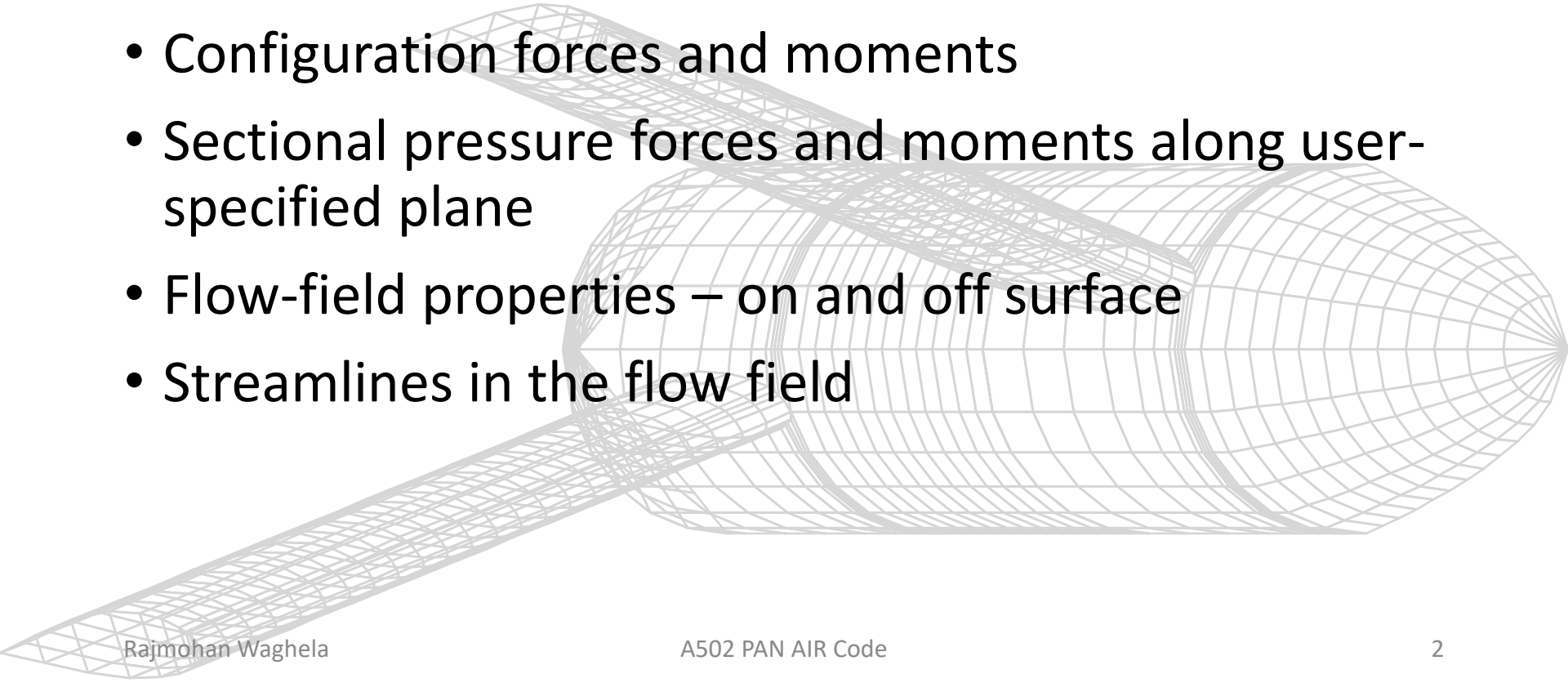
A502 PAN AIR Code

Panel Method Aerodynamic Code for Subsonic and Supersonic Flow Analysis Around An Arbitrary Configuration

Photo Credit: FGR

What Can PAN AIR Do?

- Surface flow properties
- 3D surface pressure forces and moments
- Configuration forces and moments
- Sectional pressure forces and moments along user-specified plane
- Flow-field properties – on and off surface
- Streamlines in the flow field



What PAN AIR Cannot Do?

- Predict flow dominated by viscous effects
- Predict flow dominated by transonic effects
- Predict flow with different total pressures:
- Configuration inside a jet plume with supersonic flow
- Configuration inside a propeller slipstream swirl
- Determine wake shapes

Where To Find PAN AIR?

- Public Domain Aeronautical Software

http://www.pdas.com/panair.html

- PAN AIR Documentation

https://docs.google.com/file/d/0B2UKsBO-ZMVgS1k5VElNamx1cUk/edit

- PAN AIR Executable

http://www.pdas.com/packages/panairexec.zip

- PAN AIR Source Code

http://www.pdas.com/packages/panair.zip

General Comments

- All input numbers must be decimals
- PAN AIR will misinterpret input numbers without decimal points
- Number may be input as X. or .X as necessary
- The maximum number of digits after decimal point is 4 (example XX.XXX)
- Input segments are 10 spaces long
- Multiple commands for the same input block may be inputted in a single line:

```
=ISINGS     IGEOMP     ISINGP     ICONTP     IBCONP
0.          0.         0.         0.         0.
12345678901234567890123456789012345678901234567890
```

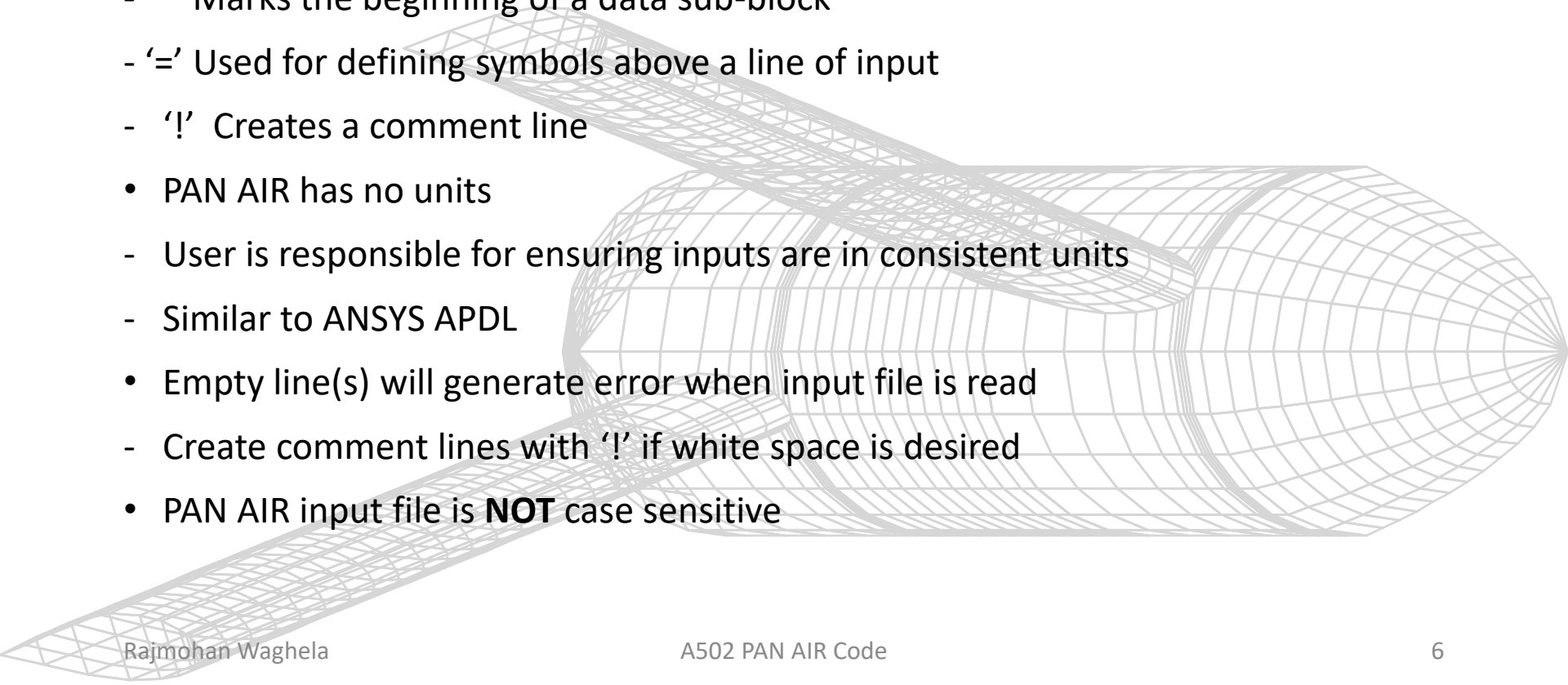
- Column 71 onwards is usually reserved for string type inputs
- Use of a text editor (example Matlab Editor) that shows text column makes editing of input files easier

General Comments (contd.)

- First Character of the Line:

- '$' Marks the beginning of a data block
- '*' Marks the beginning of a data sub-block
- '=' Used for defining symbols above a line of input
- '!' Creates a comment line

- PAN AIR has no units
  - User is responsible for ensuring inputs are in consistent units
  - Similar to ANSYS APDL
- Empty line(s) will generate error when input file is read
  - Create comment lines with '!' if white space is desired
- PAN AIR input file is **NOT** case sensitive



General Comments (Contd.)

- Data blocks may be placed in any order except start, end and sub-blocks

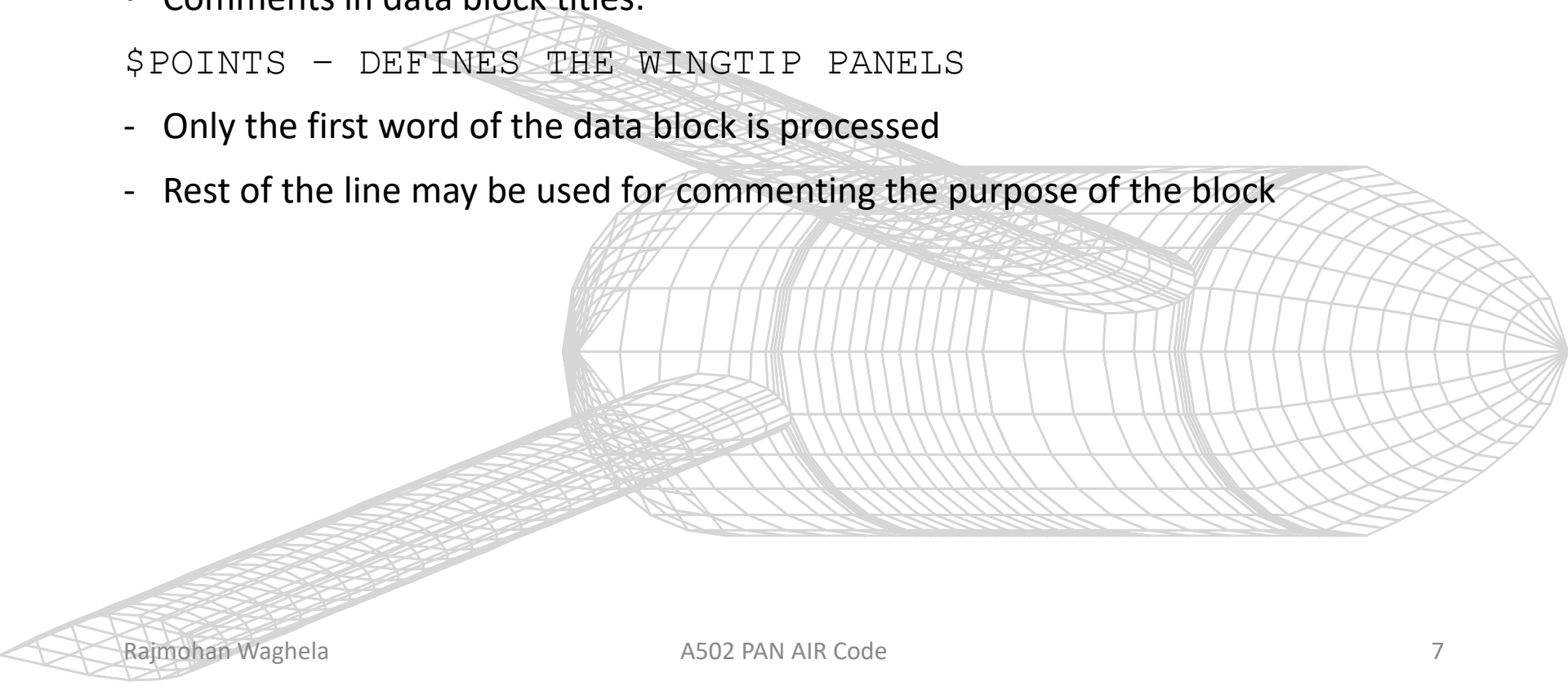
- These blocks are defined later in the presentation

- Comments in data block titles:

```
$POINTS – DEFINES THE WINGTIP PANELS
```

- Only the first word of the data block is processed

- Rest of the line may be used for commenting the purpose of the block



First And Last Data Block

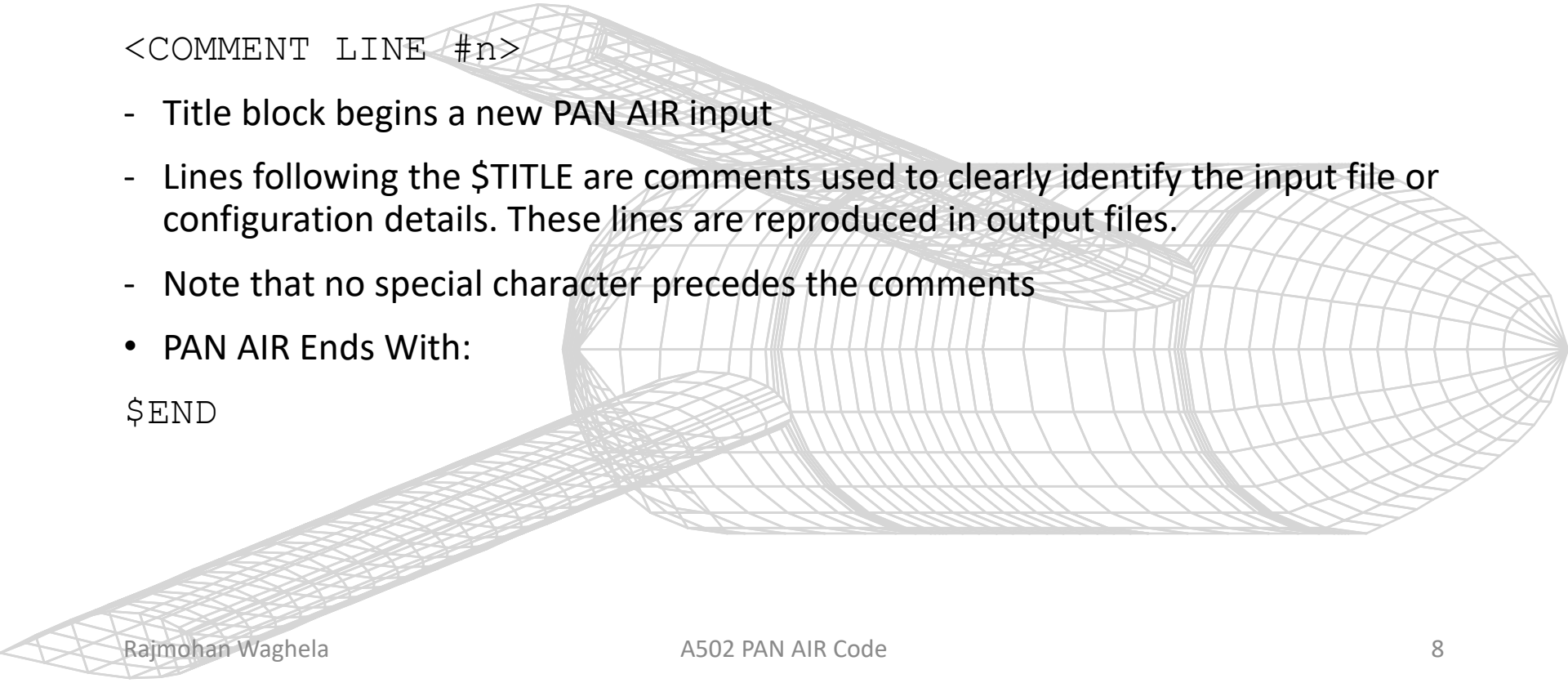
- PAN AIR Input Begins with:

```
$TITLE
<COMMENT LINE #1>
…
<COMMENT LINE #n>
```

- Title block begins a new PAN AIR input
- Lines following the $TITLE are comments used to clearly identify the input file or configuration details. These lines are reproduced in output files.
- Note that no special character precedes the comments

- PAN AIR Ends With:

```
$END
```



Process Control

- PAN AIR has archaic features:

- Software allows for processing the input file for errors, solution, or restarting solution

- Modern desktop typically takes 15 to 30 seconds to run; making restart solution feature obsolete

```
$SOLUTION
```

- Solves the boundary-value problem and computes flow properties

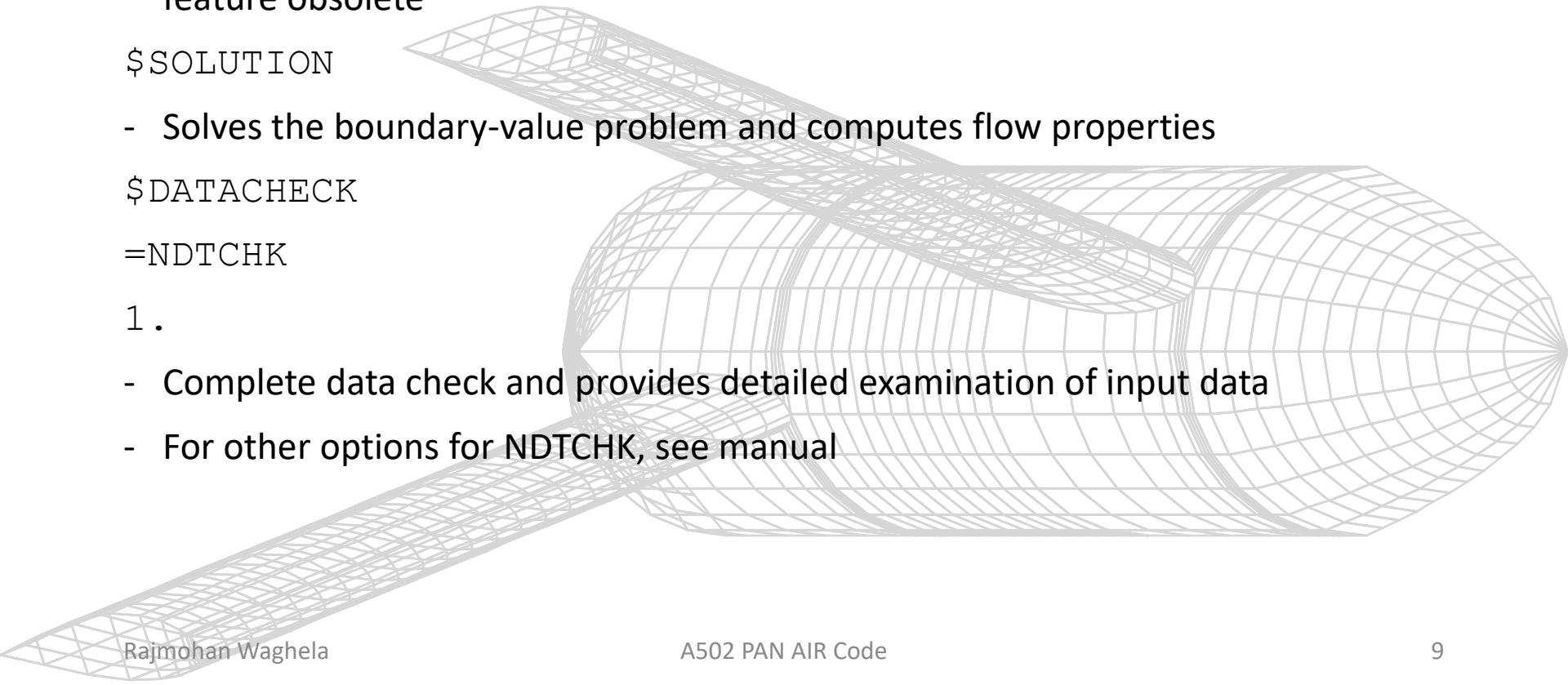
```
$DATACHECK

=NDTCHK

1.
```

- Complete data check and provides detailed examination of input data

- For other options for NDTCHK, see manual

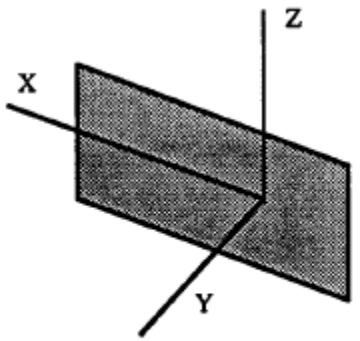


Symmetry

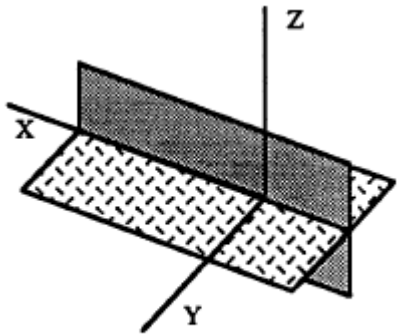
- Symmetry functions are powerful tools
- Reduces workload of defining panel **(Very Important!)**
- Symmetry can be defined only along primary axis planes (i.e. on global axis planes)
- PAN AIR Axis system
- X axis: Through the configuration
- Y axis: Out of right wing
- Z axis: Up

```
$SYMMETRY - XZ PLANE OF SYMMETRY
=MISYMM    MJSYMM
1.         0.
```

- MISYMM is symmetry about XZ-plane
- MJSYMM is symmetry about YZ-plane
- 0. – No symmetry, 1. – Symmetry, and -1. – Anti-symmetry



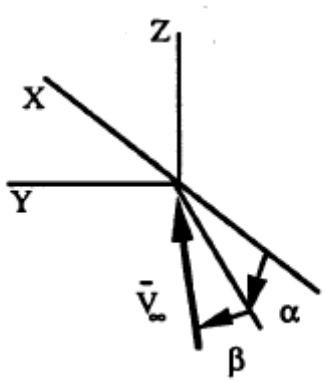
PLANE OF SYMMETRY



TWO PLANES OF SYMMETRY

Flow Conditions

- Mach Number
- Determines the compressibility effects on the flow
- Note that PAN AIR can solve supersonic flow, however, not transonic flow
- 0<Mach No.<0.99 and 1.01<Mach No.<4.0
- Flow Mach number cannot be altered during a solution run



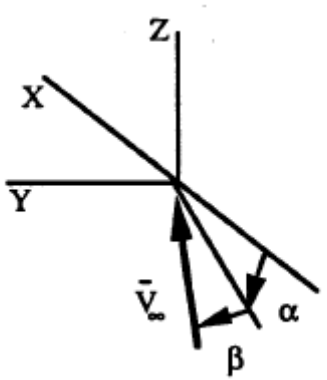

```
$MACH NUMBER
=AMACH
0.1
!AMACH - MACH NUMBER (DEFAULT VALUE 0)
```

Flow Conditions (Contd.)

- Flow Cases

- A maximum of 4 solution cases may be run at once

```
$CASES - NO. OF SOLUTIONS
=NACASE
4.
! NACASE – NUMBER OF CASES
```



- Angles of Attack

```
$ANGLE OF ATTACK IN DEGREES
=ALPC
0.
!ALPC – DIRECTION OF COMPRESSIBILITY EFFECTS
=ALPHA(1)  ALPHA(2)  ALPHA(3)  ALPHA(4)
-6.        -5.       -4.       -3.
```

- Similarly beta for corresponding angles of attack may be defined (see manual for additional details)

Reference Quantities

- Reference quantities include non-dimensionalization quantities and moment reference locations

```
$REFERENCE DATA FOR 3-D CONFIGURATION FORCES AND MOMENTS
=xref      yref      zref
0.5208     0.        0.
=sref      bref      cref      dref
0.5000     1.0000    0.5000    1.0000
!XREF - X COMPONENT OF MOMENT REFERENCE LOCATION
!YREF - Y COMPONENT OF MOMENT REFERENCE LOCATION
!ZREF - Z COMPONENT OF MOMENT REFERENCE LOCATION
!SREF - FULL AIRPLANE REFERENCE AREA (EVEN WITH SYMMETRY INPUT)
!BREF - REFERENCE LENGTH OF MX (SPAN)
!CREF - REFERENCE LENGTH OF MY (CHORD)
!DREF - REFERENCE LENGTH OF MZ (SPAN)
```

Output or Print Options

- Text files are the only form of output from PAN AIR

```
$PRINT - OPTIONS
=ISINGS     IGEOMP     ISINGP     ICONTP     IBCONP
0.          0.         0.         0.         0.
=IEDGEP     IPRAIC     NEXDGN     IOUTPR     IFMCPR
0.          0.         0.         0.         -1.
!IFMCPR - FORCE AND MOMENT SUMMERY OUTPUTS
!IFMCPR = -1 : OMITS OUTPUT
!IFMCPR =  0 : FORCE & MOMENTS FOR PER COLUMN & ACCUMULATION
!IFMCPR =  1 : FORCE & MOMENTS FOR PER NETWORK & ACCUMULATION
```

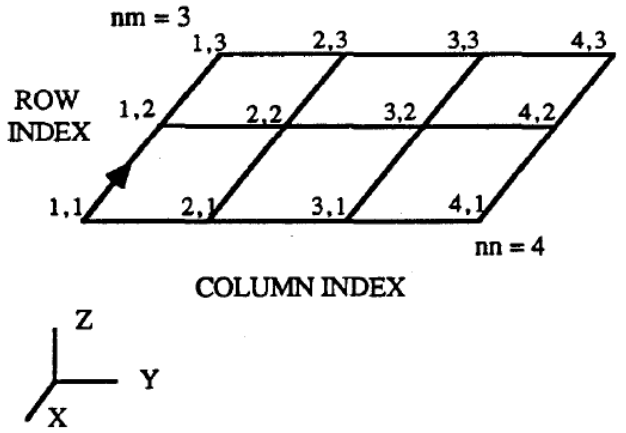
- IFMCPR provides force and moment data
- Other commands are rarely used
- See manual for details on other commands

Panel Networks

- Panels are defined by specifying network of points in a right-hand sense
- Right-Hand Network: As shown in figure, column direction crossed with row direction (marked with arrow) should point outside the model. Use right hand for cross product.
- PAN AIR requires separated row inputs. Note that column 2 data point begins in a new line.
- Each network requires boundary condition definition with variable 'KT'. Commonly used boundary conditions are:

1. KT = 1: Represents Solid Surfaces – wings, body etc.
2. KT = 5: Represents Separated Flow – bases for wings nacelles etc.

For more details, see manual.



COMPUTER INPUT FOR NETWORK FROM:

nm nn netname
x11 y11 z11 x12 y12 z12
x13 y13 z13
x21 y21 z21 x22 y22 z22
x23 y23 z23
x31 y31 z31 ...

Panel Networks (Contd.)

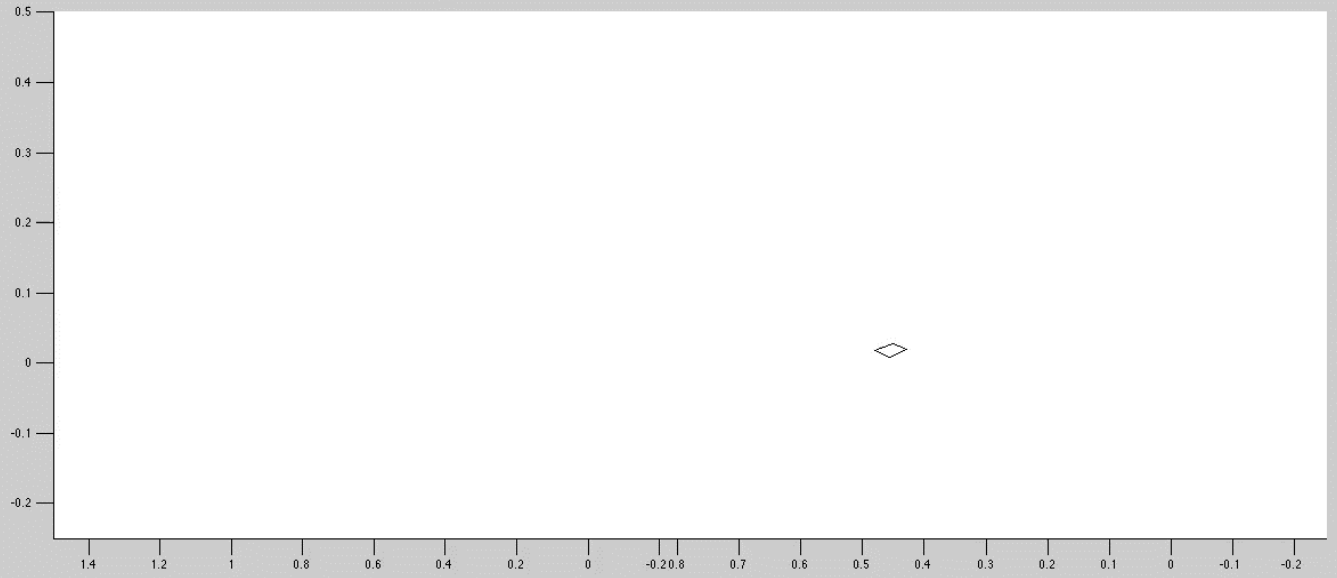
```
$POINTS
=KN
1.
!NUMBER OF NETWORK INPUT FOR THIS GROUP
=KT
1.
!KT - PARAMETER DEFINING BOUNDARY CONDITIONS *IMPORTANT*
=NM         MM                                                    NETNAME
47.         3.                                                    WING
!NM - NUMBER OF POINTS IN A NETWORK COLUMN (ROWS)
!MM - NUMBER OF POINT COLUMN IN A NETWORK
!NETNAME - NETWORK NAME; PLACED IN COLUMN 71-80
=X(1,1)     Y(1,1)     Z(1,1)     X(*,*)     Y(*,*)     Z(*,*)
0.0000     0.0000    -0.0000     0.0208     0.0271    -0.0099
0.0417     0.0384    -0.0140     0.0625     0.0470    -0.0171
.
.
```

Panel Networks (Contd.)

```
.
0.8708    0.1063   -0.0126    0.9208    0.1045   -0.0174
0.9708    0.1015   -0.0258    1.0208    0.0979   -0.0356
1.0417    0.0940   -0.0342
0.0000    0.0000    0.0000    0.0208    0.0289    0.0000
0.0417    0.0408    0.0000    0.0625    0.0500    0.0000
.
.
```

- Continue defining points until all rows are completed
- $POINTS can be used repeatedly until all networks are defined
- Note the above space for a missing point only occurs when there are odd number of rows in a network

Panel Networks (Contd.)

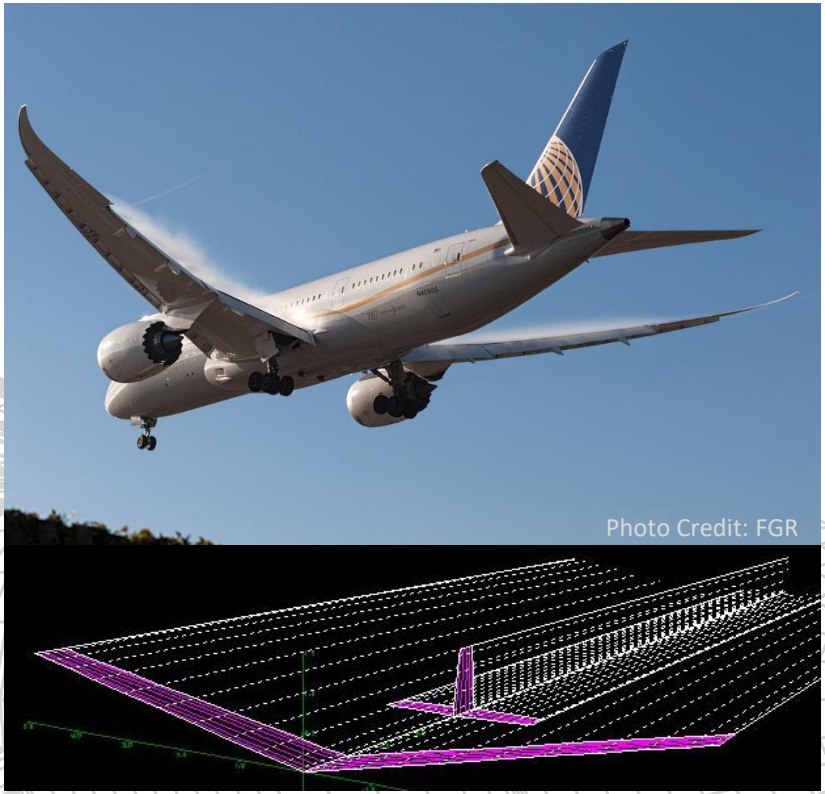


Wake Definition

- PAN AIR cannot calculate wake shape, however, PAN AIR can solve the boundary value problem without any wakes defined
- PAN AIR does not have wake relaxation/roll-up features
- PAN AIR has two methods of specifying wakes:

1. Inbuilt block: $TRAILING is used when wake surface is in contact with only the trailing edge (in the aerodynamic sense) of the surface that produced the wake
2. Define a network as for body surfaces with wake boundary condition

- In most cases, a flat wake is sufficient for aerodynamic analysis
- Wake may be terminated at a convenient location behind the configuration for Trefftz plane analysis



Wake Definition (Contd.)

- Wake Definition with $TRAILING

- The boundary condition parameter for wake, KT, is 18

```
$TRAILING
=KN
1.
!NUMBER OF NETWORK INPUT FOR THIS GROUP
=KT
18.
!KT - PARAMETER DEFINING BOUNDARY CONDITIONS *IMPORTANT*
=INAT      INSD      XWAKE     TWAKE                    NETNAME
FW         1.        1.25      0.                       FWWAKE
!INAT - USER-ASSIGNED NETWORK NAME FOR WAKE ATTACHMENT
!INSD - EDGE NUMBER OF NETWORK INAT TO WHICH SIDE OF WAKE IS ATTACHED
!XWAKE - X COORDINATE FOR DOWNSTREAM EDGE OF THE WAKE
!TWAKE = 0 : WAKE PARALLEL TO REFERENCE X AXIS
!TWAKE = 1 : WAKE PARALLEL TO DIRECTION OF COMPRESSIBILITY
```

- Remember this function can be used when the only one edge of the wake is in contact with another body i.e. for horizontal and vertical stabilizers or winglets

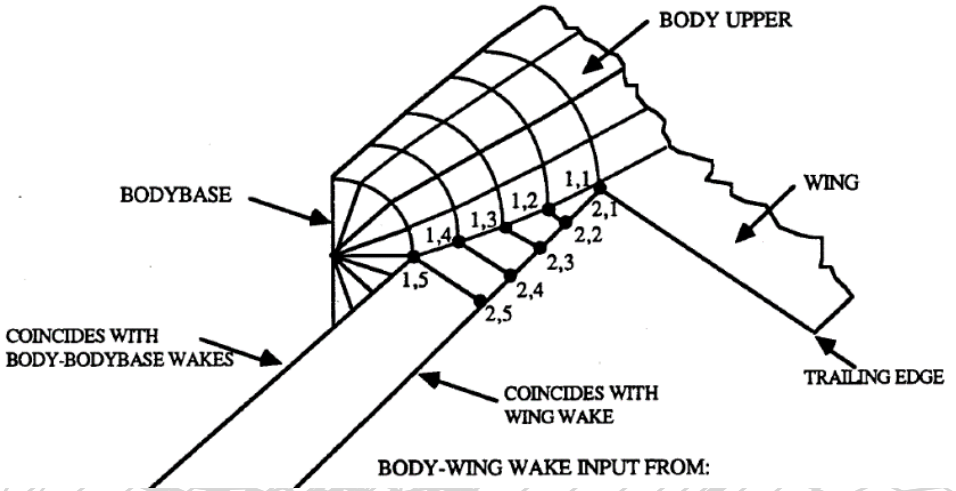
Photo Credit: FGR

Wakes that may be defined with $TRAILING

Wake Definition (Contd.)

- Defining Wake with $POINTS

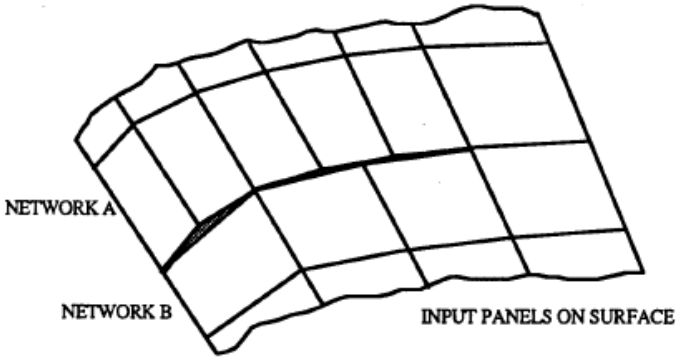
```
$POINTS
=KN
1.
=KT
20.
=NM          MM                                          NETNAME
6.           2.                                          WBDYWK
=X(1,1)      Y(1,1)      Z(1,1)      X(*,*)      Y(*,*)      Z(*,*)
<NETWORK POINTS>
```

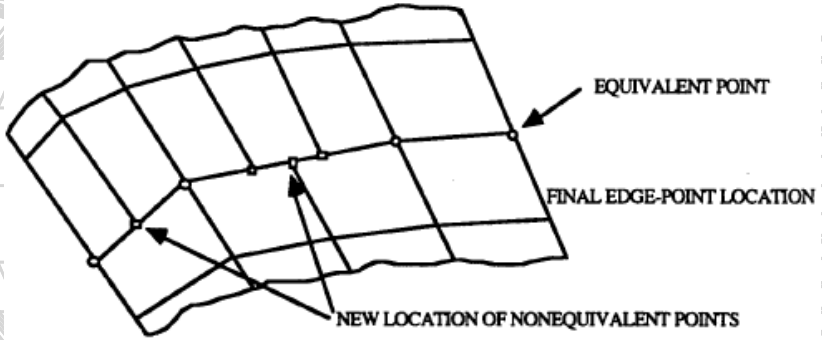


- Wake can only connect with a network (wake or body) edge and not a column/row line

Abutment of Panel Networks

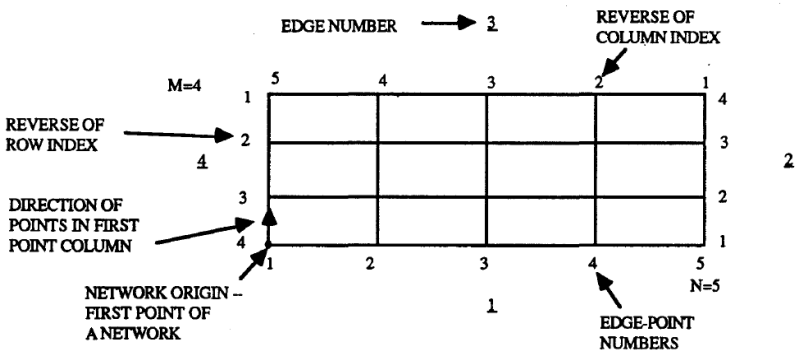
- Abutment is necessary to maintain continuity of doublet strength across network edges
- User is responsible for reviewing and accepting the abutments formed by PAN AIR
- $EAT or liberalized abutment connects the networks within a specified tolerance. This capability cannot be turned off by the user
- $PEA or partial or full edge abutment can be used for input geometry mismatched points along abutting network edges. Requires user to identify network edges and points to be abutted.
- $ABU or forced full-doublet network edge abutment can be used to match finer network edge points to coarser network edge points

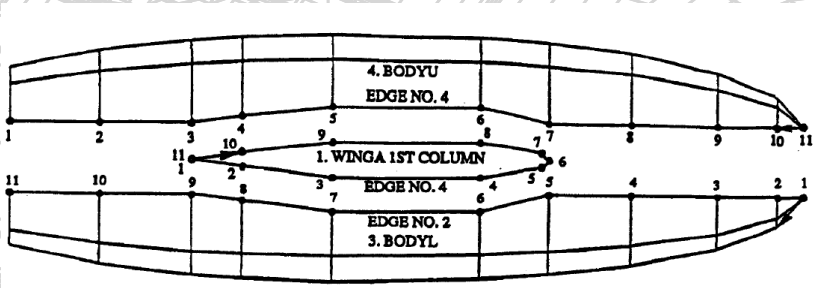




Abutment of Panel Networks (Contd.)

- Panel network edge numbers and points
- Panel edge numbers are defined as shown in figure
- Panel edge point number can reverse order as shown in the two figures
- Make a rough drawing to keep track of points and edge numbers

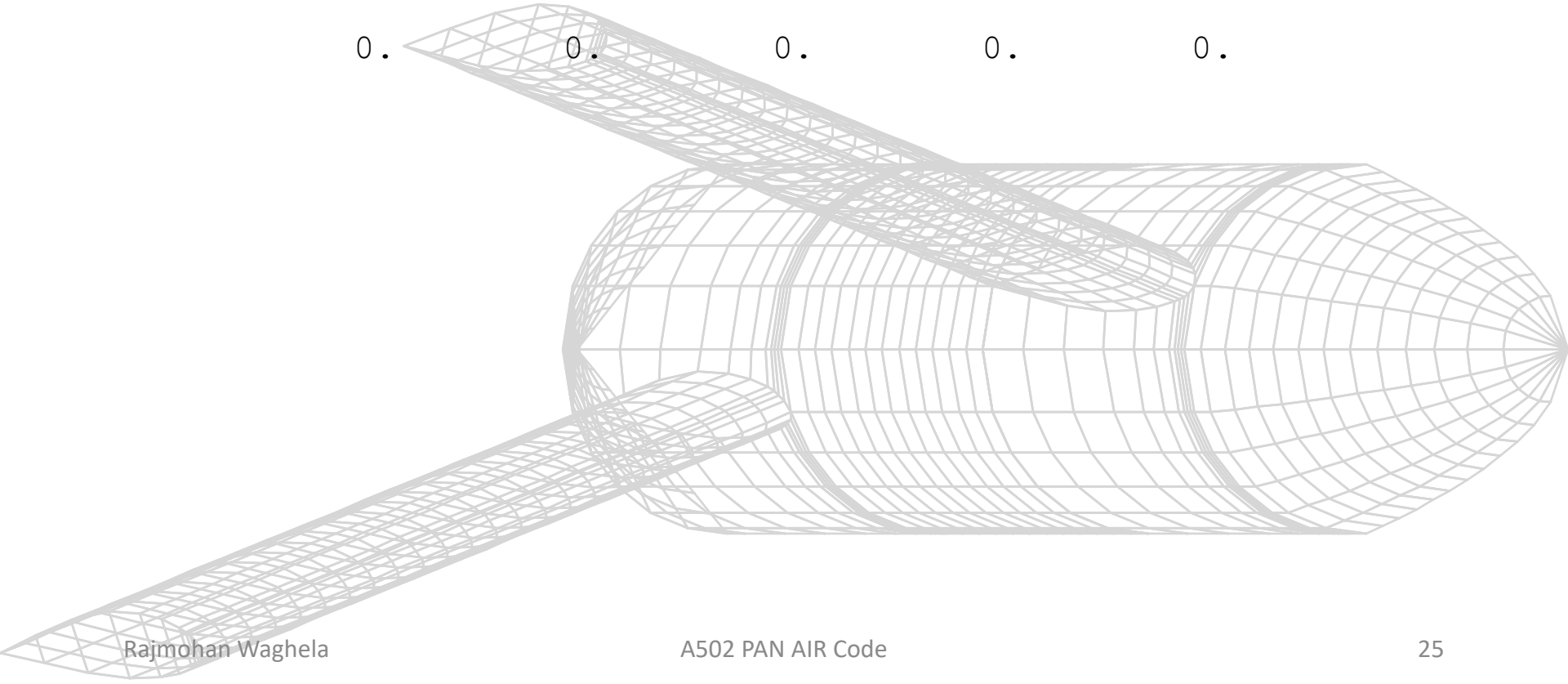




Liberalized Edge Abutment

- Input not required but may be included as:

```
$EAT
=EPSGEO     IGEOIN     IGEOUT     NWXREF     TRIINT     IABSUM
            0.         0.         0.         0.         0.
```



Partial Or Full Edge Abutment

- Used for important abutments such as wing-body etc.

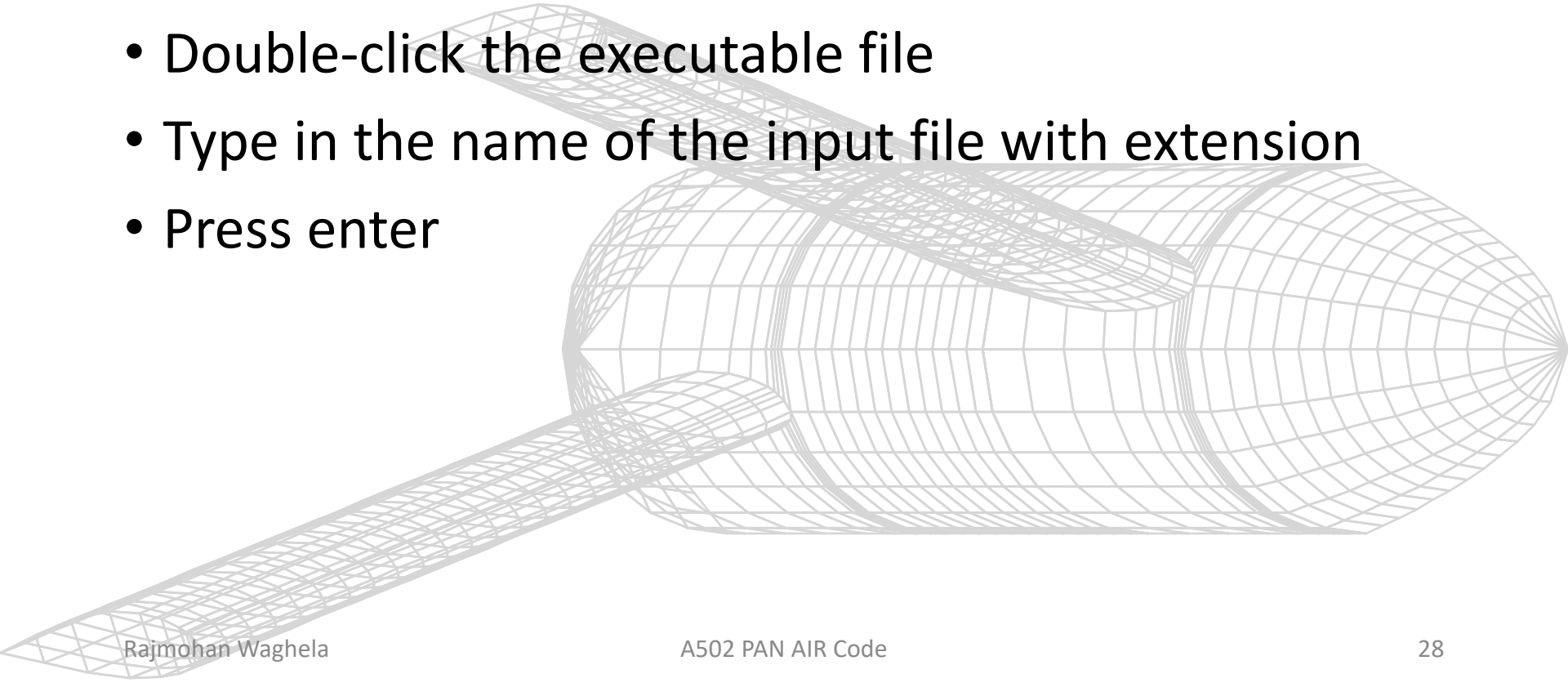
```
$PEA - PARTIAL OR FULL EDGE ABUTMENTS
=NFPA      IOPFOR    IPEAPT
1.         0.        1.
!NFPA - NUMBER OF PARTIAL/FORCED NETWORK EDGE ABUTMENTS
!IOPFOR - FORMS ABUTMENT EDGE FROM STRAIGHT LINES
!IOPFOR = 0 OR BLANK : FIRST SPECIFIED NETWORK EDGE EQUIVALENT POINTS (PREFERRED)
!IOPFOR = 1.0 : AVERAGE LOCATION OF EQUIVALENT POINTS
!IPEAPT - CONTROLS FORCED PARTIAL NETWORK EDGE PRINTOUT
!IOPFOR = 0 OR BLANK : ABUTMENT MATCHING EDGE POINT NUMBERS AND DISTANCE MOVED BY EACH POINT
!IPEAPT = 1.0 : ABOVE+PLUS ORIGINAL COORDINATE POINTS
!IPEAPT = -1.0 : NO PARTIAL NETWORK EDGE PRINTOUT
.
.
```

Partial Or Full Edge Abutment (Contd.)

```
.
.
=NNE        PEATOL
2.          0.0001
!NNE - NUMBER OF NETWORK EDGES SPECIFIED IN CURRENT ABUTMENT
!PEATOL - TOLERANCE (DISTANCE) USED TO ESTABLISH EQUIVALENT POINTS
=NN         EN         EPINIT    EPLAST
FW          4.         11.       21.
UP          4.         33.       23.
!NN - USER ASSIGNED NETWORK NAME FROM NETWORK INPUTS OR NUMBER
!EN - EDGE NUMBER *IMPORTANT - CHECK CONVENTION*
!EPINIT - FIRST NETWORK EDGE-POINT NUMBER IN ABUTMENT; FIRST AND LAST # INTERCHANGEABLE
!EPLAST - LAST NETWORK EDGE-POINT NUMBER IN ABUTMENT
```

How to run PAN AIR?

- Download executable
- Save input in the same folder as the executable
- Double-click the executable file
- Type in the name of the input file with extension
- Press enter



If Errors Persist…

- Ensure spacing of input parameters is correct
- Compare inputs with sample input files that come with the executable
- Check if network points are not too close to each other
- Check abutment edge and point numbers
- Compare your .out file to the one in user manual – line for line
- Ensure Jupiter is not in retrograde and offer sacrifices to the Gods of PAN AIR

No! The Pilot didn’t forget to turn off the chem-trails

Photo Credit: FGR