SAMPLE LETTER OF TRANSMITTAL FOLLOWED BY SHORT LAB REPORT

PROCRASTINATION INC.
The Company of Tomorrow
(307) 555-5555

January 1, 2001

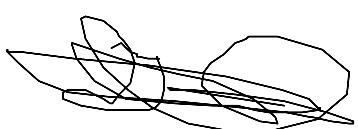
Mr. Wilbur Wright, President
Wright Brothers, Inc.
101 Huffman Prairie Road
Dayton, Ohio 45433

Mr. Wright:

This is in response to your letter of September 18,1908 wherein you requested that we determine the moment of inertia for a section of propeller shaft from the Wright A engines your company is currently supplying to the Army and other customers. This request was predicated on the Army's belief that the propeller failure that your brother experienced was caused by this component's failure to be within the specified tolerance. As noted, this failure led to both the first crash of, and first fatality in, a powered airplane. Attached is a report presenting our findings.

If you have questions, or if Procrastination Inc. can be of further service, do not hesitate to contact us. Thank you for this opportunity to serve you and your company.

Sincerely,



Mr. I. R. Late, PE

Attachments: I. Machinist's Log Data and Statistical Analysis
                II. Sample Calculations and Propagation of Error Analysis

NOTE the use of ALL CAPITALIZED letters in the headings, complete colons after the headings, and double-spacing between "information blocks".

DATE: 1/1/01

TO: Mr. Wilbur Wright, President
Wright Brothers, Inc.

FROM: A. Smith, B. Smith, C. Smith

Initial by name if no letter of transmittal attached; not necessary if letter attached.

SUBJECT: Wright A Engine Propeller Shaft Moment of Inertia

Sub headings should be left margin aligned; bold/underline optional.

Purpose
At the request of Wright Brothers, Inc., propeller shafts for the Wright A aircraft engines were tested to determine the moment of inertia. The purpose of this testing was to determine if the shafts were within the specified tolerance of $I_z = 2.1 \pm 0.05$ kg·m^2.

Summary
The results indicate that the mean moment of inertia, I_z, and the maximum probable error for the propeller shafts tested was 2.05 $\pm$ 0.05 kg·m^2 just after they were manufactured. Therefore, these components were within the specified tolerance in terms of the mean value of the sample analyzed, albeit barely. Unfortunately, at this time there is insufficient data to conclude that *all* components were within tolerance. In all probability, some shafts exceeded the specified range, but their number cannot be determined.

Procedures
No actual engine parts were available as by the time the request was processed, all the aircraft engines had been destroyed except for one in the Smithsonian which, for some reason, the curator would not let us examine. Consequently, all calculations were based on the measurement logs of the Wright Brothers, Inc. machinist, Ross Porter, Sr. The log contained dimensional measurements of twenty-two shafts. Porter measured shaft diameters with a micrometer with a minimum scale division of 0.01 mm; he measured the length with a caliper of minimum scale division of 0.1 cm. It should be noted that both dimensions, i.e. radius and length for a single given component, are not known since they were not recorded as a set. The rod manufacturer listed the steel's density as 7822 $\pm$ 20 kg/m^3. Using Porter's measurements, the mean values, standard deviations, minimum, and maximum values were calculated.

Results
The results of the calculations, for both radius and length, are shown in Table 1.

Table 1. Statistical Results Based on Machinist's Log Data

	Mean	Standard Deviation	Maximum	Minimum
Radius (mm)	50.02	0.01	50.04	50.00
Length (mm)	25.61	0.25	25.91	25.15

Conclusions
As mentioned in the Summary (above), analysis of the above data resulted in a moment of inertia about the shaft's axis of 2.05 $\pm$ 0.05 kg·m^2. Sample calculations may be found in Attachment II. The fact that this calculated value falls on the lower border of the specified range is problematic. The analysis was based on the assumption that the radius, length, and density measurements are independent of each other. Because this may not be an accurate assumption, actual moment of inertia values for some propeller shafts may be outliers. A review of the blueprints in conjunction with this sensitivity analysis indicates that the density will probably have to be specified to a closer tolerance.

ATTACHMENT I: MACHINIST'S LOG DATA AND STATISTICAL ANALYSIS

MACHINIST	Ross Porter, Sr.
DATE	2/5/07

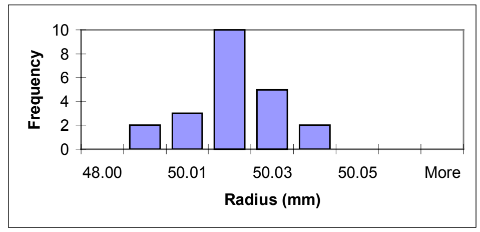
INSTRUMETNS	MANUFACTURER	Serial #	Model #	Minimun Scale
micrometer	Sears	1	SMIC3765	0.01 mm
calipers	Sears	15	SCAL367	0.01 CM

PROPELLER SHAFT DIMENSIONS

Log #	R (mm)	L (CM)	Density kg/m^3
1	50.02	25.61	
2	50.03	25.82	
3	50.02	25.22	
4	50.03	25.89	
5	50.02	25.91	
6	50.02	25.86	
7	50.03	25.15	
8	50.02	25.43	
9	50.03	25.63	
10	50.04	25.81	
11	50.00	25.71	
12	50.03	25.59	
13	50.01	25.88	
14	50.02	25.19	
15	50.02	25.73	
16	50.01	25.49	
17	50.02	25.58	
18	50.04	25.27	
19	50.02	25.44	
20	50.02	25.79	
21	50.01	25.57	
22	50.00	25.90	
Average	50.02	25.61	7822
Std. Dev.	0.011	0.25	
Std. Error [Std. Dev./Sqrt(n)]	0.002	0.03	20
Scale Division	0.01	0.1	
Accuracy [Scale Division/Sqrt(12)]	0.003	0.03	
MIN VALUE	50.00	25.15	
MAX VALUE	50.04	25.91	

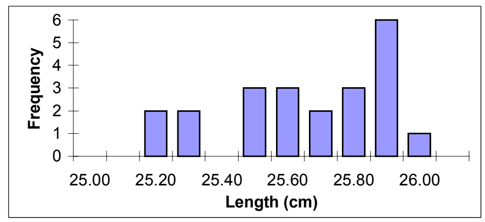
Radius (mm)

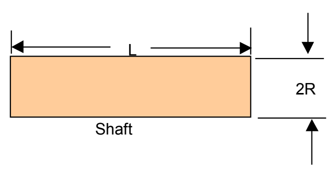
Bin	*Frequency*
48.00	0
50.00	2
50.01	3
50.02	10
50.03	5
50.04	2
50.05	0
50.06	0



Length (cm)

Bin	*Frequency*
25.00	0
25.10	0
25.20	2
25.30	2
25.40	0
25.50	3
25.60	3
25.70	2
25.80	3
25.90	6
26.00	1





ATTACHMENT II. SAMPLE CALCULATIONS AND PROPOGATION OF ERROR ANALYSIS

{NOTE: The equations in this section should be generated using Microsoft's Equation Editor}

The moment of inertia of a shaft about its axis of symmetry is given by $I_z = \frac{1}{2} mR^2 = \frac{1}{2}\pi\rho LR^4$.

Reference: Bedford, Anthony and Wallace Fowler, *Engineering Mechanics Dynamics*, Addison-Wesley, 1992)

Therefore,

$$\bar{I}_z = I(\bar{\rho}, \bar{R}, \bar{L}) = \left(\tfrac{1}{2}\right)\pi\left(7822\,\frac{kg}{m^3}\right)(0.2661m)(0.05002m)^4 = 2.05 \bullet 10^{-2}\, kg \bullet m^2$$

The maximum probable error is given by $\sigma_{\bar{I}z} = \sqrt{\left(\frac{\partial I_z}{\partial \rho}\sigma_{\bar{z}}\right)^2 + \left(\frac{\partial I_z}{\partial L}\sigma_{\bar{L}}\right)^2 + \left(\frac{\partial I_z}{\partial R}\sigma_{\bar{R}}\right)^2}$

Where

$$\frac{\partial I_z}{\partial \rho} = \pi\overline{LR}^4 / 2 = \frac{I_z}{\bar{\rho}} = \frac{2.05 \bullet 10^{-2}\,\mathrm{kg} \bullet \mathrm{m}^2}{7822\mathrm{kg}/\mathrm{m}^3} = 2.62 \bullet 10^{-6}\,\mathrm{m}^5$$

$$\frac{\partial I_z}{\partial L} = \pi\bar{\rho}\bar{R}^4 / 2 = \frac{I_z}{\bar{L}} = \frac{2.05 \bullet 10^{-2}\,\mathrm{kg} \bullet \mathrm{m}^2}{0.2561\mathrm{m}} = 8.01 \bullet 10^{-2}\,\mathrm{kg} \bullet \mathrm{m}$$

$$\frac{\partial I_z}{\partial R} = 2\pi\bar{\rho}\overline{LR}^3 = \frac{4I_z}{\bar{R}} = \frac{4(2.05 \bullet 10^{-2}\,\mathrm{kg} \bullet \mathrm{m}^2)}{5.002 \bullet 10^{-2}\,\mathrm{m}} = 1.64\mathrm{kg} \bullet \mathrm{m}$$

and

$$\sigma_{\bar{\rho}} = \mathrm{MAXIMUM}\left(\frac{\sigma_\rho}{\sqrt{n}}, \frac{\Delta\rho}{\sqrt{12}}\right) = 20\,\frac{\mathrm{kg}}{\mathrm{m}^3} \quad \text{(see attachment I),}$$

$$\sigma_{\bar{L}} = \mathrm{MAXIMUM}\left(\frac{\sigma_L}{\sqrt{n}}, \frac{\Delta L}{\sqrt{12}}\right) = 3 \bullet 10^{-4}\,\mathrm{m} \quad \text{(see Attachment I),}$$

$$\sigma_{\bar{R}} = \mathrm{MAXIMUM}\left(\frac{\sigma_R}{\sqrt{n}}, \frac{\Delta R}{\sqrt{12}}\right) = 3 \bullet 10^{-6}\,\mathrm{m} \quad \text{(see Attachment I),}$$

Therefore,

$$\left(\frac{\partial I_z}{\partial \rho}\sigma_z\right) = (2.62\bullet10^{-6}\mathrm{m}^5)(20\mathrm{kg/m}^3) = 5.24\bullet10^{-5}\mathrm{kg}\bullet\mathrm{m}^2.$$

$$\left(\frac{\partial I_z}{\partial L}\sigma_{\bar{L}}\right) = (8.01\bullet10^{-2}\,\mathrm{kg}\bullet\mathrm{m})(3\bullet10^{-4}\mathrm{m}) = 2.40\bullet10^{-5}\mathrm{kg}\bullet\mathrm{m}^2.$$

$$\left(\frac{\partial I_z}{\partial R}\sigma_{\bar{R}}\right) = (1.64\,\mathrm{kg}\bullet\mathrm{m})(3\bullet10^{-6}\mathrm{m}) = 4.92\bullet10^{-6}\mathrm{kg}\bullet\mathrm{m}^2$$

Thus

$$\sigma_{\bar{I}z} = \sqrt{\left(\frac{\partial I_z}{\partial \rho}\sigma_{\bar{z}}\right)^2 + \left(\frac{\partial I_z}{\partial L}\sigma_{\bar{L}}\right)^2 + \left(\frac{\partial I_z}{\partial R}\sigma_{\bar{R}}\right)^2} = \sqrt{\left(5.24 \bullet 10^{-4}\right)^2 + \left(2.40 \bullet 10^{-5}\right)^2 + \left(4.92 \bullet 10^{-6}\right)^2}$$

$$\sigma_{\bar{I}z} = 5.25 \bullet 10^{-4}\, kg \bullet m^2$$

Therefore, $I_z = (2.05 \pm 0.05) \bullet 10^{-2}$ kg m^2