Australian Government
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Technology Organisation

DSTO

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**Air Vehicles Division**
Platforms Sciences Laboratory

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**ABSTRACT**

DSTO operates a low speed wind tunnel within the Air Vehicles Division of the Platforms Sciences Laboratory. Air speeds up to approximately 90 m/s can be produced in the test section which is 2.7 m wide by 2.1 m high. A six-component Collins internal strain-gauge balance is used to measure forces and moments on a model under test. A manual calibration of this balance has been carried out to determine the sensitivity matrix for the new amplifiers and wiring system integrated into the low speed wind tunnel data acquisition system following its upgrade in 2000. With the new sensitivity matrix the maximum standard error of the loads measured by the strain-gauge balance was 0.19%.

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# Calibration for the Sensitivity Matrix of the Collins Strain Gauge Balance

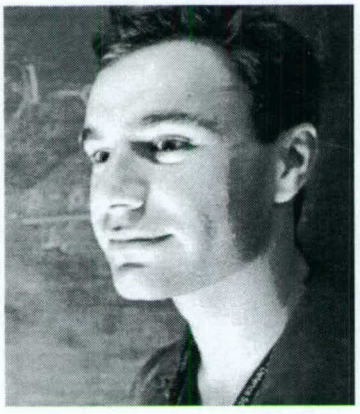
## Executive Summary

Measuring the aerodynamic forces and moments on models of airborne bodies is one of the major functions of the Low Speed Wind Tunnel (LSWT), operated by the Defence Science and Technology Organisation (DSTO). The data acquired by these measurements are needed for the evaluation, design, and research of military aircraft, missiles, and air vehicles in general, and for assessment of their performance.

One of the primary tools used to measure these loads is the internal strain gauge balance. Reliable and accurate wind tunnel measurements require frequent calibration of these balances. A calibration matrix has been determined previously for the Collins strain gauge balance. Since the upgrade of the data acquisition system in the DSTO LSWT, a new set of amplifiers has been installed and new wiring from the balance patch board to the instrumentation cabinet has also been laid. The new amplifiers and wiring will cause the values of the calibration coefficients for the Collins balance to change significantly so that a new calibration is necessary. To obtain a new set of values for the calibration coefficients in a short timeframe, only the sensitivity matrix was redetermined. This was adequate because the particular readout system in use only affects the sensitivity matrix.

Details of the calibration methodology and the equipment used are given in this report together with the new sensitivity matrix. The results have been verified allowing the continued use of the tunnel to determine the forces and moments on a model under test with acceptable accuracy pending a full calibration.

# Authors



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*Adam Blandford graduated from the Royal Melbourne Institute of Technology in 2000 completing a Bachelor of Engineering (Aerospace) with First Class Honours. The following year he obtained employment with the Defence Science and Technology Organisation at Melbourne. Working in Flight Systems, he has gained experience in the area of wind tunnels and experimental aerodynamics. Recently he played a major role in the F-111/AGM-142 store clearance project in the Transonic Wind Tunnel, and he has made significant contributions to the JDAM-ER task in this tunnel. He has also been involved in improvements to the wind tunnel data acquisition systems and the development of test techniques.*

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# Nomenclature

| | |
|---|---|
| e | sum of squares of residual |
| f | the number of degrees of freedom in the calibration coefficients |
| se | standard error |
| x | axial location from balance centre (in) |
| y | lateral location from balance centre (in) |
| z | vertical location from balance centre (in) |
| | |
| $F_x$ | axial force (lb) |
| $F_y$ | side force (lb) |
| $F_z$ | normal force (lb) |
| $M_x$ | rolling moment (lb.ft) |
| $M_y$ | pitching moment (lb.ft) |
| $M_z$ | yawing moment (lb.ft) |
| | |
| [A] | Load-Reading matrix |
| [C], [C1], [C2] | calibration coefficient matrices |
| [D] | sensitivity matrix |
| [E] | Load-Load matrix |
| [X1], [X2] | normalised calibration coefficient matrices |
| | |
| H | applied loads (lb) |
| $\hat{H}$ | calculated loads (lb) |
| N | the total number of data points used in the calibration data set |
| R* | voltage output readings (mV) |
| R | voltage output readings corrected for zeros (mV) |
| SG | strain gauge |
| V | voltage (V) |

***Subscripts***

| | |
|---|---|
| p | data point |
| bal | balance value |
| max | maximum value |
| min | minimum value |
| sens | sensed |
| amp | amplifier |

# 1. Introduction

Internal strain-gauge balances are usually used to measure the aerodynamic forces and moments acting on models in the Defence Science and Technology Organisation (DSTO) wind tunnels. Reliable and accurate wind tunnel measurements require frequent calibration of these balances.

Generally, the balance can be calibrated by applying a number of known weights to the balance, and determining the influence that each load component has on the electrical output of each strain gauge channel. The relationships between the applied load components and the strain gauge output readings can be expressed in the form of a 6-component calibration matrix.

A second order calibration matrix, with 27 coefficients for each equation, has been determined previously for the Collins strain gauge balance in 1996. Since the upgrade of the data acquisition system in the DSTO Low Speed Wind Tunnel (LSWT), a new set of amplifiers has been installed and new wiring from the balance patch board to the instrumentation cabinet has also been laid. The new amplifiers and wiring will cause the values of the calibration coefficients for the Collins balance to change significantly so that a new calibration is necessary. To obtain a new set of values for the calibration coefficients in a short time frame, only the sensitivity matrix needs to be redetermined. This sensitivity matrix accounts for the new instrumentation and can be obtained from a first order calibration. The results can then be applied to the previous second order calibration matrix, retaining the accuracy of the balance, appropriate to the new readout system.

Details of the methodology and results for the calibration of the Collins strain gauge balance, which was carried out in June 2002 on the manual calibration rig, are given in this report. This will allow the continued use of the tunnel to determine the forces and moments on a model under test with acceptable accuracy pending a full calibration.

# 2. Calibration Methodology and Details

## 2.1 Collins Internal Strain-Gauge Balance

The balance to be calibrated is the Collins internal strain-gauge balance that was designed and manufactured in 1966. It is a six-component balance and it has parallel end-fitting attachments as shown in figure 1.

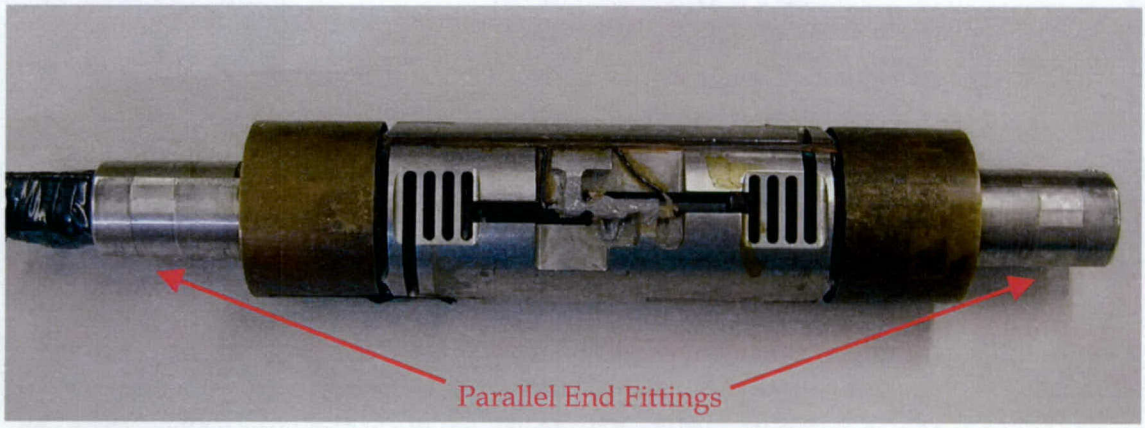


*Figure 1: Collins Internal Strain-Gauge Balance*

The design load limits of the balance are given in Table 1.

*Table 1: Design load limits of the Collins internal strain gauge balance*

| **Load Component** | **Design limit** |
|---|---|
| Axial force, $F_x$ | 890 N (200 lb) |
| Side force, $F_y$ | 1557 N (350 lb) |
| Normal force, $F_z$ | 3114 N (700 lb) |
| Roll moment, $M_x$ | 339 Nm (250 lb.ft) |
| Pitch moment, $M_y$ | 271 Nm (200 lb.ft) |
| Yaw moment, $M_z$ | 136 Nm (100 lb.ft) |

## 2.2 Axis System

The orthogonal axis system used for the calibration is shown in Figure 2 with the origin defined at the geometric centre of the balance. This axis system is defined to be fixed with the balance, with $F_x$ along the longitudinal axis, positive forward. $F_y$ is in the

horizontal plane of the balance, positive to starboard. $F_z$ axis is in the balance plane of symmetry, positive downward.

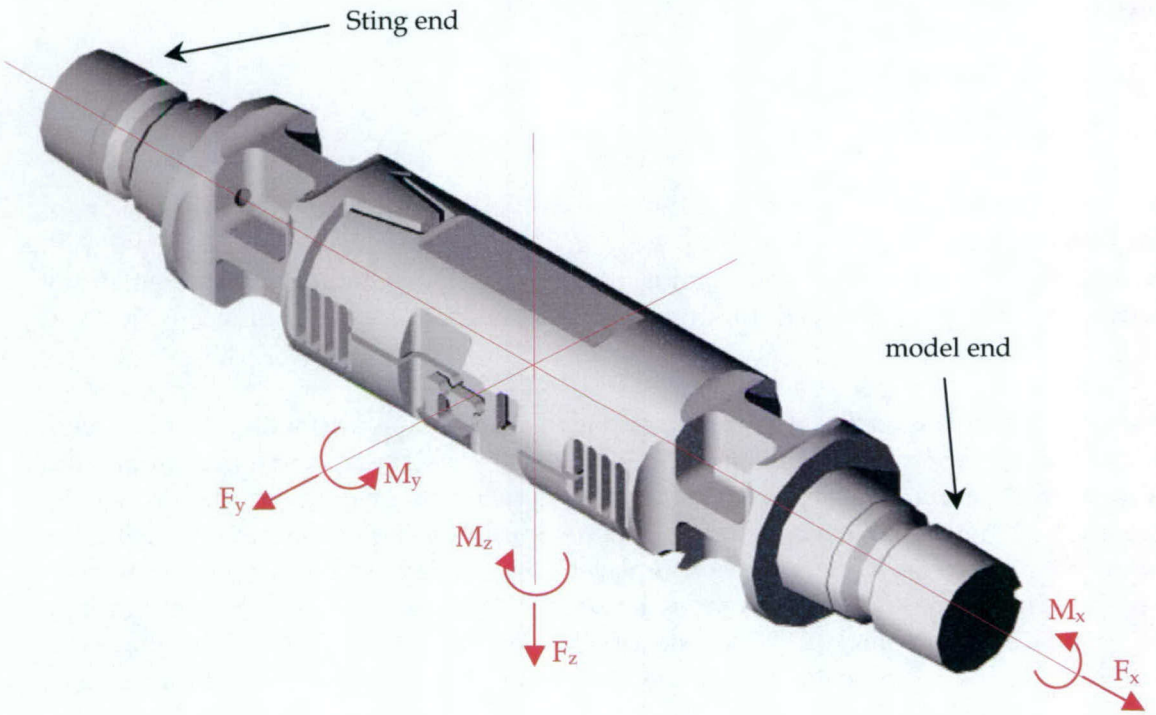


*Figure 2: Axes System*

The moments, $M_x$ (roll), $M_y$ (pitch), and $M_z$ (yaw), are defined by the right-hand screw rule along the respective axes, as shown in Figure 2.

## 2.3 Previous Calibration of Collins Strain Gauge Balance

The equations used for the calibration of strain gauge balances are given by (2.1) (Fairlie, 1985):

$$\begin{aligned}[X1]&=[D][C1]\\ [X2]&=[D][C2]\end{aligned} \tag{2.1}$$

where [C1] is the matrix of linear calibration coefficients $C_{i,j}$, and [C2] is the matrix of non-linear calibration coefficients, $C_{i,jj}$ and $C_{i,jk}$. The normalised matrices, [X1] and [X2], are independent of the readout system in use. This indicates that to find the sensitivity matrix [D], only the linear calibration matrix [C1] needs to be determined, which will be referred to as [C].

The balance had been calibrated previously using these equations with a 6 component second order calibration matrix and 27 coefficients for each equation. The square and cross-product terms were included but the cross products of the absolute terms were omitted, which gives 27 coefficients. However, this matrix was determined using the old amplifiers, which have now been replaced. The wiring system has also now been changed. The purpose of the current calibration is to determine the sensitivity matrix, [D], which accounts for the influence of the new readout system. This matrix is comprised of the reciprocals of the diagonal elements of the linear calibration matrix, [C] calculated as follows:

$$[D]=\begin{bmatrix} \frac{1}{C_{1,1}} & 0 & 0 & \cdots & 0 \\ 0 & \frac{1}{C_{2,2}} & 0 & \cdots & 0 \\ 0 & 0 & \frac{1}{C_{3,3}} & \cdots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \cdots & \frac{1}{C_{6,6}} \end{bmatrix} \tag{2.2}$$

and

$$[C]=\begin{bmatrix} C_{1,1} & C_{2,1} & \cdots & C_{6,1} \\ C_{1,2} & C_{2,2} & \cdots & C_{6,2} \\ \vdots & \vdots & \ddots & \vdots \\ C_{1,6} & C_{2,6} & \cdots & C_{6,6} \end{bmatrix} \tag{2.3}$$

This will allow the normalised matrices ([X1] & [X2]) to be used from the existing calibration results.

## 2.4 Strain-Gauge Amplifiers

The new amplifiers, which consisted of a set of six Vishay™ 2310 amplifiers, shown in figure 2, were installed in the load measurement system is 2000. All six amplifiers had the following settings:

| | |
|---|---|
| Filter setting: | 10 Hz |
| Nominal Excitation Voltage used: | 10 mV |
| Amplification Gain setting: | 1000 |

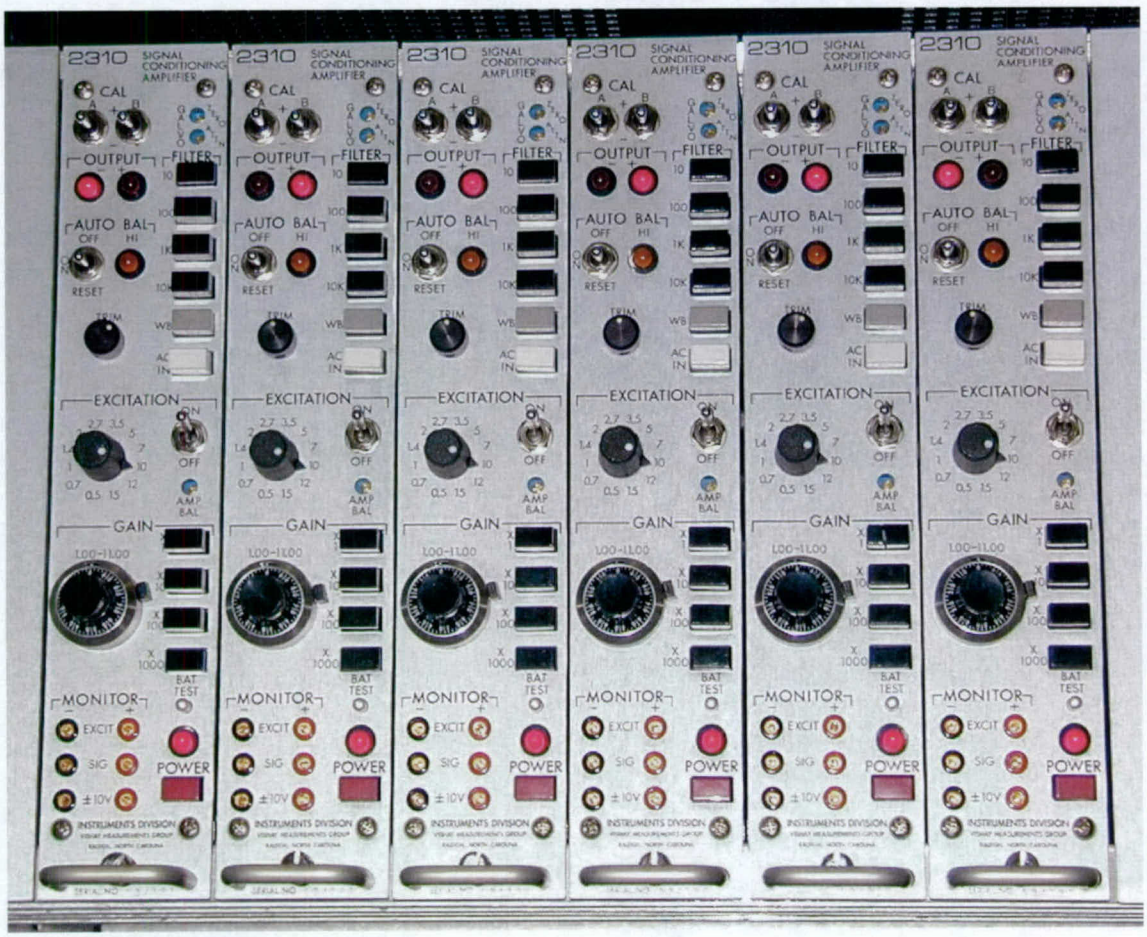


*Figure 3: Vishay Strain-Gauge Amplifiers*

## 2.5 Manual Calibration Rig

The manual calibration rig comprises of a custom built sting for the Collins balance, with a calibration box upon which knife-edges may be placed in a range of orientations on different faces. This enables the combination of loadings required to be obtained by applying known weights on a loading rod at known point locations with respect to the balance axis. The loadings used for this calibration are given in Appendix A.

The calibration box is shown in Figure 4.

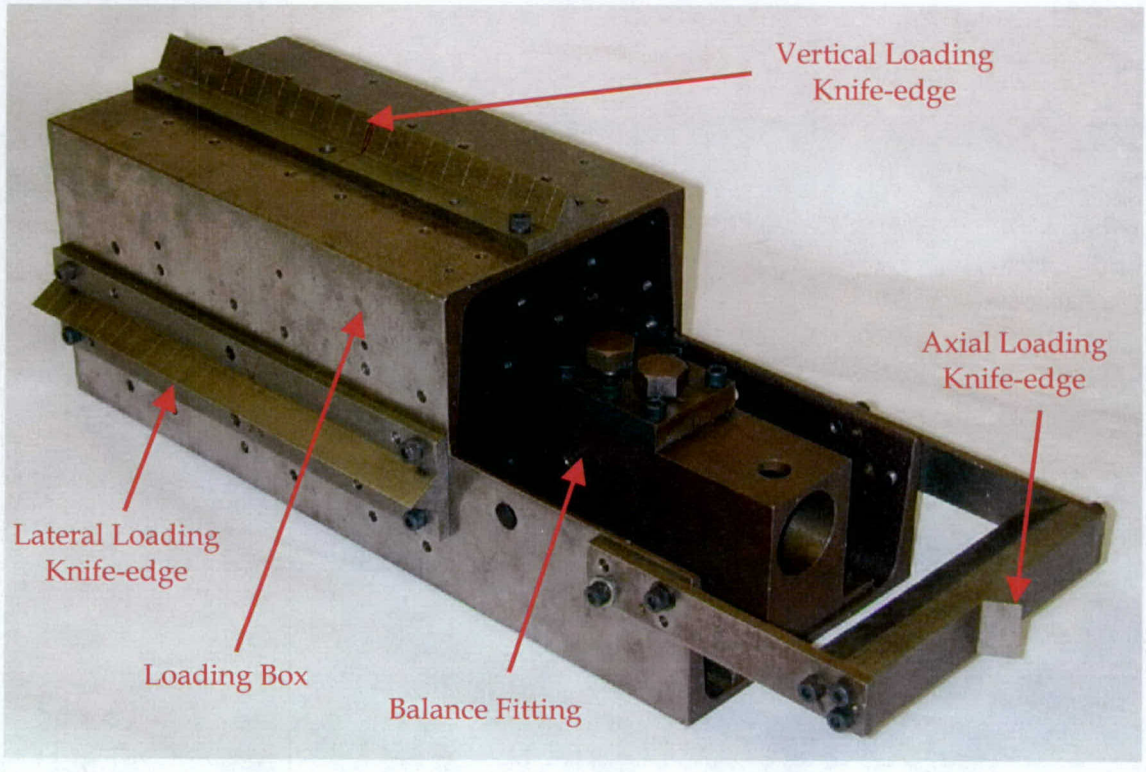


*Figure 4: Calibration Box Assembly*

Each time the load is changed, it is important to re-align the calibration box and make sure that it is level in both the longitudinal direction and the lateral direction using an inclinometer and adjustment screws that support the sting. This is required to make sure that the load vectors are in alignment with the balance axes.

The lateral and vertical loading knife-edges are used to obtain combinations of vertical loads, lateral loads, and bending moments. The axial knife-edge is used to obtain loadings purely in the axial direction.

The sting and calibration box assembled together with the balance installed for loading in the negative x-direction is shown in Figure 5.

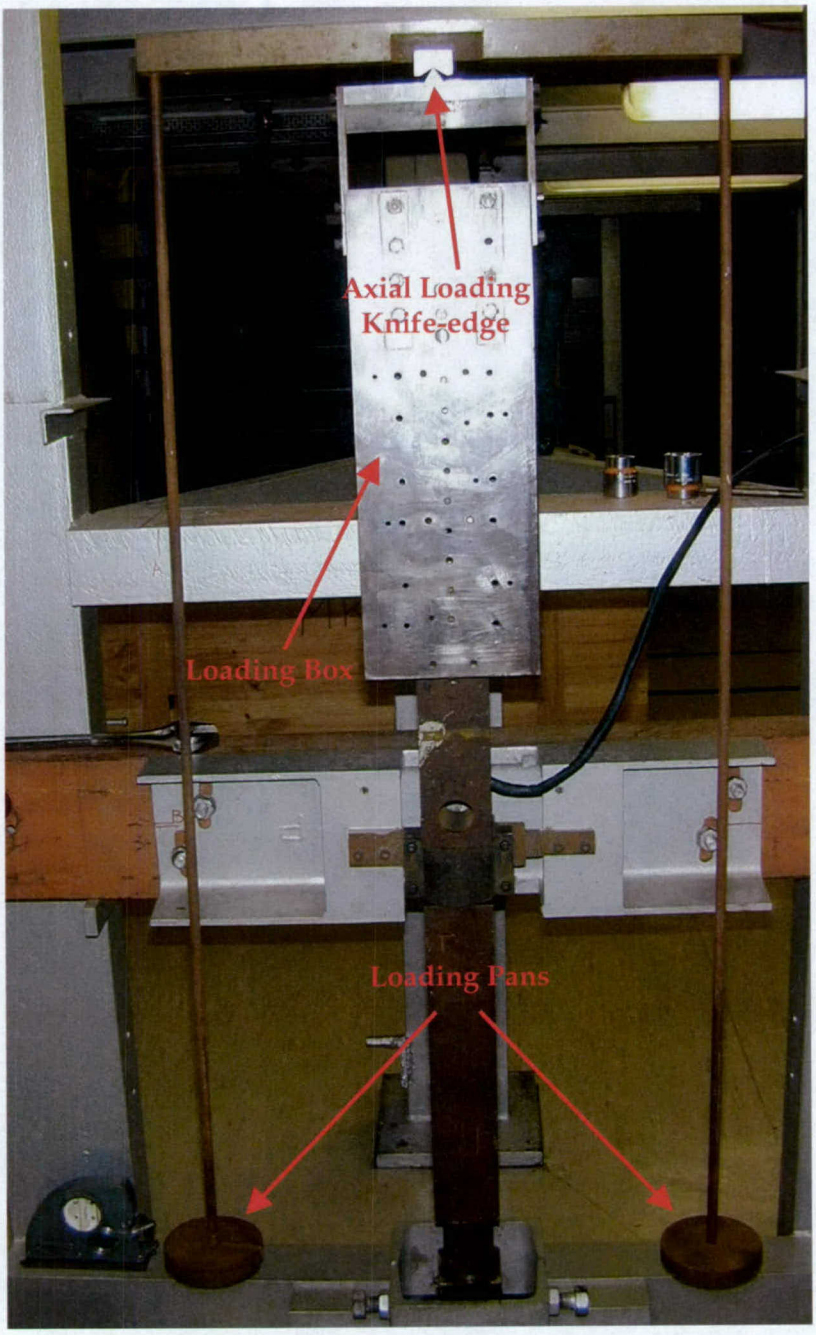


*Figure 5: Manual Rig Assembly Setup for Axial Loading*

The sting and calibration box assembled together with the balance installed for loading in the positive z-direction is shown in Figure 6.

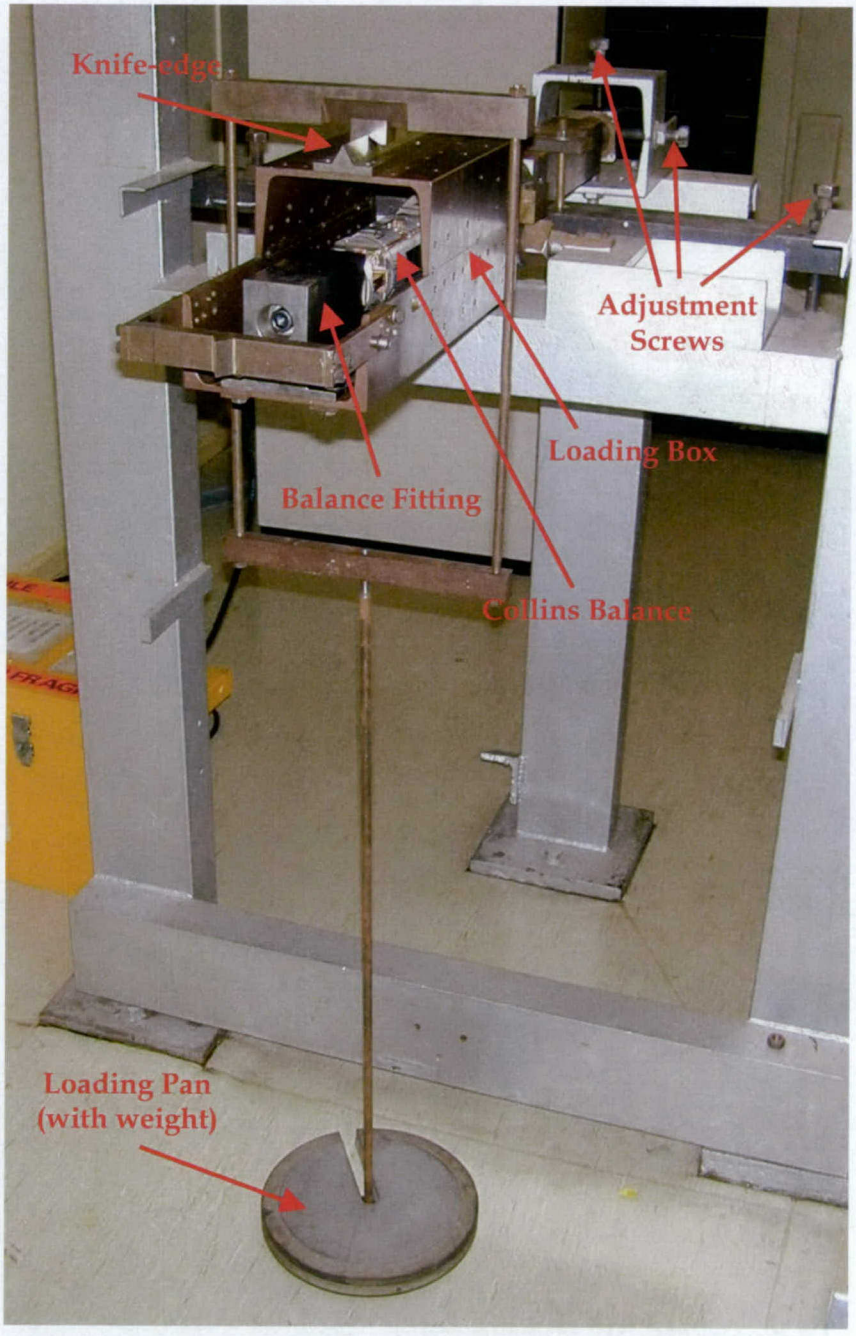


*Figure 6: Manual Rig Assembly Setup for Vertical Loading*

# 3. Results

## 3.1 Loading Program

The calibration rig was assembled in eight different orientations for different load sets:

- Loading in the positive 'x' direction to obtain loadings of + $F_x$
- Loading in the negative 'x' direction to obtain loadings of - $F_x$
- Loading in the positive 'y' direction, with the knife edge aligned along the 'x' axis to obtain combinations of + $F_y$, and $\pm M_z$
- Loading in the negative 'y' direction, with the knife edge aligned along the 'x' axis to obtain combinations of - $F_y$, and $\pm M_z$
- Loading in the negative 'y' direction, with the knife edge aligned along the 'z' axis to obtain combinations of - $F_y$, and $\pm M_x$
- Loading in the positive 'z' direction, with the knife edge aligned along the 'x' axis to obtain combinations of + $F_z$, and $\pm M_y$
- Loading in the negative 'z' direction, with the knife edge aligned along the 'x' axis to obtain combinations of - $F_z$, and $\pm M_y$
- Loading in the negative 'z' direction, with the knife edge aligned along the 'y' axis to obtain combinations of - $F_z$, and $\pm M_x$

For the orientations where the knife-edge was aligned along the 'x' axis, load sets were applied at four different axial locations:

- x = -76.2 mm (-3 in) from balance centre
- x = 0 (loading is applied at the balance centre)
- x = +50.8 mm (+2 in) from balance centre
- x = +101.6 mm (+4 in) from balance centre

For the orientations where the knife-edge was aligned along the 'y' or 'z' axis to obtain roll, load sets were applied at four different locations:

- y or z = -152.4 mm (-6 in) from balance centre
- y or z = -101.6 mm (-4 in) from balance centre
- y or z = +101.6 mm (+4 in) from balance centre
- y or z = +152.4 mm (+6 in) from balance centre

For all load sets other than when loading in the 'x' direction, weights were applied in 222 N (50 lb) increments up to a maximum of 1334 N (300 lb), and then taken off incrementally, with readings taken from the amplifiers at each point. For loading in the 'x' direction, weights were applied in 178 N (40 lb) increments up to a maximum of 890 N (200 lb).

Imperial units are used in the re-calibration because the coefficients of the original second order matrix were obtained in these units. The sensitivity matrix, [D], must therefore be expressed in the same units to produce correct results.

## 3.2 Calibration Data Reduction

The outputs obtained from the 6-component amplifiers are in mV/V, which must be multiplied by the sensed voltage to obtain the outputs, in mV, required for determining the calibration matrix:

$$R_i^* = V_{amp} \times V_{sens} \tag{3.1}$$

Twenty samples are used to obtain each reading. These readings must then be corrected for the zero offsets:

$$R_i = R_i^* - \overline{R_{i0}} \tag{3.2}$$

where $\overline{R_{i0}}$ is the average of the initial and final zero offsets.

The balance calibration model that is used is in the form of:

$$[R] = [C][H] \tag{3.2}$$

The calibration coefficients are determined using the least squares method proposed by Ramaswamy (Lam, 1989). With this method the coefficients are found when the sum of the squares of residuals between the measured strain gauge output and that obtained from the calibration equation is a minimum. For the first order calibration this can be expressed as:

$$\begin{aligned}
&\sum \left[C_{i,1}H_{1,p} + C_{i,2}H_{2,p} + \ldots + C_{i,6}H_{6,p} - R_{i,p}\right]H_{1,p} = 0 \\
&\sum \left[C_{i,1}H_{1,p} + C_{i,2}H_{2,p} + \ldots + C_{i,6}H_{6,p} - R_{i,p}\right]H_{2,p} = 0 \\
&\vdots \\
&\sum \left[C_{i,1}H_{1,p} + C_{i,2}H_{2,p} + \ldots + C_{i,6}H_{6,p} - R_{i,p}\right]H_{6,p} = 0 \qquad \text{i} = 1, \ldots, 6
\end{aligned} \tag{3.3}$$

Putting these equations into matrix notation, the balance calibration coefficient matrix, [C], can be expressed as follows:

$$[C] = [E]^{-1}[A] \tag{3.4}$$

where;

$$[E] = \begin{bmatrix}
\sum H_{1,p}H_{1,p} & \sum H_{1,p}H_{2,p} & \cdots & \sum H_{1,p}H_{6,p} \\
\sum H_{2,p}H_{1,p} & \sum H_{2,p}H_{2,p} & \cdots & \sum H_{2,p}H_{6,p} \\
\vdots & \vdots & \ddots & \vdots \\
\sum H_{6,p}H_{1,p} & \sum H_{6,p}H_{2,p} & \cdots & \sum H_{6,p}H_{6,p}
\end{bmatrix}$$

$$[A]=\begin{bmatrix} \sum H_{1,p}R_{1,p} & \sum H_{1,p}R_{2,p} & \cdots & \sum H_{1,p}R_{6,p} \\ \sum H_{2,p}R_{1,p} & \sum H_{2,p}R_{2,p} & \cdots & \sum H_{2,p}R_{6,p} \\ \vdots & \vdots & \ddots & \vdots \\ \sum H_{6,p}R_{1,p} & \sum H_{6,p}R_{2,p} & \cdots & \sum H_{6,p}R_{6,p} \end{bmatrix}$$

$$[C]=\begin{bmatrix} C_{1,1} & C_{2,1} & \cdots & C_{6,1} \\ C_{1,2} & C_{2,2} & \cdots & C_{6,2} \\ \vdots & \vdots & \ddots & \vdots \\ C_{1,6} & C_{2,6} & \cdots & C_{6,6} \end{bmatrix}$$

## 3.3 Calibration Results

A full list of the zero corrected data is given in Appendix A. The regression curve for each of the components of each load set has an $R^2$ value of greater than 0.99999. The processing of this data resulted in the following matrices:

**[E] =**

| | | | | | |
|---|---|---|---|---|---|
| 2.7200E+05 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| 0.0000E+00 | 5.2722E+05 | -2.9104E-11 | 0.0000E+00 | 2.9104E-11 | 0.0000E+00 |
| 0.0000E+00 | -2.9104E-11 | 4.3800E+06 | 0.0000E+00 | 0.0000E+00 | 1.8250E+05 |
| 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 1.4701E+05 | -1.8250E+05 | 0.0000E+00 |
| 0.0000E+00 | 2.9104E-11 | 0.0000E+00 | -1.8250E+05 | 4.3800E+06 | 0.0000E+00 |
| 0.0000E+00 | 0.0000E+00 | 1.8250E+05 | 0.0000E+00 | 0.0000E+00 | 1.4701E+05 |

**[A] =**

| | | | | | |
|---|---|---|---|---|---|
| 6.5980E+03 | -3.8402E+00 | -9.8032E-01 | -2.8268E-01 | -8.5252E-02 | -1.5654E+01 |
| -4.1483E+02 | 3.3790E+04 | 2.0615E+02 | 5.2836E+02 | -4.5593E+02 | -1.3456E+02 |
| 5.9242E+01 | 2.3691E+03 | 9.3670E+04 | -6.3296E+02 | 4.9592E+01 | 1.1131E+04 |
| 2.5312E+01 | 4.9847E+00 | -5.2426E+00 | 5.1387E+03 | -2.0765E+03 | -4.3317E-01 |
| -2.9917E+03 | -7.3766E+01 | -4.6799E+02 | -6.2427E+03 | 4.9920E+04 | 1.6476E+02 |
| -6.1329E+01 | -3.5417E+02 | 3.8845E+03 | -1.2695E+02 | 1.0184E+02 | 9.4196E+03 |

**[C] =**

| | | | | | |
|---|---|---|---|---|---|
| 2.4257E-02 | -1.4118E-05 | -3.6041E-06 | -1.0393E-06 | -3.1343E-07 | -5.7551E-05 |
| -7.8683E-04 | 6.4091E-02 | 3.9101E-04 | 1.0022E-03 | -8.6478E-04 | -2.5523E-04 |
| 3.2593E-05 | 6.7624E-04 | 2.1391E-02 | -1.1445E-04 | -1.8499E-05 | -1.3535E-04 |
| -7.1258E-04 | 1.3708E-05 | -1.7748E-04 | 3.4995E-02 | 2.4778E-05 | 4.6137E-05 |
| -7.1272E-04 | -1.6270E-05 | -1.1424E-04 | 3.2829E-05 | 1.1398E-02 | 3.9540E-05 |
| -4.5762E-04 | -3.2486E-03 | -1.3177E-04 | -7.2145E-04 | 7.1570E-04 | 6.4241E-02 |

**[D] =**

| | | | | | |
|---|---|---|---|---|---|
| 41.22 | 0 | 0 | 0 | 0 | 0 |
| 0 | 15.60 | 0 | 0 | 0 | 0 |
| 0 | 0 | 46.75 | 0 | 0 | 0 |
| 0 | 0 | 0 | 28.58 | 0 | 0 |
| 0 | 0 | 0 | 0 | 87.73 | 0 |
| 0 | 0 | 0 | 0 | 0 | 15.57 |

which define the calibration of the balance.

### 3.4 Statistical Analysis

The standard error provides an indication of the accuracy of the calculated loads using the new calibration matrix as compared with the known applied loads.

This is usually expressed as a percentage of the maximum design component loads:

$$se_i = \frac{\sqrt{\sum_{p=1}^{N}\left(\hat{H}_{i,p} - H_{i,p}\right) \Big/ N - f}}{\text{Maximum Design Load}_i} \times 100\% \tag{3.8}$$

The estimated loads have been calculated by reverse calibration using the methodology found in Leung & Link (1999, sec. 4, pp. 13-14) or Fairlie (1985,sec. 4.2, pp. 9-11) using the new sensitivity matrix and the old normalised 1996 calibration coefficient matrices, [X1] and [X2].

This results in the following standard errors:

| Fx | Mx | Fy | My | Fz | Mz |
|---|---|---|---|---|---|
| 0.131% | 0.103% | 0.163% | 0.075% | 0.105% | 0.192% |

These results are better than the original calibration and achieve the accuracy required for the balance. From past experience the majority of work in the low speed wind tunnel requires accuracies of the order of 0.2% to 0.5%.

# 4. Conclusions

Installation of new amplifiers and new wiring made it necessary to determine a new sensitivity matrix for the strain gauge balance used in the Low Speed Wind Tunnel. Details of the calibration methodology and the equipment used have been described in this report.

A first order calibration has been completed with the calibration coefficients being determined using 6 coefficients for each of the 6 components. The new sensitivity matrix was determined from the first order calibration matrix. The accuracy of this calibration was verified with standard errors that were deemed to be within acceptable limits. This new sensitivity matrix has been integrated into the pre-existing 6 component normalised matrix, with 27 coefficients for each component, to form the calibration matrix for the Collins strain gauge balance now being used for routine tests in the Low Speed Wind Tunnel.

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1. Fairlie, B., (1985), *Algorithms for the Reduction of Wind-Tunnel Data Derived From Strain Gauge Force Balances*, AR-004-017, DSTO Melbourne, Australia.

2. Lam, S., (1989), *A Fortran program for the calculation of the calibration coefficients of a six-component strain gauge balance*, AR-005-598, DSTO Melbourne, Australia.

3. Leung, S., & Link, Y., (1999), *Comparison and Analysis of Strain Gauge Balance Calibration Matrix Mathematical Models*, AR-011-051, DSTO Melbourne, Australia.

# Appendix A: Zero Corrected Data Results

***Zero Corrected Data Results***

| Filename | Fx lb | Mx lb | Fy lb | My lb*ft | Fz lb*ft | Mz lb*ft | BAL_1 mV | BAL_2 mV | BAL_3 mV | BAL_4 mV | BAL_5 mV | BAL_6 mV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *nznx30* | 0 | 0 | 0 | 0 | 0 | 0 | 0.0008 | -0.0005 | 0.0005 | 0.0003 | 0.0004 | -0.0001 |
| | 0 | 0 | 0 | -13 | -50 | 0 | 0.0469 | 0.0011 | 0.0086 | -0.4383 | -0.5693 | -0.0028 |
| | 0 | 0 | 0 | -25 | -100 | 0 | 0.0943 | 0.0020 | 0.0174 | -0.8768 | -1.1389 | -0.0061 |
| | 0 | 0 | 0 | -38 | -150 | 0 | 0.1409 | 0.0035 | 0.0250 | -1.3170 | -1.7100 | -0.0080 |
| | 0 | 0 | 0 | -50 | -200 | 0 | 0.1918 | 0.0054 | 0.0324 | -1.7554 | -2.2807 | -0.0104 |
| | 0 | 0 | 0 | -63 | -250 | 0 | 0.2397 | 0.0059 | 0.0414 | -2.1953 | -2.8507 | -0.0143 |
| | 0 | 0 | 0 | -75 | -300 | 0 | 0.2971 | 0.0069 | 0.0490 | -2.6341 | -3.4220 | -0.0151 |
| | 0 | 0 | 0 | -63 | -250 | 0 | 0.2410 | 0.0065 | 0.0410 | -2.1958 | -2.8523 | -0.0129 |
| | 0 | 0 | 0 | -50 | -200 | 0 | 0.1920 | 0.0067 | 0.0310 | -1.7554 | -2.2822 | -0.0098 |
| | 0 | 0 | 0 | -38 | -150 | 0 | 0.1390 | 0.0051 | 0.0241 | -1.3173 | -1.7112 | -0.0076 |
| | 0 | 0 | 0 | -25 | -100 | 0 | 0.0913 | 0.0047 | 0.0148 | -0.8784 | -1.1411 | -0.0044 |
| | 0 | 0 | 0 | -13 | -50 | 0 | 0.0435 | 0.0026 | 0.0074 | -0.4396 | -0.5709 | -0.0025 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -0.0008 | 0.0005 | -0.0005 | -0.0003 | -0.0004 | 0.0001 |
| *nzpx00* | 0 | 0 | 0 | 0 | 0 | 0 | 0.0002 | -0.0012 | 0.0001 | -0.0002 | 0.0006 | -0.0004 |
| | 0 | 0 | 0 | 0 | -50 | 0 | 0.0369 | 0.0012 | 0.0058 | -0.0043 | -0.5685 | -0.0027 |
| | 0 | 0 | 0 | 0 | -100 | 0 | 0.0730 | 0.0035 | 0.0113 | -0.0094 | -1.1378 | -0.0045 |
| | 0 | 0 | 0 | 0 | -150 | 0 | 0.1161 | 0.0057 | 0.0168 | -0.0121 | -1.7074 | -0.0059 |
| | 0 | 0 | 0 | 0 | -200 | 0 | 0.1576 | 0.0063 | 0.0235 | -0.0148 | -2.2770 | -0.0088 |
| | 0 | 0 | 0 | 0 | -250 | 0 | 0.1870 | 0.0076 | 0.0292 | -0.0239 | -2.8467 | -0.0096 |
| | 0 | 0 | 0 | 0 | -300 | 0 | 0.2269 | 0.0082 | 0.0351 | -0.0284 | -3.4162 | -0.0122 |
| | 0 | 0 | 0 | 0 | -250 | 0 | 0.1873 | 0.0081 | 0.0290 | -0.0236 | -2.8481 | -0.0094 |
| | 0 | 0 | 0 | 0 | -200 | 0 | 0.1465 | 0.0074 | 0.0232 | -0.0195 | -2.2786 | -0.0076 |
| | 0 | 0 | 0 | 0 | -150 | 0 | 0.1118 | 0.0068 | 0.0172 | -0.0133 | -1.7090 | -0.0051 |
| | 0 | 0 | 0 | 0 | -100 | 0 | 0.0724 | 0.0069 | 0.0098 | -0.0091 | -1.1396 | -0.0032 |
| | 0 | 0 | 0 | 0 | -50 | 0 | 0.0347 | 0.0037 | 0.0053 | -0.0046 | -0.5704 | -0.0013 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -0.0002 | 0.0012 | -0.0001 | 0.0002 | -0.0006 | 0.0004 |
| *nzpx20* | 0 | 0 | 0 | 0 | 0 | 0 | -0.0013 | 0.0001 | -0.0001 | -0.0004 | 0.0002 | 0.0001 |
| | 0 | 0 | 0 | 8 | -50 | 0 | 0.0295 | 0.0024 | 0.0043 | 0.2907 | -0.5685 | -0.0015 |
| | 0 | 0 | 0 | 17 | -100 | 0 | 0.0593 | 0.0055 | 0.0076 | 0.5811 | -1.1371 | -0.0035 |
| | 0 | 0 | 0 | 25 | -150 | 0 | 0.0897 | 0.0071 | 0.0120 | 0.8721 | -1.7059 | -0.0050 |
| | 0 | 0 | 0 | 33 | -200 | 0 | 0.1224 | 0.0085 | 0.0163 | 1.1637 | -2.2752 | -0.0063 |
| | 0 | 0 | 0 | 42 | -250 | 0 | 0.1528 | 0.0101 | 0.0202 | 1.4535 | -2.8442 | -0.0075 |
| | 0 | 0 | 0 | 50 | -300 | 0 | 0.1860 | 0.0094 | 0.0262 | 1.7455 | -3.4130 | -0.0090 |
| | 0 | 0 | 0 | 42 | -250 | 0 | 0.1597 | 0.0097 | 0.0213 | 1.4577 | -2.8445 | -0.0072 |
| | 0 | 0 | 0 | 33 | -200 | 0 | 0.1235 | 0.0083 | 0.0173 | 1.1644 | -2.2754 | -0.0057 |
| | 0 | 0 | 0 | 25 | -150 | 0 | 0.0910 | 0.0074 | 0.0125 | 0.8729 | -1.7074 | -0.0043 |
| | 0 | 0 | 0 | 17 | -100 | 0 | 0.0614 | 0.0059 | 0.0078 | 0.5822 | -1.1381 | -0.0032 |
| | 0 | 0 | 0 | 8 | -50 | 0 | 0.0308 | 0.0028 | 0.0043 | 0.2915 | -0.5695 | -0.0015 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0.0013 | -0.0001 | 0.0001 | 0.0004 | -0.0002 | -0.0001 |
| *nzpx40* | 0 | 0 | 0 | 0 | 0 | 0 | -0.0017 | 0.0004 | -0.0001 | -0.0004 | 0.0001 | 0.0001 |
| | 0 | 0 | 0 | 17 | -50 | 0 | 0.0208 | 0.0027 | 0.0025 | 0.5812 | -0.5680 | -0.0012 |
| | 0 | 0 | 0 | 33 | -100 | 0 | 0.0465 | 0.0044 | 0.0056 | 1.1643 | -1.1360 | -0.0022 |
| | 0 | 0 | 0 | 50 | -150 | 0 | 0.0748 | 0.0064 | 0.0082 | 1.7484 | -1.7041 | -0.0034 |
| | 0 | 0 | 0 | 67 | -200 | 0 | 0.0984 | 0.0068 | 0.0119 | 2.3306 | -2.2724 | -0.0040 |
| | 0 | 0 | 0 | 83 | -250 | 0 | 0.1162 | 0.0074 | 0.0150 | 2.9103 | -2.8402 | -0.0051 |
| | 0 | 0 | 0 | 100 | -300 | 0 | 0.1392 | 0.0089 | 0.0169 | 3.4933 | -3.4081 | -0.0072 |
| | 0 | 0 | 0 | 83 | -250 | 0 | 0.1181 | 0.0085 | 0.0140 | 2.9128 | -2.8413 | -0.0059 |
| | 0 | 0 | 0 | 67 | -200 | 0 | 0.0954 | 0.0078 | 0.0111 | 2.3303 | -2.2731 | -0.0051 |
| | 0 | 0 | 0 | 50 | -150 | 0 | 0.0696 | 0.0069 | 0.0080 | 1.7472 | -1.7052 | -0.0038 |
| | 0 | 0 | 0 | 33 | -100 | 0 | 0.0498 | 0.0045 | 0.0057 | 1.1665 | -1.1370 | -0.0022 |
| | 0 | 0 | 0 | 17 | -50 | 0 | 0.0260 | 0.0023 | 0.0028 | 0.5830 | -0.5690 | -0.0012 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0.0017 | -0.0004 | 0.0001 | 0.0004 | -0.0001 | -0.0001 |

***Zero Corrected Data Results***

| Filename | Fx lb | Mx lb | Fy lb | My lb*ft | Fz lb*ft | Mz lb*ft | BAL_1 mV | BAL_2 mV | BAL_3 mV | BAL_4 mV | BAL_5 mV | BAL_6 mV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *nynx30* | 0 | 0 | 0 | 0 | 0 | 0 | -0.0003 | -0.0019 | 0.0006 | 0.0000 | -0.0001 | -0.0003 |
| | 0 | 0 | -50 | 0 | 0 | 13 | -0.0085 | -0.0787 | -1.0687 | -0.0031 | 0.0105 | 0.8086 |
| | 0 | 0 | -100 | 0 | 0 | 25 | -0.0096 | -0.1527 | -2.1405 | -0.0067 | 0.0209 | 1.6154 |
| | 0 | 0 | -150 | 0 | 0 | 38 | -0.0137 | -0.2283 | -3.2106 | -0.0095 | 0.0319 | 2.4247 |
| | 0 | 0 | -200 | 0 | 0 | 50 | -0.0179 | -0.3050 | -4.2815 | -0.0129 | 0.0424 | 3.2370 |
| | 0 | 0 | -250 | 0 | 0 | 63 | -0.0099 | -0.3800 | -5.3535 | -0.0159 | 0.0534 | 4.0457 |
| | 0 | 0 | -300 | 0 | 0 | 75 | -0.0099 | -0.4539 | -6.4266 | -0.0181 | 0.0659 | 4.8607 |
| | 0 | 0 | -250 | 0 | 0 | 63 | -0.0087 | -0.3761 | -5.3548 | -0.0162 | 0.0533 | 4.0471 |
| | 0 | 0 | -200 | 0 | 0 | 50 | -0.0073 | -0.2992 | -4.2847 | -0.0131 | 0.0421 | 3.2321 |
| | 0 | 0 | -150 | 0 | 0 | 38 | -0.0103 | -0.2253 | -3.2125 | -0.0099 | 0.0315 | 2.4252 |
| | 0 | 0 | -100 | 0 | 0 | 25 | -0.0076 | -0.1486 | -2.1419 | -0.0069 | 0.0206 | 1.6159 |
| | 0 | 0 | -50 | 0 | 0 | 13 | -0.0053 | -0.0728 | -1.0709 | -0.0031 | 0.0106 | 0.8088 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0.0003 | 0.0019 | -0.0006 | 0.0000 | 0.0001 | 0.0003 |
| *nypx00* | 0 | 0 | 0 | 0 | 0 | 0 | 0.0005 | -0.0020 | 0.0014 | -0.0001 | 0.0000 | -0.0004 |
| | 0 | 0 | -50 | 0 | 0 | 0 | 0.0006 | -0.0378 | -1.0668 | 0.0057 | 0.0015 | 0.0059 |
| | 0 | 0 | -100 | 0 | 0 | 0 | 0.0009 | -0.0742 | -2.1358 | 0.0110 | 0.0023 | 0.0125 |
| | 0 | 0 | -150 | 0 | 0 | 0 | 0.0035 | -0.1081 | -3.2057 | 0.0160 | 0.0041 | 0.0201 |
| | 0 | 0 | -200 | 0 | 0 | 0 | 0.0088 | -0.1416 | -4.2760 | 0.0218 | 0.0064 | 0.0259 |
| | 0 | 0 | -250 | 0 | 0 | 0 | 0.0152 | -0.1774 | -5.3465 | 0.0273 | 0.0083 | 0.0321 |
| | 0 | 0 | -300 | 0 | 0 | 0 | 0.0167 | -0.2484 | -6.4773 | 0.0312 | 0.0099 | 0.0989 |
| | 0 | 0 | -250 | 0 | 0 | 0 | 0.0101 | -0.1750 | -5.3466 | 0.0265 | 0.0074 | 0.0385 |
| | 0 | 0 | -200 | 0 | 0 | 0 | 0.0058 | -0.1388 | -4.2784 | 0.0213 | 0.0060 | 0.0304 |
| | 0 | 0 | -150 | 0 | 0 | 0 | 0.0020 | -0.1036 | -3.2084 | 0.0163 | 0.0042 | 0.0234 |
| | 0 | 0 | -100 | 0 | 0 | 0 | 0.0003 | -0.0676 | -2.1391 | 0.0111 | 0.0031 | 0.0158 |
| | 0 | 0 | -50 | 0 | 0 | 0 | -0.0008 | -0.0327 | -1.0704 | 0.0058 | 0.0014 | 0.0085 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -0.0005 | 0.0020 | -0.0014 | 0.0001 | 0.0000 | 0.0004 |
| *nypx20* | 0 | 0 | 0 | 0 | 0 | 0 | 0.0001 | -0.0002 | 0.0005 | -0.0001 | 0.0000 | 0.0005 |
| | 0 | 0 | -50 | 0 | 0 | -8 | 0.0021 | -0.0081 | -1.0668 | 0.0112 | -0.0045 | -0.5283 |
| | 0 | 0 | -100 | 0 | 0 | -17 | 0.0074 | -0.0156 | -2.1348 | 0.0223 | -0.0086 | -1.0585 |
| | 0 | 0 | -150 | 0 | 0 | -25 | 0.0094 | -0.0243 | -3.2037 | 0.0336 | -0.0133 | -1.5862 |
| | 0 | 0 | -200 | 0 | 0 | -33 | 0.0158 | -0.0326 | -4.2731 | 0.0450 | -0.0175 | -2.1156 |
| | 0 | 0 | -250 | 0 | 0 | -42 | 0.0182 | -0.0396 | -5.3426 | 0.0563 | -0.0217 | -2.6451 |
| | 0 | 0 | -300 | 0 | 0 | -50 | 0.0249 | -0.0461 | -6.4118 | 0.0676 | -0.0260 | -3.1746 |
| | 0 | 0 | -250 | 0 | 0 | -42 | 0.0171 | -0.0402 | -5.3426 | 0.0563 | -0.0217 | -2.6451 |
| | 0 | 0 | -200 | 0 | 0 | -33 | 0.0160 | -0.0312 | -4.2740 | 0.0450 | -0.0175 | -2.1156 |
| | 0 | 0 | -150 | 0 | 0 | -25 | 0.0087 | -0.0223 | -3.2048 | 0.0339 | -0.0128 | -1.5857 |
| | 0 | 0 | -100 | 0 | 0 | -17 | 0.0057 | -0.0146 | -2.1368 | 0.0228 | -0.0086 | -1.0575 |
| | 0 | 0 | -50 | 0 | 0 | -8 | 0.0008 | -0.0071 | -1.0685 | 0.0117 | -0.0044 | -0.5282 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -0.0001 | 0.0002 | -0.0005 | 0.0001 | 0.0000 | -0.0005 |
| *nypx40* | 0 | 0 | 0 | 0 | 0 | 0 | -0.0001 | 0.0003 | 0.0003 | -0.0001 | 0.0000 | 0.0005 |
| | 0 | 0 | -50 | 0 | 0 | -17 | 0.0067 | 0.0208 | -1.0659 | 0.0170 | -0.0105 | -1.0667 |
| | 0 | 0 | -100 | 0 | 0 | -33 | 0.0124 | 0.0407 | -2.1334 | 0.0339 | -0.0206 | -2.1341 |
| | 0 | 0 | -150 | 0 | 0 | -50 | 0.0203 | 0.0607 | -3.2008 | 0.0514 | -0.0310 | -3.2028 |
| | 0 | 0 | -200 | 0 | 0 | -67 | 0.0259 | 0.0796 | -4.2678 | 0.0689 | -0.0414 | -4.2715 |
| | 0 | 0 | -250 | 0 | 0 | -83 | 0.0354 | 0.0984 | -5.3362 | 0.0865 | -0.0527 | -5.3407 |
| | 0 | 0 | -300 | 0 | 0 | -100 | 0.0418 | 0.1185 | -6.4038 | 0.1036 | -0.0637 | -6.4091 |
| | 0 | 0 | -250 | 0 | 0 | -83 | 0.0327 | 0.0978 | -5.3368 | 0.0869 | -0.0527 | -5.3392 |
| | 0 | 0 | -200 | 0 | 0 | -67 | 0.0260 | 0.0783 | -4.2697 | 0.0693 | -0.0418 | -4.2735 |
| | 0 | 0 | -150 | 0 | 0 | -50 | 0.0138 | 0.0584 | -3.2014 | 0.0521 | -0.0310 | -3.1995 |
| | 0 | 0 | -100 | 0 | 0 | -33 | 0.0120 | 0.0401 | -2.1347 | 0.0341 | -0.0203 | -2.1360 |
| | 0 | 0 | -50 | 0 | 0 | -17 | 0.0058 | 0.0196 | -1.0674 | 0.0171 | -0.0101 | -1.0678 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0.0001 | -0.0003 | -0.0003 | 0.0001 | 0.0000 | -0.0005 |

## *Zero Corrected Data Results*

| *Filename* | Fx lb | Mx lb | Fy lb | My lb*ft | Fz lb*ft | Mz lb*ft | BAL_1 mV | BAL_2 mV | BAL_3 mV | BAL_4 mV | BAL_5 mV | BAL_6 mV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *pznx30* | 0 | 0 | 0 | 0 | 0 | 0 | -0.0018 | 0.0003 | 0.0001 | -0.0003 | -0.0003 | 0.0000 |
| | 0 | 0 | 0 | 13 | 50 | 0 | -0.0451 | -0.0014 | -0.0076 | 0.4385 | 0.5705 | 0.0023 |
| | 0 | 0 | 0 | 25 | 100 | 0 | -0.0876 | -0.0028 | -0.0153 | 0.8784 | 1.1415 | 0.0047 |
| | 0 | 0 | 0 | 38 | 150 | 0 | -0.1304 | -0.0033 | -0.0222 | 1.3184 | 1.7122 | 0.0066 |
| | 0 | 0 | 0 | 50 | 200 | 0 | -0.1691 | -0.0051 | -0.0308 | 1.7569 | 2.2828 | 0.0095 |
| | 0 | 0 | 0 | 63 | 250 | 0 | -0.1981 | -0.0081 | -0.0404 | 2.1924 | 2.8533 | 0.0137 |
| | 0 | 0 | 0 | 75 | 300 | 0 | -0.2432 | -0.0041 | -0.0431 | 2.6355 | 3.4236 | 0.0122 |
| | 0 | 0 | 0 | 63 | 250 | 0 | -0.2008 | -0.0067 | -0.0384 | 2.1960 | 2.8537 | 0.0118 |
| | 0 | 0 | 0 | 50 | 200 | 0 | -0.1627 | -0.0068 | -0.0316 | 1.7577 | 2.2838 | 0.0102 |
| | 0 | 0 | 0 | 38 | 150 | 0 | -0.1233 | -0.0041 | -0.0223 | 1.3188 | 1.7131 | 0.0065 |
| | 0 | 0 | 0 | 25 | 100 | 0 | -0.0810 | -0.0038 | -0.0156 | 0.8791 | 1.1423 | 0.0049 |
| | 0 | 0 | 0 | 13 | 50 | 0 | -0.0396 | -0.0021 | -0.0077 | 0.4394 | 0.5712 | 0.0024 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0.0018 | -0.0003 | -0.0001 | 0.0003 | 0.0003 | 0.0000 |
| *pzpx00* | 0 | 0 | 0 | 0 | 0 | 0 | -0.0009 | 0.0006 | 0.0004 | 0.0001 | -0.0002 | -0.0001 |
| | 0 | 0 | 0 | 0 | 50 | 0 | -0.0354 | -0.0012 | -0.0056 | 0.0023 | 0.5703 | 0.0017 |
| | 0 | 0 | 0 | 0 | 100 | 0 | -0.0688 | -0.0028 | -0.0115 | 0.0045 | 1.1411 | 0.0036 |
| | 0 | 0 | 0 | 0 | 150 | 0 | -0.1028 | -0.0038 | -0.0166 | 0.0071 | 1.7113 | 0.0052 |
| | 0 | 0 | 0 | 0 | 200 | 0 | -0.1335 | -0.0054 | -0.0232 | 0.0088 | 2.2817 | 0.0074 |
| | 0 | 0 | 0 | 0 | 250 | 0 | -0.1659 | -0.0058 | -0.0286 | 0.0115 | 2.8529 | 0.0089 |
| | 0 | 0 | 0 | 0 | 300 | 0 | -0.1979 | -0.0038 | -0.0322 | 0.0148 | 3.4237 | 0.0108 |
| | 0 | 0 | 0 | 0 | 250 | 0 | -0.1680 | -0.0057 | -0.0282 | 0.0133 | 2.8532 | 0.0089 |
| | 0 | 0 | 0 | 0 | 200 | 0 | -0.1336 | -0.0050 | -0.0223 | 0.0098 | 2.2820 | 0.0072 |
| | 0 | 0 | 0 | 0 | 150 | 0 | -0.1003 | -0.0045 | -0.0169 | 0.0073 | 1.7113 | 0.0053 |
| | 0 | 0 | 0 | 0 | 100 | 0 | -0.0652 | -0.0044 | -0.0123 | 0.0043 | 1.1411 | 0.0037 |
| | 0 | 0 | 0 | 0 | 50 | 0 | -0.0322 | -0.0029 | -0.0067 | 0.0021 | 0.5703 | 0.0018 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0.0009 | -0.0006 | -0.0004 | -0.0001 | 0.0002 | 0.0001 |
| *pzpx20* | 0 | 0 | 0 | 0 | 0 | 0 | 0.0010 | -0.0004 | 0.0003 | 0.0003 | -0.0001 | 0.0000 |
| | 0 | 0 | 0 | -8 | 50 | 0 | -0.0287 | -0.0016 | -0.0040 | -0.2875 | 0.5697 | 0.0013 |
| | 0 | 0 | 0 | -17 | 100 | 0 | -0.0566 | -0.0021 | -0.0080 | -0.5766 | 1.1400 | 0.0029 |
| | 0 | 0 | 0 | -25 | 150 | 0 | -0.0852 | -0.0025 | -0.0115 | -0.8643 | 1.7102 | 0.0046 |
| | 0 | 0 | 0 | -33 | 200 | 0 | -0.1126 | -0.0039 | -0.0168 | -1.1532 | 2.2818 | 0.0057 |
| | 0 | 0 | 0 | -42 | 250 | 0 | -0.1419 | -0.0048 | -0.0213 | -1.4417 | 2.8535 | 0.0069 |
| | 0 | 0 | 0 | -50 | 300 | 0 | -0.1667 | -0.0043 | -0.0247 | -1.7316 | 3.4243 | 0.0086 |
| | 0 | 0 | 0 | -42 | 250 | 0 | -0.1394 | -0.0047 | -0.0209 | -1.4427 | 2.8536 | 0.0068 |
| | 0 | 0 | 0 | -33 | 200 | 0 | -0.1127 | -0.0041 | -0.0165 | -1.1541 | 2.2821 | 0.0057 |
| | 0 | 0 | 0 | -25 | 150 | 0 | -0.0862 | -0.0041 | -0.0132 | -0.8648 | 1.7114 | 0.0039 |
| | 0 | 0 | 0 | -17 | 100 | 0 | -0.0587 | -0.0028 | -0.0086 | -0.5767 | 1.1403 | 0.0027 |
| | 0 | 0 | 0 | -8 | 50 | 0 | -0.0295 | -0.0010 | -0.0042 | -0.2884 | 0.5700 | 0.0016 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -0.0010 | 0.0004 | -0.0003 | -0.0003 | 0.0001 | 0.0000 |
| *pzpx40* | 0 | 0 | 0 | 0 | 0 | 0 | 0.0017 | 0.0000 | 0.0003 | 0.0002 | -0.0002 | 0.0000 |
| | 0 | 0 | 0 | -17 | 50 | 0 | -0.0207 | -0.0020 | -0.0030 | -0.5800 | 0.5693 | 0.0007 |
| | 0 | 0 | 0 | -33 | 100 | 0 | -0.0453 | -0.0024 | -0.0050 | -1.1597 | 1.1400 | 0.0024 |
| | 0 | 0 | 0 | -50 | 150 | 0 | -0.0714 | -0.0041 | -0.0087 | -1.7390 | 1.7101 | 0.0026 |
| | 0 | 0 | 0 | -67 | 200 | 0 | -0.0937 | -0.0051 | -0.0121 | -2.3212 | 2.2821 | 0.0029 |
| | 0 | 0 | 0 | -83 | 250 | 0 | -0.1237 | -0.0013 | -0.0106 | -2.9209 | 2.8738 | 0.0115 |
| | 0 | 0 | 0 | -100 | 300 | 0 | -0.1434 | -0.0035 | -0.0164 | -3.4831 | 3.4249 | 0.0067 |
| | 0 | 0 | 0 | -83 | 250 | 0 | -0.1202 | -0.0031 | -0.0130 | -2.9019 | 2.8536 | 0.0063 |
| | 0 | 0 | 0 | -67 | 200 | 0 | -0.0952 | -0.0037 | -0.0107 | -2.3226 | 2.2829 | 0.0045 |
| | 0 | 0 | 0 | -50 | 150 | 0 | -0.0706 | -0.0033 | -0.0080 | -1.7421 | 1.7114 | 0.0035 |
| | 0 | 0 | 0 | -33 | 100 | 0 | -0.0485 | -0.0028 | -0.0058 | -1.1609 | 1.1405 | 0.0020 |
| | 0 | 0 | 0 | -17 | 50 | 0 | -0.0253 | -0.0016 | -0.0031 | -0.5807 | 0.5696 | 0.0013 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -0.0017 | 0.0000 | -0.0003 | -0.0002 | 0.0002 | 0.0000 |

## *Zero Corrected Data Results*

| Filename | Fx lb | Mx lb | Fy lb | My lb*ft | Fz lb*ft | Mz lb*ft | BAL_1 mV | BAL_2 mV | BAL_3 mV | BAL_4 mV | BAL_5 mV | BAL_6 mV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *pynx30* | 0 | 0 | 0 | 0 | 0 | 0 | 0.0001 | 0.0007 | -0.0006 | -0.0001 | -0.0002 | 0.0008 |
| | 0 | 0 | 50 | 0 | 0 | -13 | 0.0106 | 0.0781 | 1.0702 | 0.0037 | -0.0101 | -0.8075 |
| | 0 | 0 | 100 | 0 | 0 | -25 | 0.0226 | 0.1536 | 2.1403 | 0.0076 | -0.0198 | -1.6165 |
| | 0 | 0 | 150 | 0 | 0 | -38 | 0.0373 | 0.2287 | 3.2102 | 0.0115 | -0.0290 | -2.4252 |
| | 0 | 0 | 200 | 0 | 0 | -50 | 0.0544 | 0.3045 | 4.2837 | 0.0152 | -0.0387 | -3.2331 |
| | 0 | 0 | 250 | 0 | 0 | -63 | 0.0695 | 0.3806 | 5.3542 | 0.0190 | -0.0487 | -4.0452 |
| | 0 | 0 | 300 | 0 | 0 | -75 | 0.0937 | 0.4555 | 6.4254 | 0.0233 | -0.0576 | -4.8517 |
| | 0 | 0 | 250 | 0 | 0 | -63 | 0.0764 | 0.3778 | 5.3560 | 0.0189 | -0.0484 | -4.0422 |
| | 0 | 0 | 200 | 0 | 0 | -50 | 0.0595 | 0.3011 | 4.2853 | 0.0154 | -0.0382 | -3.2334 |
| | 0 | 0 | 150 | 0 | 0 | -38 | 0.0412 | 0.2250 | 3.2122 | 0.0118 | -0.0286 | -2.4261 |
| | 0 | 0 | 100 | 0 | 0 | -25 | 0.0260 | 0.1494 | 2.1424 | 0.0079 | -0.0191 | -1.6178 |
| | 0 | 0 | 50 | 0 | 0 | -13 | 0.0107 | 0.0748 | 1.0718 | 0.0039 | -0.0096 | -0.8093 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -0.0001 | -0.0007 | 0.0006 | 0.0001 | 0.0002 | -0.0008 |
| *pypx00* | 0 | 0 | 0 | 0 | 0 | 0 | -0.0003 | -0.0011 | -0.0018 | -0.0006 | 0.0000 | 0.0005 |
| | 0 | 0 | 50 | 0 | 0 | 0 | 0.0041 | 0.0346 | 1.0675 | -0.0061 | -0.0011 | -0.0064 |
| | 0 | 0 | 100 | 0 | 0 | 0 | 0.0083 | 0.0708 | 2.1360 | -0.0116 | -0.0021 | -0.0128 |
| | 0 | 0 | 150 | 0 | 0 | 0 | 0.0130 | 0.1066 | 3.2049 | -0.0170 | -0.0030 | -0.0207 |
| | 0 | 0 | 200 | 0 | 0 | 0 | 0.0219 | 0.1416 | 4.2757 | -0.0224 | -0.0034 | -0.0274 |
| | 0 | 0 | 250 | 0 | 0 | 0 | 0.0318 | 0.1767 | 5.3464 | -0.0274 | -0.0042 | -0.0327 |
| | 0 | 0 | 300 | 0 | 0 | 0 | 0.0443 | 0.2122 | 6.4172 | -0.0325 | -0.0052 | -0.0370 |
| | 0 | 0 | 250 | 0 | 0 | 0 | 0.0323 | 0.1773 | 5.3477 | -0.0270 | -0.0046 | -0.0339 |
| | 0 | 0 | 200 | 0 | 0 | 0 | 0.0242 | 0.1409 | 4.2791 | -0.0219 | -0.0031 | -0.0275 |
| | 0 | 0 | 150 | 0 | 0 | 0 | 0.0172 | 0.1054 | 3.2076 | -0.0162 | -0.0020 | -0.0210 |
| | 0 | 0 | 100 | 0 | 0 | 0 | 0.0109 | 0.0708 | 2.1404 | -0.0104 | -0.0016 | -0.0146 |
| | 0 | 0 | 50 | 0 | 0 | 0 | 0.0049 | 0.0362 | 1.0714 | -0.0051 | -0.0010 | -0.0073 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0.0003 | 0.0011 | 0.0018 | 0.0006 | 0.0000 | -0.0005 |
| *pypx20* | 0 | 0 | 0 | 0 | 0 | 0 | 0.0002 | -0.0009 | -0.0002 | -0.0001 | 0.0000 | -0.0005 |
| | 0 | 0 | 50 | 0 | 0 | 8 | 0.0009 | 0.0071 | 1.0681 | -0.0122 | 0.0050 | 0.5305 |
| | 0 | 0 | 100 | 0 | 0 | 17 | -0.0004 | 0.0148 | 2.1353 | -0.0243 | 0.0107 | 1.0610 |
| | 0 | 0 | 150 | 0 | 0 | 25 | 0.0030 | 0.0223 | 3.2021 | -0.0361 | 0.0161 | 1.5919 |
| | 0 | 0 | 200 | 0 | 0 | 33 | 0.0009 | 0.0284 | 4.2739 | -0.0479 | 0.0223 | 2.1206 |
| | 0 | 0 | 250 | 0 | 0 | 42 | 0.0027 | 0.0359 | 5.3425 | -0.0596 | 0.0270 | 2.6513 |
| | 0 | 0 | 300 | 0 | 0 | 50 | 0.0056 | 0.0428 | 6.4114 | -0.0706 | 0.0318 | 3.1828 |
| | 0 | 0 | 250 | 0 | 0 | 42 | 0.0036 | 0.0347 | 5.3414 | -0.0595 | 0.0271 | 2.6517 |
| | 0 | 0 | 200 | 0 | 0 | 33 | 0.0010 | 0.0275 | 4.2740 | -0.0476 | 0.0221 | 2.1211 |
| | 0 | 0 | 150 | 0 | 0 | 25 | 0.0003 | 0.0213 | 3.2038 | -0.0355 | 0.0160 | 1.5912 |
| | 0 | 0 | 100 | 0 | 0 | 17 | -0.0006 | 0.0144 | 2.1371 | -0.0235 | 0.0102 | 1.0609 |
| | 0 | 0 | 50 | 0 | 0 | 8 | -0.0014 | 0.0080 | 1.0688 | -0.0119 | 0.0053 | 0.5306 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -0.0002 | 0.0009 | 0.0002 | 0.0001 | 0.0000 | 0.0005 |
| *pypx40* | 0 | 0 | 0 | 0 | 0 | 0 | 0.0008 | -0.0025 | 0.0005 | 0.0001 | 0.0003 | -0.0005 |
| | 0 | 0 | 50 | 0 | 0 | 17 | -0.0035 | -0.0214 | 1.0663 | -0.0188 | 0.0112 | 1.0598 |
| | 0 | 0 | 100 | 0 | 0 | 33 | -0.0084 | -0.0412 | 2.1326 | -0.0369 | 0.0229 | 2.1184 |
| | 0 | 0 | 150 | 0 | 0 | 50 | -0.0103 | -0.0608 | 3.1993 | -0.0547 | 0.0343 | 3.1789 |
| | 0 | 0 | 200 | 0 | 0 | 67 | -0.0177 | -0.0801 | 4.2696 | -0.0725 | 0.0453 | 4.2401 |
| | 0 | 0 | 250 | 0 | 0 | 83 | -0.0207 | -0.0992 | 5.3354 | -0.0902 | 0.0563 | 5.3014 |
| | 0 | 0 | 300 | 0 | 0 | 100 | -0.0257 | -0.1176 | 6.4032 | -0.1080 | 0.0673 | 6.3626 |
| | 0 | 0 | 250 | 0 | 0 | 83 | -0.0235 | -0.0988 | 5.3354 | -0.0902 | 0.0563 | 5.3014 |
| | 0 | 0 | 200 | 0 | 0 | 67 | -0.0189 | -0.0781 | 4.2690 | -0.0720 | 0.0446 | 4.2416 |
| | 0 | 0 | 150 | 0 | 0 | 50 | -0.0127 | -0.0581 | 3.2000 | -0.0540 | 0.0333 | 3.1799 |
| | 0 | 0 | 100 | 0 | 0 | 33 | -0.0082 | -0.0380 | 2.1343 | -0.0359 | 0.0220 | 2.1207 |
| | 0 | 0 | 50 | 0 | 0 | 17 | -0.0056 | -0.0179 | 1.0678 | -0.0181 | 0.0112 | 1.0606 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -0.0008 | 0.0025 | -0.0005 | -0.0001 | -0.0003 | 0.0005 |

***Zero Corrected Data Results***

| Filename | Fx lb | Mx lb | Fy lb | My lb*ft | Fz lb*ft | Mz lb*ft | BAL_1 mV | BAL_2 mV | BAL_3 mV | BAL_4 mV | BAL_5 mV | BAL_6 mV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *nzny60* | 0 | 0 | 0 | 0 | 0 | 0 | 0.0008 | 0.0086 | -0.0002 | -0.0001 | 0.0005 | -0.0006 |
| | 0 | 25 | 0 | 0 | -50 | 0 | 0.0158 | 1.6149 | 0.0158 | 0.0219 | -0.5867 | -0.0100 |
| | 0 | 50 | 0 | 0 | -100 | 0 | 0.0300 | 3.2203 | 0.0333 | 0.0439 | -1.1736 | -0.0188 |
| | 0 | 75 | 0 | 0 | -150 | 0 | 0.0462 | 4.8155 | 0.0559 | 0.0668 | -1.7597 | -0.0220 |
| | 0 | 100 | 0 | 0 | -200 | 0 | 0.0577 | 6.4179 | 0.0812 | 0.0886 | -2.3500 | -0.0277 |
| | 0 | 125 | 0 | 0 | -250 | 0 | 0.0709 | 8.0196 | 0.1134 | 0.1120 | -2.9380 | -0.0292 |
| | 0 | 150 | 0 | 0 | -300 | 0 | 0.0832 | 9.6241 | 0.1469 | 0.1356 | -3.5276 | -0.0296 |
| | 0 | 125 | 0 | 0 | -250 | 0 | 0.0728 | 8.0122 | 0.1166 | 0.1136 | -2.9390 | -0.0259 |
| | 0 | 100 | 0 | 0 | -200 | 0 | 0.0589 | 6.4043 | 0.0920 | 0.0910 | -2.3506 | -0.0236 |
| | 0 | 75 | 0 | 0 | -150 | 0 | 0.0435 | 4.7971 | 0.0664 | 0.0683 | -1.7624 | -0.0210 |
| | 0 | 50 | 0 | 0 | -100 | 0 | 0.0306 | 3.1952 | 0.0424 | 0.0457 | -1.1745 | -0.0141 |
| | 0 | 25 | 0 | 0 | -50 | 0 | 0.0150 | 1.5908 | 0.0192 | 0.0230 | -0.5876 | -0.0080 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -0.0008 | -0.0086 | 0.0002 | 0.0001 | -0.0005 | 0.0006 |
| *nzny40* | 0 | 0 | 0 | 0 | 0 | 0 | 0.0012 | 0.0108 | -0.0036 | -0.0002 | -0.0001 | -0.0030 |
| | 0 | 17 | 0 | 0 | -50 | 0 | 0.0233 | 1.0802 | 0.0010 | 0.0137 | -0.5811 | -0.0105 |
| | 0 | 33 | 0 | 0 | -100 | 0 | 0.0464 | 2.1483 | 0.0087 | 0.0278 | -1.1615 | -0.0153 |
| | 0 | 50 | 0 | 0 | -150 | 0 | 0.0699 | 3.2168 | 0.0181 | 0.0423 | -1.7429 | -0.0181 |
| | 0 | 67 | 0 | 0 | -200 | 0 | 0.0903 | 4.2868 | 0.0617 | 0.0560 | -2.3253 | -0.0195 |
| | 0 | 83 | 0 | 0 | -250 | 0 | 0.1141 | 5.3542 | 0.0850 | 0.0709 | -2.9060 | -0.0210 |
| | 0 | 100 | 0 | 0 | -300 | 0 | 0.1375 | 6.4249 | 0.1113 | 0.0857 | -3.4895 | -0.0221 |
| | 0 | 83 | 0 | 0 | -250 | 0 | 0.1152 | 5.3497 | 0.0910 | 0.0723 | -2.9084 | -0.0186 |
| | 0 | 67 | 0 | 0 | -200 | 0 | 0.0904 | 4.2719 | 0.0710 | 0.0576 | -2.3260 | -0.0174 |
| | 0 | 50 | 0 | 0 | -150 | 0 | 0.0672 | 3.1977 | 0.0523 | 0.0433 | -1.7445 | -0.0133 |
| | 0 | 33 | 0 | 0 | -100 | 0 | 0.0447 | 2.1287 | 0.0341 | 0.0293 | -1.1626 | -0.0086 |
| | 0 | 17 | 0 | 0 | -50 | 0 | 0.0209 | 1.0588 | 0.0185 | 0.0145 | -0.5816 | -0.0038 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -0.0012 | -0.0108 | 0.0036 | 0.0002 | 0.0001 | 0.0030 |
| *nzpy40* | 0 | 0 | 0 | 0 | 0 | 0 | 0.0011 | -0.0121 | 0.0044 | -0.0007 | 0.0003 | 0.0031 |
| | 0 | -17 | 0 | 0 | -50 | 0 | 0.0505 | -1.0850 | 0.0123 | -0.0177 | -0.5565 | 0.0062 |
| | 0 | -33 | 0 | 0 | -100 | 0 | 0.1007 | -2.1566 | 0.0173 | -0.0342 | -1.1136 | 0.0076 |
| | 0 | -50 | 0 | 0 | -150 | 0 | 0.1523 | -3.2327 | 0.0258 | -0.0501 | -1.6706 | 0.0080 |
| | 0 | -67 | 0 | 0 | -200 | 0 | 0.1993 | -4.2928 | -0.0135 | -0.0666 | -2.2290 | 0.0047 |
| | 0 | -83 | 0 | 0 | -250 | 0 | 0.2508 | -5.3606 | -0.0270 | -0.0819 | -2.7877 | 0.0021 |
| | 0 | -100 | 0 | 0 | -300 | 0 | 0.3027 | -6.4297 | -0.0464 | -0.0964 | -3.3454 | -0.0025 |
| | 0 | -83 | 0 | 0 | -250 | 0 | 0.2510 | -5.3532 | -0.0323 | -0.0807 | -2.7889 | 0.0004 |
| | 0 | -67 | 0 | 0 | -200 | 0 | 0.2005 | -4.2731 | -0.0252 | -0.0641 | -2.2309 | 0.0012 |
| | 0 | -50 | 0 | 0 | -150 | 0 | 0.1494 | -3.1979 | -0.0176 | -0.0482 | -1.6731 | 0.0019 |
| | 0 | -33 | 0 | 0 | -100 | 0 | 0.0971 | -2.1266 | -0.0109 | -0.0329 | -1.1156 | 0.0029 |
| | 0 | -17 | 0 | 0 | -50 | 0 | 0.0492 | -1.0556 | -0.0072 | -0.0158 | -0.5581 | -0.0002 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -0.0011 | 0.0121 | -0.0044 | 0.0007 | -0.0003 | -0.0031 |
| *nzpy60* | 0 | 0 | 0 | 0 | 0 | 0 | 0.0009 | -0.0130 | 0.0011 | -0.0005 | 0.0004 | 0.0006 |
| | 0 | -25 | 0 | 0 | -50 | 0 | 0.0582 | -1.6151 | -0.0019 | -0.0242 | -0.5510 | 0.0049 |
| | 0 | -50 | 0 | 0 | -100 | 0 | 0.1128 | -3.2171 | -0.0091 | -0.0483 | -1.1020 | 0.0095 |
| | 0 | -75 | 0 | 0 | -150 | 0 | 0.1666 | -4.8181 | -0.0189 | -0.0722 | -1.6542 | 0.0119 |
| | 0 | -100 | 0 | 0 | -200 | 0 | 0.2231 | -6.4207 | -0.0319 | -0.0943 | -2.2068 | 0.0097 |
| | 0 | -125 | 0 | 0 | -250 | 0 | 0.2811 | -8.0179 | -0.0582 | -0.1145 | -2.7596 | 0.0018 |
| | 0 | -150 | 0 | 0 | -300 | 0 | 0.3344 | -9.6305 | -0.0822 | -0.1367 | -3.3125 | -0.0015 |
| | 0 | -125 | 0 | 0 | -250 | 0 | 0.2789 | -8.0093 | -0.0607 | -0.1142 | -2.7608 | 0.0033 |
| | 0 | -100 | 0 | 0 | -200 | 0 | 0.2238 | -6.3950 | -0.0461 | -0.0918 | -2.2084 | 0.0063 |
| | 0 | -75 | 0 | 0 | -150 | 0 | 0.1667 | -4.7901 | -0.0298 | -0.0694 | -1.6559 | 0.0083 |
| | 0 | -50 | 0 | 0 | -100 | 0 | 0.1111 | -3.1844 | -0.0177 | -0.0462 | -1.1042 | 0.0068 |
| | 0 | -25 | 0 | 0 | -50 | 0 | 0.0540 | -1.5875 | -0.0079 | -0.0235 | -0.5522 | 0.0050 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -0.0009 | 0.0130 | -0.0011 | 0.0005 | -0.0004 | -0.0006 |

***Zero Corrected Data Results***

| Filename | Fx lb | Mx lb | Fy lb | My lb*ft | Fz lb*ft | Mz lb*ft | BAL_1 mV | BAL_2 mV | BAL_3 mV | BAL_4 mV | BAL_5 mV | BAL_6 mV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *nynz60* | 0 | 0 | 0 | 0 | 0 | 0 | 0.0000 | -0.0124 | -0.0001 | 0.0001 | -0.0004 | -0.0002 |
| | 0 | -25 | -50 | 0 | 0 | 0 | 0.0185 | -1.6478 | -1.0715 | -0.0193 | 0.0206 | 0.0141 |
| | 0 | -50 | -100 | 0 | 0 | 0 | 0.0369 | -3.2783 | -2.1440 | -0.0400 | 0.0443 | 0.0293 |
| | 0 | -75 | -150 | 0 | 0 | 0 | 0.0569 | -4.9158 | -3.2189 | -0.0623 | 0.0682 | 0.0447 |
| | 0 | -100 | -200 | 0 | 0 | 0 | 0.0670 | -6.5353 | -4.2903 | -0.0815 | 0.0961 | 0.0676 |
| | 0 | -125 | -250 | 0 | 0 | 0 | 0.0899 | -8.1682 | -5.3626 | -0.1077 | 0.1262 | 0.0838 |
| | 0 | -150 | -300 | 0 | 0 | 0 | 0.1089 | -9.8037 | -6.4349 | -0.1336 | 0.1588 | 0.1027 |
| | 0 | -125 | -250 | 0 | 0 | 0 | 0.0919 | -8.1516 | -5.3632 | -0.1089 | 0.1305 | 0.0839 |
| | 0 | -100 | -200 | 0 | 0 | 0 | 0.0732 | -6.5112 | -4.2897 | -0.0839 | 0.1023 | 0.0673 |
| | 0 | -75 | -150 | 0 | 0 | 0 | 0.0550 | -4.8762 | -3.2181 | -0.0613 | 0.0751 | 0.0485 |
| | 0 | -50 | -100 | 0 | 0 | 0 | 0.0361 | -3.2457 | -2.1446 | -0.0395 | 0.0485 | 0.0321 |
| | 0 | -25 | -50 | 0 | 0 | 0 | 0.0164 | -1.6125 | -1.0718 | -0.0183 | 0.0240 | 0.0169 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0.0000 | 0.0124 | 0.0001 | -0.0001 | 0.0004 | 0.0002 |
| *nynz40* | 0 | 0 | 0 | 0 | 0 | 0 | -0.0010 | -0.0035 | 0.0002 | 0.0000 | 0.0002 | -0.0001 |
| | 0 | -17 | -50 | 0 | 0 | 0 | 0.0127 | -1.1040 | -1.0700 | -0.0110 | 0.0162 | 0.0108 |
| | 0 | -33 | -100 | 0 | 0 | 0 | 0.0251 | -2.2035 | -2.1414 | -0.0225 | 0.0325 | 0.0226 |
| | 0 | -50 | -150 | 0 | 0 | 0 | 0.0396 | -3.3021 | -3.2131 | -0.0355 | 0.0506 | 0.0346 |
| | 0 | -67 | -200 | 0 | 0 | 0 | 0.0457 | -4.3989 | -4.2851 | -0.0457 | 0.0701 | 0.0536 |
| | 0 | -83 | -250 | 0 | 0 | 0 | 0.0601 | -5.4975 | -5.3570 | -0.0592 | 0.0909 | 0.0686 |
| | 0 | -100 | -300 | 0 | 0 | 0 | 0.0766 | -6.5952 | -6.4303 | -0.0744 | 0.1132 | 0.0822 |
| | 0 | -83 | -250 | 0 | 0 | 0 | 0.0634 | -5.4880 | -5.3586 | -0.0603 | 0.0922 | 0.0682 |
| | 0 | -67 | -200 | 0 | 0 | 0 | 0.0483 | -4.3858 | -4.2867 | -0.0461 | 0.0725 | 0.0555 |
| | 0 | -50 | -150 | 0 | 0 | 0 | 0.0377 | -3.2878 | -3.2145 | -0.0344 | 0.0526 | 0.0391 |
| | 0 | -33 | -100 | 0 | 0 | 0 | 0.0248 | -2.1879 | -2.1433 | -0.0220 | 0.0341 | 0.0256 |
| | 0 | -17 | -50 | 0 | 0 | 0 | 0.0125 | -1.0904 | -1.0717 | -0.0106 | 0.0164 | 0.0128 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0.0010 | 0.0035 | -0.0002 | 0.0000 | -0.0002 | 0.0001 |
| *nypz40* | 0 | 0 | 0 | 0 | 0 | 0 | -0.0003 | 0.0093 | 0.0023 | -0.0017 | 0.0029 | -0.0001 |
| | 0 | 17 | -50 | 0 | 0 | 0 | -0.0153 | 1.0469 | -1.0648 | 0.0203 | -0.0068 | -0.0008 |
| | 0 | 33 | -100 | 0 | 0 | 0 | -0.0293 | 2.0815 | -2.1328 | 0.0431 | -0.0185 | -0.0010 |
| | 0 | 50 | -150 | 0 | 0 | 0 | -0.0405 | 3.1198 | -3.1998 | 0.0674 | -0.0317 | -0.0024 |
| | 0 | 67 | -200 | 0 | 0 | 0 | -0.0490 | 4.1528 | -4.2668 | 0.0954 | -0.0622 | -0.0045 |
| | 0 | 83 | -250 | 0 | 0 | 0 | -0.0581 | 5.1894 | -5.3340 | 0.1212 | -0.0836 | -0.0034 |
| | 0 | 100 | -300 | 0 | 0 | 0 | -0.0660 | 6.2238 | -6.4006 | 0.1490 | -0.1066 | -0.0041 |
| | 0 | 83 | -250 | 0 | 0 | 0 | -0.0558 | 5.1818 | -5.3330 | 0.1227 | -0.0868 | -0.0047 |
| | 0 | 67 | -200 | 0 | 0 | 0 | -0.0467 | 4.1432 | -4.2680 | 0.0971 | -0.0676 | -0.0047 |
| | 0 | 50 | -150 | 0 | 0 | 0 | -0.0356 | 3.1023 | -3.1999 | 0.0723 | -0.0507 | -0.0042 |
| | 0 | 33 | -100 | 0 | 0 | 0 | -0.0244 | 2.0642 | -2.1341 | 0.0476 | -0.0342 | -0.0028 |
| | 0 | 17 | -50 | 0 | 0 | 0 | -0.0121 | 1.0298 | -1.0681 | 0.0244 | -0.0180 | -0.0019 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0.0003 | -0.0093 | -0.0023 | 0.0017 | -0.0029 | 0.0001 |
| *nypz60* | 0 | 0 | 0 | 0 | 0 | 0 | 0.0001 | 0.0120 | 0.0001 | -0.0002 | 0.0005 | 0.0001 |
| | 0 | 25 | -50 | 0 | 0 | 0 | -0.0203 | 1.5844 | -1.0644 | 0.0301 | -0.0197 | -0.0039 |
| | 0 | 50 | -100 | 0 | 0 | 0 | -0.0408 | 3.1533 | -2.1296 | 0.0621 | -0.0420 | -0.0074 |
| | 0 | 75 | -150 | 0 | 0 | 0 | -0.0613 | 4.7213 | -3.1935 | 0.0958 | -0.0666 | -0.0108 |
| | 0 | 100 | -200 | 0 | 0 | 0 | -0.0806 | 6.2891 | -4.2591 | 0.1312 | -0.0930 | -0.0137 |
| | 0 | 125 | -250 | 0 | 0 | 0 | -0.1009 | 7.8480 | -5.3825 | 0.1668 | -0.1242 | 0.0643 |
| | 0 | 150 | -300 | 0 | 0 | 0 | -0.1176 | 9.4047 | -6.3884 | 0.2070 | -0.1596 | -0.0143 |
| | 0 | 125 | -250 | 0 | 0 | 0 | -0.0985 | 7.8285 | -5.3242 | 0.1692 | -0.1311 | -0.0125 |
| | 0 | 100 | -200 | 0 | 0 | 0 | -0.0790 | 6.2610 | -4.2603 | 0.1332 | -0.1014 | -0.0116 |
| | 0 | 75 | -150 | 0 | 0 | 0 | -0.0578 | 4.6883 | -3.1930 | 0.0989 | -0.0748 | -0.0107 |
| | 0 | 50 | -100 | 0 | 0 | 0 | -0.0378 | 3.1202 | -2.1297 | 0.0658 | -0.0494 | -0.0090 |
| | 0 | 25 | -50 | 0 | 0 | 0 | -0.0194 | 1.5540 | -1.0655 | 0.0320 | -0.0240 | -0.0044 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -0.0001 | -0.0120 | -0.0001 | 0.0002 | -0.0005 | -0.0001 |

***Zero Corrected Data Results***

| | Fx | Mx | Fy | My | Fz | Mz | BAL_1 | BAL_2 | BAL_3 | BAL_4 | BAL_5 | BAL_6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Filename* | lb | lb | lb | lb*ft | lb*ft | lb*ft | mV | mV | mV | mV | mV | mV |
| *px00* | 0 | 0 | 0 | 0 | 0 | 0 | -0.0018 | 0.0003 | 0.0000 | -0.0004 | 0.0001 | 0.0013 |
| | 40 | 0 | 0 | 0 | 0 | 0 | 0.9701 | -0.0006 | 0.0003 | -0.0010 | 0.0001 | -0.0003 |
| | 80 | 0 | 0 | 0 | 0 | 0 | 1.9401 | -0.0013 | 0.0004 | -0.0017 | 0.0002 | -0.0005 |
| | 120 | 0 | 0 | 0 | 0 | 0 | 2.9102 | -0.0019 | 0.0008 | -0.0023 | 0.0002 | -0.0004 |
| | 160 | 0 | 0 | 0 | 0 | 0 | 3.8825 | -0.0026 | 0.0004 | -0.0025 | 0.0002 | -0.0023 |
| | 200 | 0 | 0 | 0 | 0 | 0 | 4.8518 | -0.0031 | 0.0006 | -0.0031 | 0.0002 | -0.0032 |
| | 160 | 0 | 0 | 0 | 0 | 0 | 3.8835 | -0.0031 | 0.0005 | -0.0012 | -0.0002 | -0.0018 |
| | 120 | 0 | 0 | 0 | 0 | 0 | 2.9119 | -0.0021 | 0.0008 | -0.0022 | 0.0003 | -0.0007 |
| | 80 | 0 | 0 | 0 | 0 | 0 | 1.9428 | -0.0015 | 0.0003 | -0.0019 | 0.0002 | -0.0020 |
| | 40 | 0 | 0 | 0 | 0 | 0 | 0.9726 | -0.0011 | 0.0006 | -0.0002 | 0.0002 | -0.0002 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0.0018 | -0.0003 | 0.0000 | 0.0004 | -0.0001 | -0.0013 |
| *nx00* | 0 | 0 | 0 | 0 | 0 | 0 | 0.0008 | -0.0007 | 0.0000 | 0.0001 | 0.0000 | 0.0000 |
| | -40 | 0 | 0 | 0 | 0 | 0 | -0.9672 | 0.0000 | 0.0002 | 0.0002 | -0.0001 | 0.0048 |
| | -80 | 0 | 0 | 0 | 0 | 0 | -1.9376 | 0.0003 | 0.0000 | -0.0010 | 0.0001 | 0.0076 |
| | -120 | 0 | 0 | 0 | 0 | 0 | -2.9082 | 0.0010 | -0.0005 | -0.0011 | 0.0001 | 0.0097 |
| | -160 | 0 | 0 | 0 | 0 | 0 | -3.8797 | 0.0018 | 0.0000 | -0.0007 | -0.0001 | 0.0149 |
| | -200 | 0 | 0 | 0 | 0 | 0 | -4.8506 | 0.0022 | 0.0033 | -0.0039 | 0.0007 | 0.0223 |
| | -160 | 0 | 0 | 0 | 0 | 0 | -3.8819 | 0.0019 | 0.0039 | -0.0029 | 0.0004 | 0.0181 |
| | -120 | 0 | 0 | 0 | 0 | 0 | -2.9110 | 0.0015 | 0.0018 | -0.0011 | 0.0001 | 0.0129 |
| | -80 | 0 | 0 | 0 | 0 | 0 | -1.9406 | 0.0014 | 0.0007 | -0.0009 | 0.0001 | 0.0078 |
| | -40 | 0 | 0 | 0 | 0 | 0 | -0.9704 | 0.0013 | 0.0000 | -0.0005 | 0.0001 | 0.0029 |
| | 0 | 0 | 0 | 0 | 0 | 0 | -0.0008 | 0.0007 | 0.0000 | -0.0001 | 0.0000 | 0.0000 |

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Adam Blandford

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calibration, strain gauges, balances, wind tunnels, low speed wind tunnels, loads (forces), matrices (mathematics), data acquisition, computer programs

19. ABSTRACT

DSTO operates a low speed wind tunnel within the Air Vehicles Division of the Platforms Sciences Laboratory. Air speeds up to approximately 90 m/s can be produced in the test section which is 2.7 m wide by 2.1 m high. A six-component Collins internal strain-gauge balance is used to measure forces and moments on a model under test. A manual calibration of this balance has been carried out to determine the sensitivity matrix for the new amplifiers and wiring system integrated into the low speed wind tunnel data acquisition system following its upgrade in 2000. With the new sensitivity matrix the maximum standard error of the loads measured by the strain-gauge balance was 0.19%.

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