



Memo

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From:

Roberto Domínguez
Bishop GmbH
Blankeneser Bahnhofstraße 12, 22587 Hamburg

To:

Kolja Seeckt (seeckt@fzt.haw-hamburg.de)
HAW Hamburg

Phone: 040 - 86625827
Mail: robe_dc@hotmail.com

Copy to:

Date: 2008-06-12

Model of Fairings with PrADO

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1 Introduction

In this paper it's explained how to model the two fairings of the ATR-72 with PrADO. Those two fairings are the one in the intersection between the wing and the fuselage, and the one for the landing gear. In the following pictures it's possible to see them in the real aircraft.

For the model it's necessary two kind of input files, the master input file, which contains some general information of each fairing, and one template file for each fairing, with all the geometrical information.

The geometrical information was compiled taking measures from the aircraft views (ATR72-DIN_A3.pdf) with Mbruler (a virtual ruler to take measures in a computer).



Figure 1.1

ATR-72 lower fairing (wikimedia.org 2008a)



Figure 1.2 ATR-72 upper fairing (forocoches.com 2008b)



Figure 1.3 ATR-72 upper fairing (asa-be.com 2008c)



Figure 1.4 ATR-72 lower fairing (flightglobal.com 2008d)

The profile slope of the upper fairing is very abrupt, so it was divided in three different fairings (fairing 1 to 3). The fairing for the landing gear is the fourth one.

2 Master Input File (Input_File-Example_1.dat)

In this file are the different modules (data bank) of the airplane, like fuselage, wing, VTP, HTP, etc. The fairing module is the DB14. The variables in this module are distributed in three groups. Distances are in meters and angles in degrees.

2.1 Description of the fairing configuration

NFAIR: number of fairings.

FAIR2POSi: vector with the information of the positioning. Each fairing needs one of these vectors. The vector components have the following meanings:

FAIR2POS_i (3): X coordinate, of the center of the first section of the fairing.

FAIR2POS_i (4): angle of the radius where the center of the fairing section will be. The center of this radius is in the center of the fuselage section.

FAIR2POS_i (5): radial distance of the center of the fairing section, counted from the center of the fuselage section.

FAIR2POS_i (7): bank angle (turn around X local axis).

FAIR2POS_i (8): angle of pitch (turn around Y local axis).

FAIR2POS_i (9): yaw angle (turn around Z local axis).

The code for this part is the following one:

```
<-NFAIR      - Anzahl der Fairings
0 2 1 1
4.
<-FAIR2POS1  - Positionsvektor/Fairing 1
0 3 1 9
1. 1. 11.6 0. 0.62 0. 0. 0. 0.
<-FAIR2POS2  - Positionsvektor/Fairing 2
0 3 1 9
1. 1. 11.1 0. 0.62 0. 0. 0. 0.
<-FAIR2POS3  - Positionsvektor/Fairing 3
0 3 1 9
1. 1. 9.8 0. 0.62 0. 0. 0. 0.
<-FAIR2POS4  - Positionsvektor/Fairing 4
0 3 1 9
1. 1. 9.557 180. 0.818 0. 0. 0. 0.
```

Comments

- NFAIR = 4 because we have four fairings.
- The first three fairings starts at different X coordinate but they have its centers in the same radius position because the three ones belong to the same fairing.
- The fourth fairing is under the fuselage, so the FAIR2POS4 (4) = 180.

The next picture shows the side view of the four fairings in the real position in the aircraft, so it's easy to understand how FAIR2POS_i (3) works.

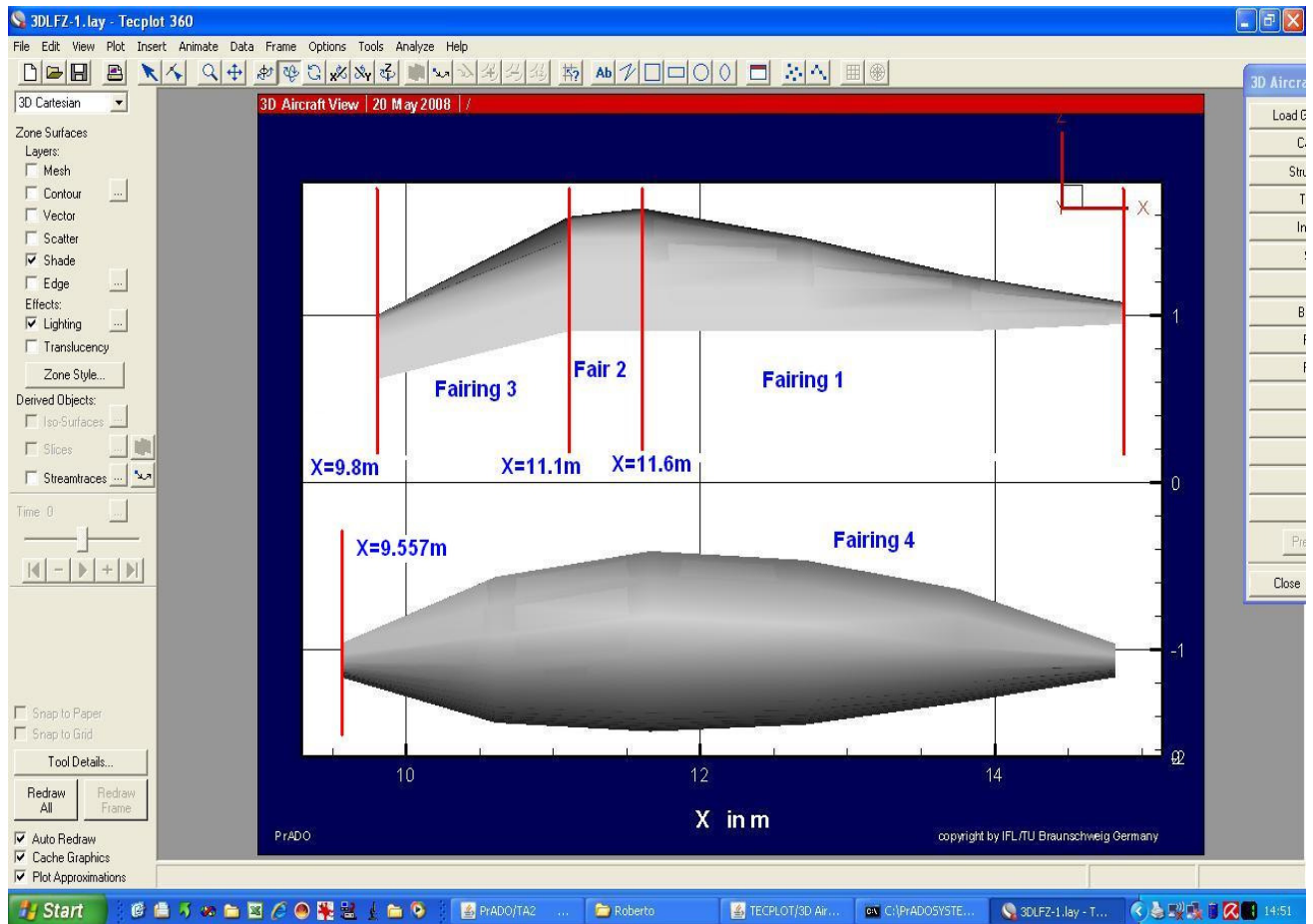


Figure 2.1 Explanation of FAIR2POSi (3)

Figure 2.2 shows also the four fairings in the real position, but in a front view. Here it's possible to see how FAIR2POSi (4) and FAIR2POSi (5) work, and where are the centers of the fairings respect to the fuselage center.

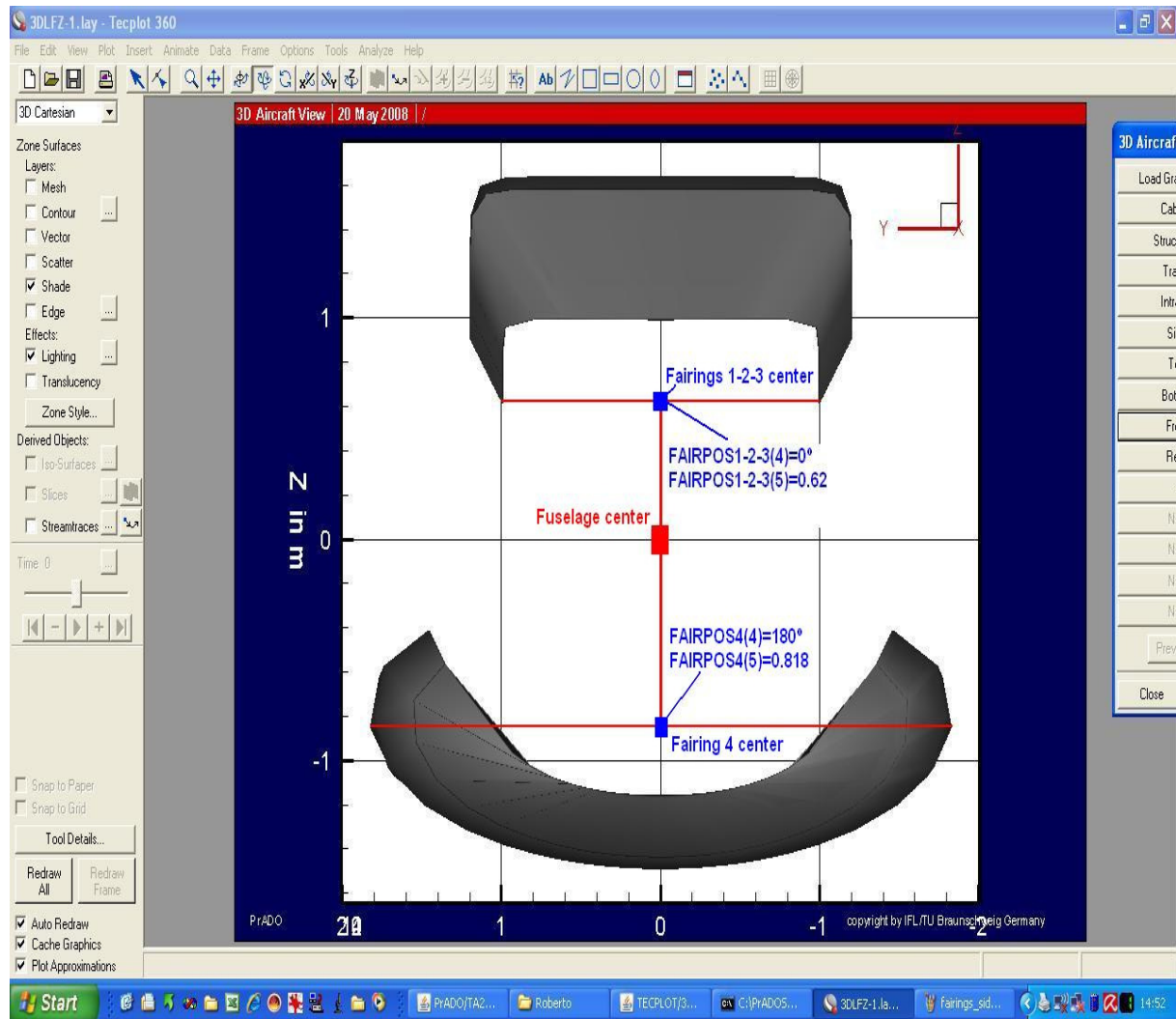


Figure 2.2 Explanation of FAIRPOS_i (4) and FAIR2POS (5)

To understand how FAIR2POS_i (7) works, compare Figure 2.3 and Figure 2.4 (both front views). In the first one FAIR2POS₄ (7) is defined as 0° and in the second one FAIR2POS₄ (7) is defined as 45°.

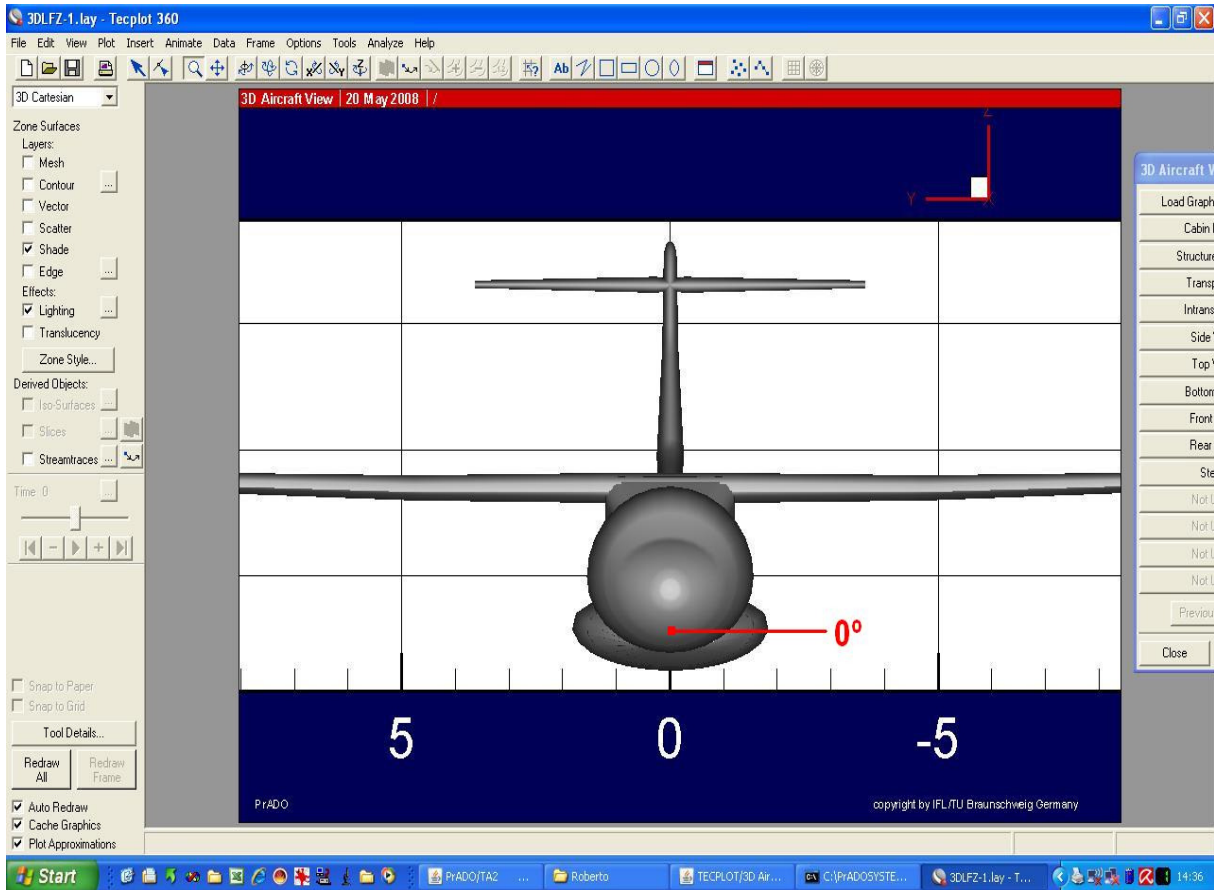


Figure 2.3 Explanation of FAIR2POSi (7). FAIR2POS4 (7) = 0°

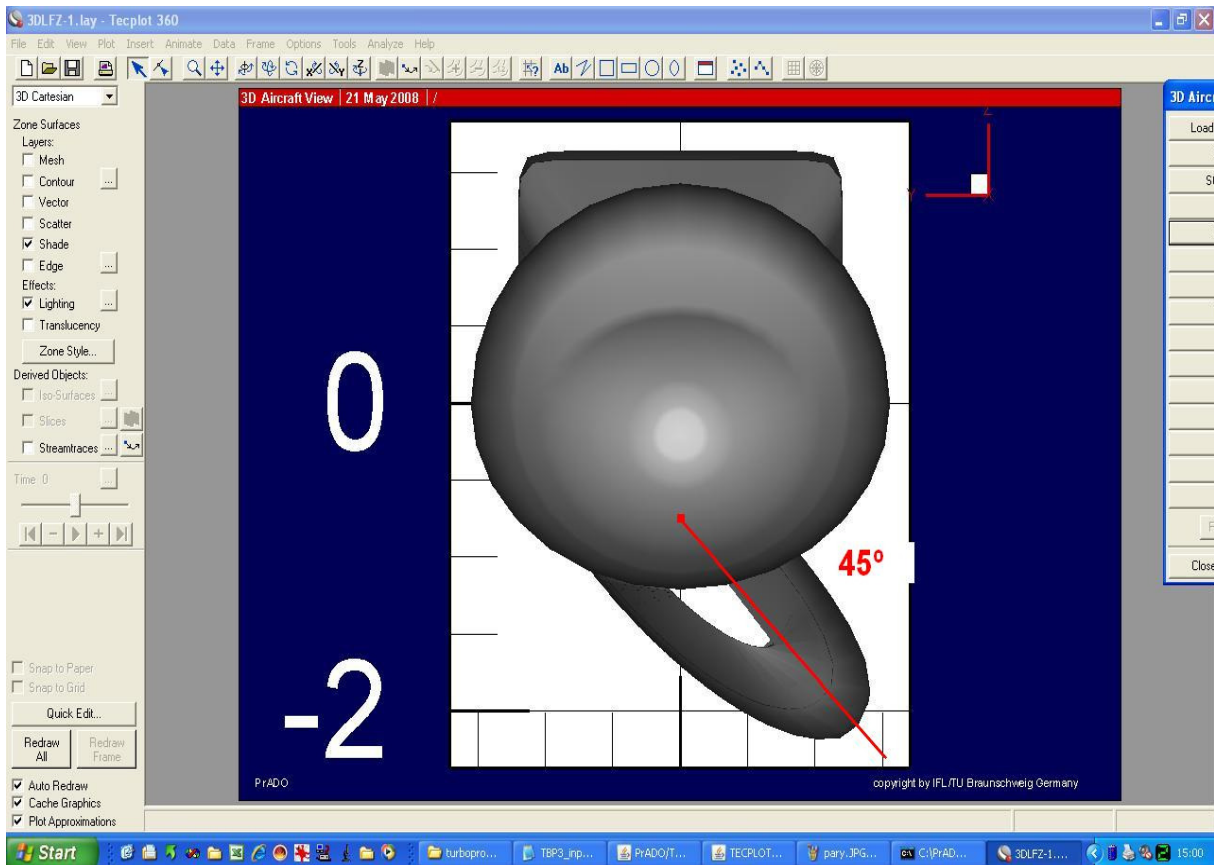


Figure 2.4 Explanation of FAIR2POSi (7). FAIR2POS4 (7) = 45°

The next two pictures (side views) show how FAIR2POSi (8) works, in the same way than before.

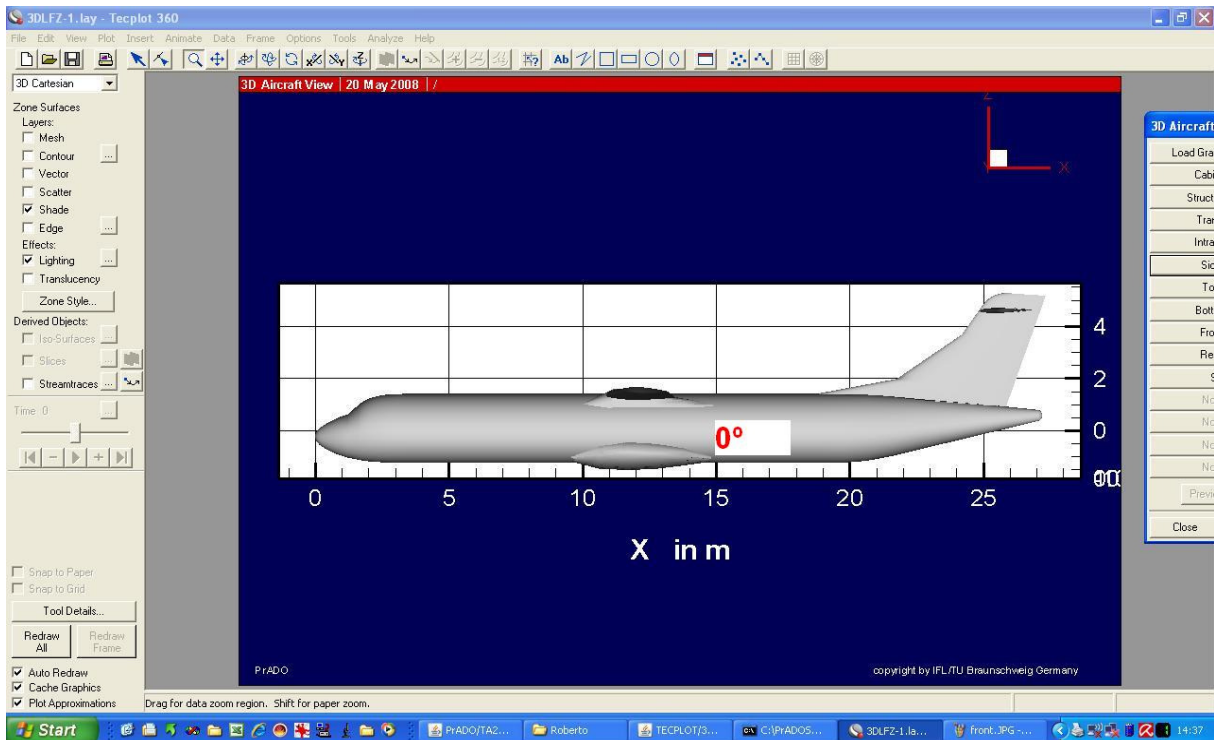


Figure 2.5 Explanation of FAIR2POSi (8). FAIR2POS4 (8) = 0°

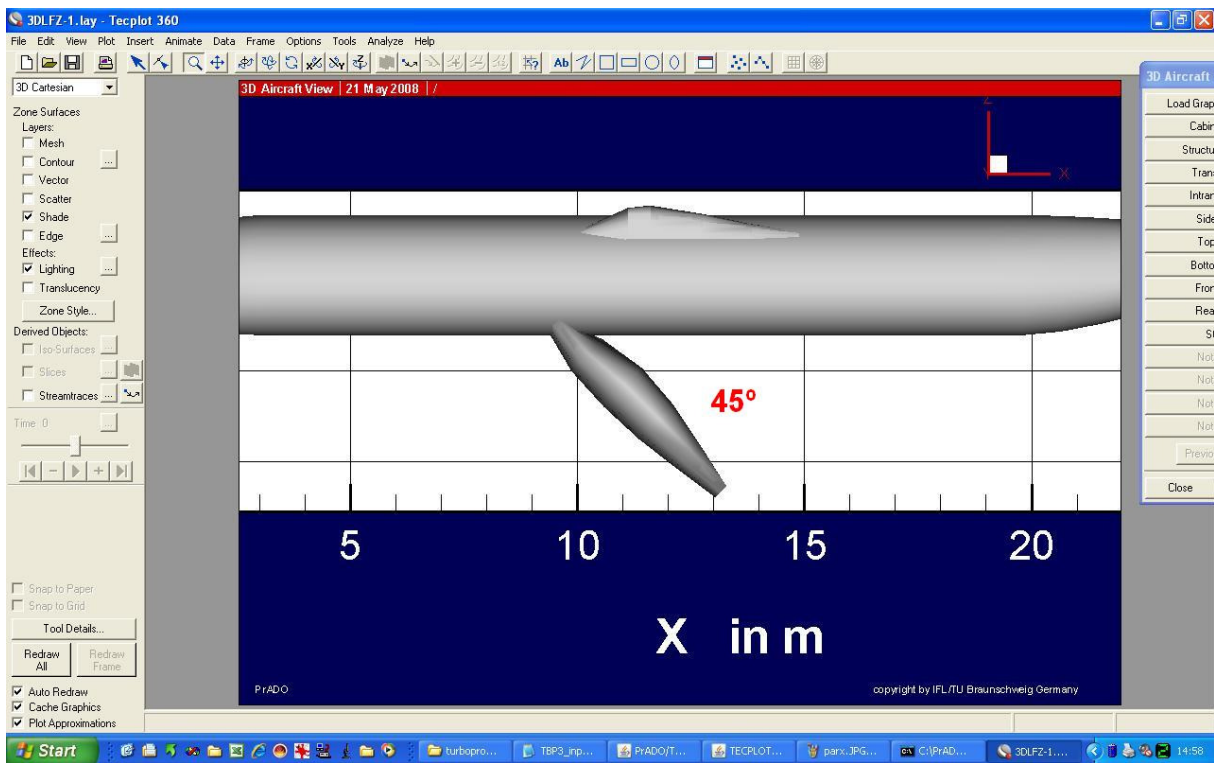


Figure 2.6 Explanation of FAIR2POSi (8). FAIR2POS4 (8) = 45°

The parameter FAIR2POSi (9) works exactly like FAIR2POS (7) and (8), but turning around Z axis.

2.2 Description of the fairing geometry

DATIFAIR1: vector with the names of the templates for each fairing.
LFAIRM: vector with the maximum length of each fairing.
HFAIRM: vector with the maximum height of each fairing.
BFAIRM: vector with the maximum width of each fairing.
DFAIRM: vector with the maximum thickness of each fairing.
SRFAIR: vector with the sand roughness of the surface of each fairing.

The code for this part is the following one:

```

<-DATIFAIR1 -    Dateiname/Fairinggeometrie-Beschreibung
  0 1 1 4
./TEMPLATE/FAIRING/fairing_ATR_1.DAT
./TEMPLATE/FAIRING/fairing_ATR_2.DAT
./TEMPLATE/FAIRING/fairing_ATR_3.DAT
./TEMPLATE/FAIRING/fairing_ATR_4.DAT
<-LFAIRM  m    Maximale Laenge/Fairing
  0 3 1 4
  3.275  0.5  1.3  5.254
<-HFAIRM  m    Maximale Hoehe/Fairing
  0 3 1 4
  1.023  1.023  0.97  1.411
<-BFAIRM  m    Maximale Breite/Fairing
  0 3 1 4
  2.4   2.4  2.4  3.657
<-DFAIRM  m    Maximale Dicke/Fairing
  0 3 1 4
  0.01  0.01  0.01  0.01
<-SRFAIR  mm   Sandrauhigkeit der Oberflaeche/Fairing
  0 3 1 4
  0.01  0.01  0.01  0.01
  
```

Comments

- The last number of the first row of numbers of each variable is equal to the number of fairings (four in this case).
- DFAIRM and SRFAIR are not calculated. These numbers are like standard values.

2.3 Fairing data for the WFAIR1-Programm

FGFAIR: vector with the specific weight per unit area for each fairing.

The code for this part is the following one:

```
<-FGFAIR kg/m**2 Spezifisches Flaechengewicht/Fairing
0 3 1 4
10. 10. 10. 10.
```

Comments

- The last number of the first row of numbers is also equal to the number of fairings (four in this case).
- This data is not calculated. These numbers are like standard values.

3 Template Fairing Description

In this file all geometric information of the fairing is contained. It's necessary to know the following variables (distances in meters and angles in degrees):

N: number of sections.
X: X-coordinate of the cross section, in local axes.
WA: initial angle of the cross section line (0... 360 degrees)
WE: final angle of the cross section line (0... 360 degrees)
IQTYP: this number defines the type of cross section.
 1 = Circle
 2 = Ellipse
 3 = Rectangle
 4 = Square
 5 = Super ellipse

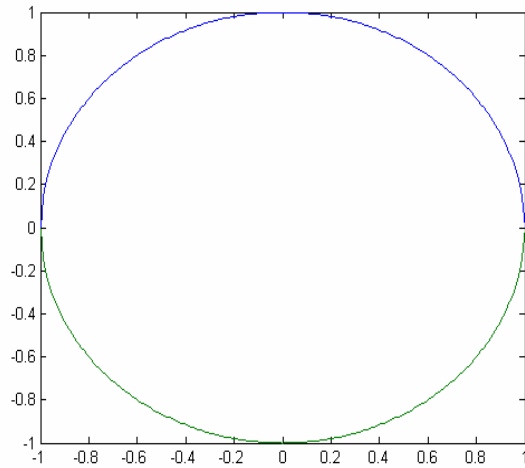


Figure 3.1 Circle section; WA=0; WE=360

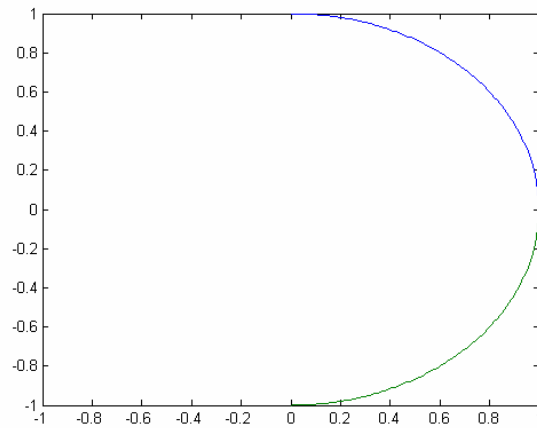


Figure 3.2 Circle section; WA=0; WE=180

IGEO: number of stored geometry information per cross section. Dependent on the type of cross section.

Cross section type 1 = 4

Cross section type 2 = 4

Cross section type 3 = 4

Cross section type 4 = 4

Cross section type 5 = 12

ZO: height over the cross section center.

ZU: height under the cross section center.

YB: half of the cross section width measured from the center.

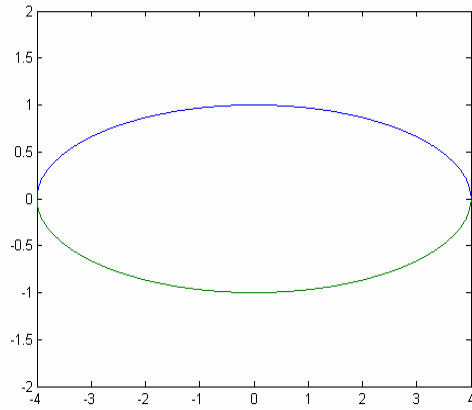


Figure 3.3 Ellipse; ZO=1; ZU=1; YB=4;

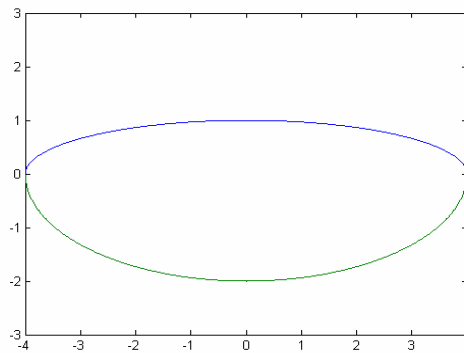


Figure 3.4 Ellipse; ZO=1; ZU=2; YB=4;

Only for super ellipses:

DZO: elevator shift of the upper cross section.

DZU: elevator shift of the lower cross section.

DY1: width shift of the cross section outward.

DY2: width shift of the lower cross section.

EXYO: ellipse exponent, Y-coordinate, upper cross section.

EXZO: ellipse exponent, Z-coordinate, upper cross section.

EXYU: ellipse exponent, Y-coordinate, lower cross section.

EXZU: ellipse exponent, Z-coordinate, lower cross section.

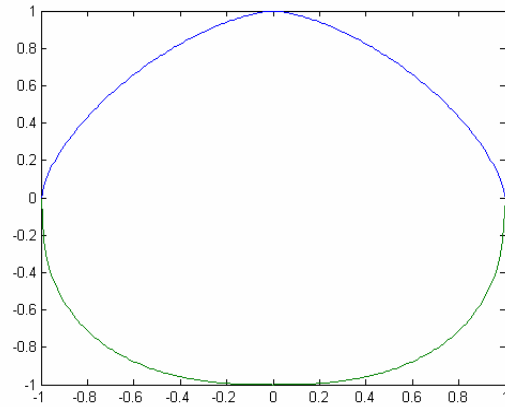


Figure 3.5 Super ellipse; ZO=1;ZU=1;YB=1; EXYO=1.5;EXZO=1.5;EXYU=2.5;EXZU=2.5

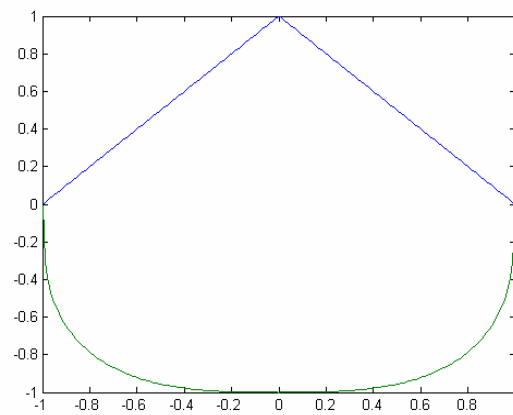


Figure 3.6 Super ellipse; ZO=1;ZU=1;YB=1; EXYO=1;EXZO=1;EXYU=3;EXZU=3

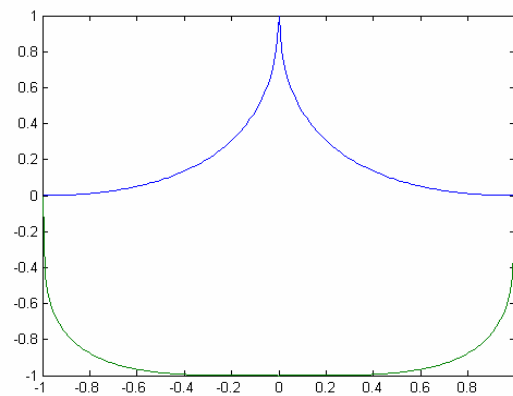


Figure 3.7 Super ellipse; ZO=1;ZU=1;YB=1; EXYO=0.5;EXZO=0.5;EXYU=4;EXZU=4

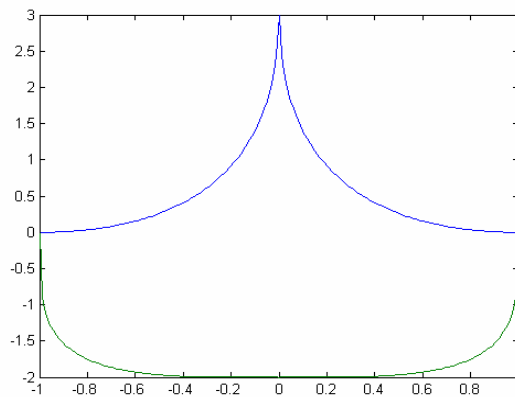


Figure 3.8 Super ellipse; ZO=3;ZU=2;YB=1; EXYO=0.5;EXZO=0.5;EXYU=4;EXZU=4;

4 Template Fairing 1 (fairing_ATR_1.dat)

This file contains the geometry information of the rear part of the upper fairing. The section is the upper half of a super ellipse, so WA=-90 and WE=90, and the width is constant along the X axis. The height is following the wing profile, and the first section is at the maximum height point. So the only parameter changing with X is ZU.

In the pictures is only possible to take measure of the intersection between the fairing and the aircraft, so is not possible to get the real measures of the fairing section. It was necessary to make a first approximation and then make some corrections by trial-error.

The code is the following one:

```
<-SPFAIR
```

```
14
```

```
0. -90. 90. 5. 12. 0. 2.000 0. 1.20 0. 0. 0. 0. 14. 14. 14. 14.
0.448 -90. 90. 5. 12. 0. 2.000 0. 1.20 0. 0. 0. 0. 14. 14. 14. 14.
0.896 -90. 90. 5. 12. 0. 2.000 0. 1.20 0. 0. 0. 0. 14. 14. 14. 14.
1.046 -90. 90. 5. 12. 0. 1.680 0. 1.20 0. 0. 0. 0. 14. 14. 14. 14.
1.196 -90. 90. 5. 12. 0. 1.6162 0. 1.20 0. 0. 0. 0. 14. 14. 14. 14.
1.344 -90. 90. 5. 12. 0. 1.5432 0. 1.20 0. 0. 0. 0. 14. 14. 14. 14.
1.494 -90. 90. 5. 12. 0. 1.4650 0. 1.20 0. 0. 0. 0. 14. 14. 14. 14.
1.644 -90. 90. 5. 12. 0. 1.3218 0. 1.20 0. 0. 0. 0. 14. 14. 14. 14.
1.792 -90. 90. 5. 12. 0. 1.3046 0. 1.20 0. 0. 0. 0. 14. 14. 14. 14.
1.942 -90. 90. 5. 12. 0. 1.2616 0. 1.20 0. 0. 0. 0. 14. 14. 14. 14.
2.092 -90. 90. 5. 12. 0. 1.2440 0. 1.20 0. 0. 0. 0. 14. 14. 14. 14.
2.242 -90. 90. 5. 12. 0. 1.2012 0. 1.20 0. 0. 0. 0. 14. 14. 14. 14.
2.742 -90. 90. 5. 12. 0. 0.9500 0. 1.20 0. 0. 0. 0. 10. 10. 10. 10.
3.275 -90. 90. 5. 12. 0. 0.9000 0. 1.17 0. 0. 0. 0. 8. 8. 8. 8.
```

****ENDE****

Figures 4.1 to 4.3 show the results:

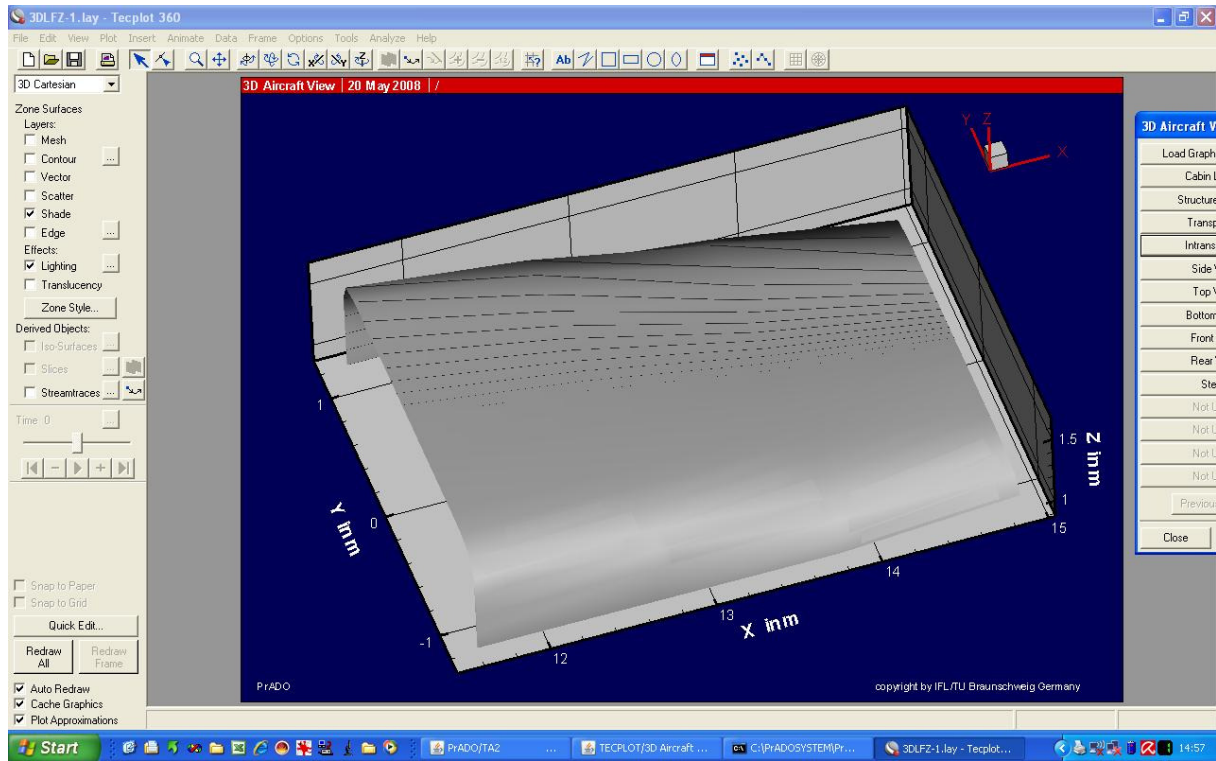


Figure 4.1 Fairing 1. 3D view.

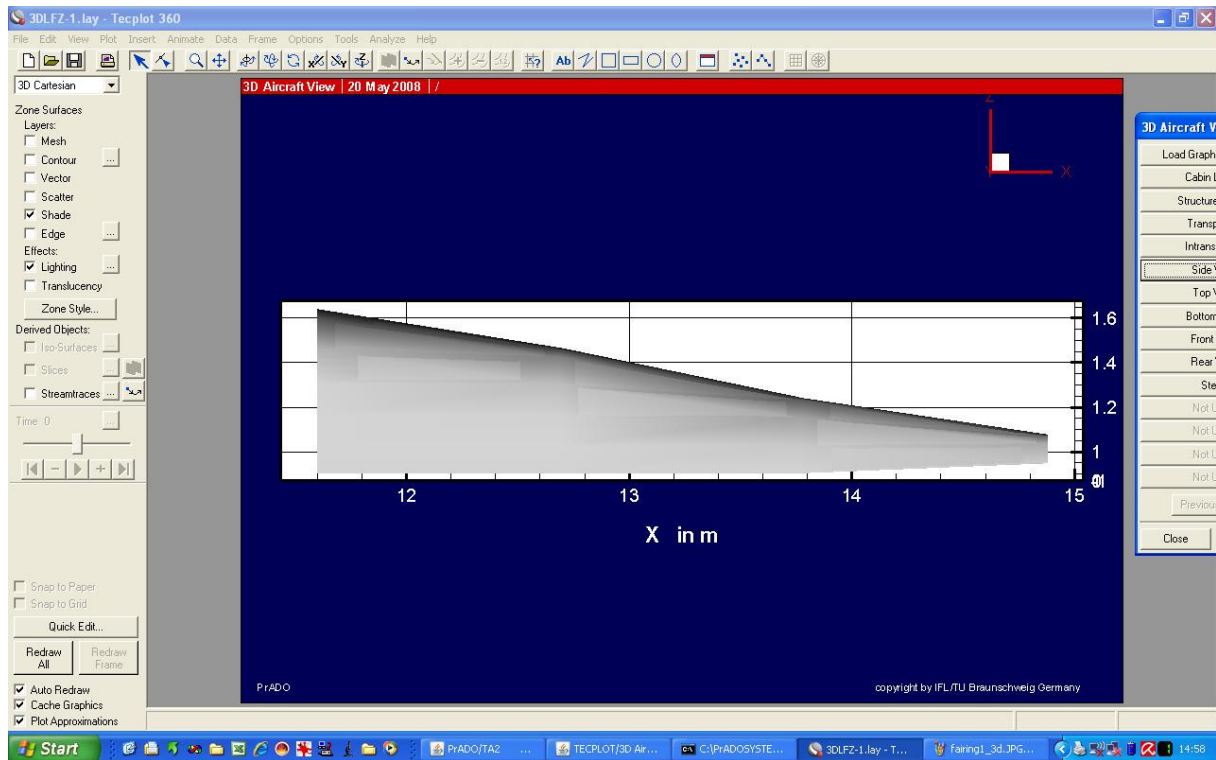


Figure 4.2 Fairing1. Side view.

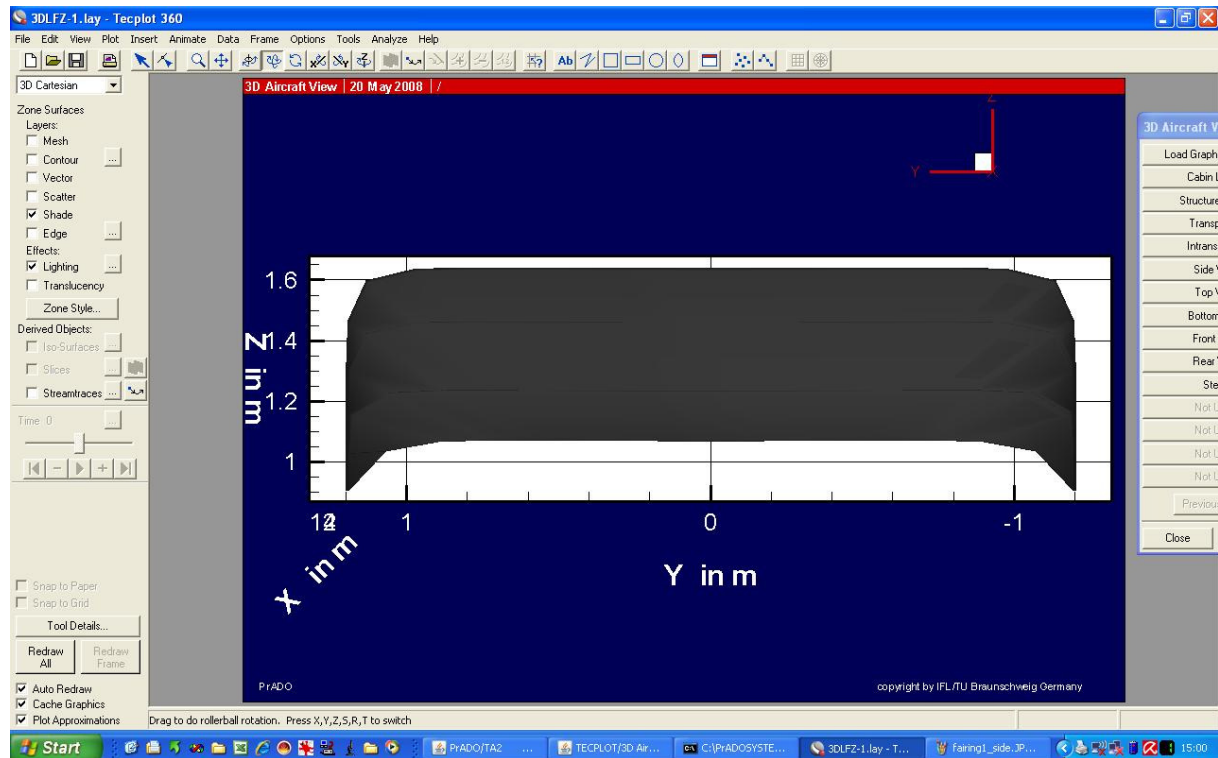


Figure 4.3

Fairing 1. Front view.

5 Template Fairing 2 (fairing_ATR_2.dat)

This file contains the geometry information of the middle part of the upper fairing. It's a small part of the whole fairing, that works as a connection between the rear and the front parts because its have very different slopes. The code is very similar to the fair1.dat because both belong to the same fairing.

The code is the following one:

```
<-SPFAIR
3
0.00 -90.90. 5.12. 0. 1.900 0. 1.20 0. 0. 0. 0. 14. 14. 14. 14.
0.25 -90.90. 5.12. 0. 2.000 0. 1.20 0. 0. 0. 0. 14. 14. 14. 14.
0.50 -90.90. 5.12. 0. 2.000 0. 1.20 0. 0. 0. 0. 14. 14. 14. 14.
**ENDE**
```

Figures 5.1 to 5.3 show the results:

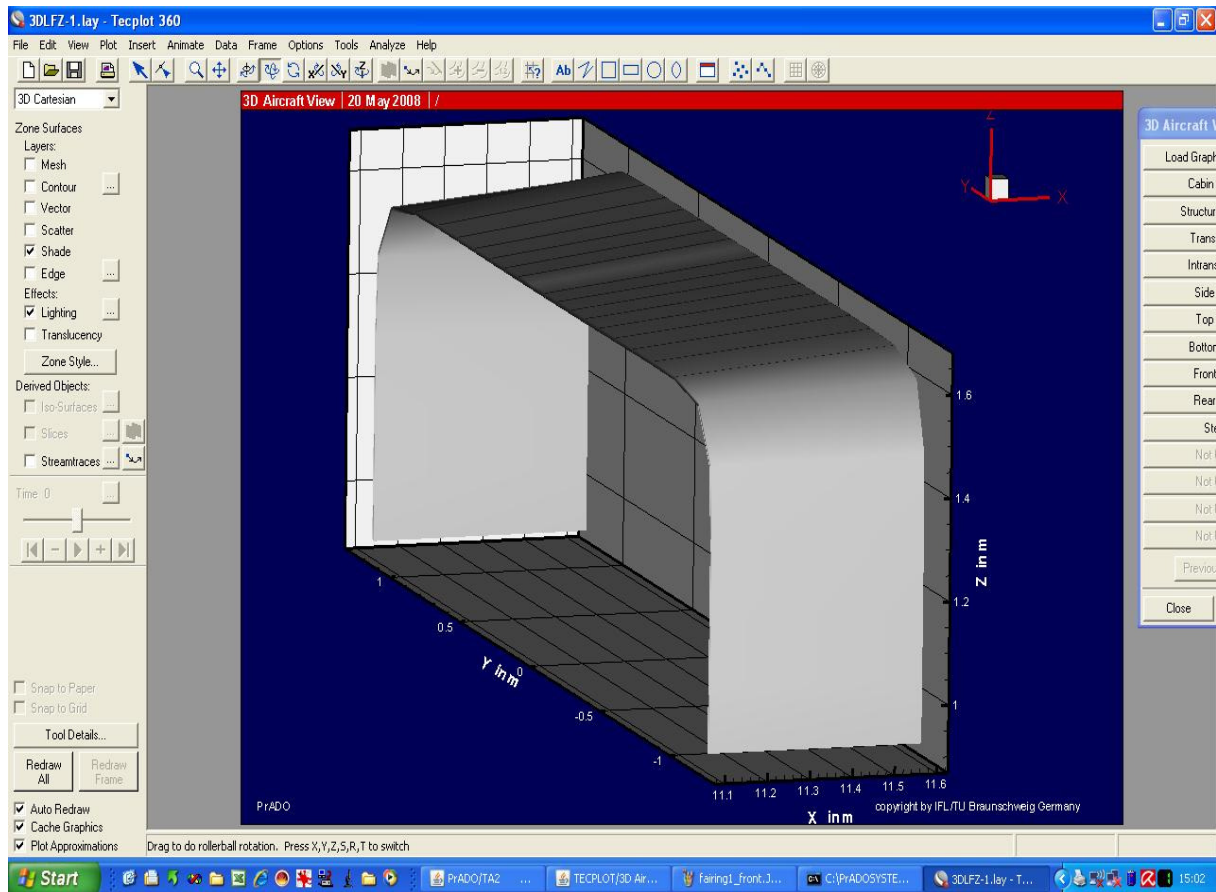


Figure 5.1

Fairing 2. 3D view.

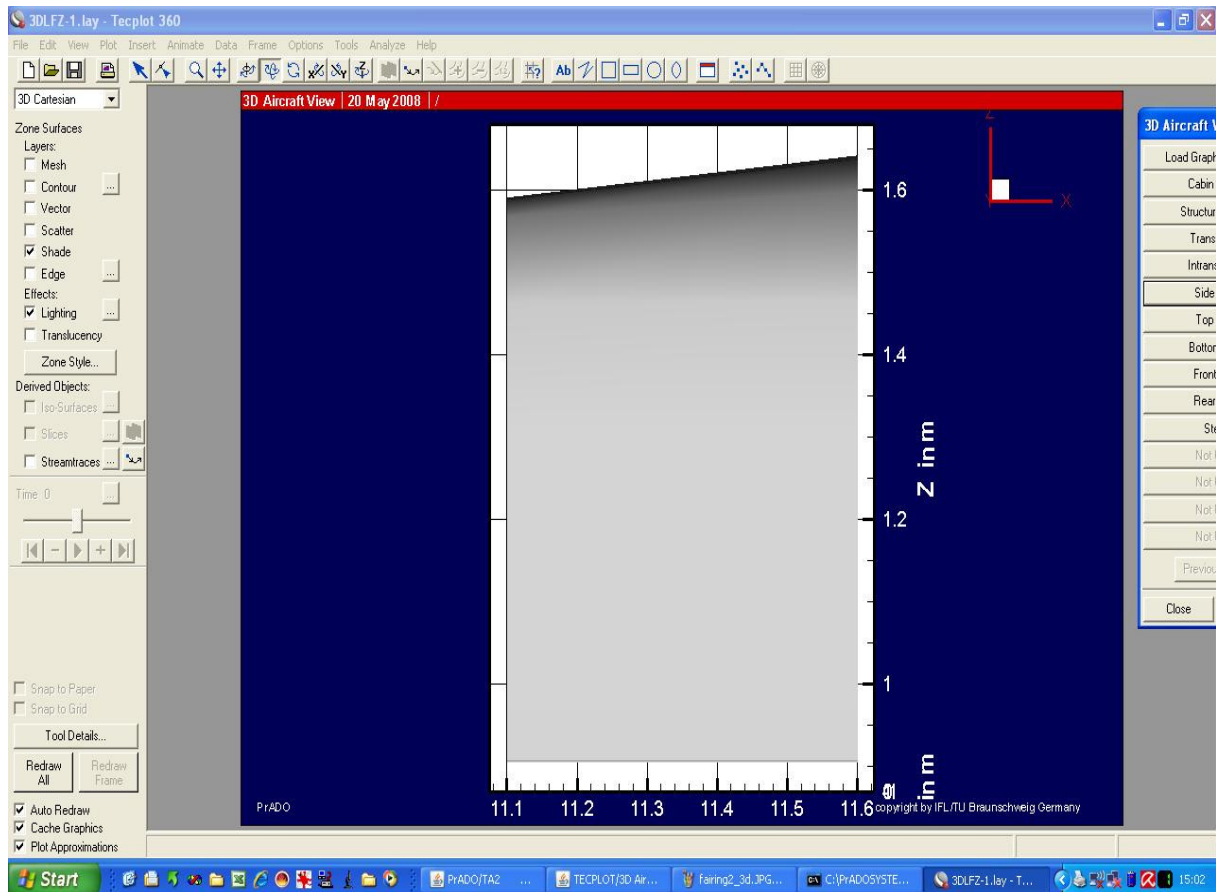


Figure 5.2

Fairing 2. Side view.

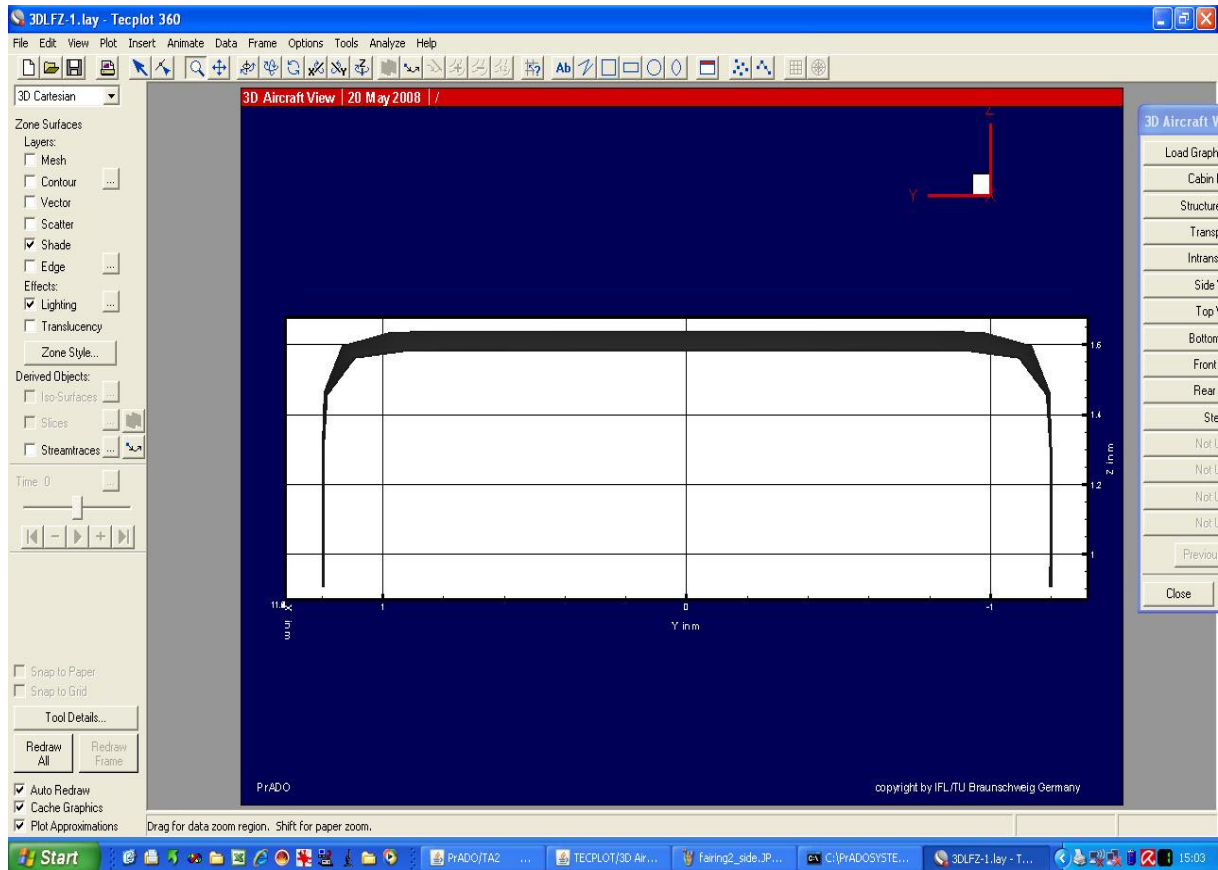


Figure 5.3

Fairing 2. Front view.

6 Template Fairing 3 (fairing_ATR_3.dat)

This file contains the geometry information of the front part of the upper fairing. This file is very similar to fairing_ATR_2.dat, but with a stronger slope. The width value at the beginning of the fairing is smaller than the rest of the fairing.

The code is the following one:

```
<-SPFAIR
```

```
2
```

```
0.00 -90.90. 5.12. 0. 0.750 0. 1.00 0. 0. 0. 0. 14. 14. 14. 14.
```

```
1.30 -90.90. 5.12. 0. 1.900 0. 1.20 0. 0. 0. 0. 14. 14. 14. 14.
```

```
**ENDE**
```

Figures 6.1 to 6.3 show the results:

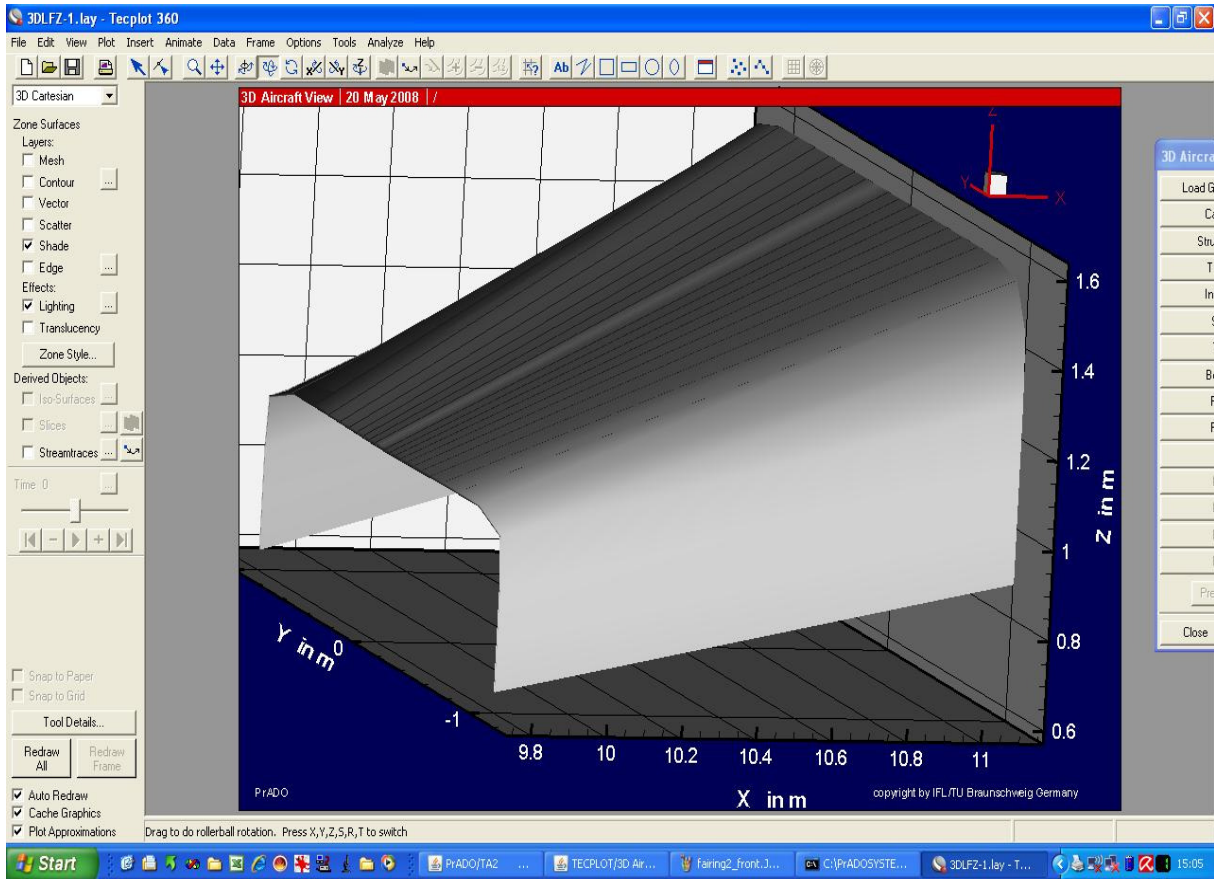


Figure 6.1 Fairing 3. 3D view.

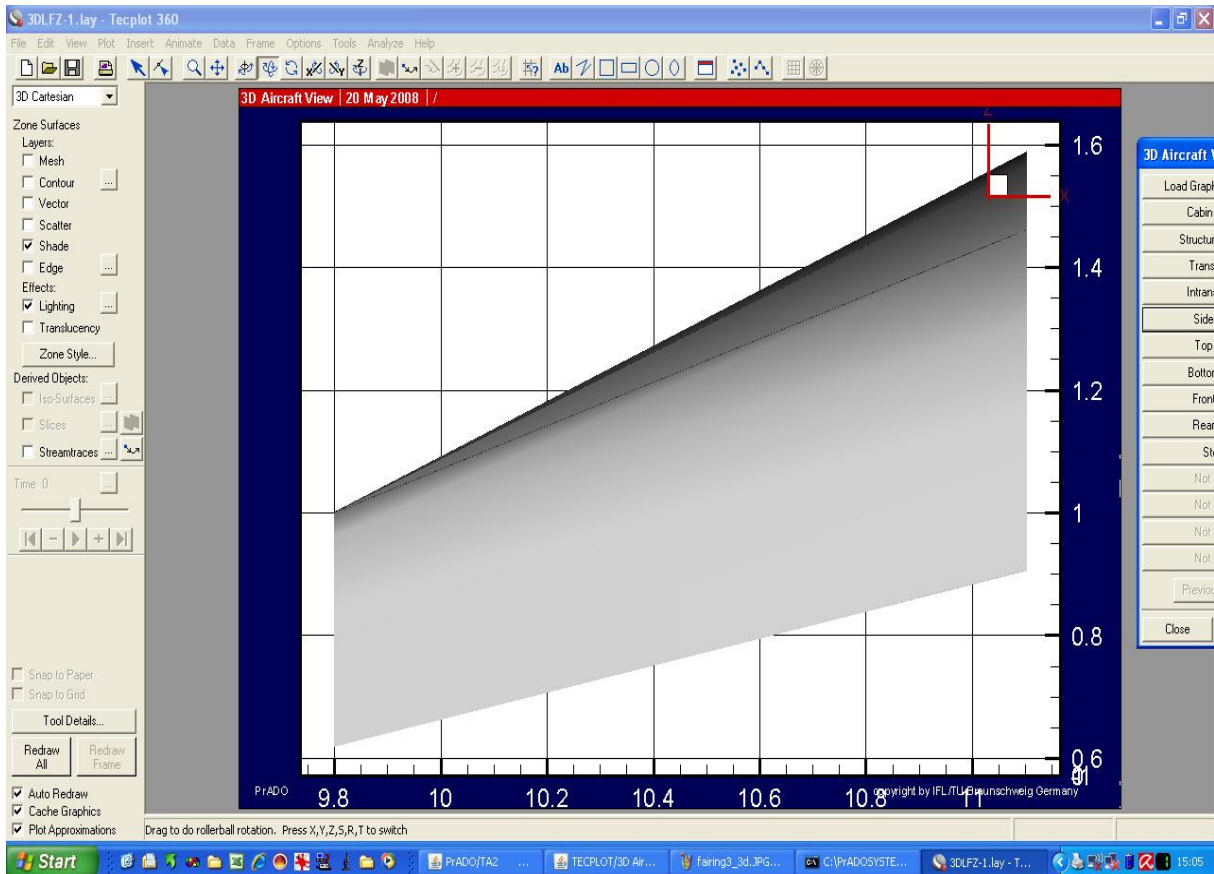


Figure 6.2 Fairing 3. Side view.

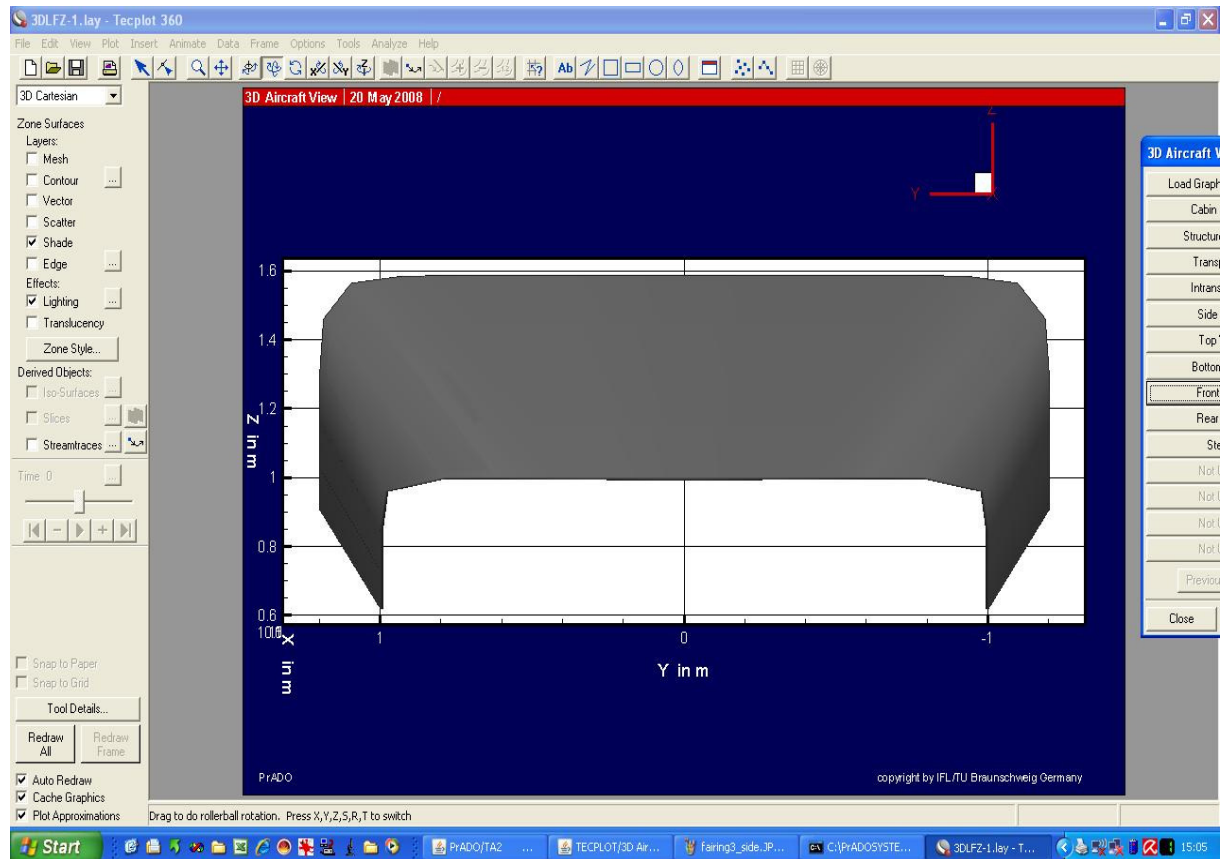


Figure 6.3

Fairing 3. Front view.

7 Template Fairing 4 (fairing_ATR_4.dat)

This file contains the geometry information of the fairing for the landing gear. It's easier than the others fairings because it's possible to take real measures of almost the whole fairing. The section is now a complete super ellipse ($WA=0$; $WE=360$), but the upper part is different than the lower part ($EXYO=5$; $EXZO=5$; $EXYU=2$; $EXZU=2$). The center of the fairing has to be between these different upper and lower parts, so a line was drawn to see where it is, and then is easy to take measures for ZO and ZU (Figure 7.1). The width change now along the whole fairing, and is very easy to take that measures.

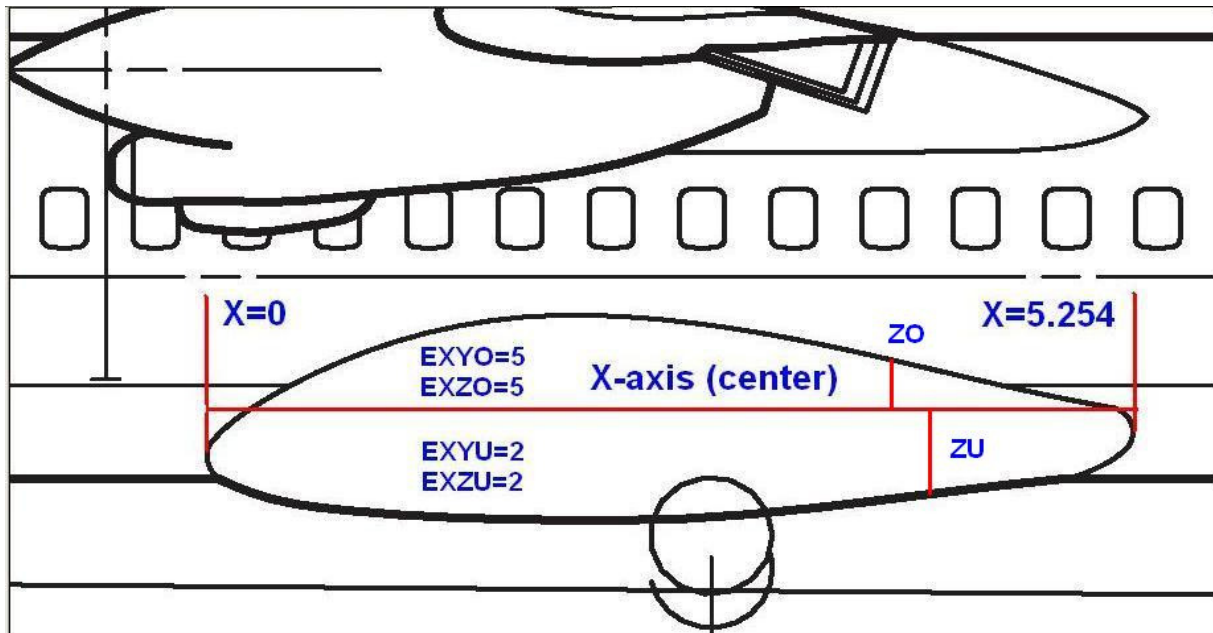


Figure 7.1 Profile of the lower fairing, showing where the center is.

The code is the following one:

```
<-SPFAIR
8
0. 0.360. 5.12. 0. 0. 0.345 1.0325 0. 0. 0. 0. 3. 3. 2. 2.
0.234 0.360. 5.12. 0. 0. 0.5 1.3325 0. 0. 0. 0. 3. 3. 2. 2.
1.222 0.360. 5.12. 0. 0.488 0.642 1.6305 0. 0. 0. 0. 3. 3. 2. 2.
2.210 0.360. 5.12. 0. 0.738 0.673 1.8285 0. 0. 0. 0. 3. 3. 2. 2.
3.198 0.360. 5.12. 0. 0.488 0.626 1.8285 0. 0. 0. 0. 3. 3. 2. 2.
4.186 0.360. 5.12. 0. 0.238 0.500 1.6305 0. 0. 0. 0. 3. 3. 2. 2.
5.174 0.360. 5.12. 0. 0. 0.380 1.3325 0. 0. 0. 0. 3. 3. 2. 2.
5.254 0.360. 5.12. 0. 0. 0.345 1.0325 0. 0. 0. 0. 3. 3. 2. 2.
**ENDE**
```

The following pictures show the results:

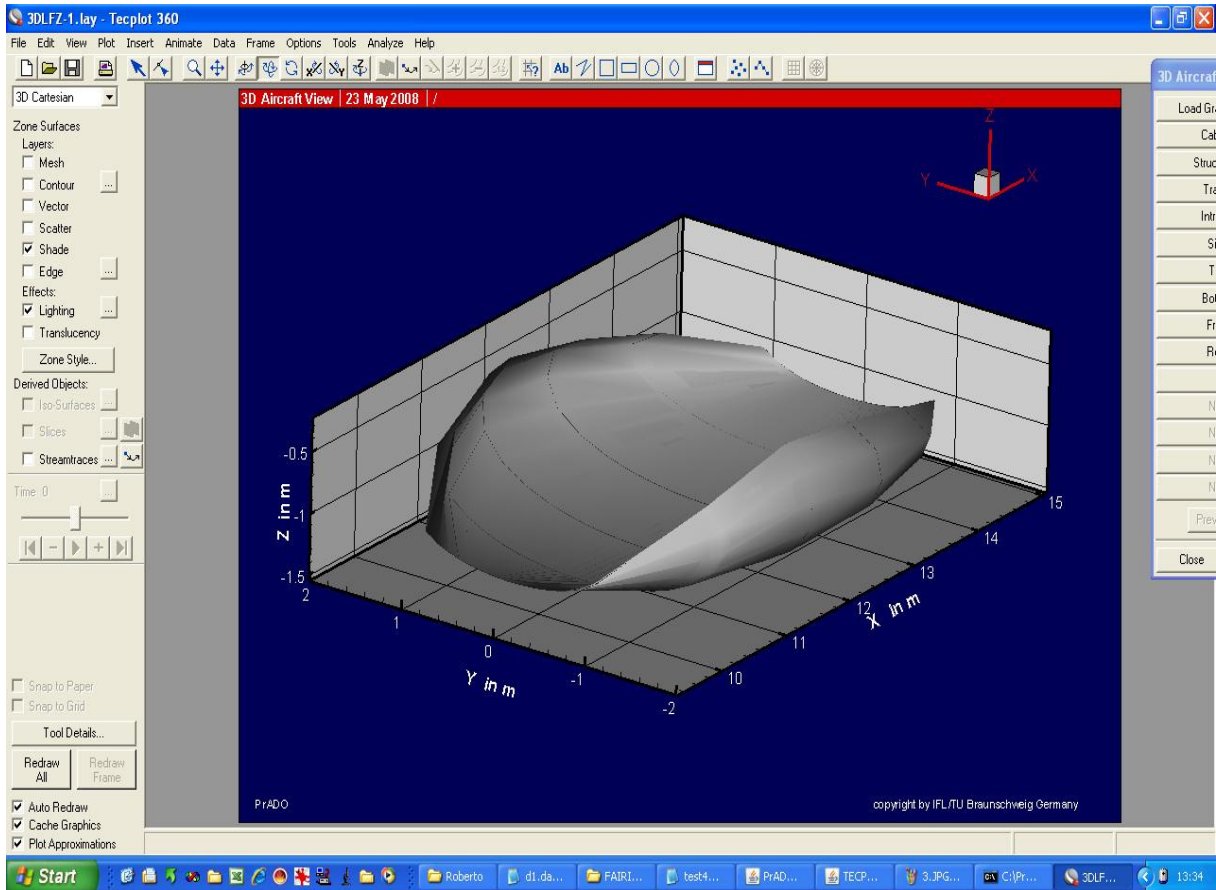


Figure 7.2

Fairing 4. 3D view.

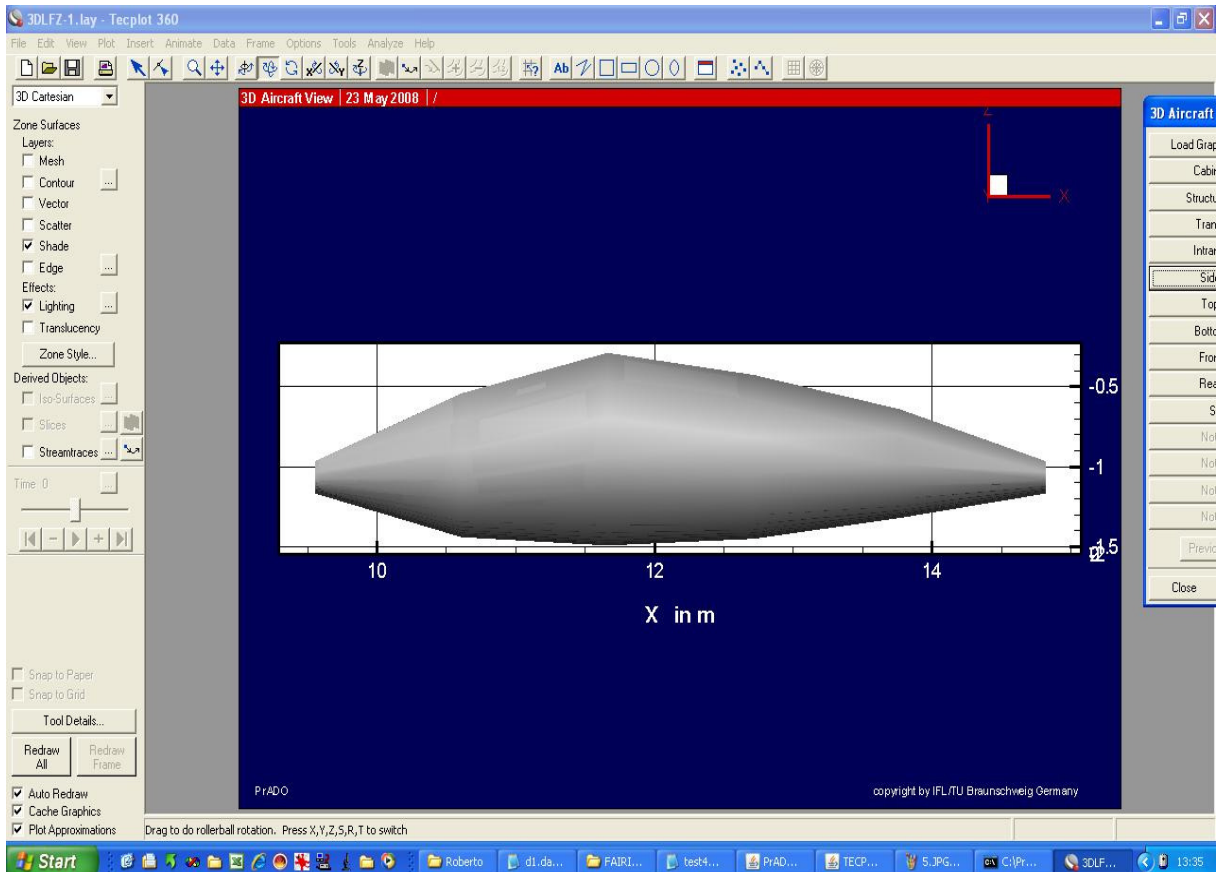


Figure 7.3

Fairing 4. Side view.

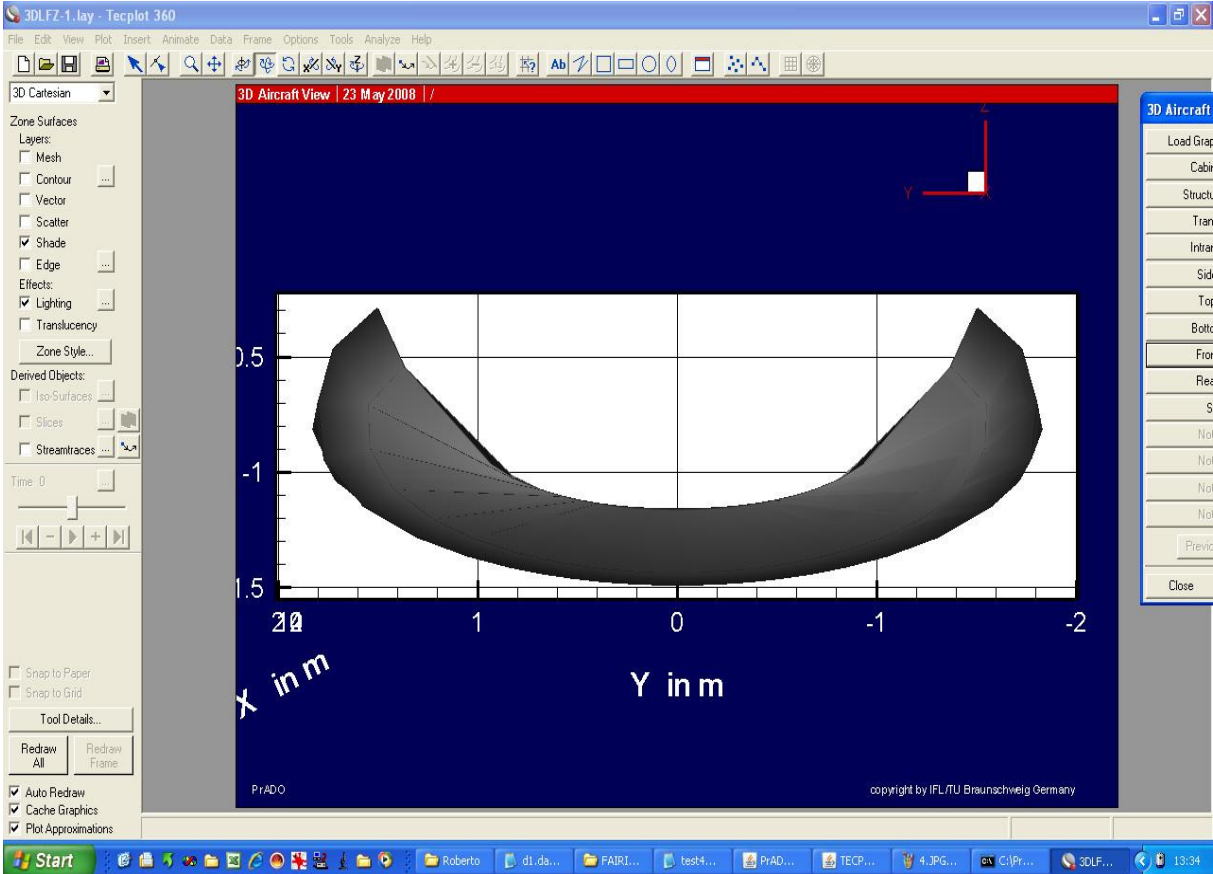


Figure 7.4

Fairing 4. Front view.

8 Views

Only some views of the fairings, now integrated in the ATR-72.

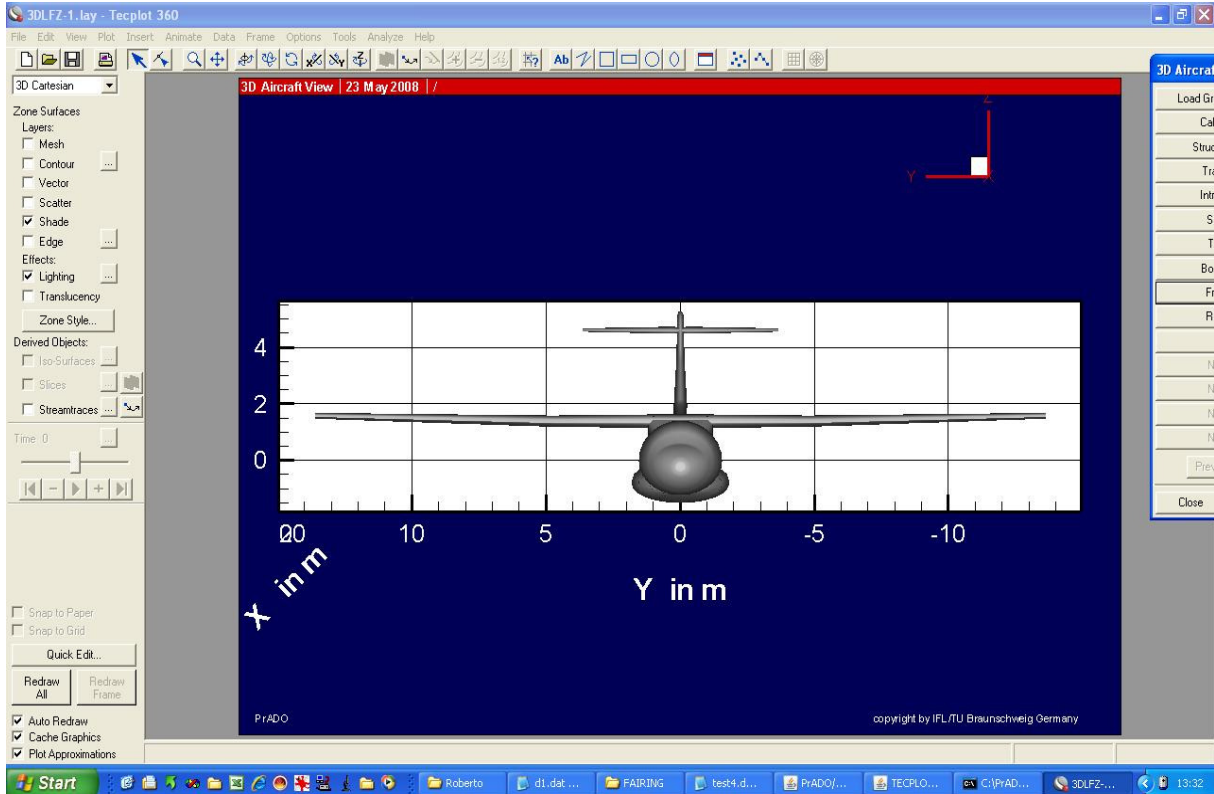


Figure 8.1 ATR-72 with fairings. Front View.

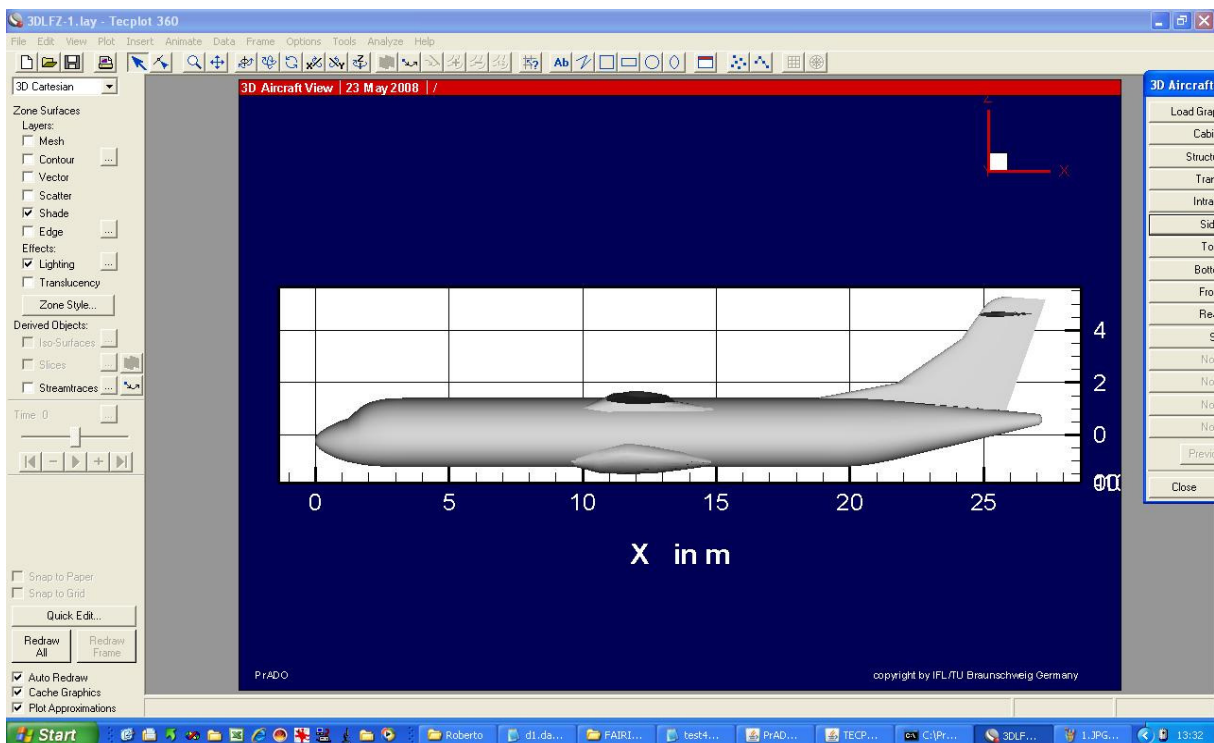


Figure 8.2 ATR-72 with fairings. Side View.

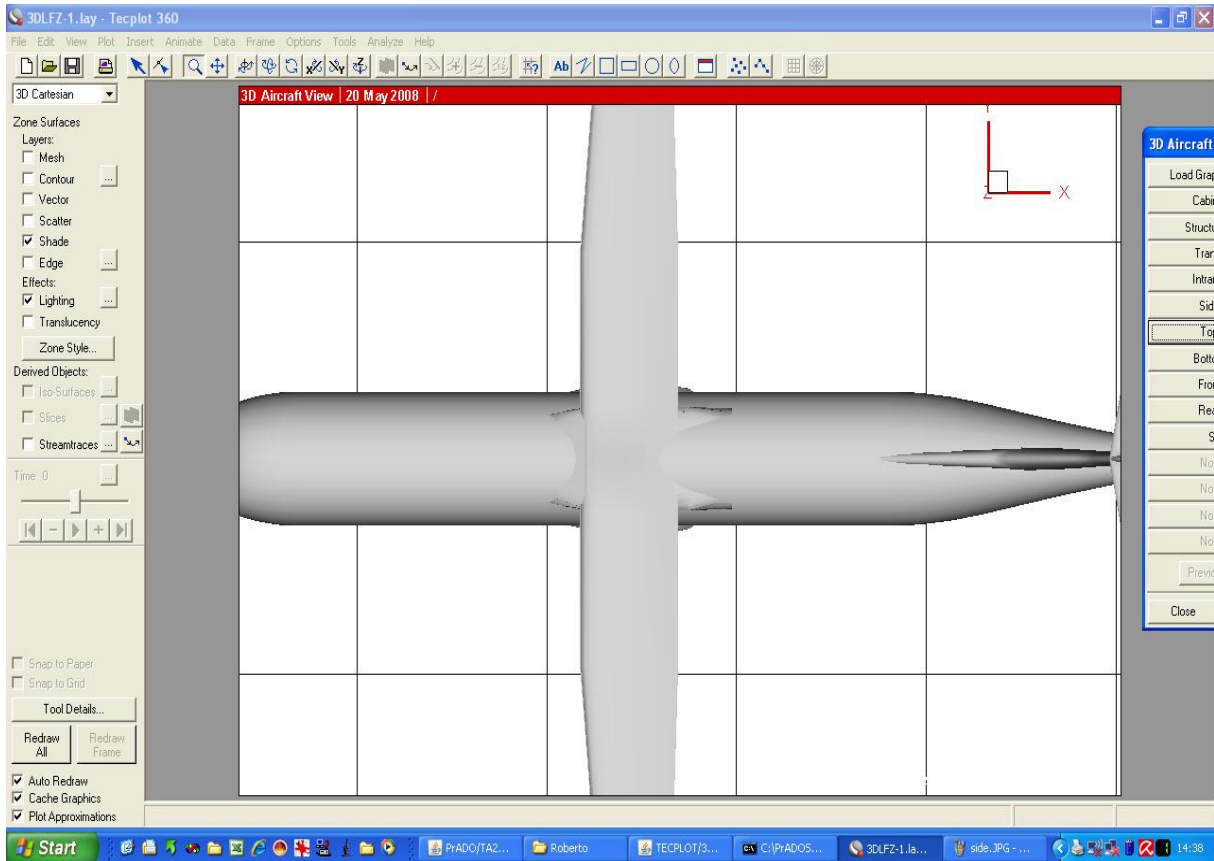


Figure 8.3 ATR-72 with fairings. Top View.

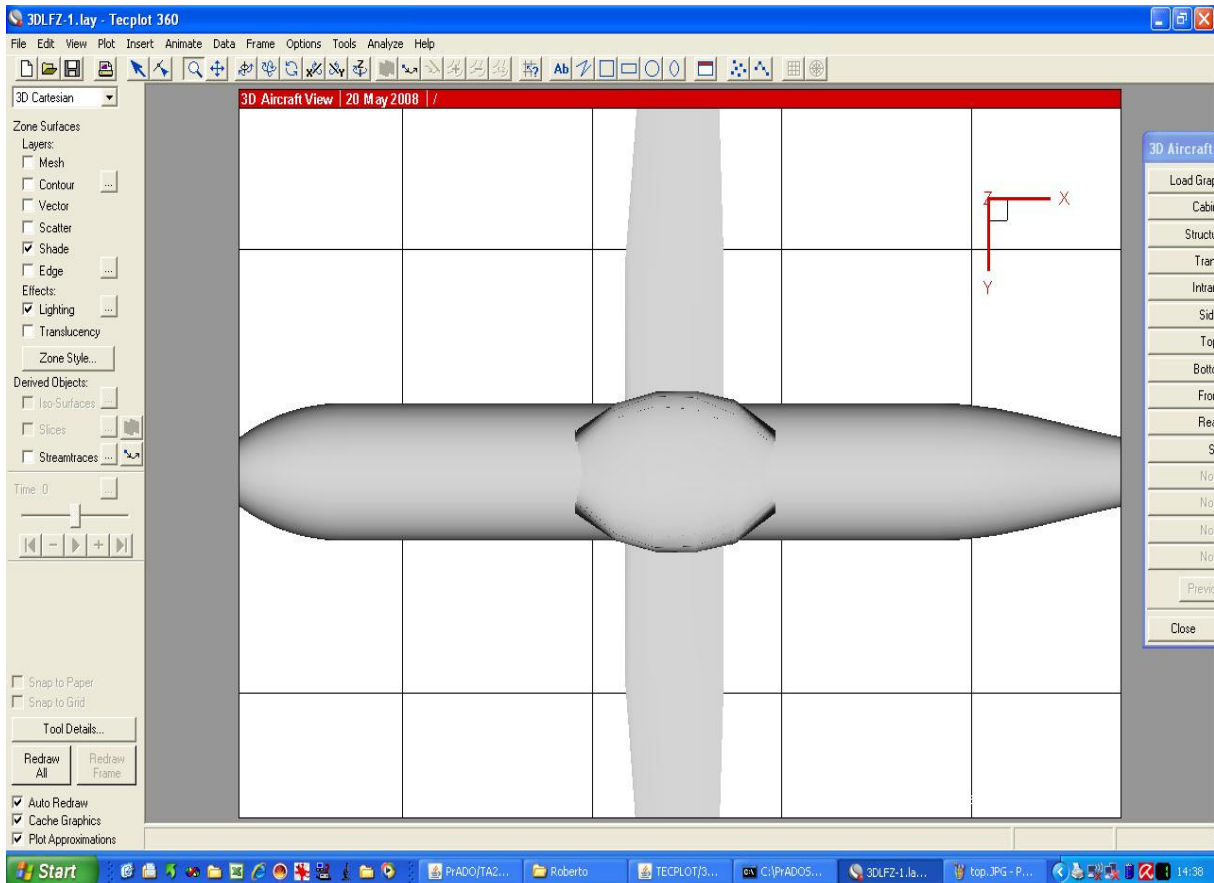


Figure 8.4 ATR-72 with fairings. Bottom view.

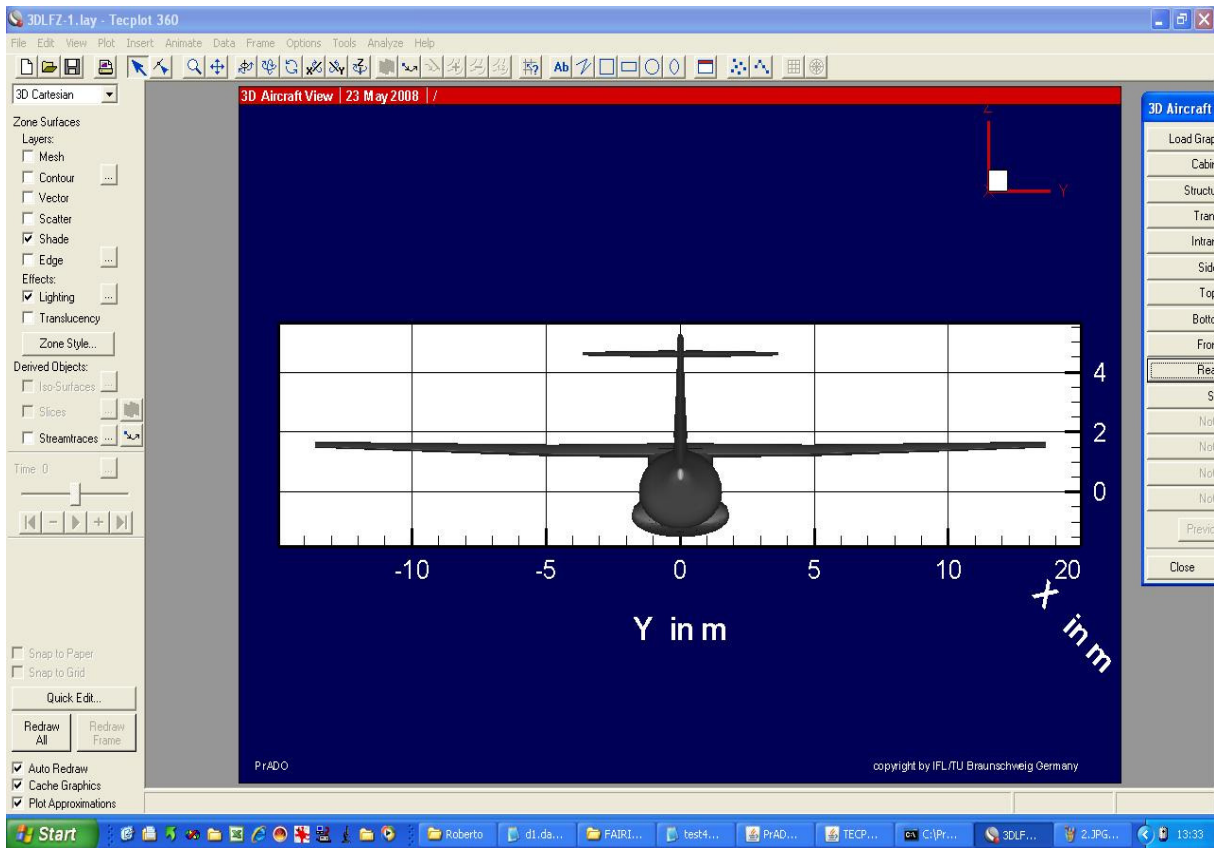


Figure 8.5 ATR-72 with fairings. Rear view.

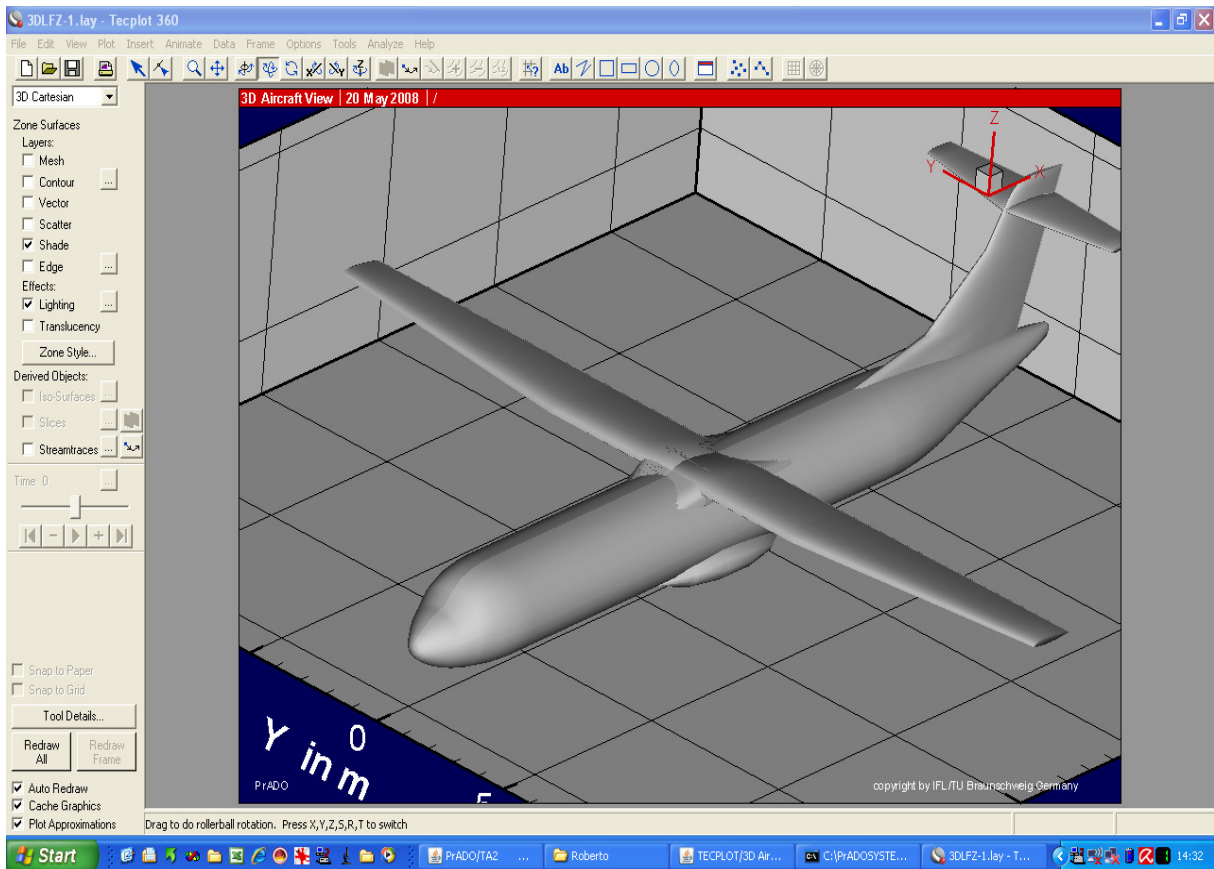


Figure 8.6 ATR-72 with fairings. Steric.

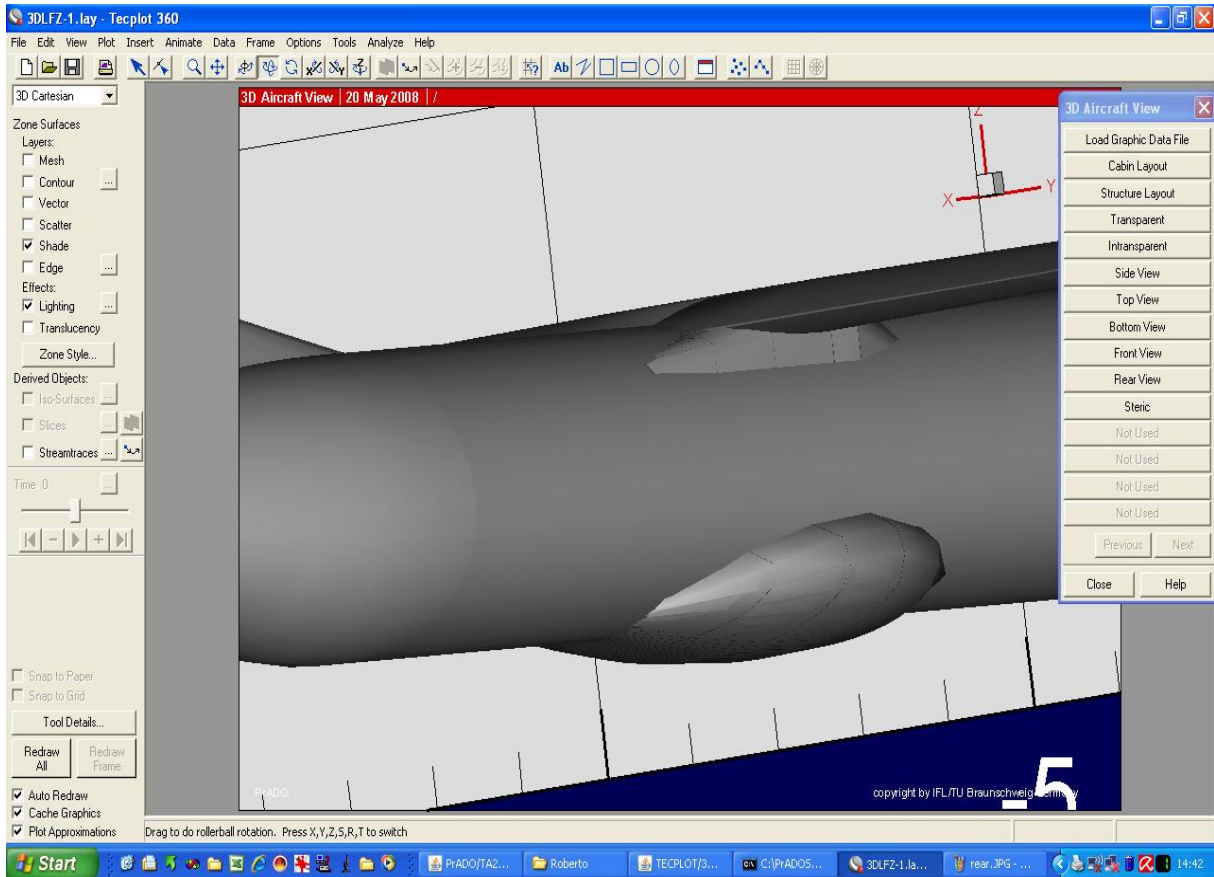


Figure 8.7

ATR-72 with fairings. Detail 1.

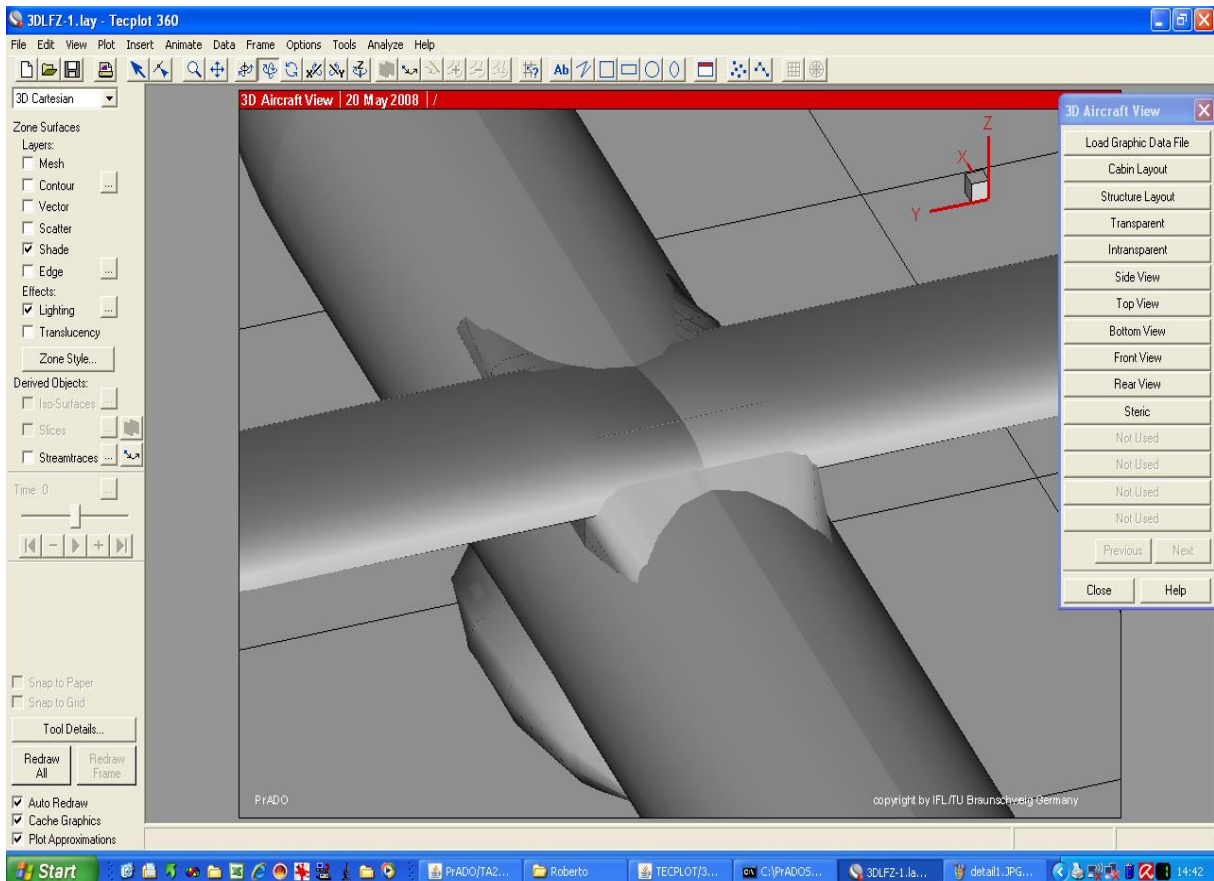


Figure 8.8

ATR-72 with fairings. Detail 2.

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10 3D drawings of the ATR-72

