

# **Aircraft Coefficient Comparisons Between Datcom and Published Data**

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## **1. Introduction**

In this paper, we will examine the aerodynamic coefficients produce by Datcom, comparing them to published aircraft values. Interpretation of the results will be left up to the reader.

The Digital Datcom program is computer program encompassing over 50,000 lines of Fortran code, which embodies many of the equations contained in the USAF Stability and Control DATCOM (Data Compendium), a document of over 1400 pages used for preliminary design of aircraft. The Digital Datcom program, also referred to just as Datcom, embodies many of the equations and techniques in the DATCOM. It was written in the late 1960's and 1970's, and supported by Wright-Patterson Air Force Base until 1996, when the code was released to the public domain.

In 1996, the author received a copy of the code and started making improvements to the interface, input and output. This eventually morphed into a package of tools called Datcom+. This was distributed and supported by the author, and boasts thousands of users around the globe, and a Yahoo support group<sup>i</sup>. In 2011, the Datcom+ package went professional, with new and better tools, better integrated with JSBSim and Matlab. It is available for a nominal cost<sup>ii</sup>.

The Digital Datcom program has been in use for 40 years, but comparison of stability coefficients produced by Datcom to published aircraft data cannot be found.

An analogy would be in order here: One person looking at the Mona Lisa might describe it as "A picture of some woman". Another might describe it in more glowing terms, describing the setting, a little of the background, and feeling invoked by the picture. A third person might talk for hours on the history of the picture, how it was created, details of the paint used, the artist and the model, on and on. From a modeling perspective, the first person would be an Aeromatic model<sup>iii</sup>, derived from a dozen generalize parameters of the aircraft. The second person would be the Datcom program, and the third would be the manufacturer's data package or coefficients derived from flight test data. The quality of the models produced by Aeromatic and Datcom should only be judged by the comparison against flight test data, as the manufacturer's data package would be. That is beyond the scope of this investigation, but it bears keeping in mind when looking at the coefficients. The stability coefficients produced by Datcom might not match the aircraft criteria numbers, but there are more factors in the aircraft data which are addressed separately, which Datcom might include these effects in its overall number.

### 1.1. General description of Input files

6 existing Datcom models were chosen, model which were already developed, and for which coefficient data was available from other sources. The aircraft chosen were:

1. North American Aviation Navion – single reciprocation engine, propeller-driven, low wing light aircraft
2. Cessna Citation – twin turbofan transonic business jet
3. Beechcraft T-34C – single reciprocation engine, propeller-driven, low wing light aircraft
4. Cessna C-172 – single reciprocation engine, propeller-driven, high wing light aircraft
5. Northrop T-38 – twin turbofan engine transonic fighter
6. Boeing 737-300 – twin turbofan transonic transport aircraft

These aircraft represent a sampling of the types of aircraft which are commonly modeled using Datcom, although do not represent all aircraft that can or will be modeled with Datcom. These aircraft are what data was readily available for.

### 1.2. Details of Input files

Existing Datcom input files were modified to be consistent for the control cards to produce similar output. Aileron, flaps, and other wing-mounted control surfaces, if present, were removed, so that there was only one case present. That case contained the fuselage, wing, horizontal and vertical stabilizers, ventral fin if originally present, and elevator or stabilator. Engines were removed to eliminate the engine effects in the longitudinal stability coefficients. Control cards **DERIV RAD** and **DAMP** were added if not already present, to present the derivatives in per radians for consistency between models. Comment lines and other formatting features exclusive to Datcom+ and *Datcom+ Pro* were removed, to allow these files to be imported into other versions of DIGDAT which might not support these modifications. All models had a range of angle of attack (AOA) values which extended at least from -4 deg to + 4 deg, and contained the value of 0.0 deg AOA. Aircraft center of gravity (CG) is critical for the determination of some parameters, so the CG used for the Datcom model matched criteria data.

### 1.3. Details of Output files

The data produced by the Datcom program was retrieved from FOR006.DAT or {aircraft}.out file, which is in the original format of the Datcom program. Coefficients were taken at the 0.0 deg AOA value from all models for consistency. The coefficients are shown in table format, with the 'criteria' value, Datcom value, and error from the criteria is presented.

## 2. Aircraft

### 2.1. North American Aviation Navion

Coefficient data for the Navion aircraft was originally identified to the author by a Datcom user, as presented in a standard university aerodynamics textbook<sup>iv</sup>. This book did reference the source of the data as NASA CR-96008<sup>v</sup>. The following paragraph appeared in the introduction of that document:

While complete coverage of each aircraft including only the "latest" and "best" data would be desirable, the major criterion used was that the data be immediately accessible to the author. This is why only isolated flight conditions are given for some aircraft, and also why, as those people more intimately familiar with each particular aircraft will recognize, the data presented may represent an early estimate in the design process and perhaps the "nominal configuration" is one which never left the drawing board. The data have been reviewed and, although not all those presented indicate unquestionable trends, those data known to be based on only early "guesstimates" or showing unreasonable trends have been deleted. As to how well the data can be expected to match the flying aircraft, it is assumed that those for whom this document is intended know well the difficulties of obtaining derivatives from flight test data. Every attempt has been made to insure reliable translation, interpretation, and transcription of the data from their source documents.

No other information concerning the origins of this data was mentioned. However, additional research uncovered another NASA report, NASA TN-6643<sup>vi</sup>, which cited the CR-96008 report, and showed that data against coefficients derived from flight test data. This report did not show all of the coefficients, and the flight test data was taken at a different Center of Gravity (CG) location, so it was not used for this comparison. Data was not available for all stability coefficients.

The Datcom model for this aircraft originated in a NASA report<sup>vii</sup> out of Langley on the plotting feature of the original Datcom program, from 1983. The only change made to this model was to move the CG location to 29.5% MAC from the original 30.33% MAC. No other aspects of the model were verified.

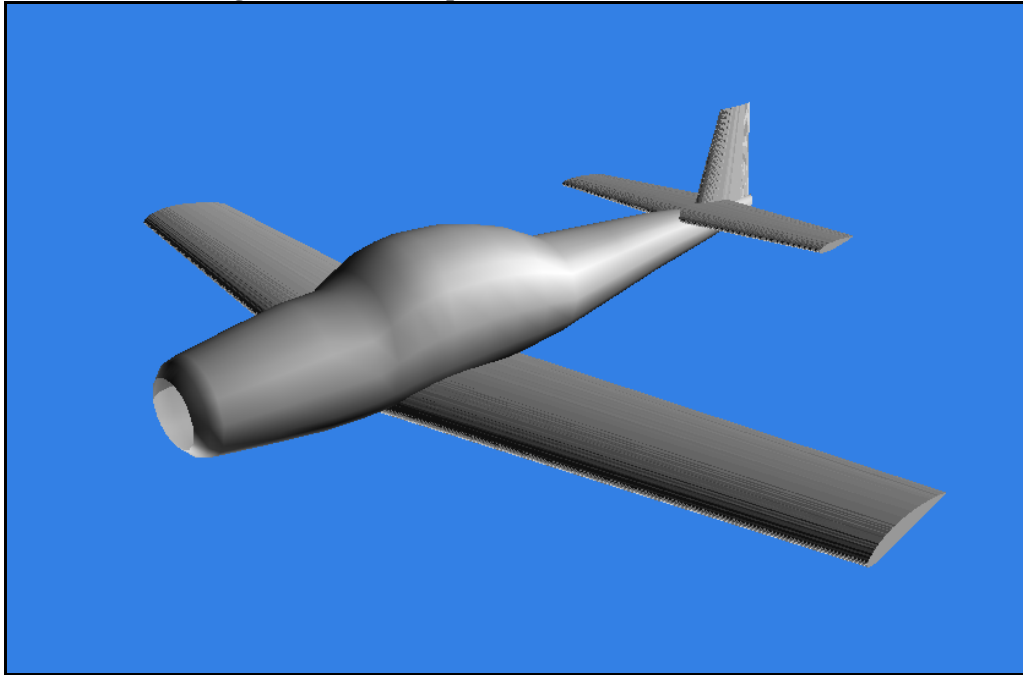
The Datcom input file for this aircraft is shown in Datcom Model 1. The resulting aircraft is shown in Figure 1. Aerodynamic stability coefficients from the criteria data and Datcom program are shown in Table 1.

**Datcom Model 1 - Navion**

```

CASEID NAVION NASA TN D-5857
DERIV RAD
DAMP
$FLTCON NMACH=1.0,MACH=0.2,NALT=1.0,ALT=0.0,
  NALPHA=15.0,ALSCHD=-4.0,-2.0,0.0,2.0,4.0,6.0,8.0,10.0,12.0,14.0,
  16.0,18.0,20.0,22.0,24.0,GAMMA=0.0,WT=2750.0,$
$OPTINS SREF=180.0,CBARR=5.67,BLREF=33.38$
$SYNTHS XCG=7.95,ZCG=-0.47,XW=6.28,ZW=-2.12,ALIW=2.0,XH=21.64,
  ZH=0.78,ALIH=0.0,XV=23.21,ZV=0.0,XVF=19.76,ZVF=1.25,VERTUP=.TRUE.$
$BODY NX=18.0,ITYPE=1.0,
  X=0.0,0.314,0.666,2.352,4.077,5.449,6.115,6.939,7.644,8.311,
  9.840,11.055,12.505,14.191,17.327,20.503,23.639,27.755,
  ZU=1.019,1.372,1.490,1.764,2.038,2.078,2.509,2.979,3.136,3.215,
  3.136,2.900,2.470,1.686,1.450,1.215,0.862,0.548,
  ZL=-1.019,-1.372,-1.490,-1.764,-2.038,-2.117,-2.156,-2.195,-2.195,
  -2.195,-2.195,-2.156,-2.117,-1.960,-1.568,-1.176,-0.862,-0.392,
  S=3.765,6.422,7.433,9.992,12.799,13.815,15.802,17.685,
  18.552,18.823,18.384,17.130,14.969,10.887,6.881,3.904,2.163,0.125,
  P=6.913,8.999,9.668,11.207,12.683,13.176,14.114,15.019,15.399,
  15.533,15.003,14.765,13.749,11.702,9.299,7.039,5.618,2.292,
  R=1.176,1.490,1.568,1.803,1.999,2.097,2.156,2.176,2.215,2.215,
  2.195,2.156,2.078,1.901,1.470,1.039,0.627,0.078$
NACA-W-4-4415
$WGPNLF CHRDR=6.89,CHRDTP=3.90,SSPN=16.69,SSPNE=14.48,
  SAVSI=2.90,CHSTAT=0.00,TWISTA=-3.0,DHDADI=7.50,TYPE=1.0$
NACA-H-4-0012
$HTPLNF CHRDR=4.00,CHRDTP=2.60,SSPN=6.58,SSPNE=6.19,
  SAVSI=6.0,CHSTAT=0.00,TWISTA=0.0,DHDADI=0.00,TYPE=1.0$
NACA-V-4-0012
$VTPLNF CHRDR=4.40,CHRDTP=2.10,SSPN=4.80,SSPNE=4.39,
  SAVSI=20.0,CHSTAT=0.00,TYPE=1.0$
NEXT CASE
    
```

**Figure 1 - Datcom representation of the Navion model**



**Table 1 - Aerodynamic Coefficients for the Navion aircraft**

	Criteria	Datcom	
		value	error
1/rad	value	value	error
<b>CL<math>\alpha</math></b>	4.44	5.3800	0.94
<b>Cm<math>\alpha</math></b>	-0.683	-0.9132	-0.2302
<b>Cy<math>\beta</math></b>	-0.564	-0.4526	0.1114
<b>Cn<math>\beta</math></b>	0.071	0.0342	-0.03682
<b>Cl<math>\beta</math></b>	-0.074	-0.0744	-0.00041
<b>CLq</b>	3.8	7.8240	4.024
<b>Cmq</b>	-9.96	-14.0400	-4.08
<b>CL<math>\dot{\alpha}</math></b>		3.3100	
<b>Cm<math>\dot{\alpha}</math></b>	-4.36	-8.6930	-4.333
<b>Clp</b>	-0.41	-0.4529	-0.0429
<b>Cyp</b>		-0.1809	
<b>Cnp</b>	-0.0575	-0.0175	0.03996
<b>Cnr</b>	-0.125	-0.0993	0.02571
<b>Clr</b>	0.107	0.0724	-0.0346

## 2.2. Cessna Citation

Coefficient data for the Cessna Citation aircraft was obtained from a flight simulator. The coefficient data was derived from flight test results. The model is a medium-to-high complexity model. The complete data package consisted of many look-up tables for both clean and dirty configurations, as well as for low and high speeds. The data presented here is only representative of that aircraft.

The Datcom model was built by the author and has been refined over the years, as this is the primary test case used for testing new features and verifying possible problems with *Datcom+ Pro*.

The Datcom input file for this aircraft is shown in Datcom Model 2. The resulting aircraft is shown in Figure 2. Aerodynamic stability coefficients from the criteria data and Datcom program are shown in Table 2.

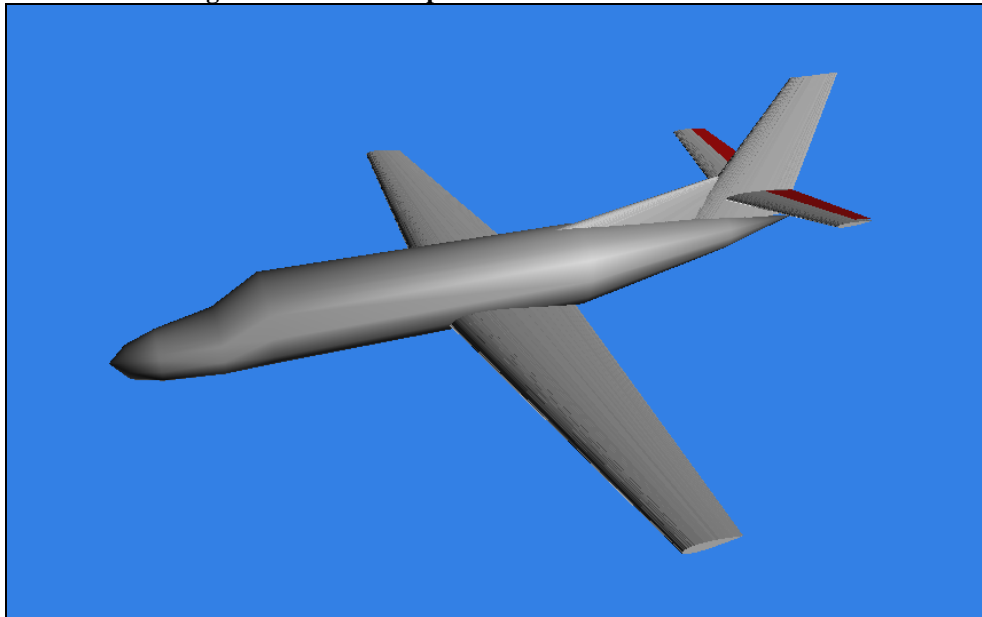
### Datcom Model 2 - Citation

```

CASEID Citation II Model 550
DERIV RAD
DAMP
$FLTCON WT=7000.0, NMACH=1.0, MACH(1)=0.4,
  NALT=1.0, ALT(1)=0.0, NALPHA=17.0,
  ALSCHD(1)= -4.0, -2.0, 0.0, 2.0, 4.0, 8.0, 9.0,
  10.0, 12.0, 14.0, 16.0, 18.0, 19.0, 20.0, 21.0,
  22.0, 24.0$
$SYNTHS XCG=20.79, ZCG=3.125, ALIW=2.5, ALIH=0.0,
  XW=19.1, ZW=3.125, XH=39.2, ZH=7.75,
  XV=36.0, ZV=6.0, XVF=23.0, ZVF=6.7$
$BODY NX=8.0, ITYPE=1.0, METHOD=1.0,
  X(1)=0.0,1.0,2.7,6.0,8.8,28.5,39.4,44.8,
  R(1)=0.0,1.25,2.1,2.7,2.76,2.7,1.25,0.0,
  ZU(1)=3.5,4.3,4.8,5.5,7.4,7.4,6.5,5.7,
  ZL(1)=3.5,2.5,2.25,2.1,2.0,2.2,4.3,5.7$
NACA W 5 23014
$WGPLNF CHRDR=9.4, CHRDTP=3.01, TYPE=1.0, SSPN=25.85, SSPNE=23.46,
  SAVSI=1.3, CHSTAT=0.25, TWISTA=-3.0, DHDADI=3.6$
NACA H 4 0010
$HTPLNF CHRDR=4.99, CHRDTP=2.48, SSPN=9.42, SSPNE=9.21, SAVSI=5.32,
  CHSTAT=0.25, TWISTA=0.0, DHDADI=9.2, TYPE=1.0$
NACA V 4 0008
$VTPLNF CHRDR=3.63, CHRDTP=3.63, SSPN=8.85, SSPNE=9.42, CHRDR=8.3,
  SAVSI=32.3, CHSTAT=0.25, TYPE=1.0$
NACA F 4 0004
$VFPLNF CHRDR=19.3, CHRDTP=0.0, CHSTAT=0.0, DHDADO=0.0,
  SAVSI=80.0, SSPN=3.3, SSPNE=3.1, TYPE=1.0$
$SYMFLP FTYPE=1.0, NTYPE=1.0, NDELTA=9.0,
  DELTA(1)=-20.0,-15.0,-10.0,-5.0,0.0,5.0,10.0,13.0,16.0,
  CHRDFI=1.94, CHRDFO=1.03, SPANFI=0.7, SPANFO=9.21$
NEXT CASE

```

**Figure 2 - Datcom representation of the Citation model**



**Table 2 - Aerodynamic coefficients for the Citation aircraft**

	Criteria	Datcom	
1/rad	value	value	error
<b>CL<math>\alpha</math></b>	4.555	5.5430	0.988
<b>Cm<math>\alpha</math></b>	-0.8436	-1.8500	-1.0064
<b>Cy<math>\beta</math></b>	-0.670158	-0.7500	-0.079842
<b>Cn<math>\beta</math></b>	0.099226	0.0681	-0.031096
<b>Cl<math>\beta</math></b>	-0.066931	-0.1301	-0.063169
<b>CLq</b>	8.01875	9.2900	1.27125
<b>Cmq</b>	-11.0	-18.4100	-7.41
<b>CL<math>\dot{\alpha}</math></b>	2.130625	2.5170	0.386375
<b>Cm<math>\dot{\alpha}</math></b>	-18.06	-7.4880	10.572
<b>Clp</b>	-0.556338	-0.4676	0.088738
<b>Cyp</b>	-0.1004	-0.0965	0.00388
<b>Cnp</b>	-0.034969	-0.0154	0.019539
<b>Cnr</b>	-0.062892	-0.1111	-0.048208
<b>Clr</b>	0.149231	0.0628	-0.086431



### 2.3. Beechcraft T-34C

Coefficient data for the Beechcraft T-34C aircraft was obtained from the manufacturer's data package used to build a flight simulator. The model is a medium complexity model, but did not conform completely to standard coefficient breakdown. Several of the terms were modified by other effects, but the representative effects of the aircraft are presented. Data was not available for all stability coefficients.

The Datcom model was built by the author in 1996, and has been checked since then. The author was working on a T-34C flight simulator at the time, and was investigating using Datcom as a possible source of coefficient data.

The Datcom input file for this aircraft is shown in Datcom Model 3. The resulting aircraft is shown in Figure 3. Aerodynamic stability coefficients from the criteria data and Datcom program are shown in Table 3.

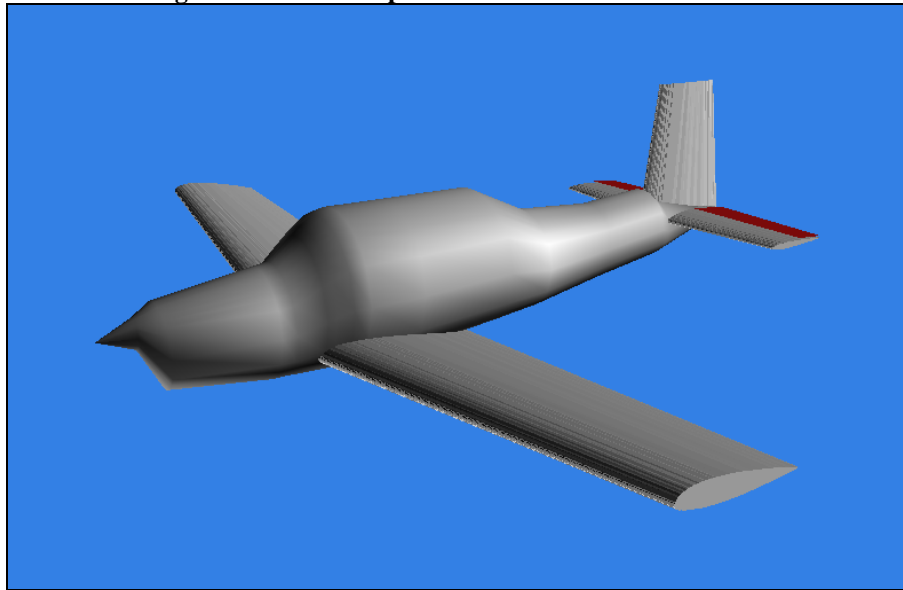
#### Datcom Model 3 - T-34C

```

CASEID Beechcraft T-34C
DAMP
DERIV RAD
$FLTCON NMACH=1.0,MACH(1)=0.227,NALPHA=20.0,WT=4000.0,LOOP=2.0,
  ALSCHD(1)=-16.0,-8.0,-6.0,-4.0,-2.0,0.0,2.0,4.0,8.0,9.0,10.0,12.0,
    14.0,16.0,18.0,19.0,20.0,21.0,22.0,24.0,
  NALT=1.0,ALT(1)=0.0$
$OPTINS SREF=179.9,CBARR=5.42,BLREF=33.396$
$SYNTHS XCG=7.375,ZCG=3.7,XW=6.02,ZW=-1.1,ALIW=3.81,XH=21.4,ZH=1.2,
  ALIH=0.0,XV=20.9,ZV=0.89,XVF=20.4,SCALE=1.0,VERTUP=.TRUE.$
$BODY NX=16.0,ITYPE=1.0,METHOD=1.0,
  X=0.0, 1.11, 1.78, 5.01, 5.48, 6.33, 6.59, 7.09, 7.62, 9.54, 12.9, 15.2,
    18.3,21.0,21.6,25.7,
  ZU=0.45, 0.98, 1.34, 1.83, 1.92, 2.67, 2.9, 3.25, 3.39, 3.39, 3.39, 2.32,
    2.14,2.36,1.87,0.94,
  ZL=0.45,0.0,-1.38,-1.78,-1.78,-1.78,-1.78,-1.78,-1.78,-1.78,
    -1.43,-1.29,-0.76,-0.31,-0.22,0.94,
  R=0.0,0.49,1.4,1.78,1.83,2.21,2.29,2.5,2.61,2.61,2.61,1.8,
    1.4,1.38,1.07,0.0$
NACA-W-5-23016
$WGPLNF CHRDTDP=3.92,SSPNE=14.1,SSPN=16.0,CHRDR=6.68,SAVSI=3.98,CHSTAT=0.0,
  DHDADI=7.21,TYPE=1.0$
NACA-H-4-0009
$HTPLNF CHRDR=3.6, CHRDTDP=2.63, SSPN=5.79, SSPNE=5.35, SAVSI=5.7, CHSTAT=0.0,
  TWISTA=0.0, DHDADI=0.0, TYPE=1.0$
NACA-V-4-0009
$VTPLNF SAVSI=7.5,CHSTAT=0.0,TYPE=1.0,CHRDTDP=2.90,SSPNE=4.72,SSPN=5.53,
  CHRDR=4.46$
NACA F 4 0009
$SYMFLP FTYPE=1.0, PHETE=0.0522,PHETEP=0.0523,
  NDELTA=9.0,DELTA(1)=-25.0,-20.0,-15.0,-10.0,-5.0,0.0,5.0,10.0,20.0,
  CHRDFI=1.4,CHRDFO=1.17,SPANFI=0.6,SPANFO=5.79,TC=.22,NTYPE=1.0$
NEXT CASE

```

**Figure 3 - Datcom representation for the T-34C model**



**Table 3 - Aerodynamic coefficients for the T-34C aircraft**

1/rad	Criteria	Datcom	
	value	value	error
<b>CL<math>\alpha</math></b>	4.3	5.0180	0.718
<b>Cm<math>\alpha</math></b>	-1.25	-1.1560	0.094
<b>Cy<math>\beta</math></b>	-0.5515	-0.5815	-0.03
<b>Cn<math>\beta</math></b>	0.0967	0.0793	-0.01737
<b>Cl<math>\beta</math></b>	-0.06732	-0.0730	-0.00567
<b>CLq</b>	4.0	6.9570	2.957
<b>Cmq</b>	-12.4	-11.0700	1.33
<b>CL<math>\dot{\alpha}</math></b>	-1.203	2.3620	3.565
<b>Cm<math>\dot{\alpha}</math></b>	-2.83	-6.5890	-3.759
<b>Clp</b>	-0.36	-0.4167	-0.0567
<b>Cyp</b>	-0.2	-0.1596	0.0404
<b>Cnp</b>	-0.09	-0.01748	0.07252
<b>Cnr</b>		-0.1077	
<b>Clr</b>	0.17	0.0719	-0.09814

## 2.4. Cessna C-172

Coefficient data for the Cessna C-172 aircraft were obtained from an aerodynamics textbook<sup>viii</sup>. They were generated by a computer program, but no details of the computer program were presented in the textbook.

The Datcom model was built by Sebastian Deubler for his thesis in Aerospace Dynamics MSc at Cranfield University. The author has not checked this model.

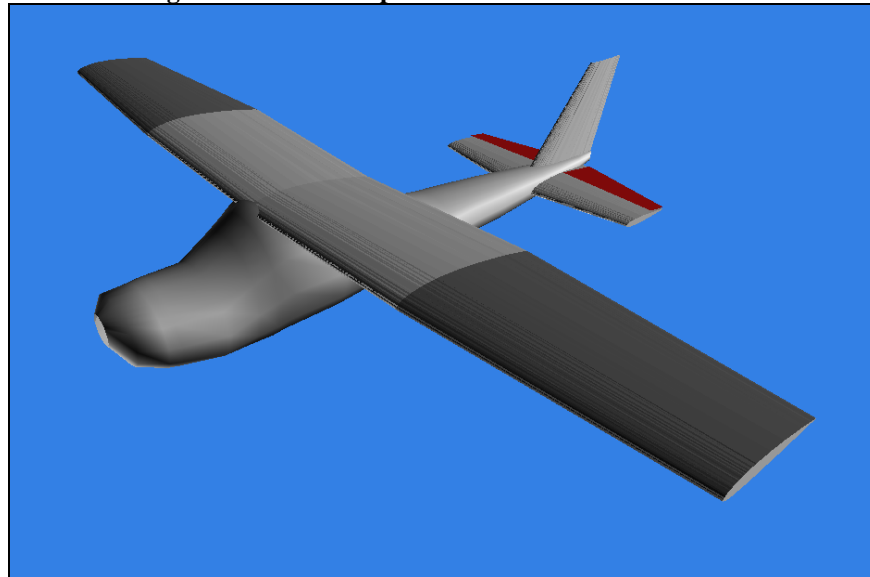
The Datcom input file for this aircraft is shown in Datcom Model 4. The resulting aircraft is shown in Figure 4. Aerodynamic stability coefficients from the criteria data and Datcom program are shown in Table 4.

### Datcom Model 4 - C-172

```

CASEID Cessna C-172 Aircraft
DIM FT
DERIV RAD
DAMP
$FLTCON WT=2205.29, LOOP=3.0, NMACH=1.0, MACH(1)=0.16,
  NALT=1.0, ALT(1)=5000.0, NALPHA=8.0,
  ALSCHD(1)=-2.5,0.0,1.0,2.43,4.9,7.5,10.0,12.5$
$SYNTHS XCG=7.29, ZCG=3.25, XW=6.05, ZW= 6.80, ALIW= 1.5,
  XH=19.53, ZH= 3.82, ALIH= 0.0, XV=20.26, ZV= 4.25,
  SCALE=1.0, VERTUP=.TRUE.$
$BODY NX=20.0, ITYPE=2.0, METHOD=2.0,
  X(1)=0.34,0.85,1.80,2.21,3.82,5.01,5.73,6.16,8.49,10.15,11.55,
  12.95,14.39,15.92,17.75,19.27,20.76,22.29,23.69,24.84,
  S(1)=7.63,20.45,21.76,22.88,24.37,28.03,31.54,34.55,35.08,32.20,
  26.38,23.37,19.90,17.51,14.92,12.13,10.00,6.99,4.79,0.65,
  P(1)=17.61,18.76,18.46,18.74,20.46,21.76,22.80,22.91,22.22,19.99,
  18.69,18.04,17.59,17.08,16.57,16.32,16.19,16.05,15.98,
  R(1)=0.57,1.60,1.80,1.91,2.11,2.19,2.32,2.42,2.45,2.27,2.06,1.88,
  1.70,1.44,1.24,1.00,0.82,0.57,0.39,0.05,
  ZU(1)=4.84,5.26,5.31,5.35,5.35,6.20,6.71,7.05,6.96,6.71,5.77,
  5.14,4.97,4.92,4.80,4.67,4.54,4.42,4.33,4.25,
  ZL(1)=3.74,2.89,2.38,2.29,2.00,1.95,1.95,2.04,2.17,2.34,2.45,2.55,
  2.72,2.80,2.89,3.01,3.18,3.31,3.57,3.74$
$WGPLNF CHRDR=5.3332, CHRDBP=5.3332, CHRDTP=3.708, SSPN=18.0,
  SSPNE=15.59, SSPNOP=9.651, SAVSI=0.0, SAVSO=3.0, CHSTAT=0.0,
  TWISTA=-3.0, DHDADI=1.7333, DHDADO=1.7333, TYPE=1.0$
NACA-W-4-2412
NACA-V-4-0009
$VTPLNF CHRDR=4.58, CHRDTP=2.12, SSPN=4.45, SSPNE=4.25,
  SAVSI=35.0, CHSTAT=0.25, TYPE=1.0$
NACA-H-4-0012
$HTPLNF CHRDR=4.55, CHRDTP=2.52, SSPN= 5.67, SSPNE=4.92,
  SAVSI= 9.0, CHSTAT=0.0, TWISTA=0.0, DHDADI=0.0, TYPE=1.0$
$SYMFLP FTYPE=1.0, SPANFI=0.75, SPANFO=5.667, CHRDFI=1.83, CHRDFO=0.87,
  NTYPE=1.0, DELTA=9.0,
  DELTA(1)=-20.0,-10.0,-5.0,0.0,7.5,15.0,20.0,25.0,30.0$
NEXT CASE
    
```

**Figure 4 - Datcom representation of the C-172 model**



**Table 4 - Aerodynamic coefficients for the C-172 aircraft**

1/rad	Criteria	Datcom	
	value	value	error
<b>CL<math>\alpha</math></b>	4.6	5.4080	0.808
<b>Cm<math>\alpha</math></b>	-0.89	-0.6420	0.248
<b>Cy<math>\beta</math></b>	-0.31	-0.2697	0.0403
<b>Cn<math>\beta</math></b>	0.065	-0.0070	-0.071998
<b>Cl<math>\beta</math></b>	-0.089	-0.2013	-0.1123
<b>CLq</b>	3.9	7.0260	3.126
<b>Cmq</b>	-12.4	-5.4980	6.902
<b>CL<math>\dot{\alpha}</math></b>	1.7	2.0770	0.377
<b>Cm<math>\dot{\alpha}</math></b>	-5.2	-5.6660	-0.466
<b>Clp</b>	-0.47	-0.4748	-0.0048
<b>Cyp</b>	-0.037	-0.0463	-0.00927
<b>Cnp</b>	-0.03	-0.0108	0.0192
<b>Cnr</b>	-0.099	-0.0275	0.07154
<b>Clr</b>	0.096	0.0299	-0.06607

## 2.5. Northrop T-38

Coefficient data for the Northrop T-38 aircraft was obtained from a NASA report<sup>v</sup>. This report referenced a report<sup>ix</sup> from the manufacturer, but this report could not be located. It is surmised that this is manufacturer data. Data was not available for all stability coefficients.

The builder of the Datcom model for the T-38 is unknown. The author has checked and fixed numerous things with this Datcom model, and has added control surfaces (although not shown in this report), including ailerons, flaps, and stabilators. This model is being used as the test bed for any *Datcom+ Pro* development with stabilators. The CG location was moved to 23% MAC from the original 62.5% MAC. This original CG location was too far aft, well beyond the aircraft limits, and produced some pretty ugly stability coefficients.

The Datcom input file for this aircraft is shown in Datcom Model 5. The resulting aircraft is shown in Figure 5. Aerodynamic stability coefficients from the criteria data and Datcom program are shown in Table 5.

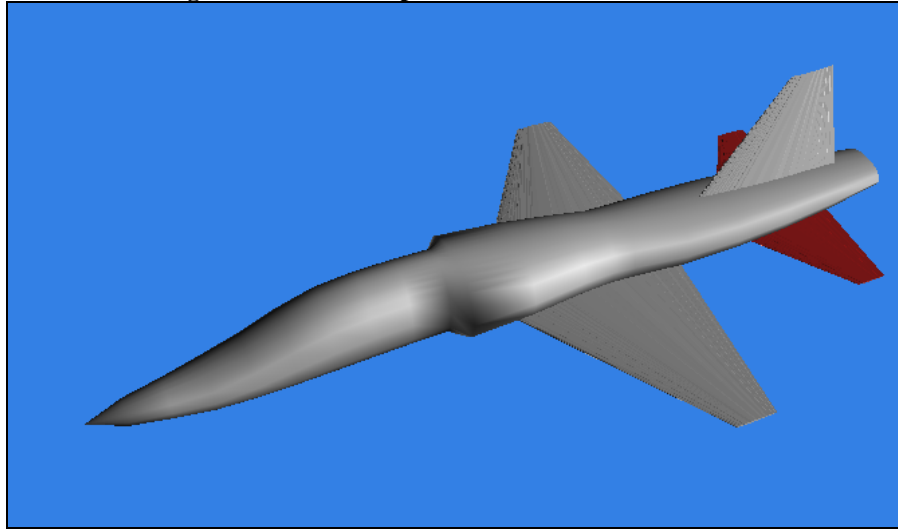
### Datcom Model 5 - T-38

```

CASEID Northrop T-38
DERIV RAD
DAMP
$FLTCON TSMACH=1.04,NMACH=1.0,MACH=0.6,
  NALT=1.0,ALT=0.0,WT=9000.0,LOOP=2.0,
  NALPHA=16.0,ALSCHD=-6.0,-4.0,-2.0,0.0,2.0,4.0,6.0,8.0,
  10.0,12.0,14.0,16.0,18.0,20.0,22.0,24.0$
$OPTINS SREF=170.0,CBARR=7.73,BLREF=25.25$
$SYNTHS XCG=21.94, ZCG=1.15, XW=20.1667, ZW=0.00, ALIW=0.0,
  XH=34.500, ZH=0.0, XV=32.0, ZV=1.15, HINAX=38.625$
$BODY NX=20.0, ITYPE=3.0,
X(1)= 0.00, 2.00, 4.00, 6.00, 8.00, 10.00, 12.00, 14.00, 16.00, 18.00,
  18.75, 22.20, 25.20, 27.00, 28.20, 31.25, 34.50, 37.75, 41.00, 44.25,
ZU(1)= 0.00, 0.65, 1.05, 1.50, 2.25, 3.20, 3.90, 4.15, 4.20, 4.15,
  4.10, 3.80, 3.50, 3.20, 3.10, 2.80, 2.60, 2.40, 2.20, 1.90,
ZL(1)= 0.00, -0.65, -0.90, -1.00, -1.10, -1.15, -1.10, -1.00, -0.90, -0.85,
  -0.80, -0.70, -0.65, -0.65, -0.65, -0.60, -0.50, -0.40, -0.10, 0.40,
S(1)= 0.00, 1.95, 4.29, 7.50, 11.05, 15.22, 17.75, 18.28, 18.11, 17.75,
  29.40, 25.20, 19.50, 16.55, 16.50, 17.00, 15.50, 12.60, 8.86, 4.50,
P(1)= 0.00, 5.60, 8.30, 11.00, 13.30, 15.70, 17.10, 17.40, 17.30, 17.10,
  21.80, 20.20, 17.70, 16.30, 16.30, 16.80, 16.20, 14.60, 12.30, 9.00,
R(1)= 0.00, 0.75, 1.10, 1.50, 1.65, 1.75, 1.78, 1.78, 1.78, 1.78,
  3.00, 2.80, 2.35, 2.15, 2.20, 2.50, 2.50, 2.25, 1.93, 1.50$
NACA-W-6-65A005
$WGPLNF CHRDR=11.221,CHRDTP=2.244,SSPN=12.625,SSPNE=10.2,
  SAVSI=24.0,CHSTAT=0.25,TYPE=1.0$
NACA-H-6-65A004
$HTPLNF CHRDR=6.667,CHRDTP=1.667,SSPN=7.083,SSPNE=4.8,
  SAVSI=25.0,CHSTAT=0.25,TYPE=1.0$
NACA-V-6-65A004
$VTPLNF CHRDR=10.3,CHRDTP=2.5,SSPN=8.0,SSPNE=6.7,
  SAVSI=25.0,CHSTAT=0.25,TYPE=1.0$
$SYNTHS ALIH=0.0$
NEXT CASE

```

**Figure 5 - Datcom representation of the T-38 model**



**Table 5 - Aerodynamic coefficients for the T-38 aircraft**

	Criteria	Datcom	
1/rad	value	Value	error
	<b>CL<math>\alpha</math></b>	4.2370	
	<b>Cm<math>\alpha</math></b>	-1.8220	
	<b>Cy<math>\beta</math></b>	-1.1630	-0.448
	<b>Cn<math>\beta</math></b>	0.2812	0.0192
	<b>Cl<math>\beta</math></b>	-0.1089	-0.0519
	<b>CLq</b>	10.8300	
	<b>Cmq</b>	20.7400	
	<b>CL<math>\dot{\alpha}</math></b>	3.4780	
	<b>Cm<math>\dot{\alpha}</math></b>	-7.3130	
	<b>Clp</b>	-0.2991	0.0209
	<b>Cyp</b>	0.0	
	<b>Cnp</b>	0.0000	-0.076
	<b>Cnr</b>	-0.5389	-0.0689
	<b>Clr</b>	0.1212	0.0412

## 2.6. Boeing 737-300

Coefficient data for the Boeing 737-300 aircraft was obtained from the manufacturer's data package for a flight simulator. The model is a high complexity model, with dozens of data plots for each axis, encompassing low-speed and high-speed conditions, as well as high-lift device deflections and gear positions. Effects for Mach number are also presented. The basic coefficients extracted from that data can be considered a representative set of data for the aircraft, but is not all-inclusive of the aerodynamic properties of the aircraft.

The Datcom model for this aircraft originated with the Datcom plotting report<sup>vi</sup>. That model was for a Boeing 737-100, and had numerous errors in it. The wing airfoil section was grossly wrong, as was the size of the vertical stabilizer. Other measurements were wrong as well. The model was updated to a Boeing 737-300, the process for which was documented in the *Datcom+ Pro* User's Manual. One of the main sources of data used was the Boeing 737 Technical Site<sup>x</sup>. Recent investigations have cast some doubt on some of those aircraft parameters, but this dispute has not been resolved yet.

The Datcom input file for this aircraft is shown in Datcom Model 6. The resulting aircraft is shown in Figure 6. Aerodynamic stability coefficients from the criteria data and Datcom program are shown in Table 6.

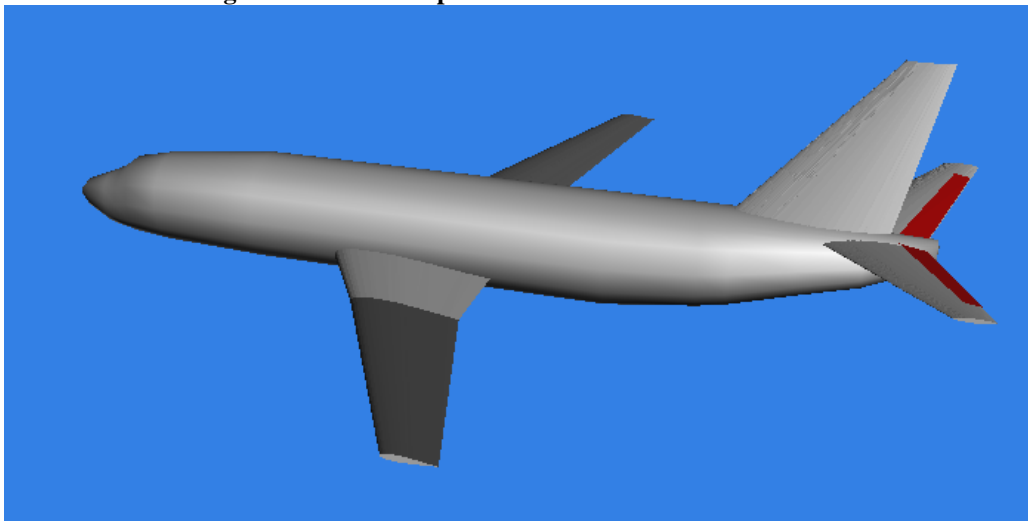
**Datcom Model 6 - Boeing 737-300**

```

CASEID Boeing 737-300
DERIV RAD
DAMP
$FLTCON NMACH=1.0, MACH(1)=-.5, WT=83000.0, NALT=1.,ALT(1)=0.0, NALPHA=18.0,
  ALSCHD(1)=-6.0, -4.0, -2.0, 0.0, 2.0, 4.0, 8.0, 9.0,
  10.0, 12.0, 14.0, 16.0, 18.0, 19.0, 20.0, 21.0, 22.0, 24.0,
  GAMMA=0., LOOP=2.0, RNNUB(1)=20120887.0$
$OPTINS BLREF=94.7,SREF=1171.0,CBARR=12.3$
$SYNTHS XW=34.9, ZW=-1.4, ALIW=1.0, XCG=37.97, ZCG=0.0, XH=92.15, ZH=6.2,
  XV=81.2, ZV=5.0, XVF=81.75, ZVF=13.1, VERTUP=.TRUE.$
$BODY NX=14.0, BNOSE=2.0, BTAIL=2.0, BLA=20.0,
  X(1)= 0.0, 1.38, 4.83, 6.90, 8.97, 13.8, 27.6,
  70.75, 81.15, 84.55, 91.45, 98.35, 105.5, 105.7,
  ZU(1)= 0.69, 2.07, 3.45, 4.38, 5.87, 6.90, 8.28,
  8.28, 8.28, 8.28, 7.94, 7.59, 7.50, 6.9,
  ZL(1)=-0.35, -1.73, -3.45, -3.80, -4.14, -4.49, -4.83,
  -4.83, -3.45, -2.76, -0.81, 1.04, 4.14, 6.21,
  R(1)= 0.34, 1.38, 2.76, 3.45, 4.14, 5.18, 6.21,
  6.21, 5.87, 5.52, 4.14, 2.76, 0.69, 0.0$
$WGPLNF CHRDR=23.3, CHRDP=5.31, CHRDBP=12.85, SSPN=47.4, SSPNOP=31.2,
  SSPNE=41.2, CHSTAT=0.25, TWISTA=-1.0, TYPE=1.0, SAVSI=25.0, SAVSO=25.0,
  DHDADI=0.0, DHDADO=6.0$
$WGSCHR TYPEIN=1.0, NPTS=23.0, DWASH=1.0,
  XCORD= 0.000000, 0.002600, 0.004700, 0.007500, 0.012900, 0.022900,
  0.053000, 0.073600, 0.099600, 0.151300, 0.208000, 0.250000,
  0.297200, 0.360200, 0.407500, 0.454700, 0.510100, 0.552500,
  0.600100, 0.700300, 0.826600, 0.902100, 1.000000,
  YUPPER=0.008800, 0.019800, 0.023600, 0.027500, 0.033200, 0.040800,
  0.055200, 0.061300, 0.066600, 0.072800, 0.075600, 0.076100,
  0.075600, 0.073400, 0.070500, 0.066700, 0.061400, 0.056700,
  0.051200, 0.038800, 0.023300, 0.014200, 0.000400,
  YLOWER=0.008800, 0.000400, -0.003700, -0.006200, -0.010300, -0.014700,
  -0.024400, -0.030100, -0.035200, -0.043200, -0.047700, -0.049300,
  -0.050000, -0.049800, -0.048600, -0.046300, -0.042800, -0.039700,
  -0.035700, -0.027500, -0.013100, -0.006000, -0.000400$
$VTPLNF CHRDR=19.0, CHRDP=4.8, SAVSI=35.0,
  SSPN=21.4, SSPNOP=0., SSPNE=19.5, CHSTAT=.25, TWISTA=0., TYPE=1.$
$HTPLNF CHRDR=11.9, CHRDP=3.927, SAVSI=30., DHDADI=7.0,
  SSPN=20.8, SSPNE=19.5, CHSTAT=.25, TWISTA=0., TYPE=1.0$
$SYMFLP FTYPE=1.0, SPANFI=1.3, SPANFO=17.4, CHRDFI=2.5, CHRDFO=1.72,
  NDELTA=9., DELTA(1)=-40.0, -30.0, -20.0, -10.0, 0.0, 10.0, 20.0, 30.0, 40.0,
  NTYPE=1.0, CB=0.50, TC=0.44, PHETE=.003, PHETEP=.002$
NACA-H-4-0012-25
NACA-V-4-0012-25
NACA-F-4-0012-25

```

**Figure 6 - Datcom representation of the B737-300 model**





**Table 6 - Aerodynamic coefficients for the Boeing 737-300 aircraft**

	Criteria	Datcom	
		value	error
1/rad	value	value	error
<b>CL<math>\alpha</math></b>	4.555	5.5430	0.988
<b>Cm<math>\alpha</math></b>	-0.8436	-1.8500	-1.0064
<b>Cy<math>\beta</math></b>	-0.670158	-0.7500	-0.079842
<b>Cn<math>\beta</math></b>	0.099226	0.0681	-0.031096
<b>Cl<math>\beta</math></b>	-0.066931	-0.1301	-0.063169
<b>CLq</b>	8.01875	9.2900	1.27125
<b>Cmq</b>	-11.0	-18.4100	-7.41
<b>CL<math>\dot{\alpha}</math></b>	2.130625	2.5170	0.386375
<b>Cm<math>\dot{\alpha}</math></b>	-18.06	-7.4880	10.572
<b>Clp</b>	-0.556338	-0.4676	0.088738
<b>Cyp</b>	-0.1004	-0.0965	0.00388
<b>Cnp</b>	-0.034969	-0.0154	0.019539
<b>Cnr</b>	-0.062892	-0.1111	-0.048208
<b>Clr</b>	0.149231	0.0628	-0.086431

### 3. Conclusions

The author does not wish to draw any overarching statements about the validity of the Datcom program, as it is highly dependent on the model and conditions. However, in preparing this report and with previous experience, there are a few things that stand out which affect the quality of the data generated by Datcom:

- Aircraft measurements must be checked and rechecked. If possible, avoid using just one source of data, even if it is believed to be the best data available. The data report for one of the aircraft mentioned here had gross errors in it, and has raised some questions.
- In comparing published data, track down the original source of the data if possible. The NASA Technical Report Server<sup>xi</sup> is an excellent reference for existing US aircraft. When existing data is identified in more than one source, verify that the configurations of the aircraft match, especially center of gravity.
- Be wary of multiple flight test reports written during the acceptance of an aircraft into military service. It is possible that deficiencies with the aircraft were identified in early tests, and later tests included configuration changes. These changes may or may not have been incorporated into the final design of the aircraft. Additionally, changes could invalidate earlier test data.
- Go back and verify your dimensions again. Adding the AC3D output, used to display the 3-representation of the Datcom input model has helped countless users find the problems with their models. Sometimes, the corrections are eyeballed in. These measurements need to be confirmed with an aircraft, other sources, or measured from a scale drawing. Use of multiple angles if possible is also recommended.

References:

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- <sup>i</sup> [http://tech.groups.yahoo.com/group/digital\\_datcom/](http://tech.groups.yahoo.com/group/digital_datcom/)
- <sup>ii</sup> <http://www.holycows.net/datcom/>
- <sup>iii</sup> From the JSBSim website <http://jsbsim.sourceforge.net/readme-aeromatic.html>, “Aero-Matic is an internet application that uses an HTML interface to collect user-submitted data on an airplane, then generates configuration files for use with the JSBSim Flight Dynamics Model. Aero-Matic tries to strike a balance between simplicity and accuracy when modeling an airplane. The generated configuration files will result in a *plausible* airplane model, and is based on only a few data points that should be easily available from books or internet sources.” It is available at <http://jsbsim.sourceforge.net/aeromatic2.html>
- <sup>iv</sup> Appendix B of “Flight Stability and Control”, by Robert C. Nelson, 1989.
- <sup>v</sup> “Aircraft Stability and Control Data”, by Gary L. Teper, April 1969, N69-31783, NASA CR-96008.
- <sup>vi</sup> Aerodynamic Parameters of the Navion Airplane Extracted from Flight Test Data”, by William T. Suit, March 1972, NASA TD-6643.
- <sup>vii</sup> “A Computer Program for Obtaining Airplane Configuration Plots from Digital Datcom Input Data”, NASA Technical Memorandum 84639, N83-20933, but Marie-Louise Roy and Steven W. Sliwa, 1983.
- <sup>viii</sup> “Airplane Flight Dynamics and Automatic Flight Controls”, by Jan Roskam, 1979.
- <sup>ix</sup> “T-38 Dynamic Stability”, Norair report NAI 58-704, April 1959
- <sup>x</sup> <http://www.b737.org.uk/index.htm>
- <sup>xi</sup> <http://ntrs.nasa.gov/>