BUGS, ETC

Note: this talk is off the record.
I may find it necessary to disavow
any remarks that may be attributed to me.

ESTIMATED FREQUENCY OF BUGS

1 PER 50 LINES
(early phase)

1 PER 1000 LINES
(after intensive effort)

THEOREM

If the code has more than 5000 lines

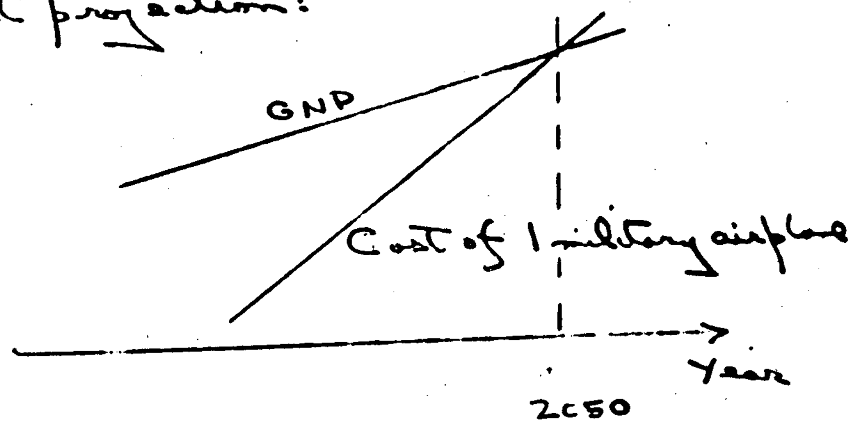
it gives the WRONG ANSWER

with PROBABILITY ONE

PRESSURES FOR COMPLEXITY

COMPLEXITY IN AIRCRAFT

Cost projection:



GNP will be sufficient for 1 airplane in 2050

Pressures for complexity:

1). DOD has departments to generate requirements. It can be estimated that the number of requirements will be roughly proportional to the number of people employed to think of them.

2). 2000 subcontractors each have an interest in introducing more complex subsystems.

3). A design staff of 1000 have to occupy themselves somehow (35 designed the Mirage 3)

COMPLEXITY IN COMPUTER PROGRAMS

Is there a danger that 1 computer program will require the GNP say by the year 2100?

Pressures for complexity:

1) One might imagine that the purpose of computers is to replace HUMAN effort by MACHINE effort. The GOAL of numerical analysts is precisely the OPPOSITE!

2). The objective of professors and research scientists is generally to show how clever they are. This objective is not realized by a SIMPLE SOLUTION — that merely suggests that the problem was easy.

3). A solution terminates funding — the secret of funding is the LIGHT AT THE END OF THE TUNNEL

CASE HISTORIES

OF BUGS

BUGS

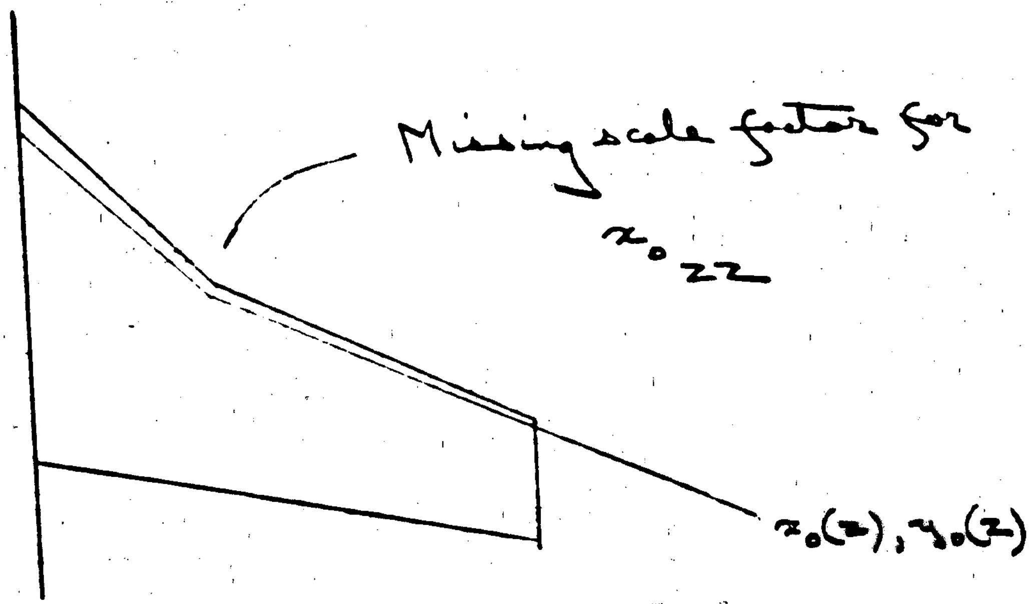
CRANKED WING	FL022	1976 - 1983
SWEPT FORWARD WING	FL027	1977 6 weeks
EXTENDED WING TIP	FL057	1981 - 1982
MISSING TAILPLANE	FL059	1983

(MULTIGRID)

WRONG CALLING SEQUENCE	FL052	April 1981 - February 1983
MISSING DO STATEMENT	FL057	1983 3 months

CRANKED WING BUG

FLO22 1976-1983



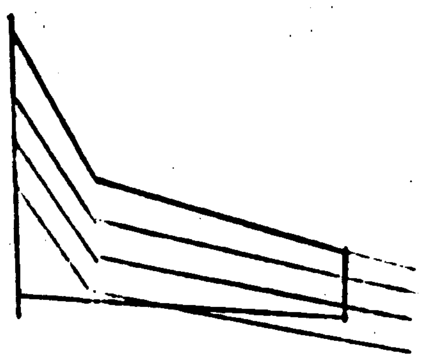
Found by I Chung Chang / D Caughey

THE CRANKED WING FAILURE

1) I tried a change of scale (GOOD),
but I did it with a straight leading edge
(BAD — not exercizing all the OPTIONS)

2) I expected FAILURE
— I assumed a KINK would invalidate
the assumptions of the coordinate transformation

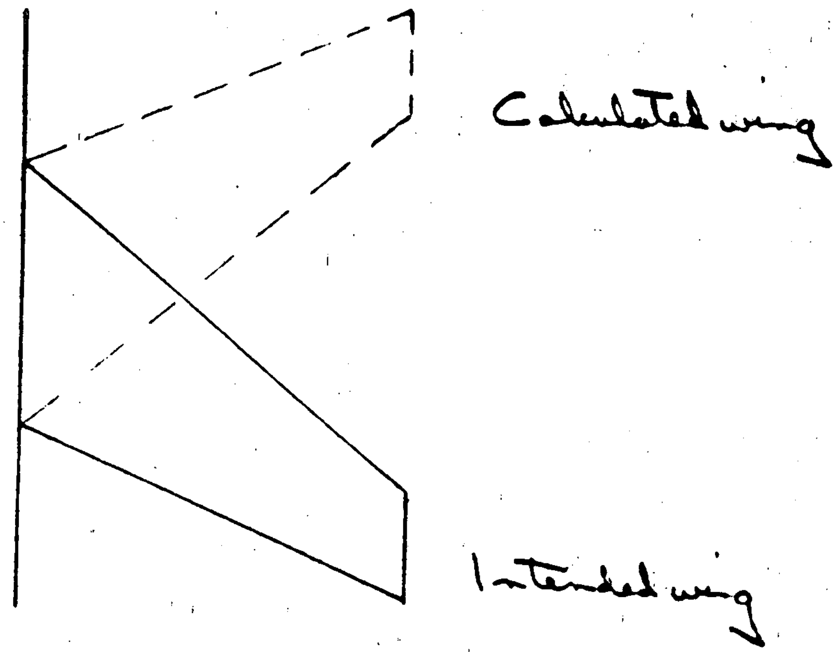
3) I attributed bad results for TACT wing to
(1) Singularity in the transformation
(2) Sparse mesh on outer wing

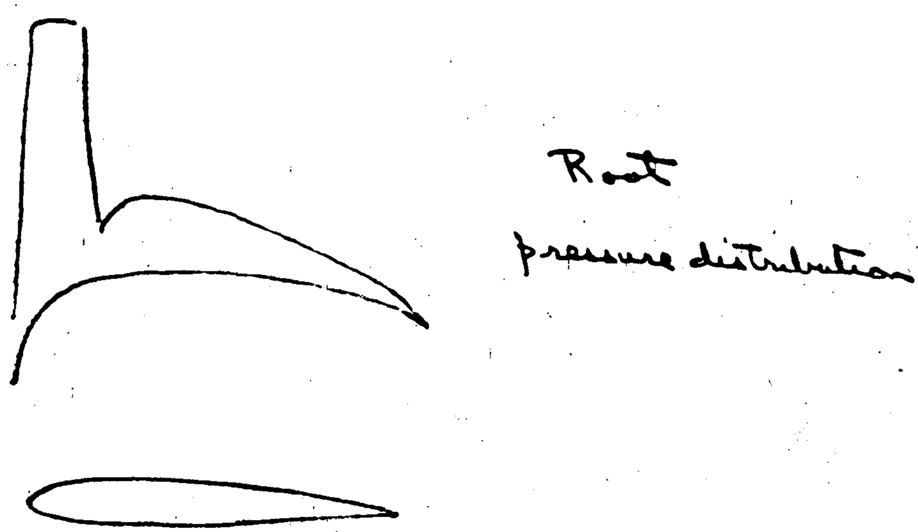


These were WRONG PLAUSIBLE EXPLANATIONS

SWEPT FORWARD WING

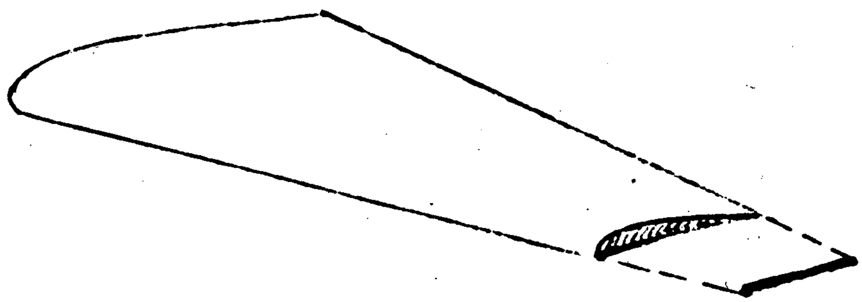
FLO 27 1977

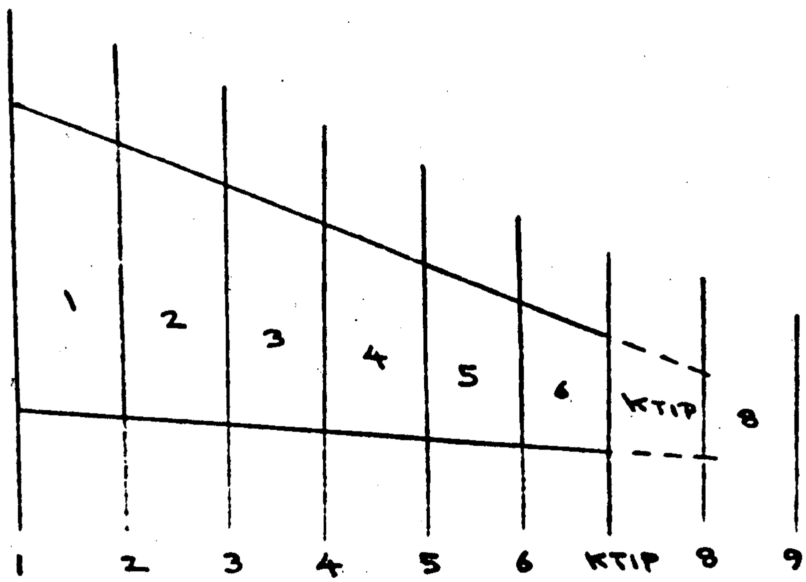




EXTENDED WING TIP

FLO57 1981-1982



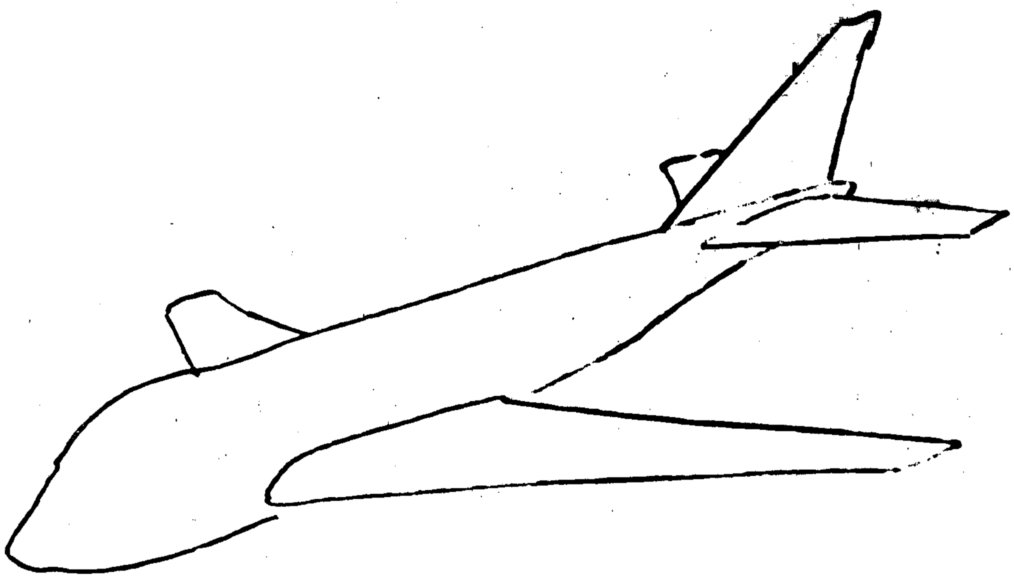


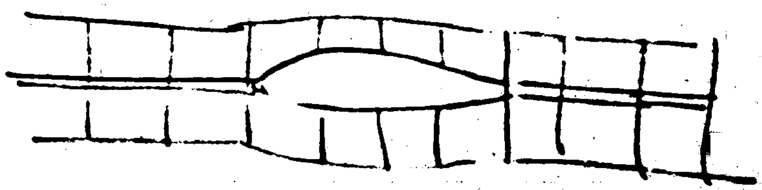
On the wing IF (K. LT. KTIP)

not IF (K. LE. KTIP)

MISSING TAILPLANE

FLO 59 1983





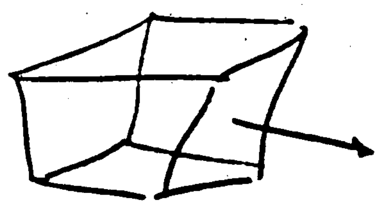
Fluxes recalculated for tailplane cells

Δt not transmitted to this subroutine

INSIDE OUT PROBLEM

FL057, FL059

What is sign of projected face area
(surface normal)

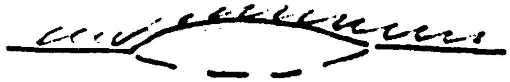


Wrong sign on all faces

April 1981 24 hours

1 inside out tail

1983 6 months



THE SIGN PROBLEM

KORN'S LEMMA

The sign is either POSITIVE,

or else it is NEGATIVE.

When in doubt TRY BOTH

DEBUGS (1)

(Frequently not performed be me
when they should have been)

CONSISTENCY CHECKS

Double the scale of the profile

Insert uniform flow

Check* symmetry with symmetric flow

Check convergence with decreasing mesh size

PROGRAMMING CHECKS

Exercize all options

Set core to indefinite

DEBUGS (2)

EXTERNAL CHECKS

Check against known exact solutions

Check plausibility of result

Check against experimental data

Plot everything

ACCIDENTAL DISCOVERY

When coding new versions

By third parties
- release pilot code
  to carefully selected friendly users

By concentrated thinking
- it pays to carry the whole code
  in your head

DEFENSIVE PROGRAMMING

1) MODULAR STRUCTURE

   — change one thing at a time

2) DUAL PATH PROGRAMMING

   — interchangeable subroutines in each segment

3) SIMPLICITY: avoid

   (1) AICS

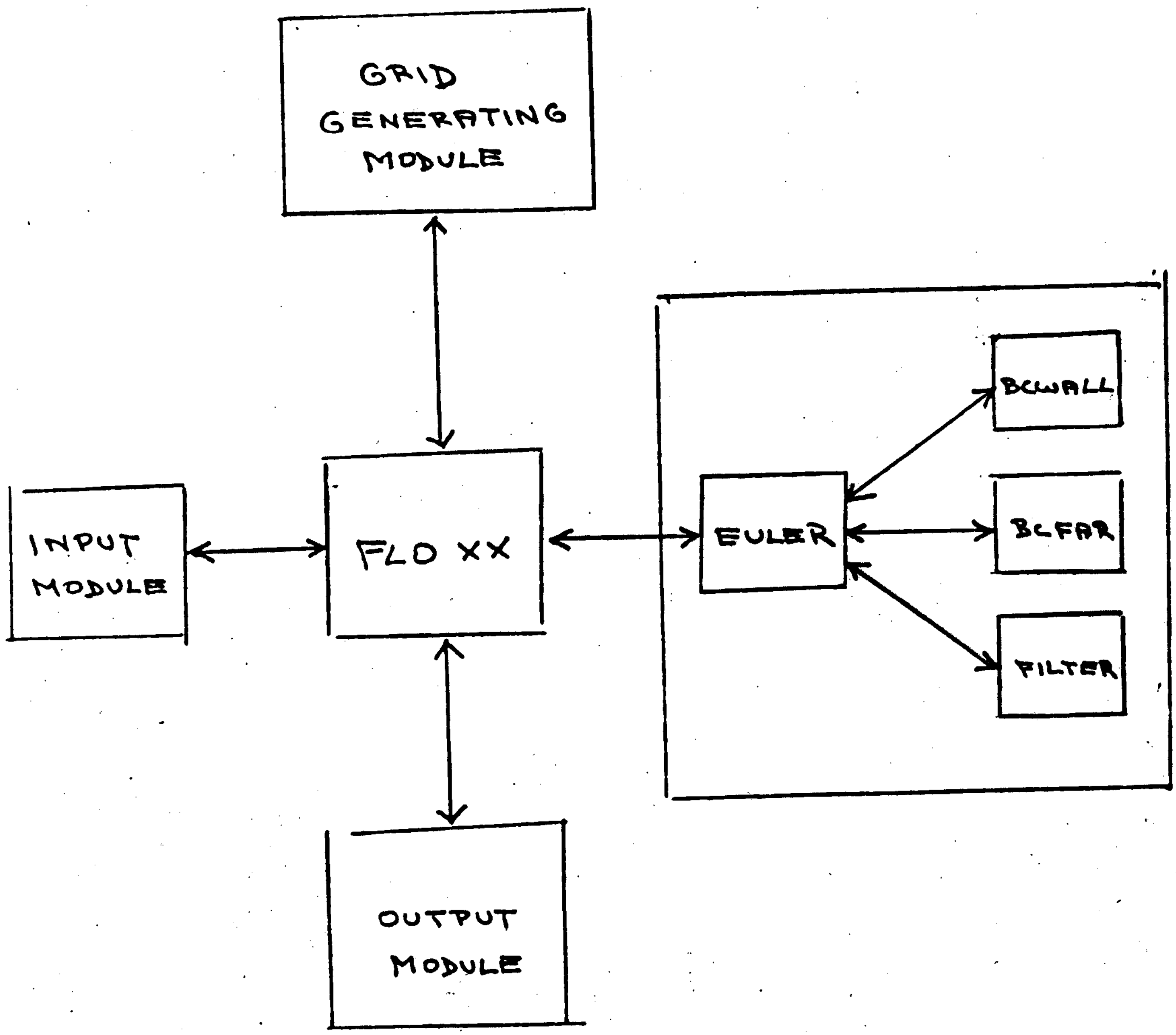
   (acquired if contamination syndrome)

   (2) RSNS

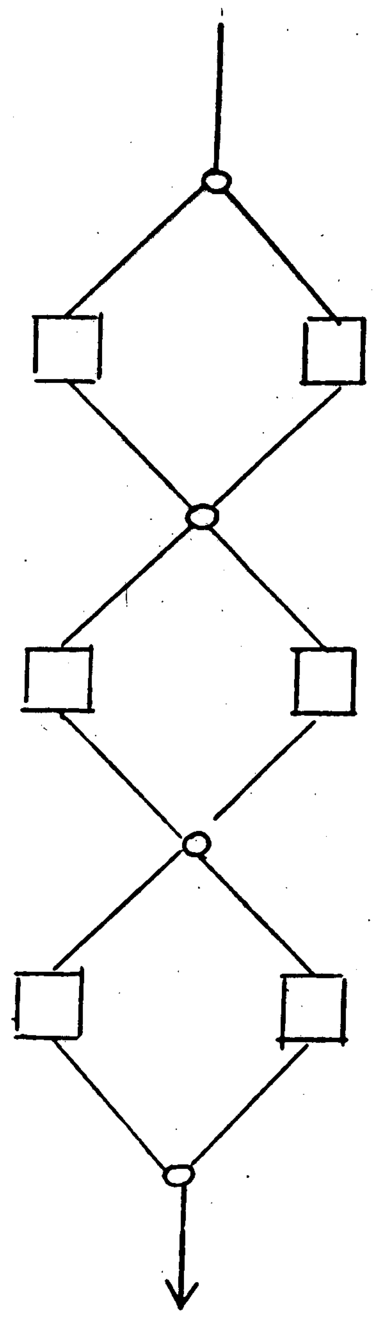
   (random statement number syndrome)

4) RIGID PROTOCOL

MODULAR PROGRAMMING

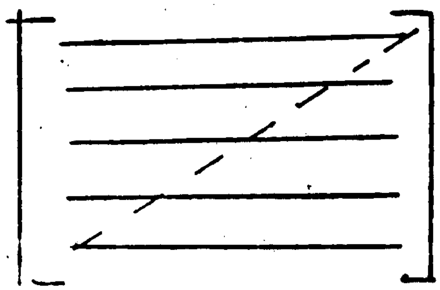


DUAL PATH PROGRAMMING

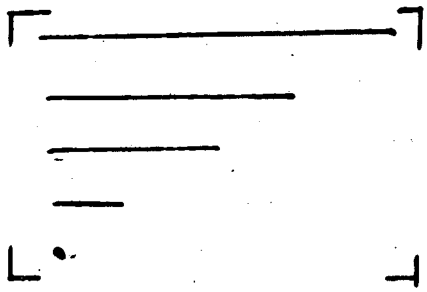


EFFICIENCY SIMPLICITY TRADE-OFF

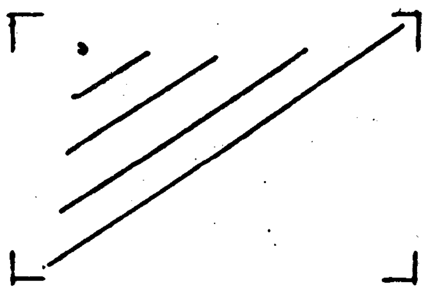
Example: SYMMETRIC MATRICES



Complete storage



Reduced storage (1)



Reduced storage (2)

One certain result: schemes (1) and (2) lead to

INCOMPREHENSIBLE CODE