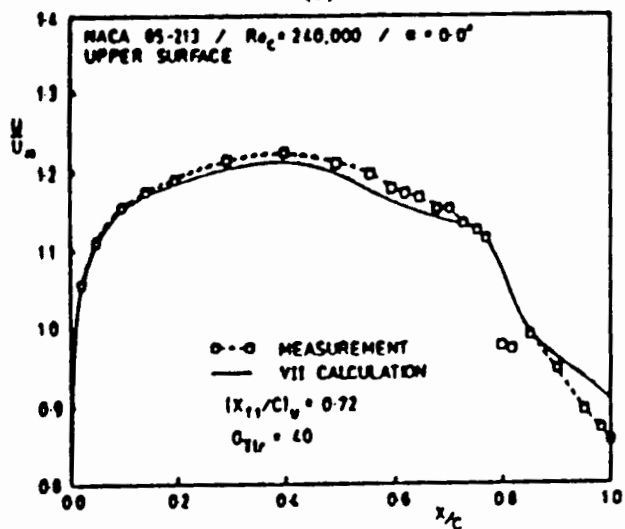




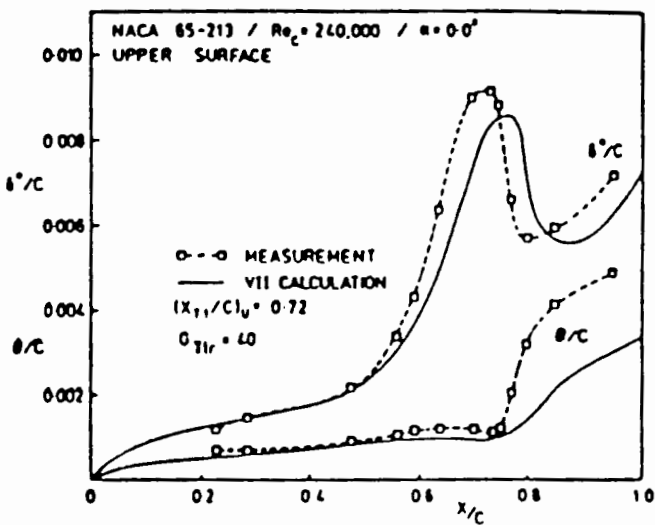
(a)



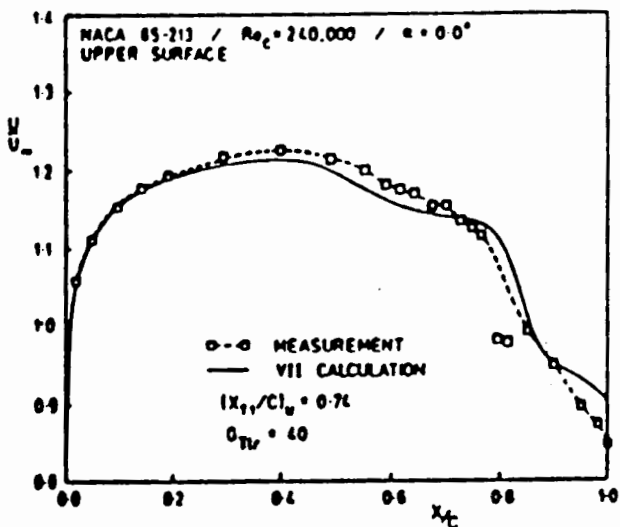
(a)



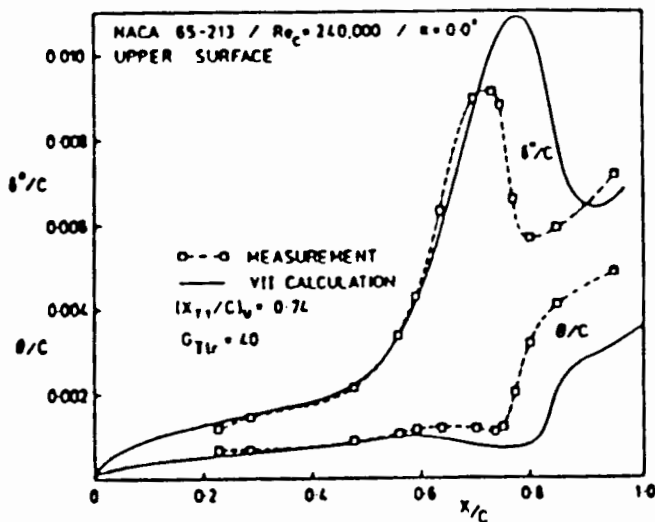
(b)



(b)



(c)

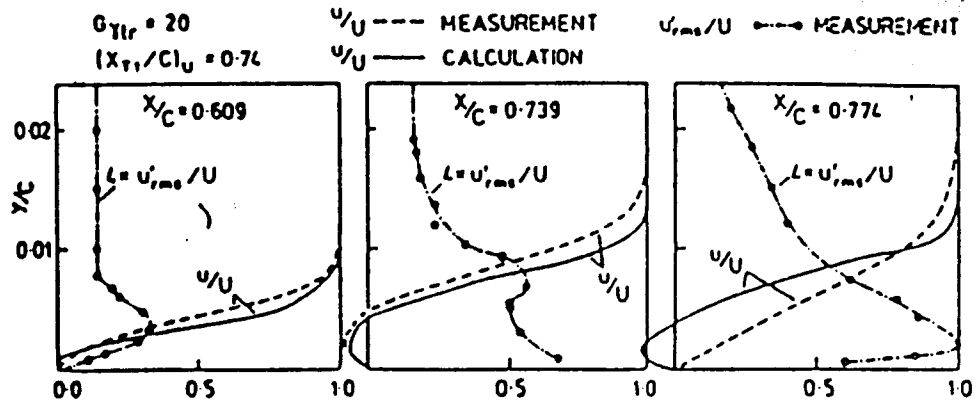


(c)

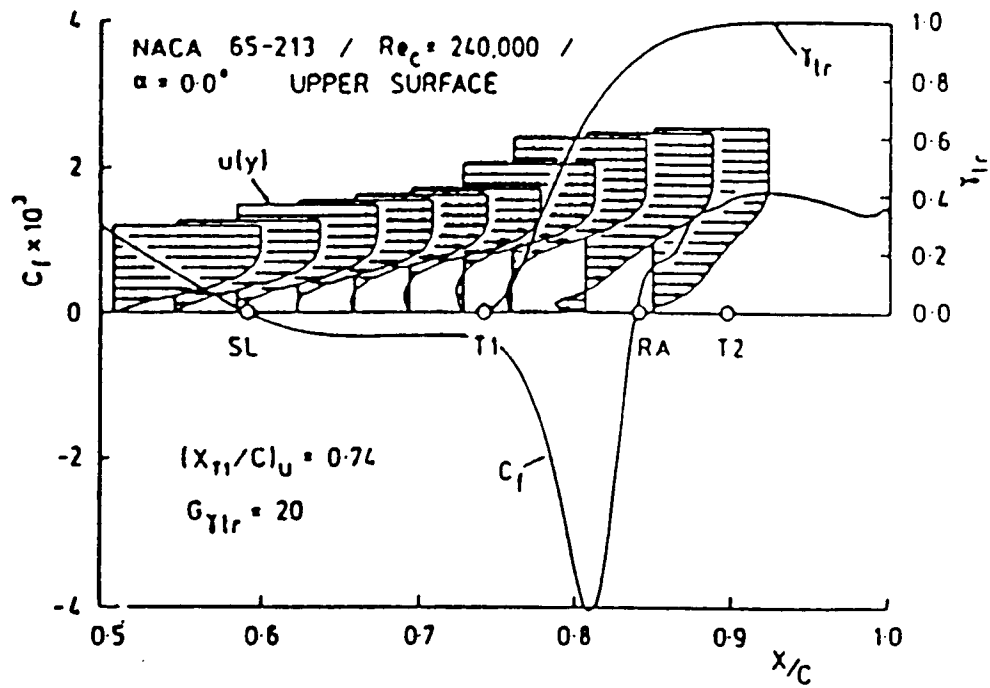
Calculated and measured inviscid surface velocity distributions: C_{T1r} fixed, varying $(x_{T1}/c)_u$

Calculated and measured displacement and momentum thicknesses of viscous layer: C_{T1r} fixed, varying $(x_{T1}/c)_u$

NACA 65 213 / $Re_c = 240,000$ / $\alpha = 0.0^\circ$
 UPPER SURFACE



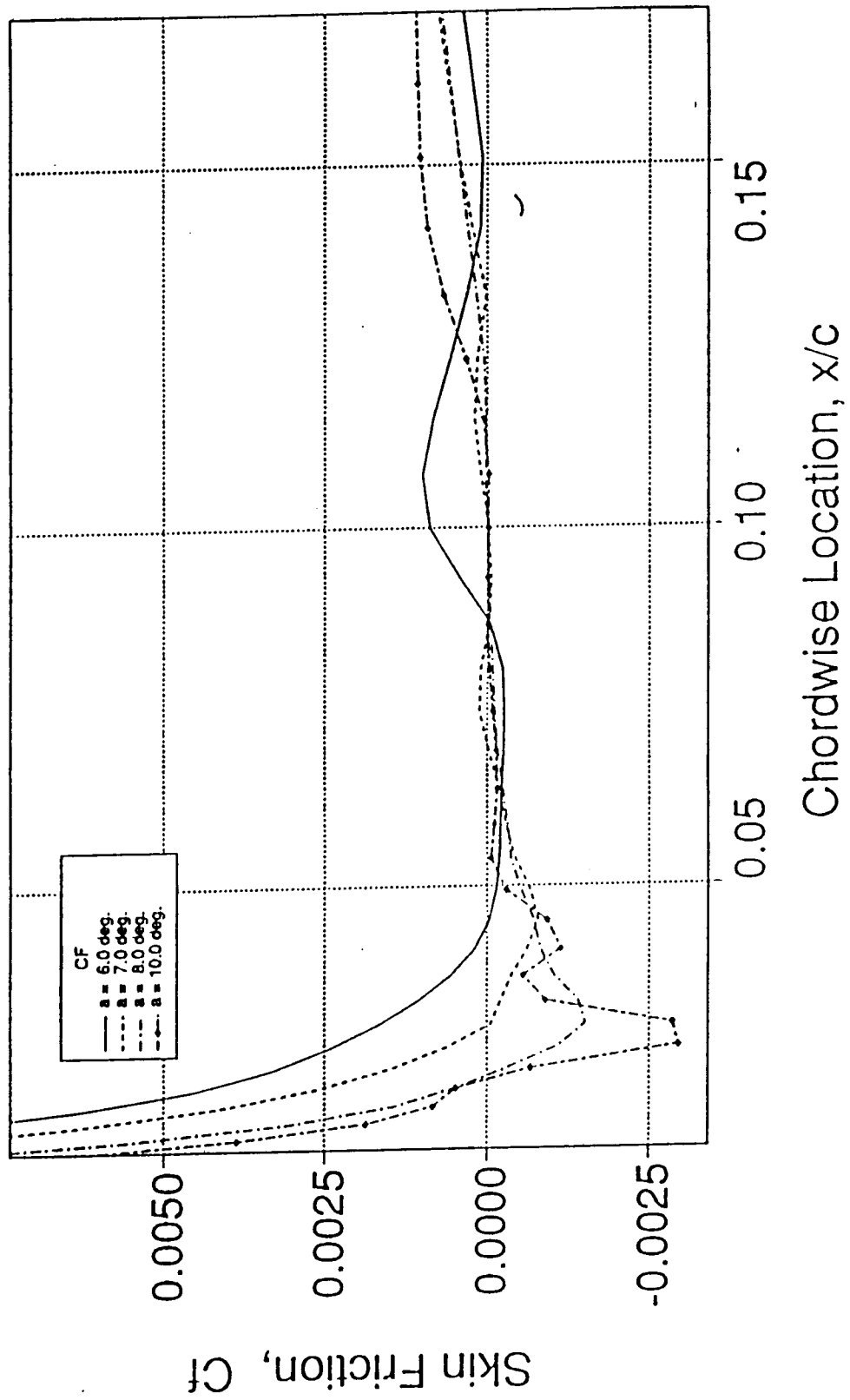
Velocity and turbulence intensity profiles in separation bubble region



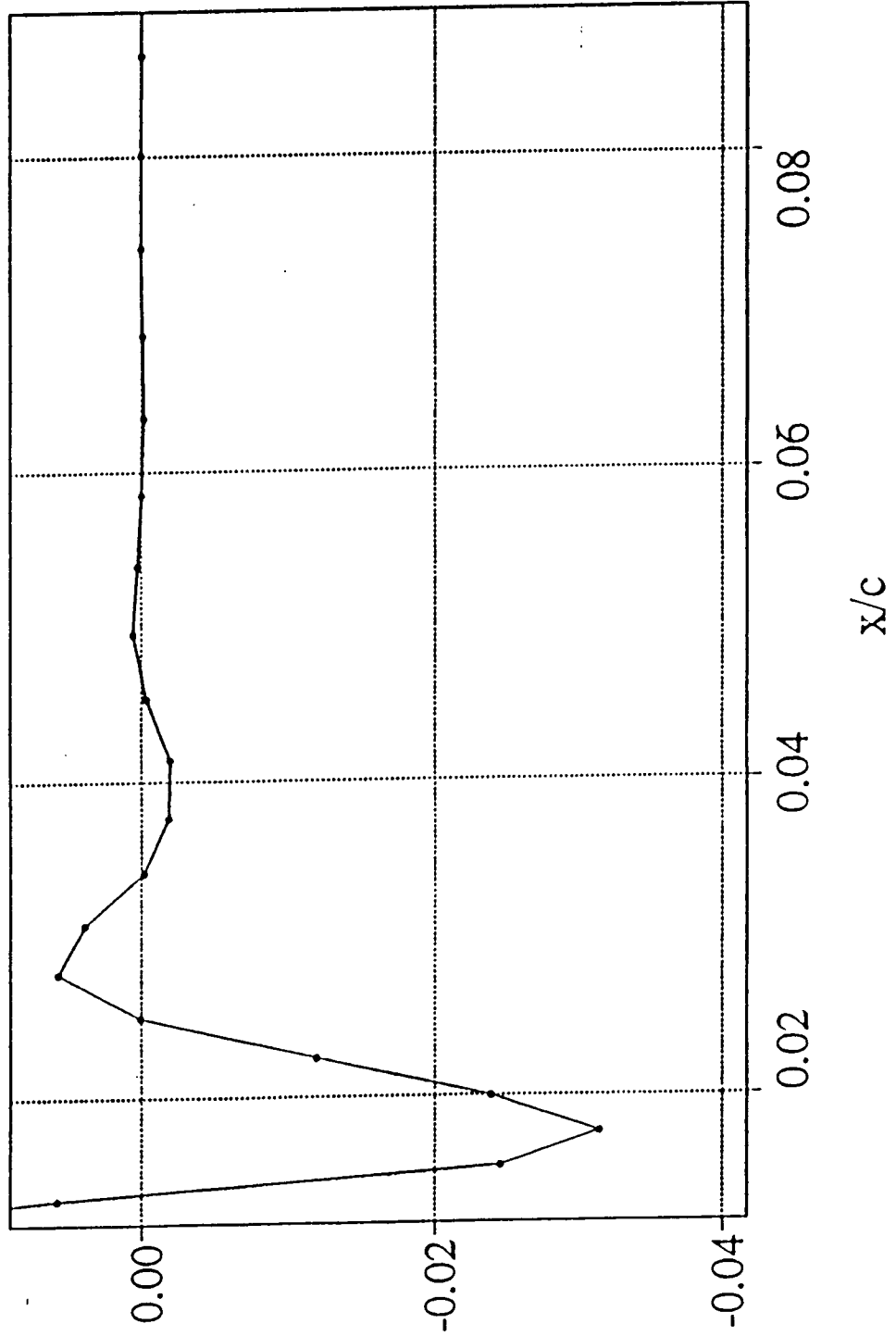
Typical computed separation bubble flow

**ANALYSIS
OF
NACA 0012 AIRFOIL
USING
NAVIER-STOKES METHOD**

Computed C_f , $M = 0.3$, $Re = 0.54$ mil. (Chen-Thyison Transition M



$a=10+2\sin(t)$, $a=12$ up, $Re = .54$ mil.

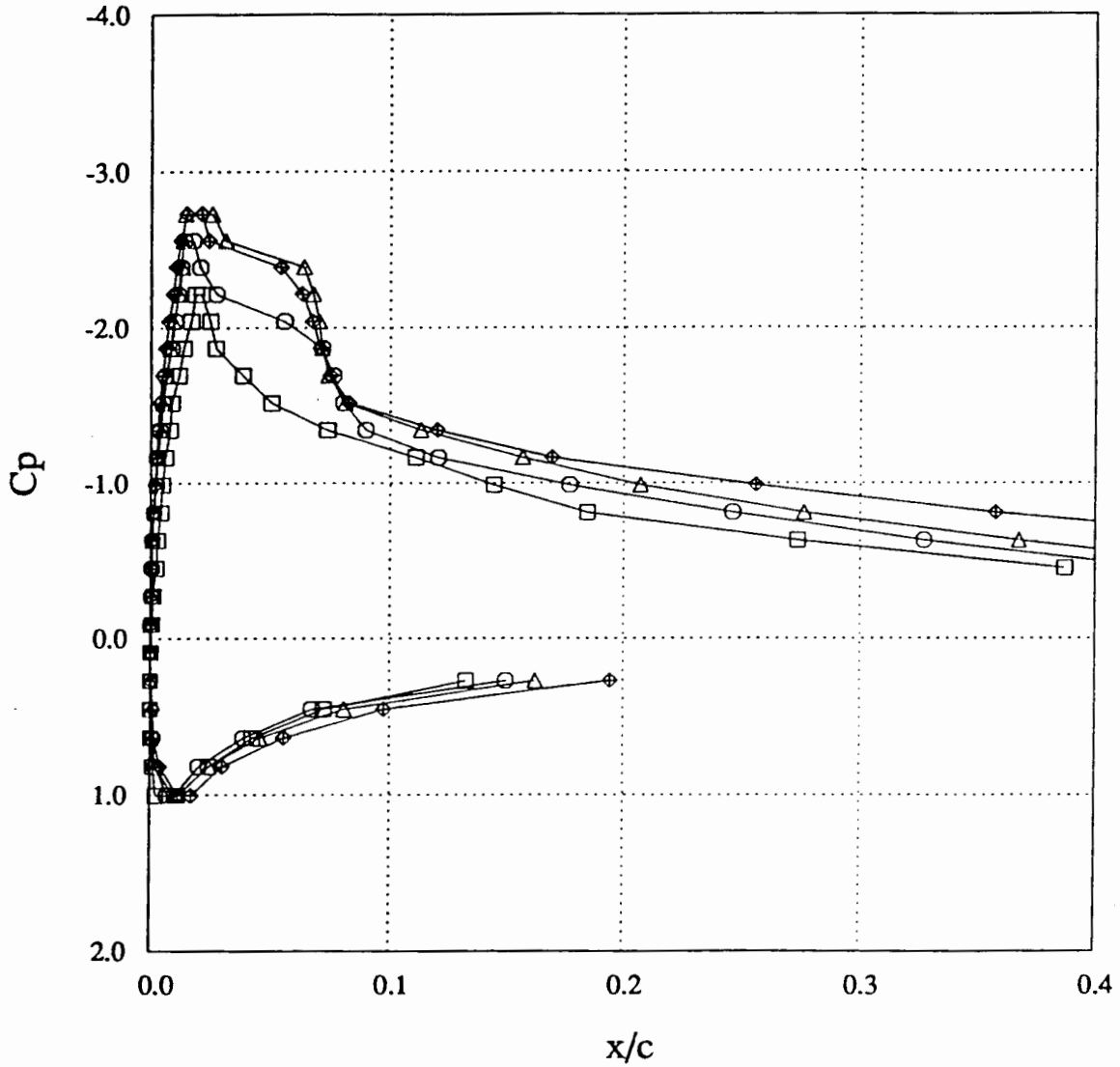


CF

Pressure Distributions Over NACA 0012 Airfoil

M = 0.3, Steady Flow

- $\alpha = 6.0$ deg.
- $\alpha = 7.0$ deg.
- △ $\alpha = 8.0$ deg.
- ◇ $\alpha = 9.0$ deg.



SUMMARY

**Separation Bubbles on
NACA 65-213 and
NACA 0012 could be
predicted successfully
with a modified
Chen-Thyson transition
model**

