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The Wright Stuff: A Redesign of the 1905 Wright Flyer

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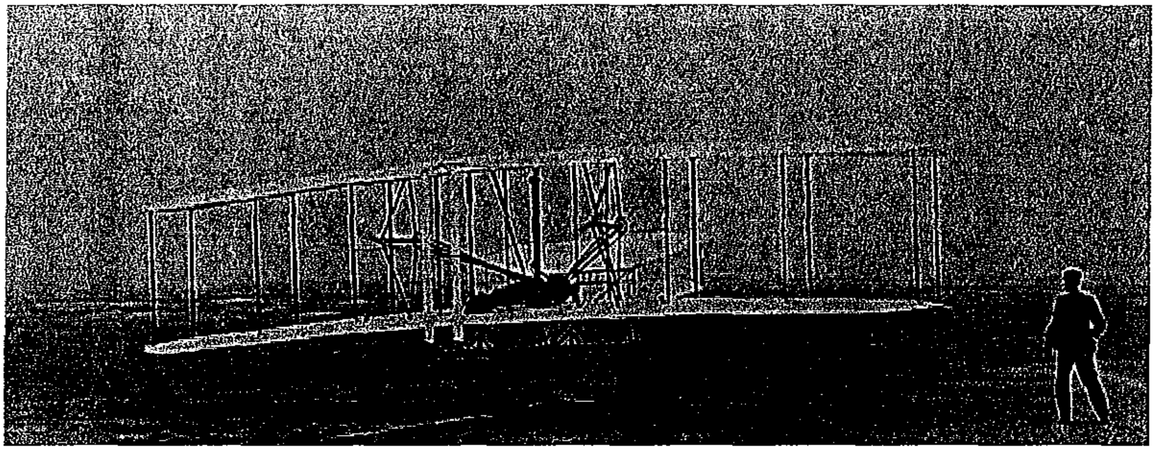
THE WRIGHT STUFF



A Redesign of the 1905 Wright Flyer

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MAE 4810
Senior Design Report

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Introduction

On the morning of December 17, 1903 Wilber and Orville Wright crossed a historic milestone by achieving the first powered flight controlled by a pilot. This event marked the beginning of a new era of flight. The flight was brief, a mere 12 seconds covering a distance of 120 feet, but by 1905 the brothers had developed a practical aircraft that could sustain flight as long as 38 minutes. This was the model that the Wright Brothers showcased at Paris and Washington DC in 1908, bringing them international recognition and fame, with the pilot and a passenger sitting upright on the wing.

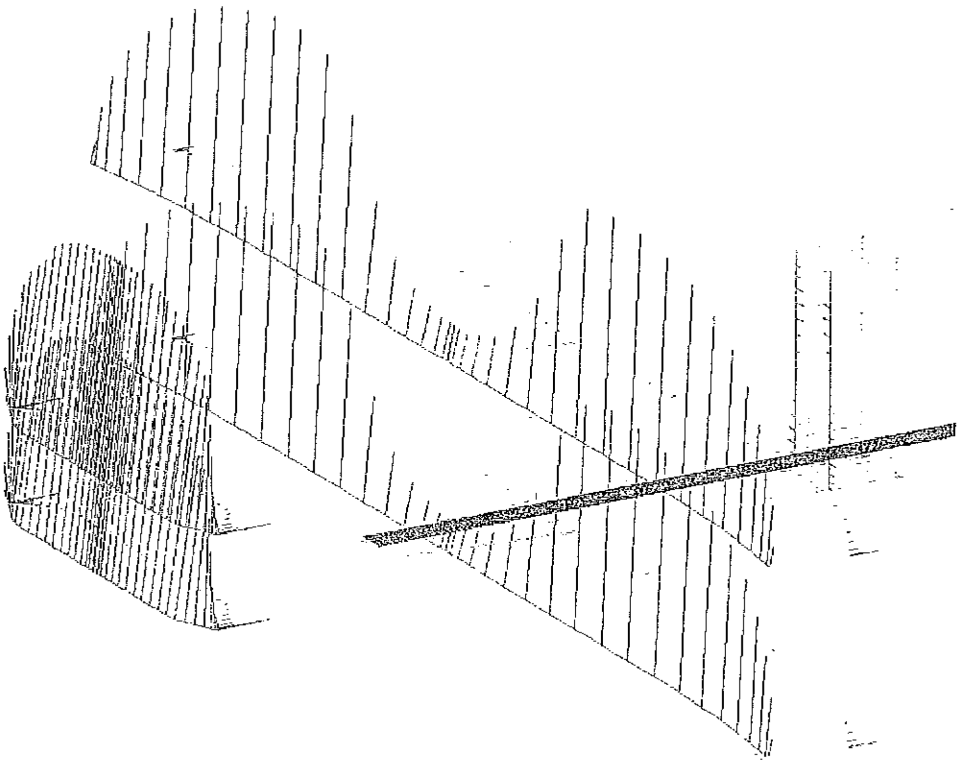
The year 2003 marks the 100^{th} anniversary of this monumental achievement. Although several groups around the nation are attempting to create exact replicas of the Wright Brothers' aircraft, two professors at Utah State University had a different idea of how to pay homage to the grandfathers of flight.

Dr. Dave Widauf and Professor Chuck Larsen entertained the idea of creating an aesthetically similar plane to the 1905 Wright Flyer while incorporating space-age materials and modern aerodynamic sciences. After presenting the idea to USU administrators, the project received an enthusiastic approval. The USU Wright Flyer project would be funded as a K-12 outreach program, culminating with participation in the 2003 festivities in Dayton, Ohio. It was determined that the Industrial Technology and Education Department would build the USU Wright Flyer. Construction would begin after a design team, consisting of ten senior engineering students from the Department of Mechanical and Aerospace Engineering, had completed the modified design.

Nick Alley, a graduate student in mechanical engineering, was assigned to be the project manager. Twenty-one students applied to be on the design team, of which ten were selected. Five students were responsible for the aerodynamic redesign of the USU Wright Flyer and the other five were responsible for the structural redesign. The process took two semesters, with the goal in mind to build the plane built during the summer of 2002.

It became the responsibility of the student design team to produce a working, full-scale, modified design of the 1905 Flyer. The USU Wright Flyer was to be a more stable and stronger aircraft than its 100-year-old predecessor. The USU Wright Flyer was to look amazingly similar to the 1905 Flyer, while incorporating characteristics that are necessary for modern, conventional aircraft. This report contains a complete, comprehensive review of the eight-month design process.

AERODYNAMIC DESIGN



Introduction

The characteristics of the 1905 Wright Flyer were ingenious and yet displayed the limits of the Wrights' understanding of flight mechanics and dynamics. They were great engineers, but luckily they were even better pilots. Today's level of aerodynamic properties in the subsonic realm are well understood and implementation of the now considered "basic" theories and principles of aircraft design are able to easily mend the shortcomings of the 100 year old design.

At the time, relatively little was known about the flight dynamics, and the 1905 Wright Flyer, though advanced for its time, was aerodynamically unstable by today's standards. The objective of USU Wright Flyer design team has been to research the characteristics of the original 1905 Flyer and improve the flight ability of the plane.

One of the major constraints placed upon the project was to retain the aesthetics of the original Flyer. This, of course, required the use of a canard-style biplane powered by two pusher propellers. The general dimensions of the aircraft were retained as much as possible so that the plane would look like the Wright Flyer from a distance to the average airplane enthusiast.

All of the powered aircraft that the Wrights' designed from 1903 to 1909 suffered from moderate to severe instability in pitch. Pitch stability was the first major goal for improving the Flyer. Stall speed was another characteristic worth exploring since the Wright Brothers' plane was stalled much of the time during flight, cruising at a relatively slow 28 mph. Higher design speeds would permit higher stall speeds, but also would increase the drag significantly.

These regulations and other governing parameters for safe flight helped to establish the following targets for the redesign:

1. **Aesthetically similar to the original 1905 Wright Flyer**
2. **Stable in Pitch (Static Margin ≥ 8%)**
3. **Stall Speed no less than 15 mph under cruise speed**

The Wright Flyer was an engineering marvel of its time, the first step into a whole new world. Naturally, since it was the first airplane, it left much to be desired in comparison to the aircraft of today. The flight characteristics of the original 1905 Wright Flyer could have been greatly improved by implementing just a few basic aerodynamic principles.

Tools of Analysis

In order to make improvements on the 1905 Wright Flyer Design it was necessary to perform an analysis on the original to understand quantitatively its flight characteristics. The necessary analysis was divided into two general areas, the individual parts of the aircraft (airfoils and bluff bodies) and the aircraft as a whole.

The analysis of the airfoils was done using two different computer programs: 1) a program developed by Dr. W. F. Phillips at Utah State University called *AIRFOIL2001*, and 2) an online program called *CALCFOIL*. *AIRFOIL2001* uses an inviscid vortex panel numerical method to calculate lift and moment coefficients of an airfoil. This was used primarily as a quick preliminary analysis tool. *CALCFOIL* uses a simple viscous bubble method in conjunction with a vortex panel method to calculate the viscous drag and stall angle of attack of an airfoil in addition to the coefficients that *AIRFOIL2001* calculates.

The data for the airfoils collected from *CALCFOIL* was then used in another program written by Dr. Phillips called *WINGS2001*. This uses Prandtl's inviscid lifting-line theory to calculate the aerodynamic interaction between all parts of an aircraft. By entering the aerodynamic coefficients of each part of an aircraft, the flight characteristics of that plane can be analyzed in a variety of situations. Aerodynamic coefficients obtained from *WINGS2001* were then used to calculate the stall speed, static stability and dynamic stability of the airplanes. Calculated values from *WINGS2001* were in agreement with available historical or experimental data and flight performance of the 1905 Wright Flyer.

The Original 1905 Wright Flyer

All of the powered aircraft the Wright Brothers built up to 1909 suffered from moderate to severe instability in pitch. One major reason for the pitch instability of the1905 flyer is its oversized canard control surface. This placed the aerodynamic center of the aircraft in front of the center of gravity by almost a foot and a half, as seen in Figure 1.1 (Hooven 1978). The other major contributing factor to the pitch instability is that the Wright Brothers preferred controllability rather than stability for fear of going into a stall dive. This caused the death of many would-be aviators including Otto Lilienthal, an inspiration to the Wrights and the father of modern aviation (Hooven 1978).

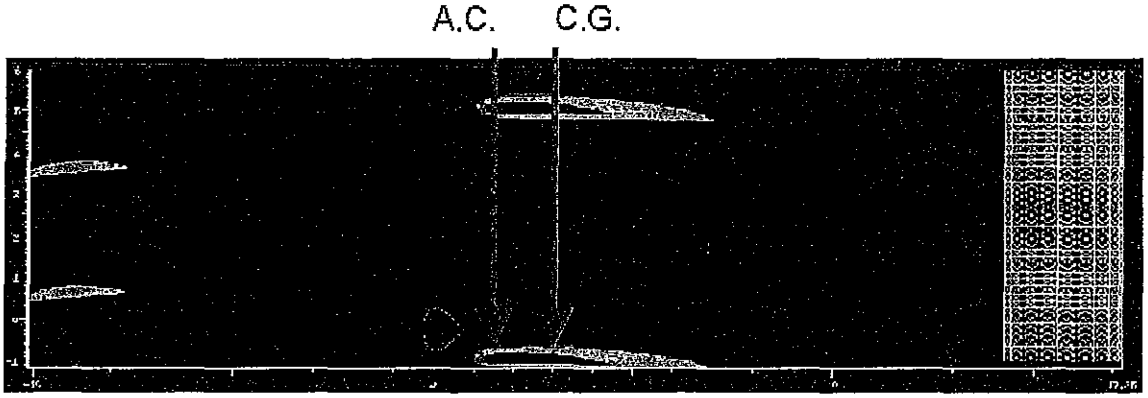


Figure 1.1: Locations of Center of Gravity and Aerodynamic Center of 1905 Flyer.

A modern measurement for pitch stability is the static margin, which, for modern conventional aircraft, should be around 5%. By contrast, the first iteration of the 1905 Flyer was approximately –23%. By 1908 the static margin had improved to –8%, which is still below –5%, today's limit for human-controlled aircraft (Hooven 1978). This instability can be observed in film footage of the airplane in flight, with the airplane constantly porpoising throughout the flight. This instability led to frequent "hard" or otherwise unplanned landings for the Wright Brother's flyer. More often than not their planes needed some level of repair after this type of landing.

Another area of concern with the Flyer is the fact that the airfoils used were very thin and therefore extremely susceptible to stall. The canard's ability to produce lift was only slightly better than that of a flat plate. Although it had a very ingenious mechanism to increase its camber as it was deflected upward, it still did not perform any better than a NACA 0002, while producing significantly higher drag. Also, in order to produce enough lift in steady level flight the wings had to fly at an 8° angle of attack, right on the verge of stall.

Another shortcoming of the 1905 design was its high parasitic drag. Both the wing and canard had blunt leading and trailing edges resulting in high drag coefficients. Also, all of the aircraft structure for the airplane had the same level of streamlining: nothing more than rounded corners on their woodwork. Wind tunnel data for the 1903 Flyer, which had the same general drag cross section as the 1905, showed that it developed approximately 125 pounds of drag in level flight at 28 miles per hour (NASA 1999). This could have easily been reduced by a factor of 2 or 3 using appropriate streamlining.

Characteristics of Canard Aircraft

In standard tail-configured aircraft the elevator often has negative lift in trimmed flight in order to counter the negative pitching moment of the main wing. With a canard-configured aircraft the lift in trimmed flight is positive in order to counter the main wings' pitching moment. Thus the canard carries a percentage of the aircraft's weight. The canard configuration is more efficient in that both the canard and wing contribute to lifting the aircraft where in tail configured aircraft the main wing supports the aircraft's weight plus the negative lift created by the elevator. The absolute lift created is less for canards than tail-configured aircraft, which means less drag is induced.

For a canard-configured aircraft to be statically stable, the canard must have higher wing loading than the main wing and thus an airfoil with a high maximum lift coefficient. A statically unstable canard aircraft has a low wing loading on the canard and thus does not need to create much lift. The 1905 Wright Flyer was statically unstable and this is why it was able to fly with an airfoil that had such a low maximum lift coefficient.

One of the design criteria was to have a stall speed below the Federal Aviation Regulation (FAR) requirement of 40 mph minimum stall speed for an ultralight trainer. Minimum stall speed of a canard-configured aircraft is determined by the stall speed of canard. The high wing loading on the canard for stability increases the minimum canard stall speed, which increases the stall speed of the whole aircraft. Stability (high canard wing loading) and low minimum stall speed requirements are satisfied using an airfoil with a high maximum section lift coefficient. High maximum section lift coefficients are obtained for an all-flying canard predominantly by increasing the camber and thickness of the airfoil section. However if thickness and camber are increased dramatically the aesthetic design criterion is compromised.

Airfoil Considerations

The Wright Brother's performed airfoil analysis using rudimentary wind tunnel testing that was advanced for its time, however present-day technology allows for much improvement. Many different airfoil types including the NACA 4-digit and the USU 12-digit series were analyzed to evaluate lift, drag, moment, and stall characteristics. USU airfoils are designed for a uniform pressure distribution at zero angle of attack. The uniform pressure distribution minimizes adverse pressure gradients, drag, and probability of boundary layer separation, or stall.

Canard Airfoil Design

As previously described, the 1905 Wright Flyer canard airfoil is closely modeled as an all-flying NACA 0002. A NACA 0002 produces a very small maximum lift coefficient, approximately 0.25. As previously concluded, a higher lifting airfoil would need to replace the 1905 canard airfoil. The 1905 used an all-flying canard, meaning that the entire surface rotated to obtain a deflection. To satisfy aesthetics, the USU Wright Flyer also utilizes an all-flying canard.

Airfoil sections for the canard were optimized by first changing camber. Several aircraft were modeled in *WINGS2001*, the only difference being the camber of the canard airfoil. The camber was increased from 2.2% to 4.5%. Over this range, the static margin only decreased 0.6%, while the canard stall speed decreased 5 mph. Increasing camber had a desirable effect, which was to lower the stall speed without significant change in the stability. A camber of 4.5% was chosen because it was the highest cambered airfoil that would not take away from the aesthetic value of the design.

Next, an optimization of canard airfoil section thickness was made. Aircrafts with 8%, 9%, and 10% airfoil thickness were analyzed. Static margin dropped 0.06 % from 8% to 9% thickness, and dropped 0.12 % from 9% to 10% thickness. Stall speed dropped 0.85 mph from 8% to 9% thickness, and dropped 0.11 mph from 9% to 10%. Increasing thickness had a better effect from 8% to 9% than from 9% to 10% because there was a larger drop in stall speed and a smaller drop in static margin. Therefore a 9% thick airfoil for the canard was the best choice.

The USU 12-digit airfoil that corresponded to the 4.5% camber and 9% thickness was a USU 993009-3040.13 shown with the 1905 canard in Figure 1.2. Lift slope and maximum section lift coefficients were then obtained from *CALCFOIL* and compared to the NACA 0002 as shown in Figure 1.3. Obvious improvements in maximum section lift can be seen in this comparison.

An analysis of pressure distributions on the upper and lower surfaces of the USU 993009-3040.13 and NACA 0002 airfoils was done using *AIRFOIL2001* to check for the presence of adverse pressure gradients. As previously mentioned, adverse pressure gradients can cause an abrupt stall. Both airfoils were analyzed at zero degree angle of

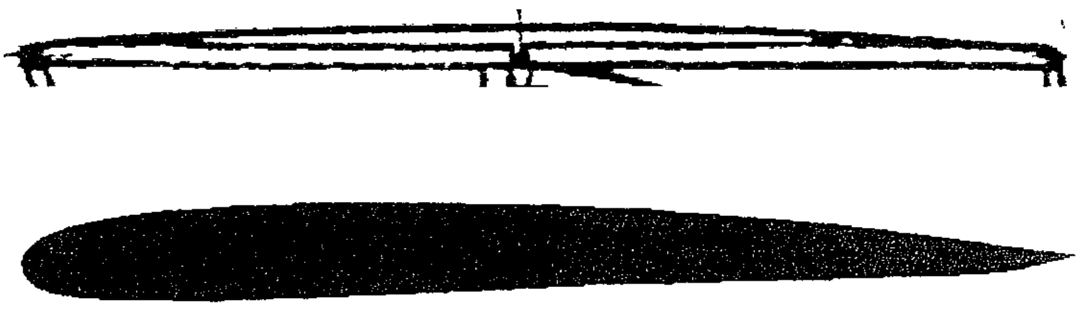


Figure 1.2: 1905 Wright Flyer (top) and USU 993009-3040.13 (bottom) canard airfoil cross-sections.

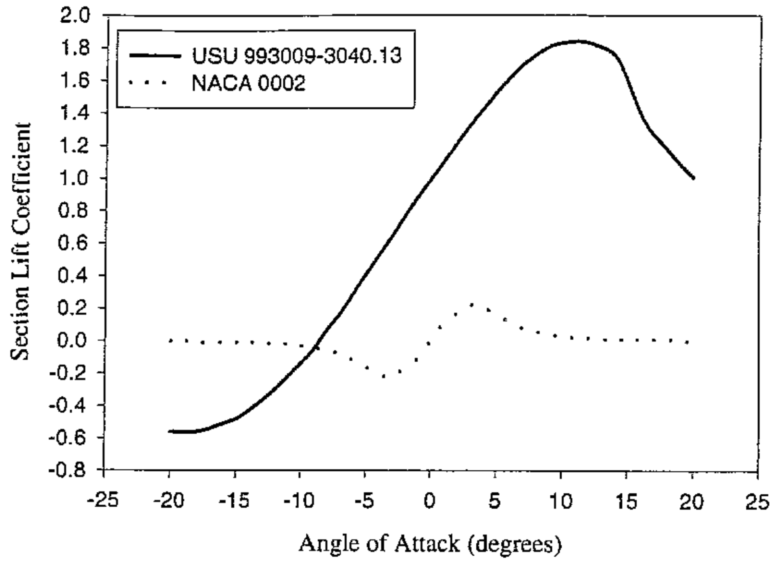


Figure 1.3: A section lift coefficient comparison between USU 993009-3040.13 and NACA 0002 airfoils.

attack and at a takeoff/landing condition of 10 degrees angle of attack as seen in Figure 1.4 and Figure 1.5 respectively. The obvious effects of camber can be seen as the change in pressure between the upper and lower surfaces in Figure 1.4. The USU airfoil has a smoother pressure distribution and the desired smaller pressure gradient near the leading edge of the airfoil section as seen in Figure 1.5.

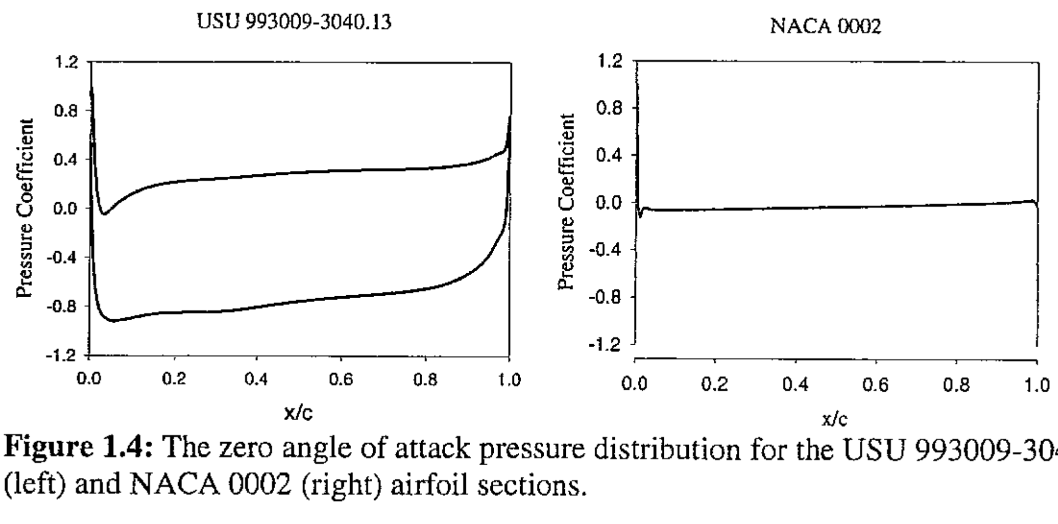


Figure 1.4: The zero angle of attack pressure distribution for the USU 993009-3040.13 (left) and NACA 0002 (right) airfoil sections.

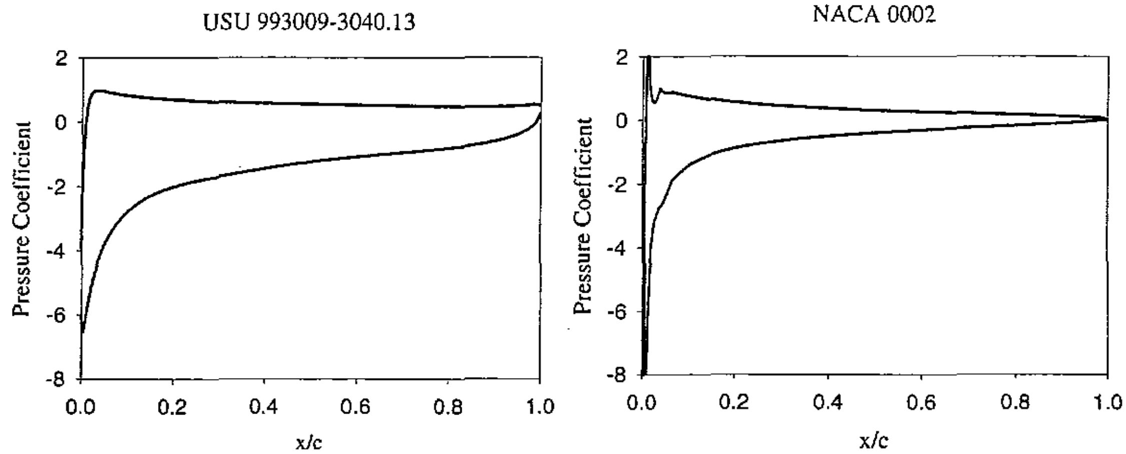


Figure 1.5: The 10-degree angle of attack pressure distribution for the USU 993009-3040.13 (left) and NACA 0002 (right) airfoil sections.

Main Wing Airfoil Design

The 1905 Wright Flyer main wing airfoil had a poor lift to drag ratio due to its thin shape and blunt leading edge. The main factors considered in selecting a new airfoil were the lift and stall characteristics along with the pitching moment created. Because of the large wing area with respect to the overall weight of the aircraft, it was not necessary to select a high lift airfoil. It was more important to select an airfoil that had an acceptable pressure distribution and good stall characteristics.

Airfoil Optimization and Analysis

There were several variables that were taken into account that affect the performance of an airfoil. These variables included airfoil thickness, location of maximum thickness, leading and trailing edge geometry, and camber. After much iteration a modified USU 402509-3040.13 airfoil was selected. It is shown in Figure 1.6 along with the 1905 Wright Flyer airfoil.

The USU airfoil has a much larger maximum thickness than its 1905 counterpart (9% of the chord length vs. 3.5%), which allows larger angles of attack before stall. The 1905 airfoil has very blunt leading and trailing edges and has a near constant thickness over the whole chord length. The USU airfoil is thickest at the quarter chord, tapers to a sharp point at the trailing edge and is smoothly rounded in the front. These characteristics reduce flow separation and allow the suitable pressure distribution shown in Figure 1.7.

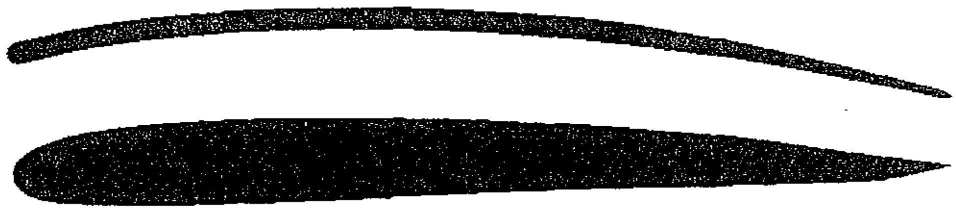


Figure 1.6: 1905 Wright Flyer airfoil (top) and USU 402509-3040.13 airfoil (bottom)

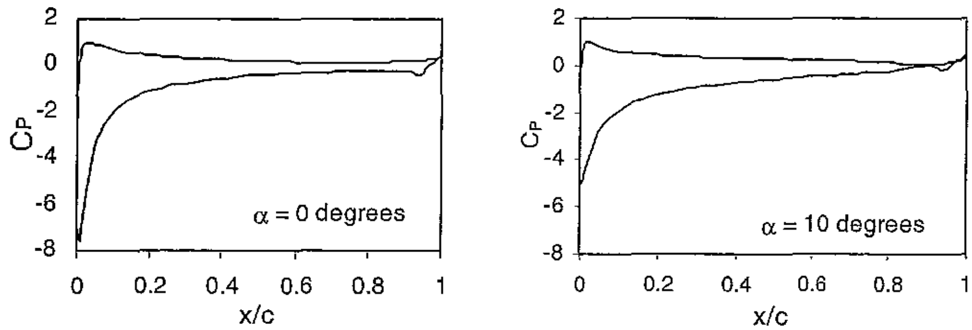


Figure 1.7: Pressure distribution of modified USU 402509-3040.13 airfoil.

Due to the improved aerodynamic efficiency of the new airfoil design, it was not necessary to have such a highly cambered design. Even with less then half the camber of the 1905 airfoil, the lift characteristics of the modified USU airfoil are much more desirable. Figure 1.8 shows the predicted lift slopes of the two airfoils using data obtained from *CALCFOIL*. It can be seen that the USU airfoil has a higher maximum lift coefficient, and can achieve higher angles of attack before stalling.

The USU airfoil was modified slightly in order to reduce the forward pitching moment that is created by cambered airfoils. This was done in order to reduce the loading of the canard. The last 5% of the trailing edge was reflexed upward slightly 7 degrees which reduced the lift on the end of the airfoil. At high angles of attack the end section of the airfoil actually produced a small amount of negative lift. While this does reduce the lift efficiency of the airfoil, it is justifiable due to the low wing loadings required for flight. Figures 1.9 and 1.10 illustrate the slight design modification and how it drastically reduces the forward pitching moment coefficient.

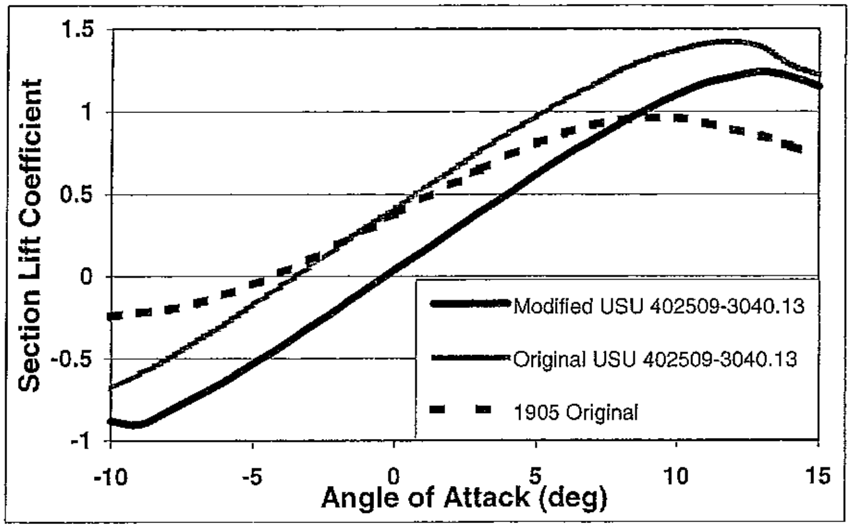


Figure 1.8: Lift slopes of 1905 Wright Flyer and USU airfoil.

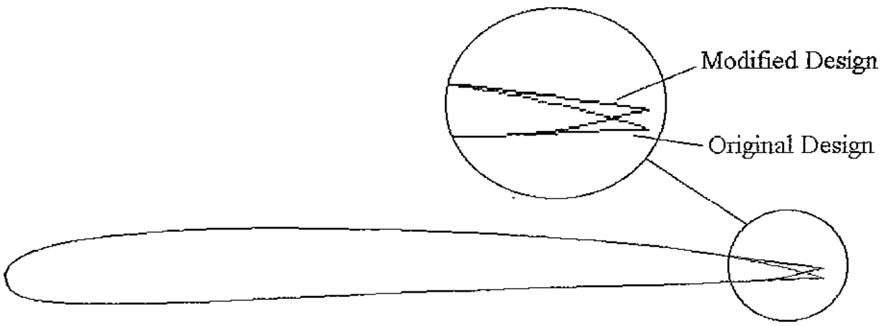


Figure 1.9: USU 402509-3040.13 airfoil with modified trailing edge.

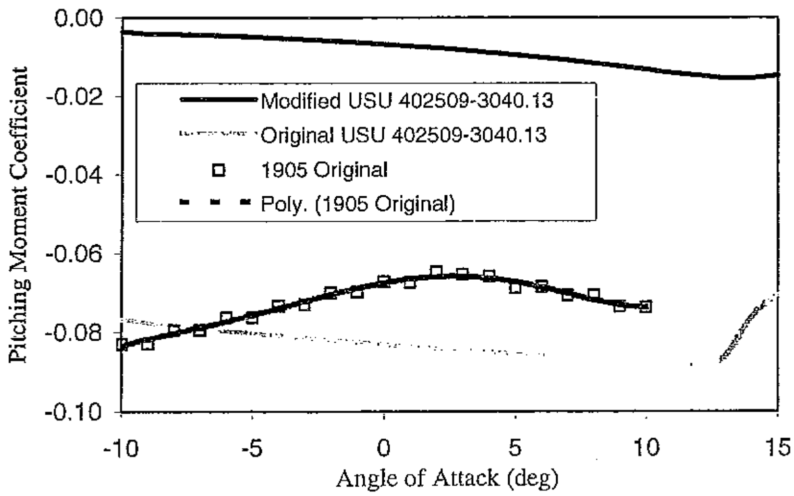


Figure 1.10: Moment Slopes of 1905 and USU airfoils.

Longitudinal Static Stability

The improvement in the airfoils assisted in developing a more stable aircraft, but many more parameters needed to be studied. The most accurate representation of the airplane and its flight stability was found by modeling it in *WINGS2001.* However, when the affects of many variables needed to be explored, using *WINGS2001* was very time consuming. In order to assist in the analysis, a computer program named *STAB* was developed to quickly approximate the static margin. *STAB* incorporated the basic equations that govern the longitudinal stability of an aircraft, including simple statics (Newton's Second Law), and basic flight mechanics, to compute the static margin. A free-body diagram similar to the one used in the derivation is shown in Figure 1.11. Though the program was designed to produce only an estimate of the static margin it proved to be quite accurate in its predictions when compared to the results found from *WINGS2001.*

When comparing a bi-plane to a conventional single-wing aircraft the non-dimensionalization process must be changed. The reference area must be doubled, to represent an area equivalent to both the top and bottom wings. The longitudinal reference length was also doubled to represent the two wings. Another factor of concern was that two wings in a biplane configuration do not create the same amount of lift (and therefore upwash on the canard), when placed together. In order to account for this inefficiency *WINGS2001* was used to determine how a bi-plane configuration affected the lift of two wings. Then the lift and upwash created by the main wings were scaled proportionally (the scaling factor was 0.91).

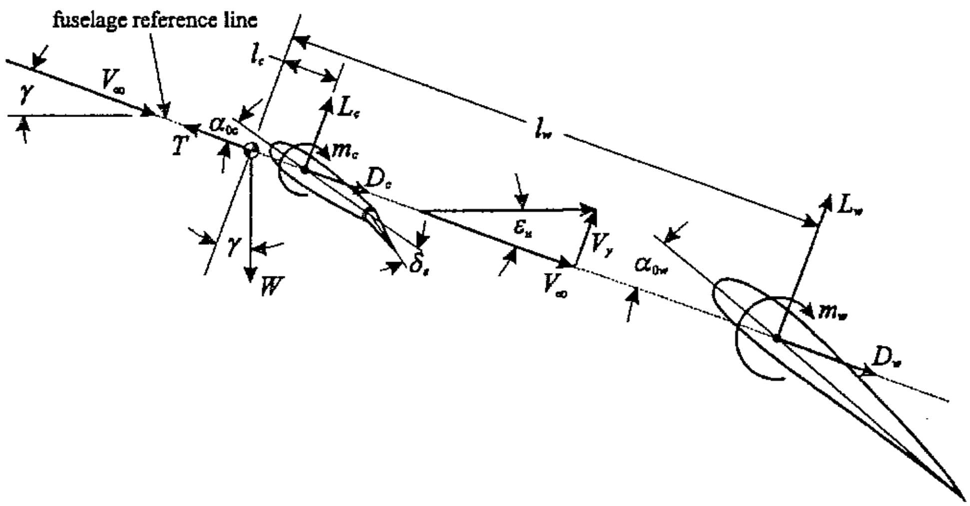


Figure 1.11: Simplified free-body diagram of a canard aircraft (without vertical offsets).

In order to find the desired static margin, certain parameters of the plane were altered while others were held constant in order to retain aesthetics to the highest possible degree (such as the span and chord length of the main wing). After eliminating these and other parameters, the following remained as variables altered to find the ideal static margin:

- Location of the center of gravity
- Canard span
- Canard chord length
- Canard location.

After experimenting with many different configurations and values for the chosen variables, the following changes increased the static margin:

1. Moving the CG position further forward.
2. Decreasing the canard span.
3. Decreasing the canard chord length.
4. Moving the canard further aft.

Notice that changing all of these parameters in the manner specified also increases the wing loading on the canard surfaces, affecting not only the static margin but also the stall speed of the aircraft. The coupling of higher stall speeds with low static margins was a difficult obstacle to overcome. Figure 1.12 shows a plot generated using *STAB*. It represents a flyer with a canard span of 12.5 feet and the CG placed one foot in front of the leading edge of the main wing.

The following parameters were chosen from the preliminary analysis:

1. CG position = 1.0 feet forward of the main wing's leading edge
2. Canard span = 12.5 feet
3. Canard chord length = 2.5 feet
4. Canard placement = 9.5 feet forward of the CG (referenced to the ¼ chord)
5. Static Margin = 8.0%

The 1905 Wright Flyer parameters for comparison:

1. CG position = 3 to 6 inches behind the ¼ chord of the main wing
2. Canard span = 15 feet, 7 ½ inches
3. Canard chord length = 3.125 feet
4. Canard placement = 11.2 feet forward of the CG (referenced to the ¼ chord)
5. Static Margin ≈ -23%

Final results after analysis with *WINGS2001*:

6. CG position = 1.0 feet forward of the main wing's leading edge
7. Canard span = 12.5 feet
8. Canard chord length = 2.5 feet
9. Canard placement = 9.5 feet forward of the CG (referenced to the ¼ chord)
10. Static Margin = 9.5%

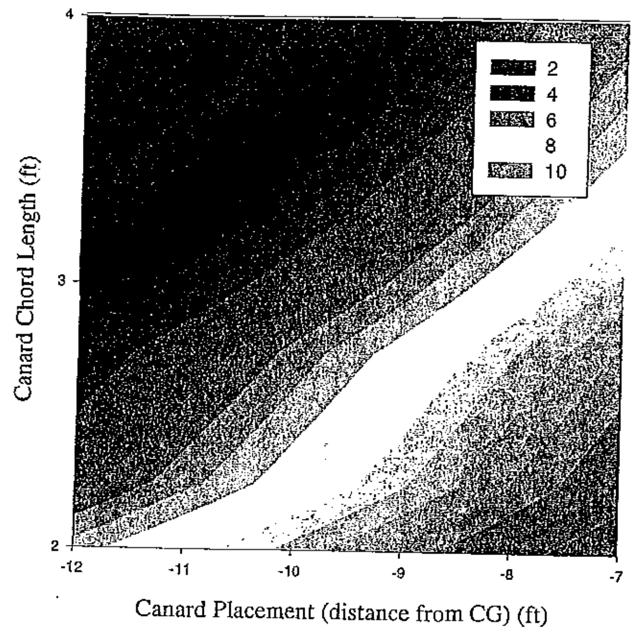


Figure 1.12: Static Margin (%) as a function of the canard chord length and placement with respect to the CG. Using a span of 12.5 ft. and the CG being placed 1 ft. in front of the leading edge of the main wing.

Aerodynamic Drag Reduction

To improve the aerodynamic design of the 1905 Wright Flyer, a detailed analysis of structural parasitic drag of the original was performed. Once the characteristics of the original aircraft were understood, improvements could be recommended and designed.

The 1905 Wright Flyer

The aerodynamic drag forces that affected the 1905 Wright Flyer were estimated using a set of blueprints drawn under the direction of Wilbur Wright nearly forty years after the plane was flown. The main equation used in the analysis was the definition of the non-dimensional drag coefficient.

$$C_D \equiv \frac{DragForce}{\frac{1}{2}\rho V^2 Area} \qquad \text{(eq. 1.1)}$$

The process was simply a matter of examining each part of the plane, estimating the frontal area of the part, then determining the best value for the drag coefficient. The areas were estimated by measuring the blueprints and scaling the dimensions. The drag coefficients were determined by comparing each part to a list of geometries described in Fluid Mechanics by Frank M. White, and then choosing the geometry best describing the part. The aerodynamic forces calculated for each part were then added together to give an approximation of the total drag force exerted on the original aircraft during flight.

In using the drag coefficient equation, density was assumed to *be 0.0023769 slug/ft*^{3} (standard sea-level air density). The velocity used was *28 mph*, which is about the speed the Wrights are reported to have flown. The drag coefficients and corresponding geometries used are tabulated below in Table 1.1.

A large portion of the drag was actually developed by the main wings. The drag coefficients for the main wing, canard, and rudder were found using *CALCFOIL*. To be consistent with the derivation of their coefficients, the reference areas used in the drag force calculations were the planform areas. A spreadsheet was then used to organize the analysis of each part and calculate the drag forces (see Appendix A).

Although the Wright brothers had done a good deal of airfoil testing in the development of their plane, they seem to have been primarily interested in the lift produced by the surfaces they tested. It is not evident that they paid much attention to the aerodynamic drag caused by the many other parts on their flying machine. For example, the parasitic drag coefficient for the main wing airfoil on the original plane was estimated to be about $C_{Do} = 0.047$, while most modern commercial planes have wings with parasitic drag coefficients around $C_{Do} = 0.02$.

All of the flying machines designed and built by the Wright brothers developed relatively large aerodynamic drag from bluff bodies as well. The 18 struts between the main wings, and the 9 struts on the canard were all simply oval cylinders. The entire chassis was made of a similar cross section. Several hundred feet of wires and cables held the plane together. A round cylinder, such as a wire or cable, has a drag coefficient of 1.2. A small cylinder about 0.0625" diameter, such as a wire, creates the same drag force as a streamlined body that is six times as thick. There was much room for improvement in the structural/aerodynamic design of the world's first airplane.

Round Nose	L/H	0.5	1.0	2.0	4.0	6.0
Section	C_D	1.16	0.90	0.70	0.68	0.64
Flat Nose	L/H	0.1	0.7	2.0	3.0	6.0
Section	C_D	1.90	2.70	1.80	1.30	0.90
Cylinder	CD	1.20				
Disk	C_D	1.17				
Main Wing	$C_{D\ Parasitic}$	0.047				
Canard Wing	$C_{D\ Parasitic}$	0.030				
Rudder	$C_{D\ Parasitic}$	0.002				

Table 1.1: Drag coefficients of varying geometries.

The USU Wright Flyer

The reduction of drag for a more modern design was a straightforward process. The structural elements of the plane were redesigned with two objectives aside from the requirements of holding the plane together. The first periphery constraint was to maintain a form that would represent the 1905 Wright Flyer from about 100 feet away. The second periphery constraint was to reduce the aerodynamic drag.

By using stronger and more modern materials, along with better construction techniques, many extraneous structural elements were either eliminated, or their numbers reduced. The remaining parts were redesigned to reduce their frontal area or use geometries with smaller drag coefficients. In the case of the wings and canard, more efficient airfoils were used, thereby not only increasing the performance and stability of the plane, but also greatly reducing the parasitic drag. The final design of the main wing airfoil resulted in an impressive parasitic drag coefficient of $C_{Do} = 0.0073$.

After the final structural design of the USU Wright Flyer was finished, a second spreadsheet (Appendix A) was developed to estimate the drag forces experienced in flight. Comparing the two spreadsheets shows the drag differences between the new USU flyer with the old 1905.

For the USU flyer the number of struts needed for structural support was reduced, the struts that remained were changed to have a streamlined cross-section, and all of the wires used to hold the plane together were eliminated. Figure 1.13 shows how these changes benefit the performance of the USU Wright Flyer. The 1905 fought approximately 120 pounds of aerodynamic drag at a cruise speed of 28 mph. The new aircraft at the same speed had only 55 pounds of drag. If the original aircraft had enough propulsive power to reach the design cruise speed of the new aircraft (45 mph) the drag would be 300 pounds. The new aircraft is estimated to induce only 120 pounds at cruise.

From a copy of the Wright brother's 1908 notebook, they recorded a static thrust from their propellers of 134 pounds (Ash 1999). Their propellers would produce less thrust at 28 mph, and the thrust must equal the drag in steady-level flight. So a prediction of 120 pounds of drag seems quite reasonable.

It is interesting to note the influence that a passenger had on the two airplanes. There is not much difference between flying with or without a passenger in the original aircraft. The drag from the 1905 airframe was so large that the second person didn't make much difference. On the new aircraft however, the airframe drag is low enough that adding a passenger significantly adds to the over all drag.

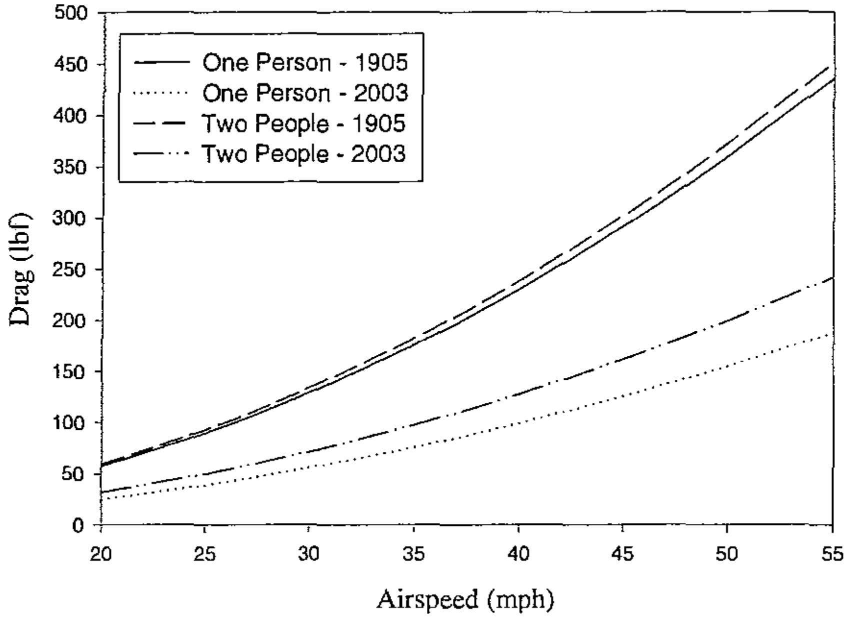


Figure 1.13: Aerodynamic drag force developed as a function of airspeed.

The aerodynamic drag forces on the aircraft also produce a moment about the center of gravity. Since the majority of the aircraft's frontal area is above the center of gravity a pitching-up moment is produced. As the speed of the aircraft increases the pitching moment also increases. Figure 1.14 shows a prediction of how the positive pitching moment is expected to increase as a function of forward airspeed. At a cruise speed of 45 mph, the moment acting on the USU Wright Flyer should be about 700 ft-lb. The propellers, sitting two feet above the center of gravity will have to produce enough thrust to balance the expected drag force of about 125 lbf, thus producing a negative moment of 250 ft-lb. A remaining moment of 450 ft-lb is left acting on the aircraft. The possible stability problems due to the increased pitching moment were evaluated by adding an extraneous surface to the *WINGS2001* model that would produce the same results as the total parasitic drag of the aircraft.

The detailed estimations of the drag forces and moments that are expected for both the 1905 and the USU Wright Flyer made it possible to find ways to improve the 1905 Wright Flyer and also predict the needs of the USU Wright Flyer. The thrust needed for take off and cruising flight were predicted, and values needed to predict the static stability of the aircraft were found.

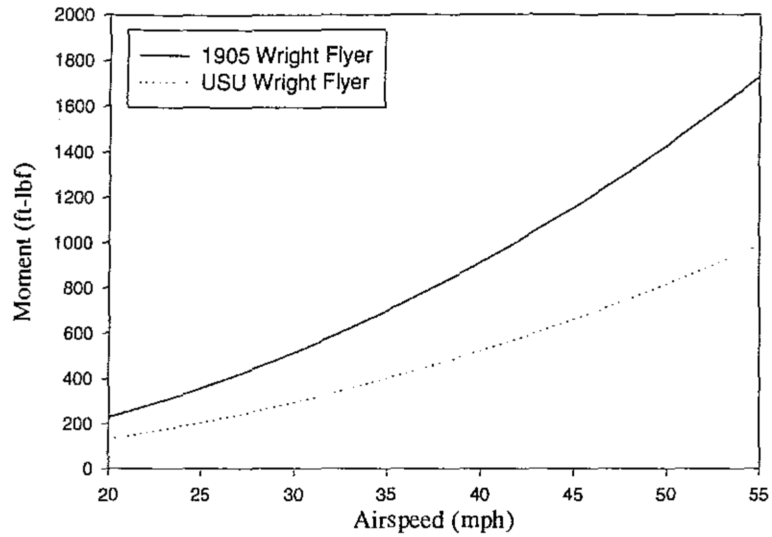


Figure 1.14: Drag moments as a function of airspeed.

Performance

Canard configured aircraft can be susceptible to an unrecoverable stall if the main wing stalls before the canard. If the wing were to stall first the aircraft would pitch backwards and there would be no way to restore the flow over the wings surface and regain level flight. When the canard stalls first the aircraft pitches forward and loses altitude (potential energy), which is exchanged for an increase in airspeed (kinetic energy). The boundary layer re-attaches to the canard surface inducing lift, which allows the pilot to pitch back the aircraft and return to level flight.

To verify a "canard first" stall, the new aircraft was balanced in *WINGS2001* at speeds ranging from 20 mph to 80 mph. Data from *WINGS2001* showed that as the aircraft approached stall, the balanced angle of attack for the canard approached its maximum angle of attack at a faster rate than the wing did. Thus the canard would stall first. Downwash on the wing tends to decrease its absolute angle of attack and move away from stall, while upwash on the canard tends to increase its absolute angle of attack and move it closer to stall.

A "canard first" stall analysis was also done with respect to lift coefficients using the same method outlined above. The data also showed that as the aircraft approached stall the lift coefficient for the canard increased at a higher rate than that of the wing, thus the canard always stalled first. Static margin was found to increase with decreasing speeds. This verified that the aircraft would maintain good stability throughout its design speed range.

The USU Wright Flyer performance analysis found in Appendix B was developed using equations based on Newton's second law (Phillips 2002), data obtained from *WINGS2001*, and the drag analysis (Appendix A). Results of this analysis are best presented graphically as: Figure 1.15 - Thrust Required/Available, Figure 1.16 - Power Required/Available, Figure 1.17 - Rate of Climb, and Figure 1.18 - Sink Rate. The analysis also found the USU Wright Flyer to have a stall limited minimum turning radius of 84.2 ft, and take off distance of 222.0 ft.

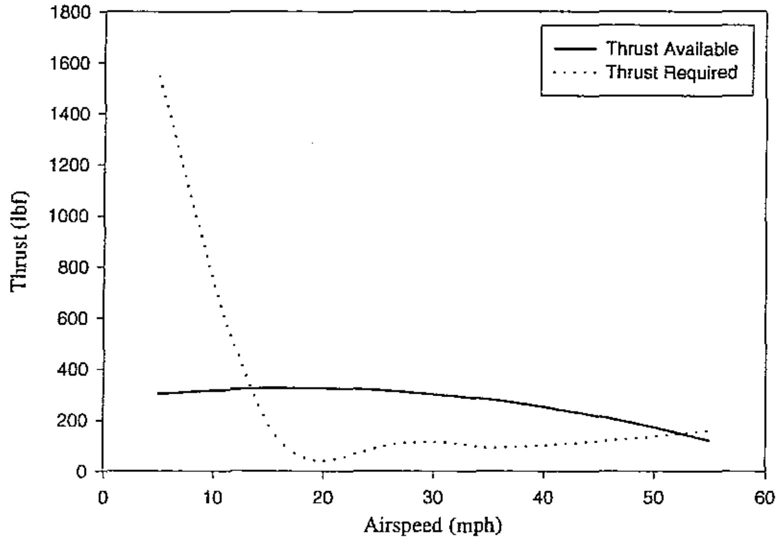


Figure 1.15: Comparison of thrust required to maintain level flight and thrust available given the chosen engine and propellers at standard sea level.

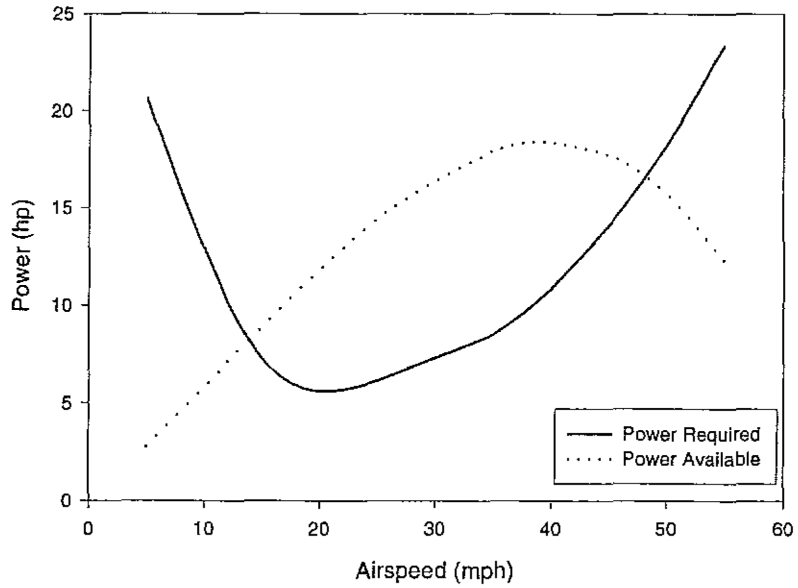


Figure 1.16: Comparison of power required to maintain level flight and power available given the chosen engine and propellers as standard sea level.

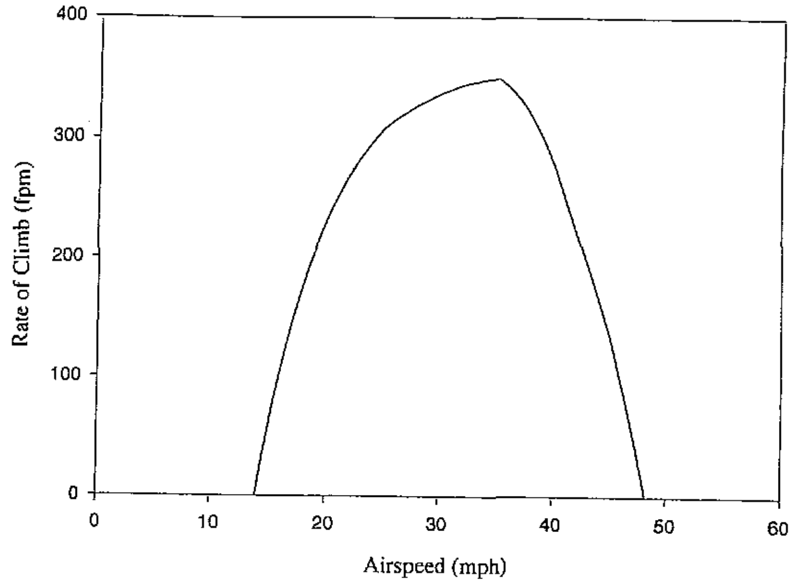


Figure 1.17: Rate of climb at standard sea level.

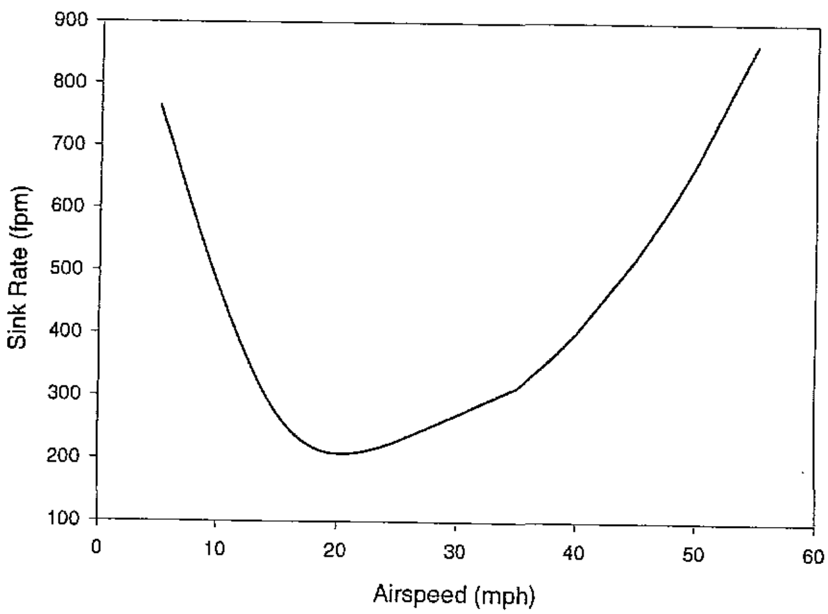


Figure 1.18: Sink rate at standard sea level.

Dynamic Stability

After finding the USU Wright Flyer to be statically stable it was necessary to ensure its dynamic stability. Many modern aircraft design projects are delayed because of problems with dynamic stability, as it can be a difficult characteristic of an airplane to predict (Phillips 2002).

The dynamic stability of an aircraft is found by determining how the airplane would respond to different perturbations from the equilibrium state. Just as a spring-mass system has different dynamic modes, so does an aircraft. The airplane is the mass and the atmosphere is the spring. The five main dynamic modes for an aircraft are:

1. Short-period
2. Long-period or Phugoid
3. Roll
4. Spiral
5. Dutch Roll

Each mode represents conditions that could either make the flight uncomfortable or, in some cases, dangerous.

In order to quantify an airplane's characteristics in dynamic stability, the government has established a classification system that measures how an aircraft's dynamic modes affect the quality of flight. Cooper and Harper (1969) developed a rating system that ranked an aircraft's handling characteristics according to pilot opinion. A Level I rating in this system corresponds to an aircraft for which "pilot compensation (is) not a factor for desired performance." Level 4, the lowest pilot rating, states "control will be lost during some portion of required operation" (Phillips 2002).

Different classes of aircraft and categories of flight phases are also taken into account when classifying an airplane's dynamic flight capabilities. The USU Wright Flyer is a Class I aircraft, which means it is small, light, and used for training or "general observation." The flight phase for the flyer will be a Category C, implying "gradual maneuvers" requiring "accurate flight-path control" (Hodgkinson 1999). Table 1.2 shows the requirements of a Level I pilot rating for each of the major dynamic modes given this particular aircraft class and flight category.

Just as a spring-mass system has a governing equation to describe its motion, so does an aircraft. A computer program named *DYNSTAB* was developed using the linearized equations of motion to find the properties of the different dynamic modes of an aircraft. *DYNSTAB* required as input a list of moments of inertia and derivatives characterizing the motion of an aircraft. The moments of inertia were found using solid models of the 1905 and USU Wright Flyers made with *Autodesk® Mechancial Desktop©* and *Inventor©*. The aerodynamic derivatives were found using *WINGS2001* and

DYNSTAB was then able to find the dynamic flight qualities of both the USU Wright Flyer and the 1905 flyer (see Table 1.2).

As can be seen in Table 1.2, the USU Wright Flyer passed almost all of the requirements for Level I status in steady-level flight. The divergent spiral mode had a Level II doubling time, which is less than ideal. However, in the conditions the airplane will be flying in (visual flight reference or VFR), it should be only a slight inconvenience to the pilot, and not a dangerous quality.

The positive pitching moment of the 1905 Flyer, which resulted in static instability, prevents a proper prediction of its short-period mode. The spiral mode doubling time of the 1905 Flyer was just above the threshold of a Level IV pilot rating (4.0 seconds), resulting in a nearly uncontrollable aircraft.

The Level II spiral mode of the USU flyer gave rise to a study of the effects of how dihedral and a smaller rudder would effect the plane's dynamic stability. Not mentioned earlier was the fact that the initial dynamic analysis did not consider the fact that under regular flight conditions the wings would have natural dihedral due bending in the wing spar. Ignoring the natural dihedral resulted in a doubling time of 9.54 seconds. Using a simple cantilever model, dihedral was placed in the wing representing the natural wing deflection during steady-level flight. The doubling time of the spiral mode was then found to be 12.62 seconds. The result was not only more pleasing, but also more realistic. The dynamic stability results shown in Table 1.2 for the USU Wright Flyer are actually the results obtained by incorporating the natural dihedral.

Hodgkinson Classifications (1999)

Aircraft Classification: *Class I*

Flight Phase: *Category C*

Mode	Requirements for a Pilot Rating of *Level I*:		*USU Wright Flyer*	*Original 1905 Flyer*
Short-period	Range of ζ	0.35 to 1.30	0.87156	n/a
Phugoid	Minimum ζ	0.04	0.12814	0.52627
Roll	Maximum $1/\sigma$ (sec)	1.0	0.03733	0.08827
Spiral	Minimum Doubling Time (sec)	20	12.62	
Dutch Roll	Minimum ζ	0.08	0.46145	0.56481
Key: Level I Level II	Minimum $\zeta\omega_n$	0.15	1.84903	1.35461
Level IV	Minimum ω_n	1.00	4.00701	2.39834

Table 1.2: Hodgkinson (1999) classification comparison for Level I pilot rating. Values for the USU Wright Flyer and the original 1905 Flyer represent steady-level flight.

Another attempt to increase the doubling time of the spiral mode was to decrease the size of the rudder. The design team was hesitant to do so in the first place because of the negative effect it would have on the aesthetics of the airplane. Decreasing the chord length of the rudder was the best possibility. However, by reducing the rudder's chord length from 3.0 feet to 2.75 feet in the *DYNSTAB* model, the resulting doubling time was 12.68 seconds, only a 0.5% increase. Needless to say, the original rudder size remained in use.

Velocity is a large contributor to the quality of an aircraft's dynamic stability. Figure 1.19 represents the manner in which the velocity affects the doubling time of the spiral mode. The figure also presents the relationship between the spiral mode's doubling time and changes in climb angle. As one can see, high climb angles can the plane to plummet below the Level III threshold, placing the aircraft in a potentially dangerous situation.

In the continued study of airspeed effects, a phugoid mode of decreasing quality was found at lower speeds, as shown in Figure 1.20. A flight speed of 35 mph causes a higher climb angle to be potentially dangerous. With this and the potential spiral mode problems at lower airspeeds, it will be important for the pilots of the USU Wright Flyer to be gradual in their maneuvering. In take-off configuration, for example, the pilot must maintain a high speed and a low climb angle to secure safe handling of the aircraft.

The effects of bank angles were also studied, but found only to increase the dynamic stability of the aircraft within the realm of the USU Wright Flyer's flight conditions.

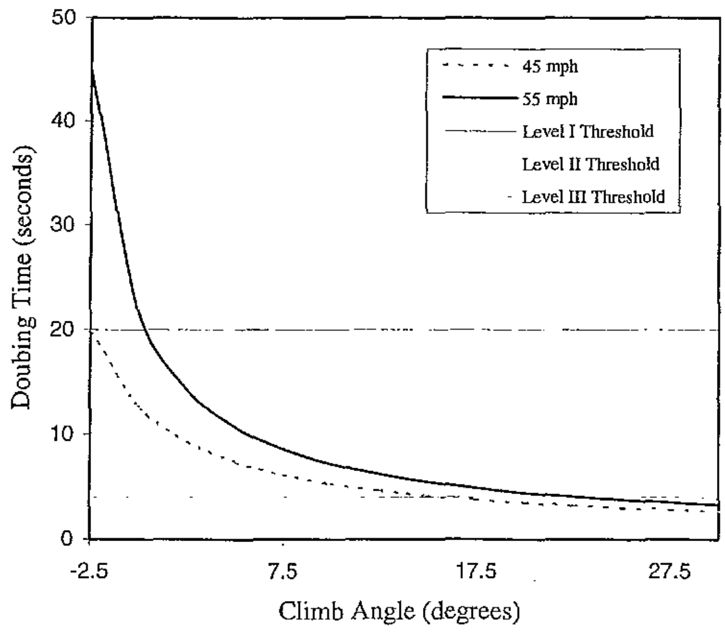


Figure 1.19: Doubling time of the spiral mode amplitude as the climb angle changes for airspeeds of 45 and 55 mph.

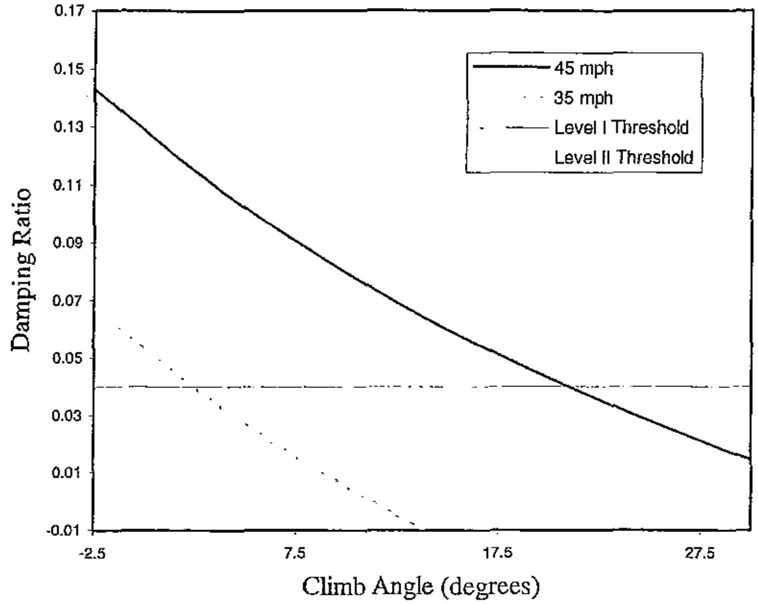


Figure 1.20: Damping rate of the phugoid mode as the climb angle changes for airspeeds of 35 and 45 mph.

Early in the year of 1905 the Wright Brothers added blinkers to their canard to keep the nose of the plane from sliding to the side when banking. The blinkers were small vertical plates that sat between the two canards. Little did the Wright Brothers know that the blinkers would also increase the dynamic stability of their aircraft. In the initial design phases of the USU Wright Flyer the blinkers were assumed to create more drag than they would assist in stability, and were therefore emitted. The small difficulties encountered in both the spiral and phugoid modes led to a decision to reapply the blinkers. Adding the blinkers raised the spiral doubling time to almost 18 seconds. They also had a small positive effect on the phugoid damping ratio, most likely due to the winglet effect the blinkers had on the canard. It is common for modern aircraft to use what is called a strake to create a similar stabilizing effect, due to the commonality of the divergent spiral mode. The actual application of the blinkers to the USU Flyer will be beyond the scope of our time frame.

The design of the USU Wright Flyer has been one to create a unique airplane – one to bring the past into the future. Had the goal of this design been to create a more conventional aircraft, different design criteria would have been established, and the performance in dynamic stability would have been greatly improved. However, it has been shown that the dynamic stability of the USU Wright Flyer surpasses the performance of the 1905 Wright Flyer. Due to the overall improvement and the competent performance of the new plane the less-than-ideal circumstances presented above, such as the spiral and phugoid modes, are permissible.

If design changes were possible, the first step in improving the dynamic stability would be to increase the airspeed. This alone would raise the dynamic stability pilot rating to Level I for all modes, and allow for steeper climb angles. Blinkers would also increase the dynamic stability, especially for the spiral mode. However, the effects of the blinkers are still small compared to simply increasing the airspeed.

Conclusion

The Wright Brothers' work was ingenious for their time, laying the groundwork for the advancement in flight sciences for 100 years. As aerodynamic sciences have built upon their findings, this project has built upon their aircraft. The targets established at the beginning of this re-designing; an aircraft that appears as the 1905 Wright Flyer, positive pitch stability and a stall speed 15 miles per hour less than cruise have been accomplished according to the analysis completed thus far.

1. **Aesthetically similar to the 1905 Wright Flyer (See Figure 1.21)**
2. **Stable in Pitch (Static Margin = 9.5%)**
3. **Stall Speed = 30 mph (2 people), 25 mph (1person).**

All of these results are based upon a 45 mph cruise speed and a 496 lbf aircraft empty weight. The relevant results of the aerodynamic design were passed along to the structural team members to bring the design to life as is detailed in the following chapters.

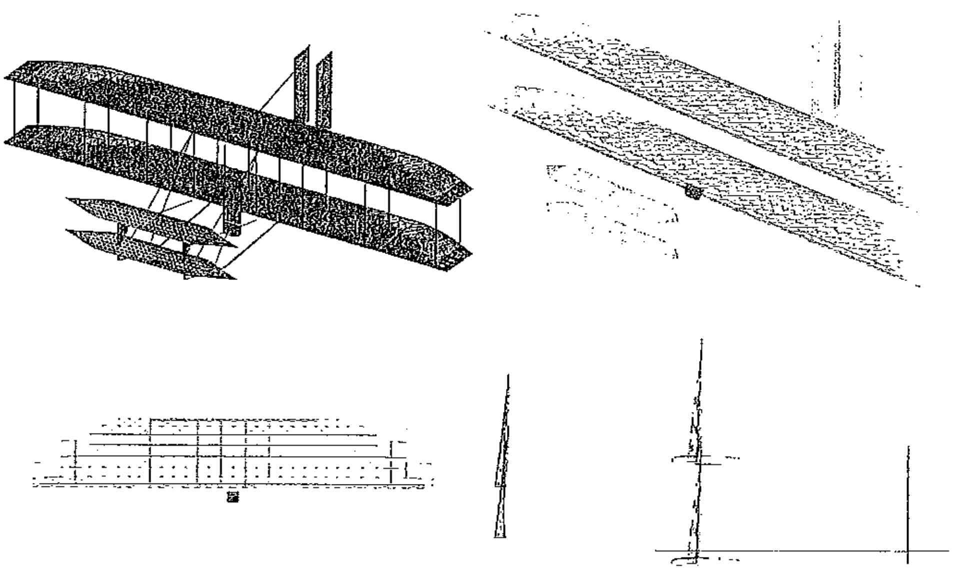
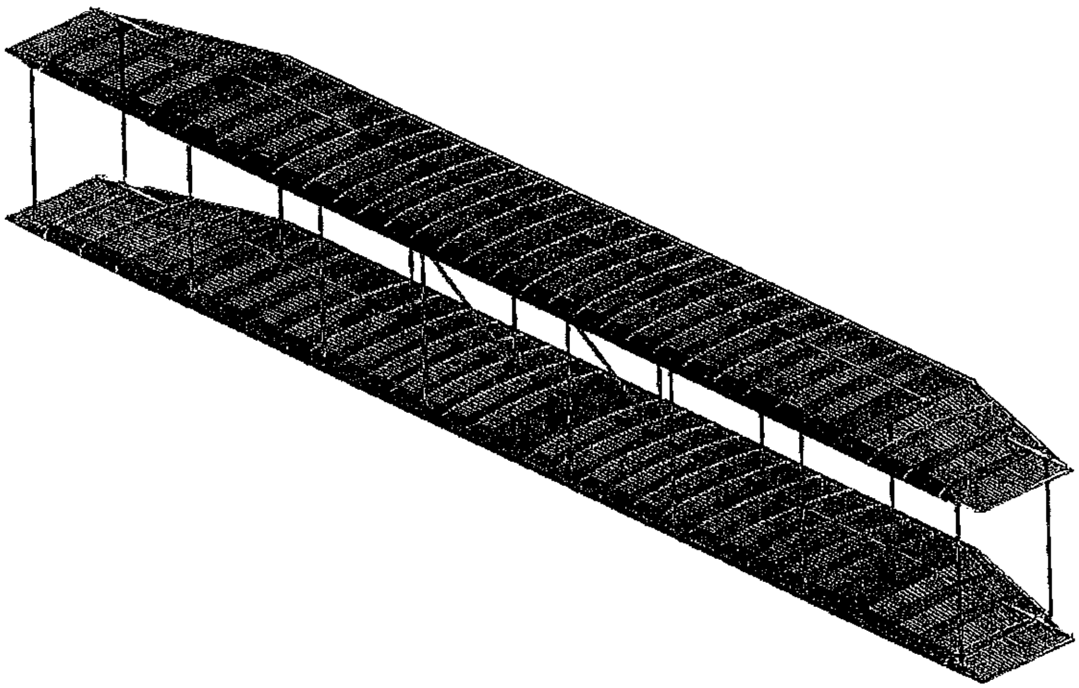


Figure 1.21: *WINGS2001* models of 1905 and USU Wright Flyers. Clockwise from top left: 1905 Wright Flyer, USU Wright Flyer, USU Wright Flyer, USU Wright Flyer side view showing lift of airfoils (red), USU Wright Flyer top view.

MAIN WING DESIGN



Introduction

The main wing the 1905 Wright Flyer was ingenious in many ways. The spars, ribs, and struts were made of spruce and ash, making them light and easy to work with. The wings could be attached and detached easily using simple, modular hardware. The wing warping method designed to control the plane was ahead of its time. The exceptional designs invented by the Wright Brothers made their wing simple and light weight.

Although the original wing design was extraordinary, major changes were needed to accommodate the aerodynamic redesign. For example, the original airfoil was replaced by a thicker more efficient design. The simple change in the wing thickness necessitated changes in many other aspects such as the spars, struts and cabling system.

Despite these large changes, every care was taken to remain sincere to the Wright Brother's original wing design. Wing warping is the defining characteristic of the 1905 Wright Flyer wings. As will be shown, all designs of the USU Wright Flyer were done around wing warping in hope of honoring the great builders of a legacy.

Concept Requirements

1. Weight
   A. Thc final design must weigh less than 120 pounds without compromising safety and/or functionality.

2. Wing Warping
   A. When warped, the wings must keep an acceptable airfoil shape (minimal skin wrinkling).
   B. The design must accommodate a maximum pilot force of 70 lbf.
   C. The design must produce an acceptable roll rate.

3. Strength
   A. The wings must be built so that the deflection of the wingtips is 20 inches when the aircraft is in a 2.5g turn.
   B. The wing spars must be able to withstand a maximum distributed load of 525 lbf at the interfaces.

4. Aesthetics
   A. The aircraft must look like the 1905 Wright Flyer from a distance of 100 feet to a person that has a general knowledge of the design.

5. Interfaces with other parts of the airplane
   A. All interfaces must withstand all possible loads that could occur during normal flight and landing conditions.

6. Manufacturing

A. All designs must take into account the construction capabilities of the Utah State University Industrial Technology Department.
B. All designs must be capable of being manufactured within a reasonable time frame.

Wing Warping

1905 Wright Flyer Design

Initial wing warping ideas for the USU Wright Flyer were based on the warping devices of the 1905 Wright Flyer (see Figure 2.1). The 1905 Wright Flyer used two flimsy spars that could be deflected to warp the wing. Each rib was attached to two spars, one at the leading edge of the wing and one about four feet back. With a clever cable setup, the Wright Brothers deflected the back spar to achieve an acceptable rolling rate. The design worked well with the thin airfoil of the 1905 Wright Flyer.

USU Wright Flyer Design

Using the wing warping method designed by the Wright Brothers as a foundation, internal changes were made to accommodate the new airfoil shape. Several ideas considered were twisting a single spar, splitting a rib to include an elastomeric interface and twisting the leading edge of the wing with free floating ribs.

Twisting a Single Spar

This concept uses a single main spar to carry both the lifting loads and the wing warping loads. The spar would have a torsion load applied at the wingtip to cause the attached ribs to deflect.

Initial concepts using a twisting spar had some very appealing properties. Foremost was the elimination of the rear spar, which greatly reduced the overall weight of the wing structure. Control cables and rods would be located inside the wing structure, eliminating parasitic drag caused by external cables.

Several attributes of the Single Spar design were found to be unacceptable. First, the main spar would be subjected to continuous torsion and bending loads. Torsion loads would be further increased by the inherent moment caused by the wing. Such a combination of loads was frightening bearing in mind that if the spar failed the aircraft would crash. Second, no acceptable twisting mechanism was found to apply controlled warping.

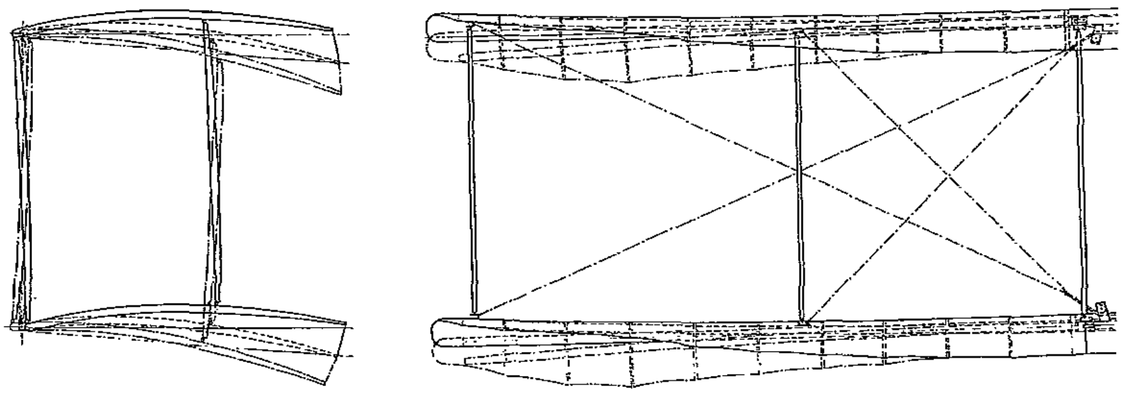


Figure 2.1: The 1905 Wright Flyer wing warping detail from original drawings.

Splitting the Ribs with an Elastomeric Interface

This concept splits the outer ribs near the quarter-chord and reattaches them with an elastomeric material effectively creating a large, internal aileron. A load applied to the back spar would bend the back portion of the ribs while the front piece remained rigidly attached to the main spar. Two rubber-like interfaces would hold the pieces to together (Figure 2.2). This eliminates the constant loading of the main spar, allowing it to carry the lifting forces while the rear spar experiences only the predictable bending loads created by the control cables.

A mockup was built to analyze the feasibility of construction and locate any problems that were not originally taken into account. Motion was found to be acceptable, but the front and back rib pieces tended to separate. Applying retaining blocks to the edges of the ribs impeded this problem, but still left concern (Figure 2.3).

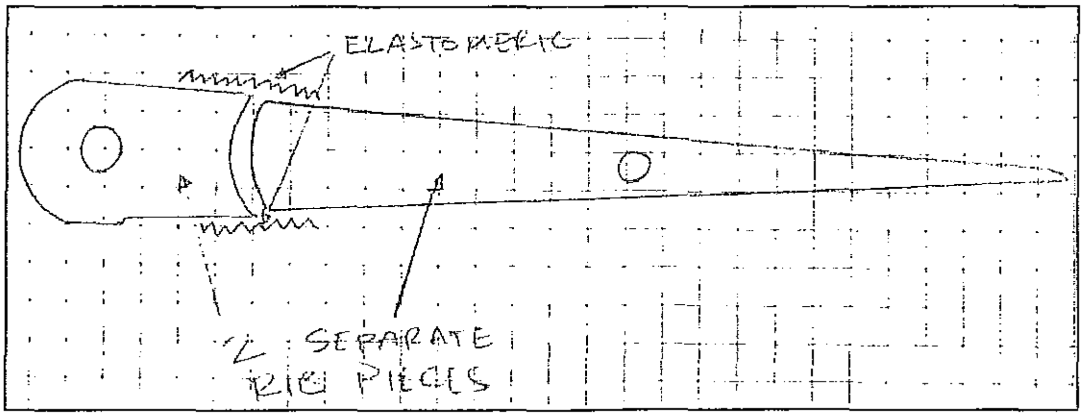


Figure 2.2: Split rib with elastomeric material.

Figure 2.3: Split rib with elastomeric material mockup.

Unfortunately, this design did not meet the requirement for simplicity. As the individual parts were considered, the design quickly grew too complex. This design required two to three separate D-tubes, elastomeric material that would run the entire length of the warping section, two spars, and four spar collars (Figure 2.4).

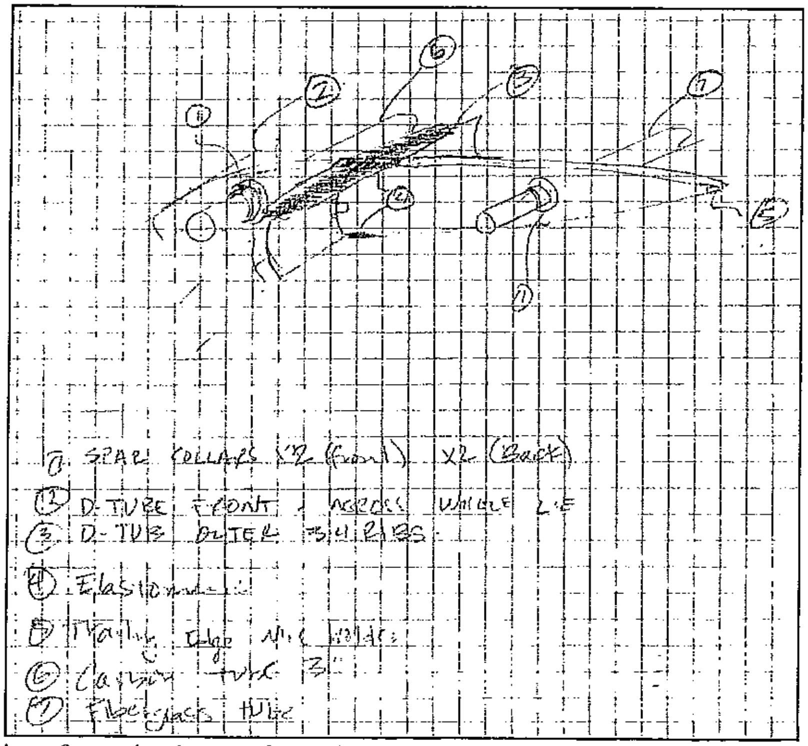


Figure 2.4: List of required parts for split rib idea.

Twisting Leading Edge with Free-Floating Ribs

Work was then done to simplify the previous design. It was found that the leading edge of the airfoil was nearly three inches in diameter. Therefore, a three-inch diameter front spar was placed at the leading edge. This would strengthen the leading edge and effectively eliminate the need for the two heavy D-tubes, which could now be replaced with a single lightweight composite piece. The rib was also left as a solid piece that could rotate around the front spar, eliminating the need for the elastomeric material. Finally, simple wooden blocks bonded to the spar replaced the spar collars to constrain the ribs in the lateral direction.

This idea, consisting of only five main parts (the ribs, the back spar, the front spar, the leading edge, and the wingtip) is much simpler than the previous design, which incorporates ten. As shown in Figure 2.5, the outer seven ribs are free-floating over both spars and are bonded only to the slightly flexible leading edge. The wingtip simply constrains the distance between the two spar tips and is also free-floating. Control cables bend the back spar to provide the same warping motion as the 1905 Wright Flyer. Ironically, the best design found was nearly identical to the 1905 Wright Flyer, which is great testament to the ingenuity and engineering skill of the Wright Brothers.

Leading Edge Design

To achieve the flexibility for the required motion of the leading edge, the expertise of Dave Widauf and Charles Larsen was sought. According to their opinion, woven graphite laid up at a 45° angle would provide the needed strength and flexibility.

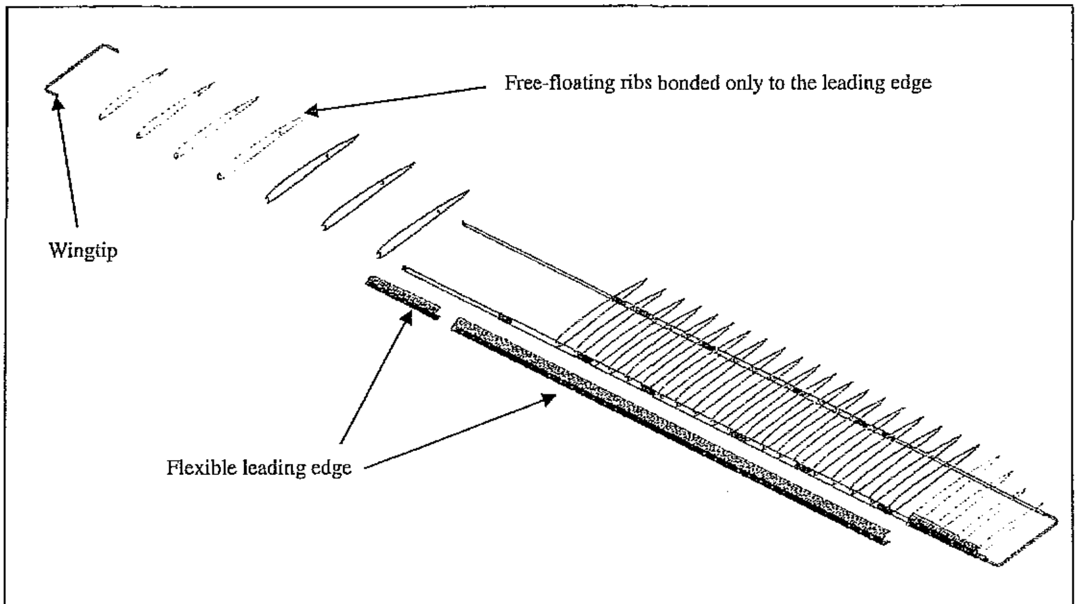


Figure 2.5: Twisting leading edge idea detail.

Determination of Required Wing Deflection

To ensure proper aileron size and placement it was necessary to model the USU Wright Flyer using *WINGS2001*. The process of studying the affects of aileron deflection entails matching a desired rolling rate with the required aileron deflection. If a large deflection is required the ailerons may be undersized or poorly located. Similarly, small deflections might indicate that the ailerons are too large.

The difficult part in obtaining assurance of proper aileron sizing and deflection is generating an accurate model of the airplane. For most aircraft it is not a problem because the ailerons have a specific location and size. However, it is difficult to model a warping wing.

WINGS2001 applies the same angle of aileron deflection on every flap designated as an aileron. With wing warping, the wing is most deflected toward the tips of the wing and the deflection decreases until the wing can be considered rigid, having no deflection. Since it was impossible to model this gradual decrease in deflection angle in *WINGS2001*, a different technique was used. First of all, the wing was broken up into sections as shown in Figure 2.6(a). After dividing the wing, the midpoint of each section was treated as a point on a cantilever beam. Next, the ratio of a section's midpoint deflection compared to the maximum deflection was used as the percent of the chord of each section used as an effective aileron, as shown in Figure 2.6(a) and (b).

A rolling rate value *p*, commonly used for aileron sizing in low-maneuverability aircraft is shown non-dimensionalized as follows (Phillips):

$$(pb_w/2V_o)_{max} \geq 0.07 \qquad \text{(eq. 3)}$$

After placing this value into *WINGS2001*, the resulting rolling moment was then balanced by an opposing aileron deflection. At this balanced configuration, the aileron deflection required in the lifting line model was 5.4°, which corresponds to a wingtip deflection of 4.3 inches. A visual of the exaggerated wing warping used in WINGS2001 is shown in Figure 2.7.

Trailing Edge Design

1905 Wright Flyer Design

The Wright Brothers simply attached a wire, pulled as tight as possible, to the trailing edge of the ribs. This design did an adequate job, but still allowed the fabric to 'dip' and 'bubble' in flight.

(a)

(b)

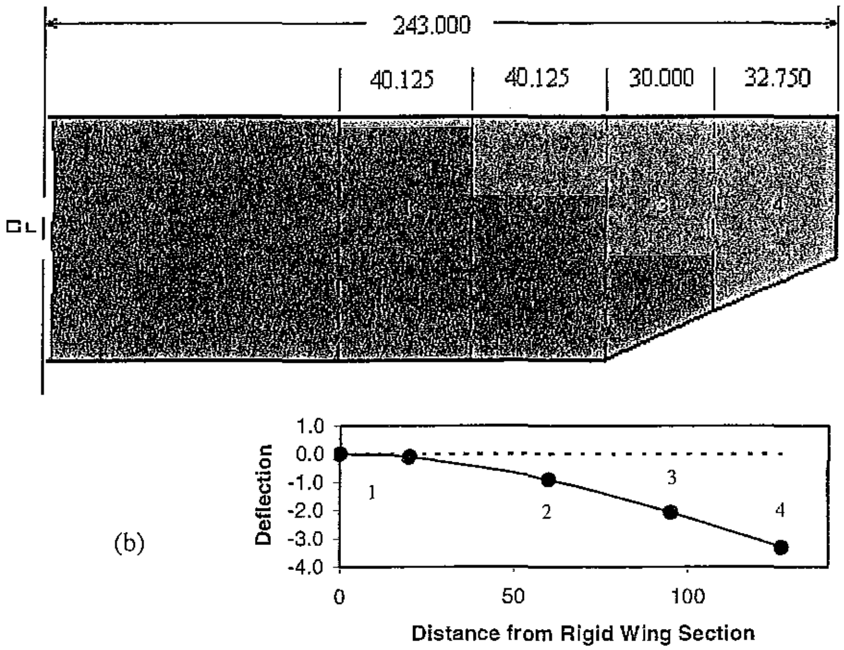


Figure 2.6: (a) Visual of how the main wing was sectioned, and the percent chord used on each section as an effective aileron. (b) Cantilever beam model used to approximate the percent chord modeled as an aileron.

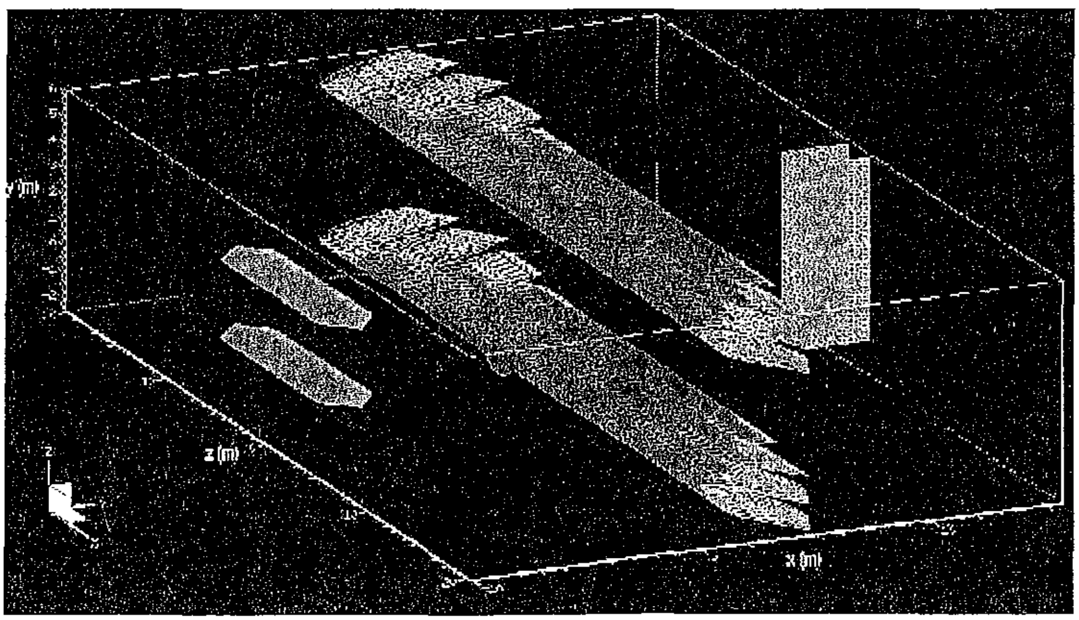


Figure 2.7: Exaggerated wing warping of the WINGS2001 model.

USU Wright Flyer Design

Great thought was given to this aspect of the design mainly because of a paper written by J. D. DeLaurier of the University of Toronto, "The Development of an Efficient Ornithopter Wing." The DeLaurier-proposed ornithopter wing had many similar warping motions and requirements, namely the design required that the skin of a double-surface airfoil remained relatively unwrinkled. To achieve this, a sliding trailing edge was developed for the ornithopter wing.

"The essential feature is that the trailing edge has to be split, thus opening the 'torque box' formed by the airfoil's cross section. Two unidirectional carbon fibre/epoxy strips are glued to the ends of the ribs to form the trailing edge. However, these are not glued to each other. Instead, clips are attached which prevent spreading of the trailing edge while allowing free relative lateral motion between the strips" as seen in Figure 2.8 (DeLaurier 1993).

Final Design

Upon further investigation, the motion of the USU Wright Flyer was considered small when compared to the ornithopter motion, and the shearflex trailing edge concept was retired. Therefore, a simple, off-the-shelf trailing edge was specified as seen in Figure 2.9.

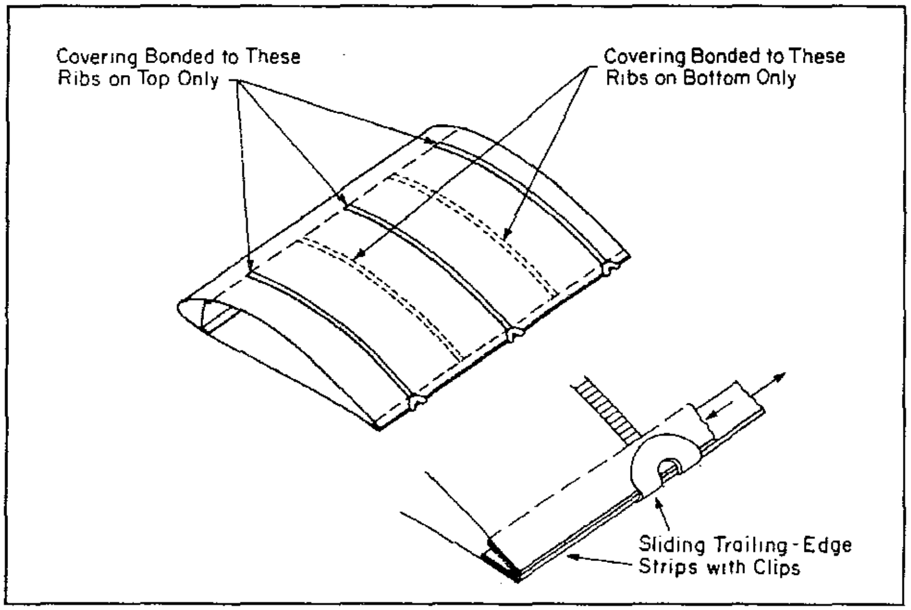


Figure 2.8: Shearflex concept.

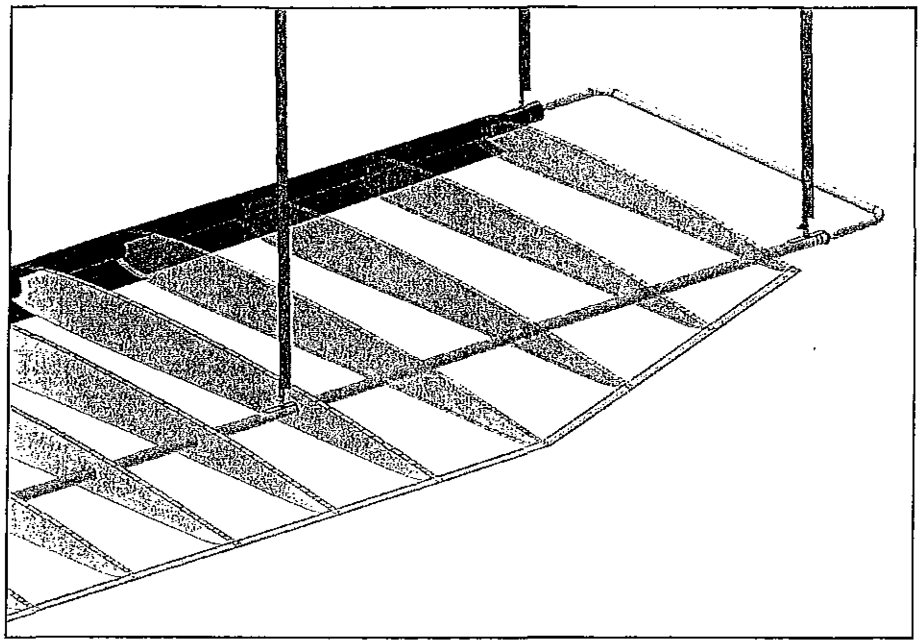


Figure 2.9: Trailing edge detail.

Spar Design

1905 Wright Flyer Design

The 1905 design, as mentioned in the 'Wing Warping' section, consisted of a rectangular arrangement of relatively flimsy spars that depended on cables for stiffness. Wing warping and weight seemed to be the reason behind the idea.

USU Wright Flyer Design

To accommodate the wing warping mechanics, two spars would be required: a main front spar that would carry most of the lifting load and a smaller, flexible back spar that would share some of the lifting load and provide the proper deflection motion for wing warping. Each spar would also require a high enough radial stiffness to bear landing loads at each of the chassis interfaces.

To meet the strength requirement stated above, the combination of the bending stiffness of the front spar, the back spar, and the cables would have to have a deflection of 20 inches while carrying a wingtip load of 60 lbf ($\frac{Weight \cdot LoadPercentage}{4}$). This test simulates a 2.5g load to the aircraft. In order to design to these specifications, several assumptions were made. First, since a canard-configured aircraft will always have some load being carried by the canard, a percentage of the load will be sustained by the canard. Second, the load on the wings will be equally distributed over both wings. Finally, the addition of ribs, skin, and especially cables will carry a substantial percentage of the load. It was decided to model the load percentages as follows:

Front Spar:	30%
Back Spar:	20%
Canard:	15%
Cables/Ribs/Skin:	50%

Front Spar Design

To determine the size and layup to carry the aforementioned load, a simple cantilever model was used (much the same that was used to determine aileron deflection) where the chassis interface location was considered the rigid point of the cantilever (207 inches from the wingtip). The bending load would be placed at the wingtip (see Figure 2.10).

From the chosen wing warping design, the front spar would have to fit the ribs' leading edge of three inches in diameter. It was found that a 3.2-inch diameter tube would only change the leading edge by 0.01 inches. Therefore, a range of values was known for the outer diameter: 3.0 to 3.2 inches in diameter. The outer three ribs' leading edge radii decreased linearly as they were placed further from the center. The front outer spar diameter was reduced to fit this change.

All that was now required to complete the initial design was the inner diameter or thickness of the tube. To find this, the stiffness of the tube would have to be modeled. Composites have been known to have moduli that are difficult to predict. For help with this aspect, a paper written by Chan and Demirhan of The University of Texas at Arlington was consulted. It states that the bending stiffness of composite tube[s] can be obtained by using smeared modulus of the laminate and multiplying the moment of inertia of the tube. The expression is given as:

$$EI = E_x \frac{\pi}{4} \cdot (R_o^4 - R_i^4) \qquad \text{(eq. 2.1)}$$

where E_x is the smeared modulus of the tube laminate and can be obtained by lamination. (Chan, Demirhan 1995) According to one of the composites donators, Bill Pratt of Patterned Composites Inc., the smeared modulus of the contributed material would be 95 to 100 MPa.

Armed with these assumptions and values, calculation was done to find the thickness of the tube to be ten laminate layers (.05 inches) on the inner section of the spar and twelve layers on the outer section of the spar (Appendix C).

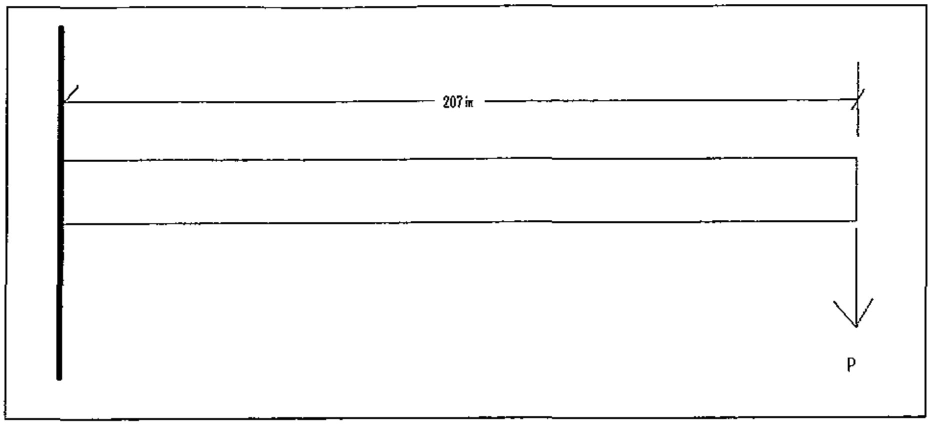


Figure 2.10: Cantilever model used to size front and back spars.

The front spar's layup was done according to the suggestion of Bill Pratt. He suggested that multiples of four were required when using wavy composites to retain even curing properties. Therefore, four wavy layers, two 0° layers, and then another four wavy layers were used for the inner section. This layup takes advantage of the ease of building, beauty, and torsional stiffness of the wavy graphite while retaining the good bending stiffness qualities of the 0° layers. The front outer spar would use a twelve layer wavy design.

Back Spar Design

While the front spar was mainly designed to hold the bending forces of lift, the back spar was made to support lift, propeller forces, and to assist the warping motion. As can be seen in Figure 2.11, the back outer spar is a large, flexible glass tube much like a vaulting pole in order to provide the proper warping mechanics. The larger middle section of the spar was made to be a rigid anchor for the outer spar and a stiff connection for the engine struts.

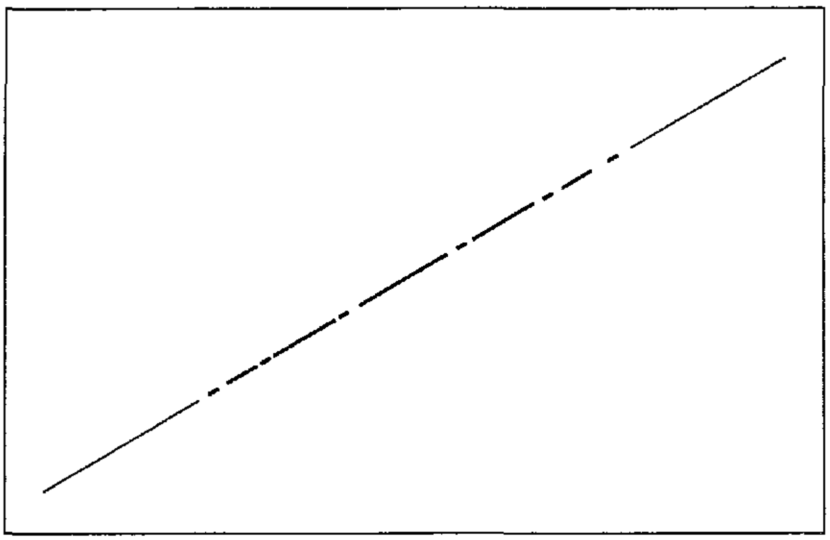


Figure 2.11: Back spar assembly.

Again, the smearing method was used to calculate the proper thickness for the inner and outer tubes. The exact motion that would be caused by forces from lift, control cable, and/or propeller forces is unknown because of coupling effects, but has been accounted for in designs discussed in the 'Interface Design' section.

Thicknesses for the back spar pieces were found to be eight layers of graphite and a lay-up of eight wavy layers would be used (see Appendix C).

Spar to Spar Interfaces

Since the complete spar would be difficult to build as one piece, each spar would have to be made in section and attached together using interfaces. These consisted of shorter, stiffer graphite tubes made to slide into the ends of each spar section and would be filled with foam, wood or any acceptable filler. A filler was used to support the part from crushing since most spar locations have either a chassis interface or a wing strut interface or both.

At the locations where the diameter of the spar is reduced, a different insert would be used. A 'spar cap' was inserted into the end of the larger diameter spar having the smaller diameter spar adhered to the inner part. Consisting of a balsa center and spruce end caps, the spar cap would resist the bending loads of the smaller spar while remaining lightweight (Figure 2.12).

Spar Weight

Fortunately, the required stiffness of the spars resulted in a lightweight tube. The total weight of the front spar would be about 15 pounds (1/3 lb/foot). The total weight of the back spar drops to 12 pounds (1/4 lb/foot). This left 66 pounds for ribs, struts, connections and skin (see Appendix C). The final spar design follows in Figure 2.13.

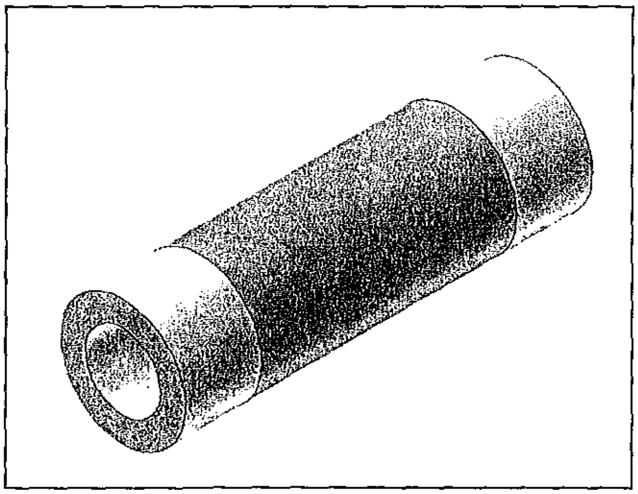


Figure 2.12: Spar cap assembly.

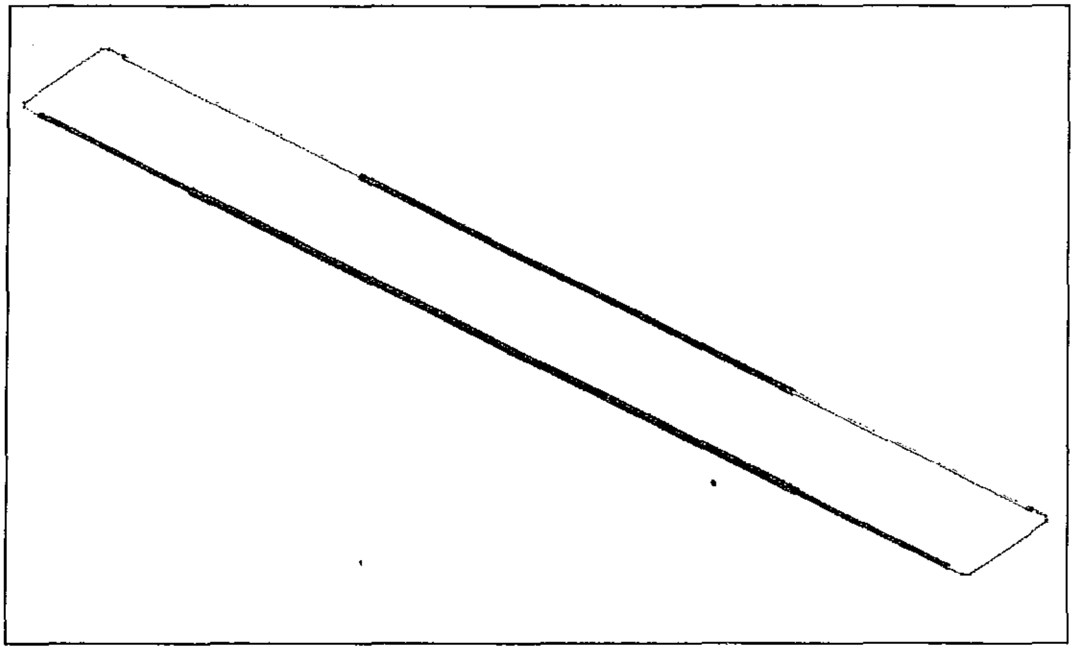


Figure 2.13: Final spar assembly.

Rib Design

The two functions of the USU Wright Flyer ribs were to carry the lifting forces (bending loads) and to constrain the spars in the longitudinal direction (buckling loads). The ribs would form the airfoil shape, and require stiffness in every direction. Also, with over 60 ribs, weight was of great concern.

A number of ribs were manufactured by students of the ITE Department. Each rib consisted of a low-density foam core and a single layer of glass/epoxy adhered to the surfaces of the foam (Figure 2.14). Since the manufacturing method was proven, this general design was chosen for further analysis and modifications.

A simple test was done to determine the bending strength of the ribs (Figure 2.15). Weight was added in a suspended bucket until rib failure. One rib that was recorded to weighed less than 0.5 pounds carried a load of 142 pounds.

The load each rib carried was determined by taking the theoretical lift distribution from *WINGS2001* and finding a polynomial to fit the curve (Figure 2.16). The largest rib load in a 2.5g maneuver was calculated to be 50 lbf, well below the tested 142 lbf. This relatively small value was expected because of the small wing loading.

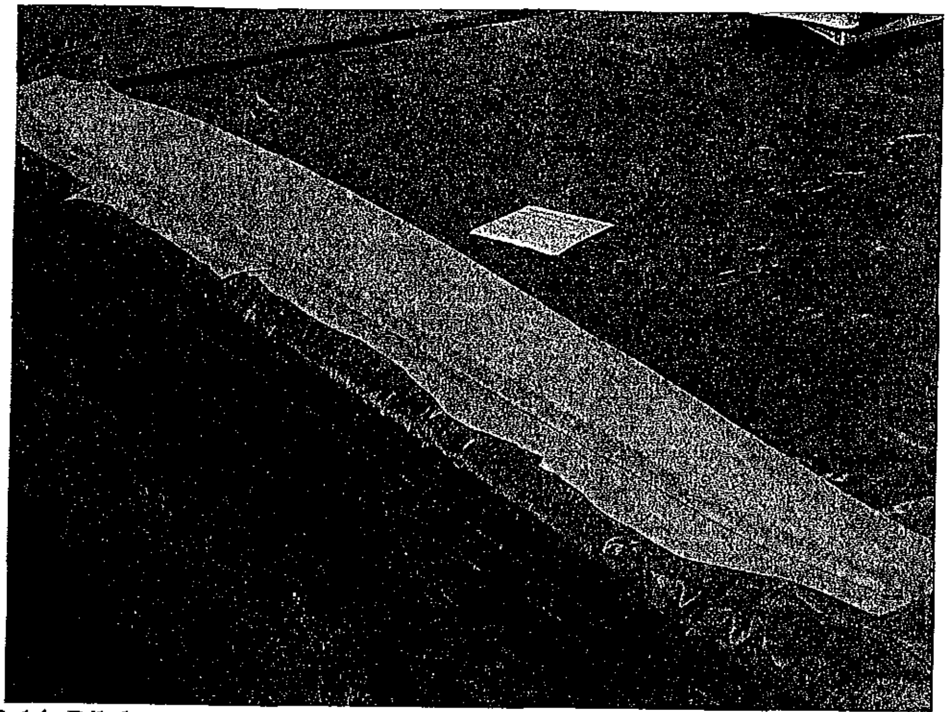


Figure 2.14: Rib layup.

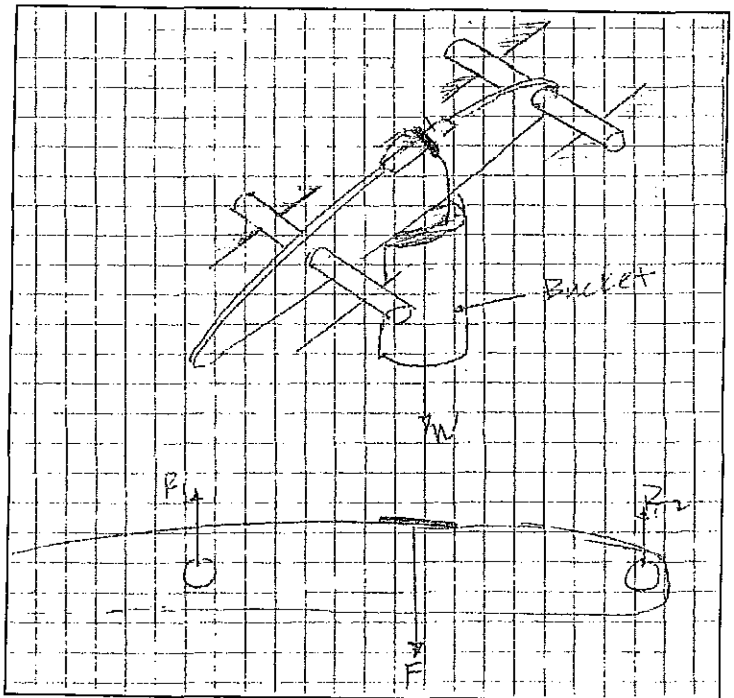


Figure 2.15: Rib testing method

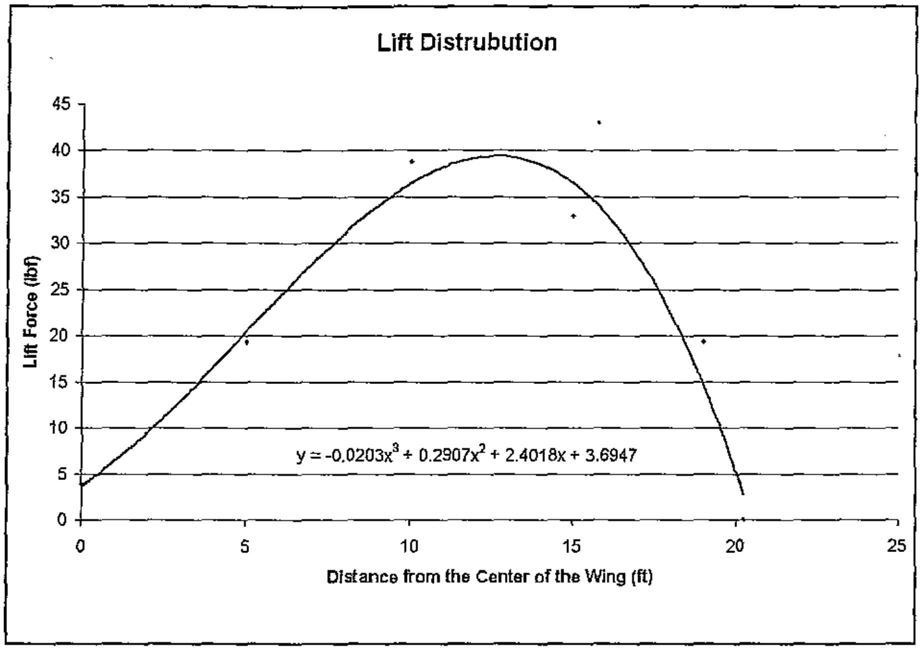


Figure 2.16: Lift distribution of the USU Wright Flyer

This result left room for weight reduction and several more rib designs were tested, such as the "swiss cheese" design seen in Figure 2.17. Before this testing was done, it was decided that manufacturability would be sacrificed if holes were cut in the rib structures. If holes were cut the exposed foam would have to be covered by composite – a painstaking process for 60 ribs. Since this only reduced the weight of the wing by 3 pounds, it was decided to reduce the weight by using less foam and replacing the fiberglass skin with Kevlar.

Wing Strut Design

1905 Wright Flyer Design

The Wright Brothers used spruce sticks to provide a vertical constraint between the wings. Each strut had an eyebolt lashed to the end that was run though a hook fastened to each spar. This prevented the strut from applying any torsional forces to the spars.

USU Wright Flyer Design

Several aspects of the strut design were explored. First, since the strut cross-section with respect to the free-stream velocity was rather large, drag would be a major consideration. Second, a six-foot strut could be rather heavy and weight was an issue. Third, the struts would have to meet requirements for strength and manufacturability. Several ideas were considered.

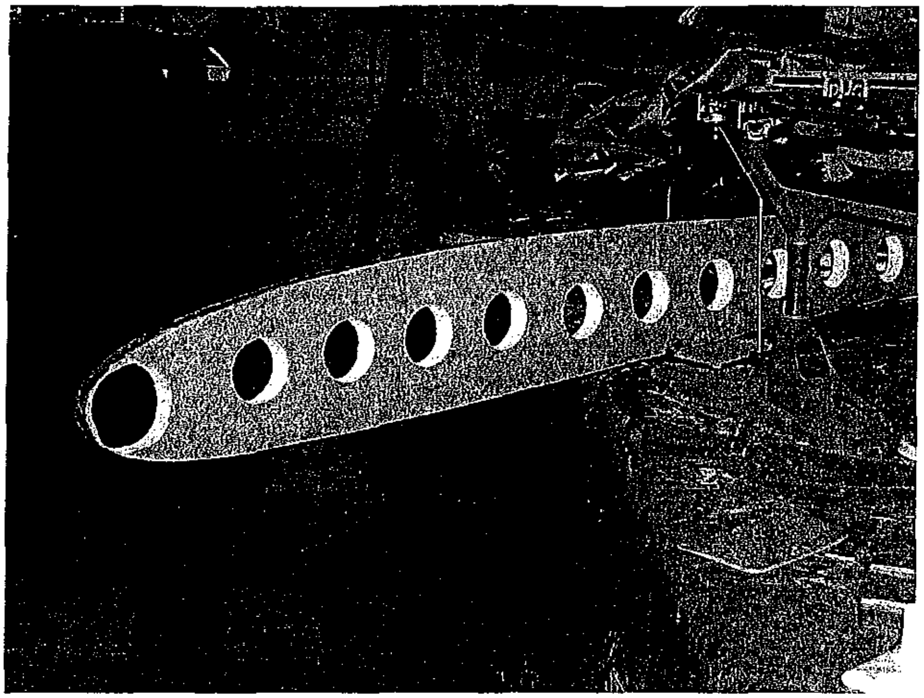


Figure 2.17: "Swiss cheese" rib concept.

Graphite, Cylindrical Tube with Graphite/Nickel Streamlined Fairing

To be consistent with the spar design, a cylindrical tube was initially chosen as the strut structure. The tube and fairing would be made of graphite/epoxy. Simple buckling calculations showed that a ¾-inch tube would be required to hold the loads. A nickel-coated fairing would be wrapped around the strut to reduce drag and provide aesthetics.

Graphite, Airfoil Shaped Tube

The second idea consisted of using an airfoil-shaped bar as a mandrel for the strut. Composite would then be laid around the mandrel and cured. Since the airfoil shape was wider and longer than the diameter of the cylindrical tube, the buckling resistance would be higher and there would be no need for a fairing. The only problem was that the concept was unproven.

With the help and expertise of Professor Charles Larsen, a method was developed to make a streamlined strut (Figure 2.18). This aspect of the USU Wright Flyer is perhaps the most innovative of the entire wing structure. By using this unique building scheme, the struts were created with an airfoil shape made from graphite and epoxy with a nickel surface to create the appearance of wood.

Configuration

The layout of the struts is nearly identical to the 1905 Wright Flyer with one exception: the USU Wright Flyer has added cross struts (see Figure 2.19). By doing this, the stress box was closed where the wings attach to the chassis to provide longitudinal stiffness and help carry the landing and thrust loads.

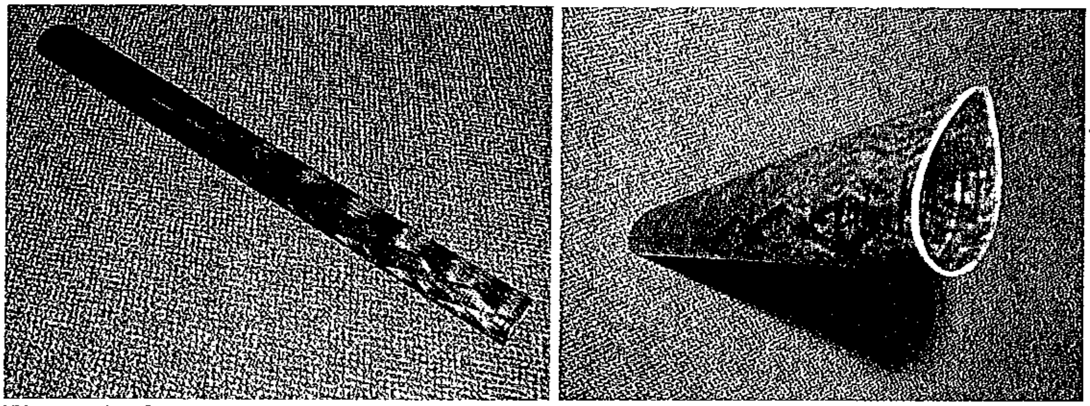


Figure 2.18: Streamlined tube made with wavy graphite.

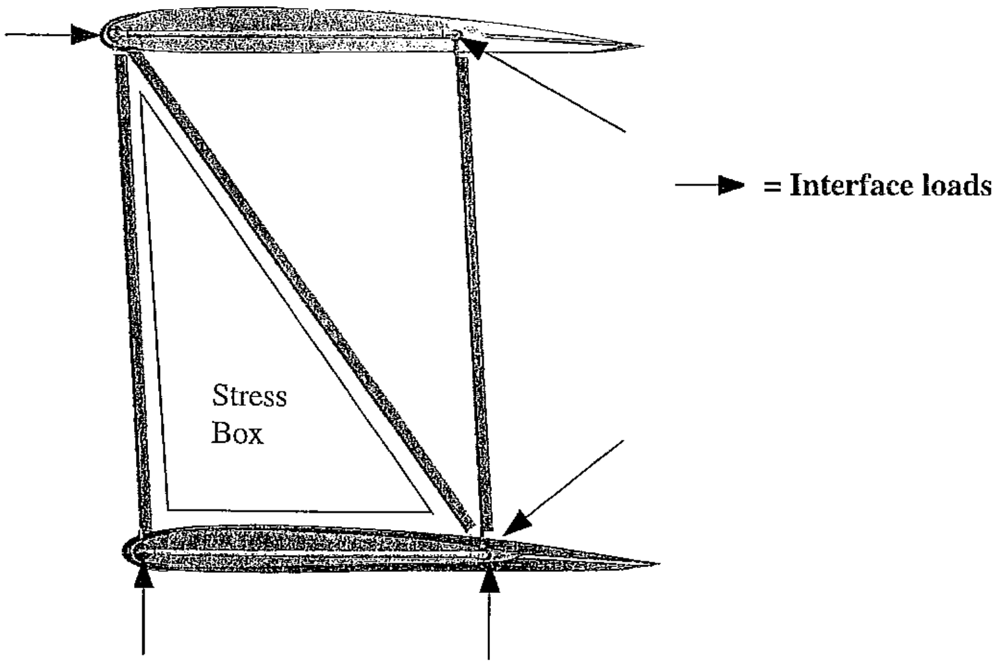


Figure 2.19: Demonstration of the 'stress box'.

Strut Interface Design

With a finalized strut design, the last obstacle was to connect these struts to the spars. Each interface would have to withstand expected loads while not affecting the properties of the spar. Also, since the above mentioned loads were unknown before actual flight-testing, a modular design was developed to meet the requirements if unforeseen problems arose.

The first part of the design was a simple aluminum plate that would be bonded and strapped to the spar with epoxy and graphite strips. The plate could be bonded in any direction on the spar, providing modularity. Also, the effect on the spar properties would be minimal. Second, a simple aluminum tube would be welded onto the center of the plate. The support bar of the strut would then be inserted inside the tube and affixed to the strut by an epoxy/cotton filler (see Figure 2.20).

Weldament strength was a concern and strength calculations were done to determine that a 0.20x0.20 weld bead would provide strength to withstand the expected bending load of 421 pounds. Where needed, universal joints (Figure 2.21) were used instead of the inserted bar to protect the structure from repeating loading. These joints were constrained in twisting and axial directions, and still allow bending.

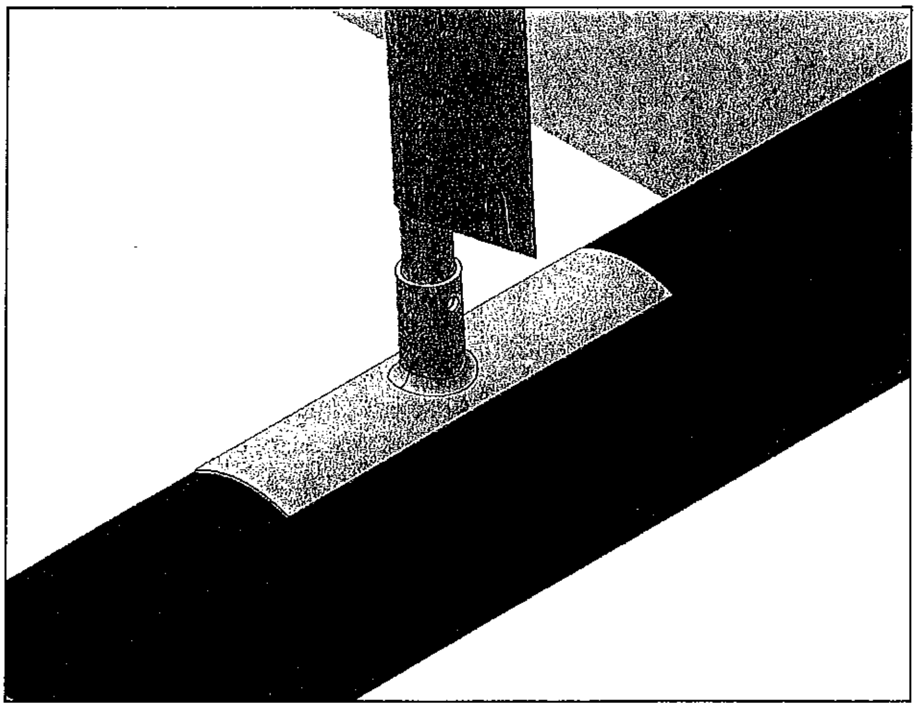


Figure 2.20: USU Wright Flyer interface assembly.

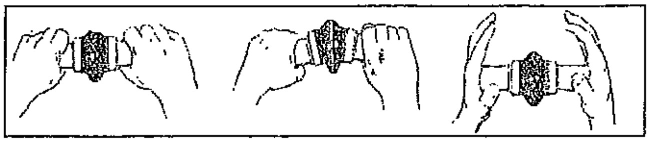


Figure 2.21: A universal joint in twisting, bending, and compression.

Cable Design

1905 Wright Flyer Design

The majority of the 1905 Wright Flyer wing stiffness was provided by a large matrix of cables. These cables were required because of the inherent flaws of the aircraft configuration such as large wings, no fuselage, and flimsy wing spars.

USU Wright Flyer Design

Structural Cabling

For aesthetic purposes, the inherent problems mentioned above were slightly improved but not avoided. Therefore cables were needed to add stiffness to the USU Wright Flyer wing box. The wing spars would be much stiffer than their 1905 predecessors, and the exact stiffness of the entire wing structure would be very difficult to analytically determine. It was determined to make a modular interface design that would allow different cable configurations.

Simple cable plates were designed to fit the bar of the strut interface (Figure 2.22), which could easily be added or removed to any strut interface. The one-pronged cable plate would accommodate a strut interface with only one cable connection while the two-pronged cable plate could fit two connections. It was estimated that the largest load to be carried by the structural cables would be 412 pounds and a 1/16-inch cable (break strength of 460 pounds) was specified.

Control Cabling

To provide routing for the cable design shown in Figure 2.23, another modular pulley idea was used (Figure 2.24). The pulley assembly was also attached to the strut interfaces via cable plates. The cable plates were then bent to the proper angles to prevent cable derailment. Standard 1/8-inch control cable was used on all control routing.

Conclusion

As was shown in the previous sections, many concepts of the USU Wright Flyer mimic the Wright Brothers' original wing design while accommodating the needs of the USU Wright Flyer. By doing this, the design remains true to the Wright Brothers' legacy while creating a safer platform.

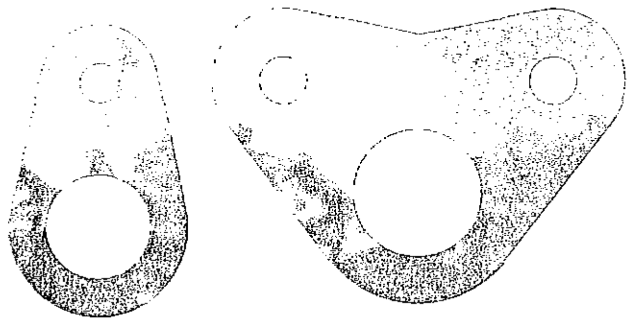


Figure 2.22: USU Wright Flyer cable plates (one and two-pronged).

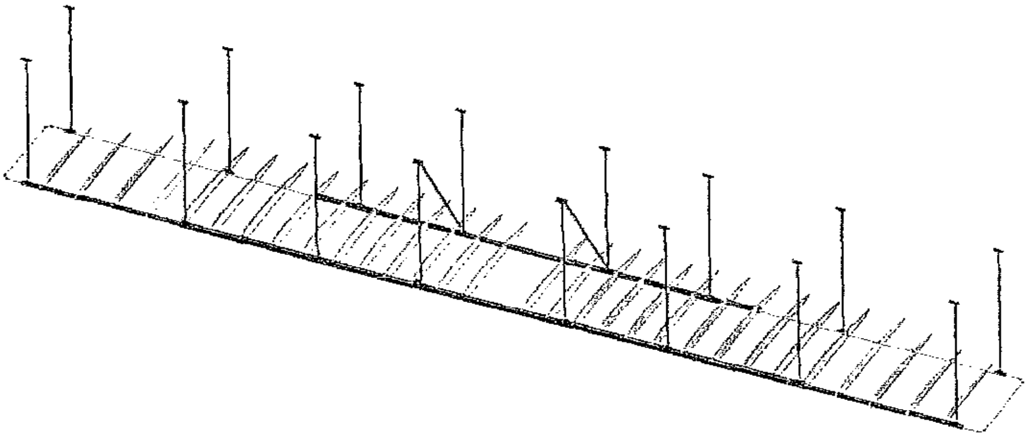


Figure 2.23: Control cable routing design.

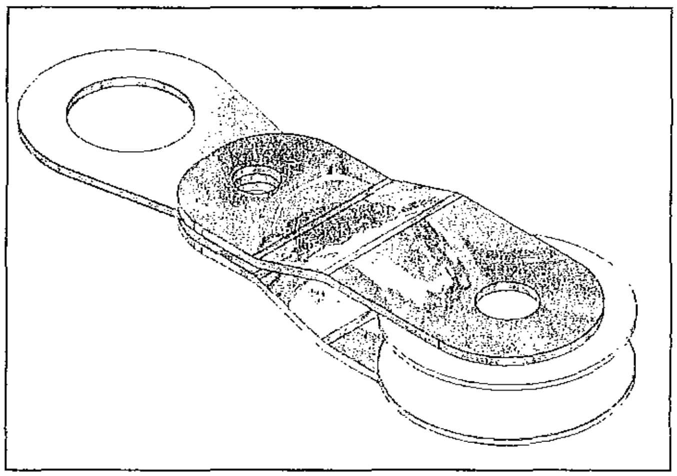
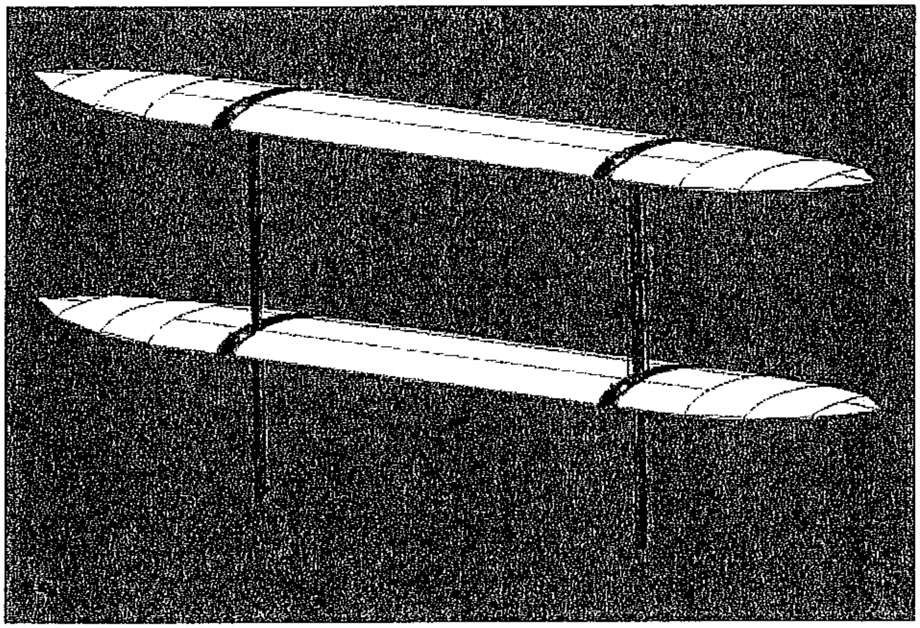


Figure 2.24: USU Wright Flyer pulley assembly.

CANARD DESIGN



Introduction

The main objective of the USU Wright Flyer canard redesign was to make a strong, simple bi-wing canard, which looked like the 1905 Wright Flyer canard. A canard is the vertical elevator for the aircraft. The dominating problem was the design had to be flexible to accept aerodynamic design modifications and constraints which were undetermined at the beginning stages of the design. Also new material types were to be used and it was important to understand the different characteristics of innovative composite materials.

Concept

When designing a component of an aircraft such as the canard, it is critical to understand the loads and moments that it will experience during normal use and the maximum loads encountered. The initial estimation of the loads in flight was estimated as half the weight of the plane plus a safety factor of two. Resulting in a maximum load of 500 pounds, this was used to calculate stresses. In actuality, the final aerodynamic analysis predicts a trimmed flight load of 183.1 lbs and a 2.5G loading of 457.75 lbs. The 500-pound estimation was an adequate loading in comparison to the predicted values.

Preliminary Design

To allow the airfoil shape, size and location to be variable until aerodynamic analysis was complete meant the structure had to be able to accept a wide variety of constraints and dimensions such as chord length and thickness. A preliminary design package was created and presented to the customer, which incorporated the variability of the structural components and placement.

The initial design for the aerodynamics was finished on November 20 establishing specific parameters such as the chord length, mounting angle, span and distance from the leading edge of the wing. These numbers were later finalized on January 10 and all subsequent drawings that used preliminary design numbers were modified but the basic design did not change.

The 1905 Wright Flyer canard pivoted about the half-chord, which allowed for the varying camber as the angle of attack increased (see Figure 3.1). Canard design constraints were no ailerons, no airfoil deformation during changes in angle of attack, and pivoting about the quarter chord. Pivoting about the quarter chord allows the hinge pins to take most of the load. This minimizes the pitching moments or control forces, and reduces the input force required from the pilot.

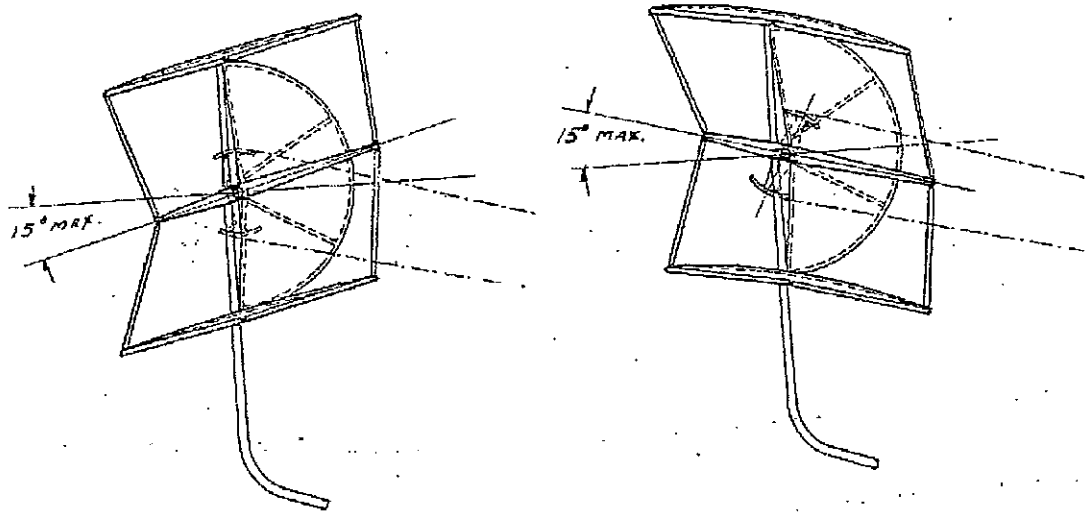


Figure 3.1: Original canard changing airfoil shape as angle of attack varies.

Airfoil

The airfoil shape changed drastically as shown by Figure 3.2. The drawing package needed the correct airfoil shape for the construction of the foam core. To determine the dimensions of various components, an X-Y data point file for the airfoil was plotted in *AutoCAD 2000* and then imported into *Inventor*. The airfoil shape was extruded as the basis for all subsequent parts.

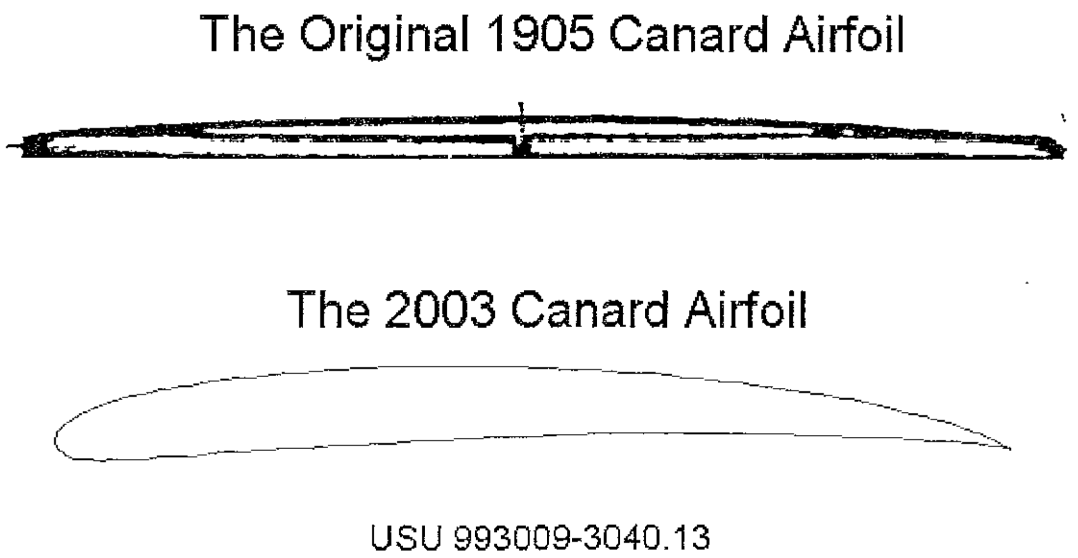


Figure 3.2: A comparison of the original canard airfoil versus the 2003 design.

Hinges

Vital structural components of the canard are the hinges, ensuring that both lifting surfaces rotate at the same angle. The shear loads on the hinge pins are small: 125 lbf (500 lbf being divided among the 4 hinges). The main spar was initially along the quarter chord for strength, but was moved forward properly locating the hinge pins. The main spar and hard plates are important mounting points; a collar and two plates were logical ways to mount to these components. A round collar was initially used to mount on a round support strut. The strut was changed to an airfoil cross-section to reduce drag. This required the collar to be changed to a plate that welded onto the strut. The new hinge assembly is shown in Figure 3.3.

Control linkages

Control linkages start with cables coming from the cockpit, running along the left skid from the control stick to a bell crank. The bell crank connects the cables to push-pull rods that connect to the hinge assembly. Hinges are coupled and are attached to the hard plates on one side of the strut supports. The hard plates and hinge assembly transfer the torque from the controls throughout the foam. The first idea was to form hard plastic to make these hard plates. A more suitable solution, considering cost and ease of manufacturability, was to bolt the hinge to half-inch plywood.

For the final selection, a bell crank was mounted on the support struts in between the two lifting surfaces of the canard to control angle of attack. Running parallel to the chassis struts, the control cables from the cockpit attach to the bell crank at a variable distance from the pivot point. This adjustability of control wires allows the pilot to set a desired deflection rate and stick force (see Figure 3.4).

Also seen in the figure are the push-pull rods attached to the bell crank, which connect to the hinge assemblies mounted in the lifting surfaces of the canard. A symmetric four-bar linkage was designed such that the angle of attack of each lifting surface was identical.

Structure:

The objective in the overall structure was to keep it as strong and as light as possible, while retaining a safety factor. The notion of designing a carbon fiber-truss-airfoil-shaped structure as rib supports with varying pressure loads was possible but unnecessary. The most feasible and modular design, from a manufacturing standpoint, was to use a solid foam core. Dave Widauf, an expert in composite fabrication, suggested several options that were available for construction. He mentioned several hybrid methods not generally found in engineering textbooks such as plastic or foam cores with fiberglass skins, D-tube spar and graphite shell, or shaped honeycomb with graphite layers similar to that used in F-16 fighter planes. A foam core rib reinforced with fiberglass skin was chosen for manufacturability, which includes the low cost of materials, little training needed for technicians, and no need for special equipment.

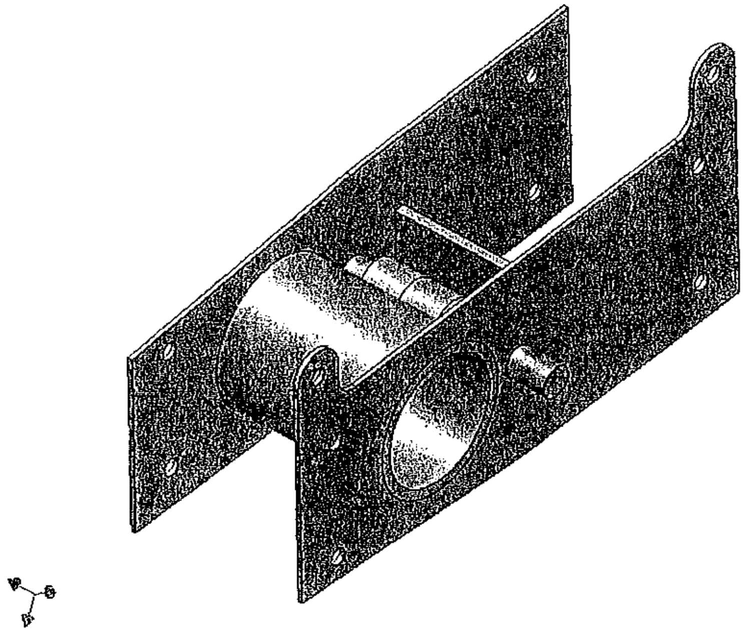


Figure 3.3: Final lower hinge assembly showing hinge pin.

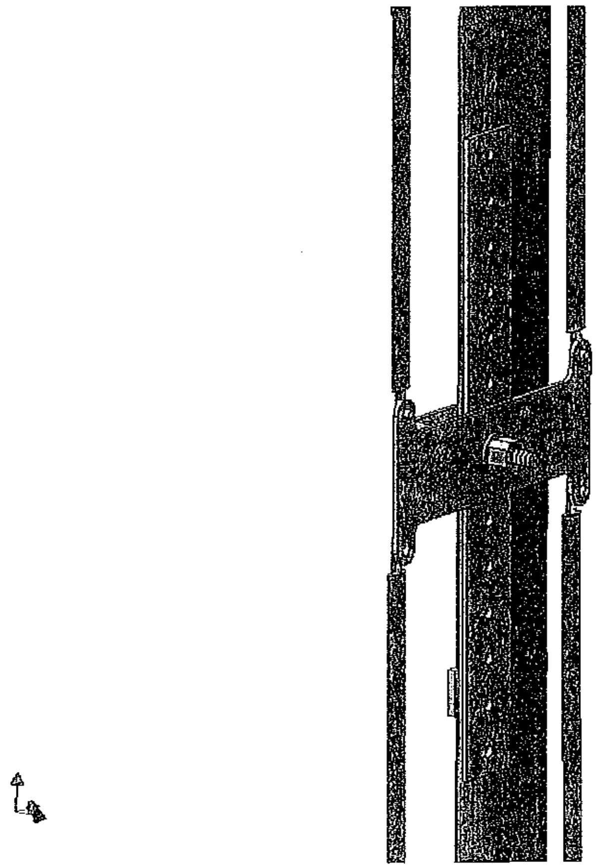


Figure 3.4: Canard bell crank mounted to support strut.

Testing and Mockups

A full size mock up of one of the canard wings was built and assembled. An excellent job of covering the foam core with a graphite skin was done. Figure 3.5 gives a reference for how large the canard lifting surfaces are.

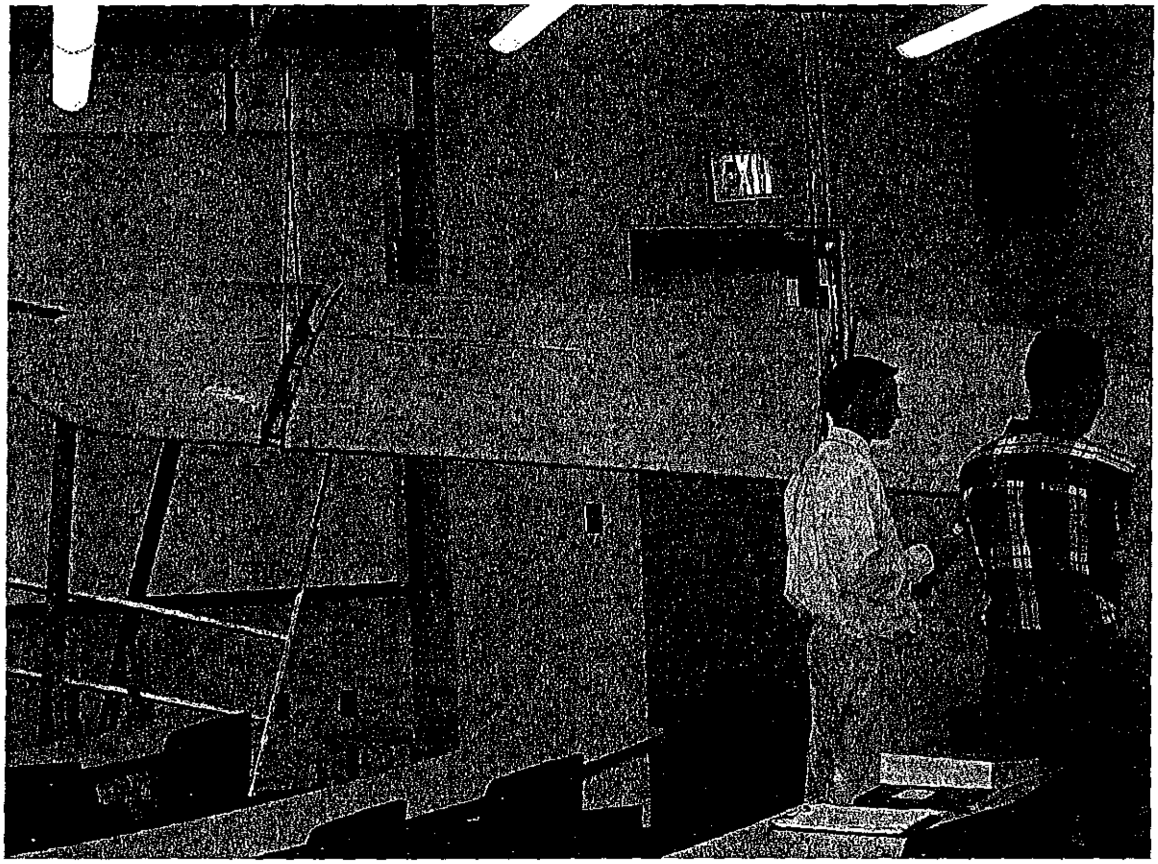


Figure 3.5: Nate standing in front of the canard wing.

Final Design

Due to a sound preliminary design, the final design did not vary much from the initial ideas. Some materials and dimensions were modified, but most modifications were putting details into the assembly. To match the aesthetics of the original planform view of the canard, the wing tips had to be made in several pieces as shown in Figure 3.5. Each section has a different chord length of the same USU airfoil shape with a scaled down thickness and width. A template of the cross-sections for each piece had to be made so the foam cores could be hot-wired out. Each section is glued to the next and sanded for a smooth finish before being coated with a layer of fiberglass.

The location of the center of gravity, an important design constraint, needed to be moved forward. Weight was added to the canard to ballast the aircraft. As a result, steel was used for many components instead of hanging odd-looking items from the canard. The main spar is made of large steel tubing. The rear spar size and position were chosen such that the sum of the moments about the 1/4 chord was zero. With the added weight, the center of gravity was moved to the correct location, meeting the aerodynamic requirements of the aircraft.

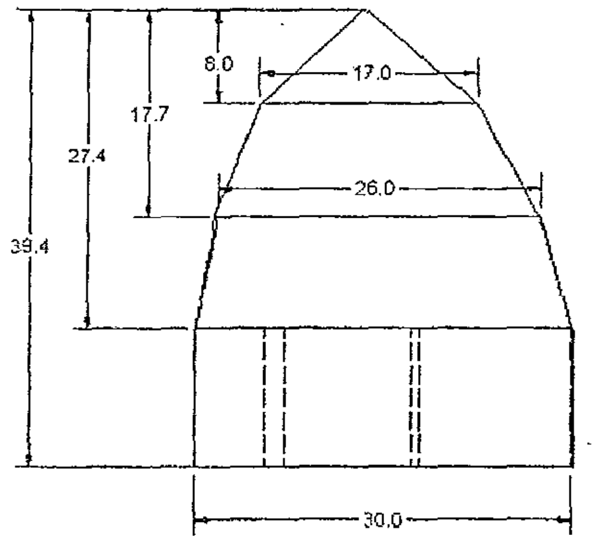
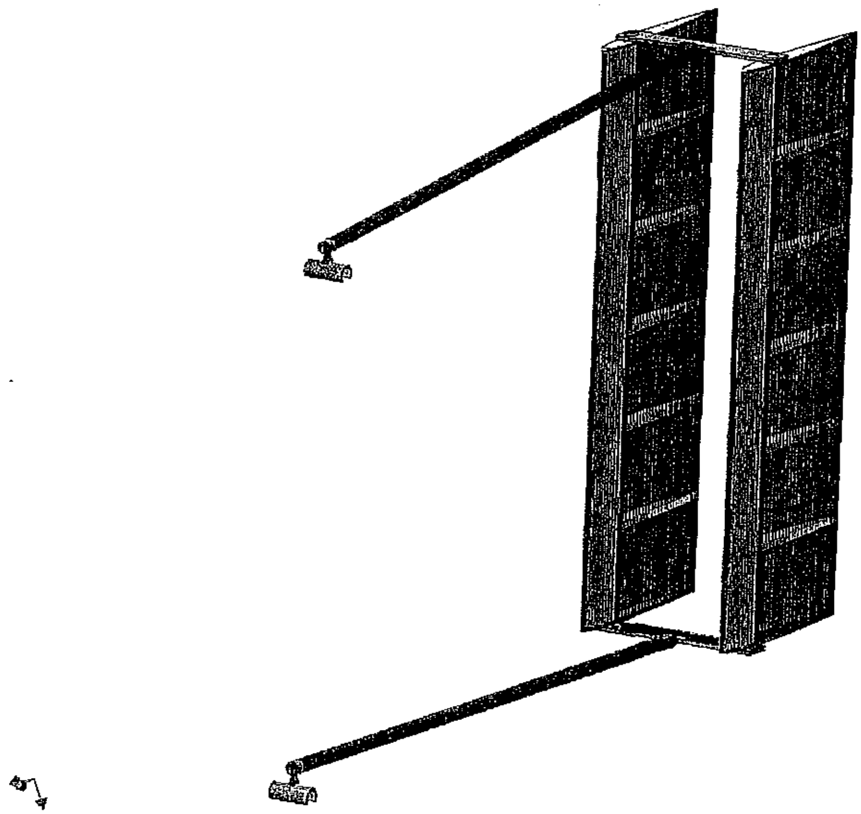


Figure 3.5: Diagram of the different foam sections of the canard end caps.

Rudder Design



Preliminary Design

The design constraints for the rudder were to reduce weight and drag. The requirement of minimal drag set the rudder airfoil shape as a thin airfoil. The lifting surface needed to be symmetric with the objective that the lift coefficient must remain equivalent as angle of attack varied from one direction to the other. The NACA 0009 was selected, being symmetric and having a maximum thickness that is 9% of the chord length. From *WINGS2001* the maximum lifting coefficient was found to be at $\alpha = 8°$ and the maximum force for this angle of attack was found to be 130 lbs. Initial designs were established using this number as the preliminary maximum force on each panel.

The early design was composed of a simple foam core covered with one or two layers of fiberglass and resin depending on the strength test performed. The chord length, spar length, and the distance between centers were kept at the same dimensions as the 1905 Wright Flyer to retain aesthetics. The two rudder panels would no longer be joined as a rigid box pivoting about a center point, but rather rotate parallel to each other about the quarter chord (see Figure 4.1). There are many advantages of changing this design including minimizing the effects of downwash from one panel to the other, and having the center of pressure acting along the pivot points.

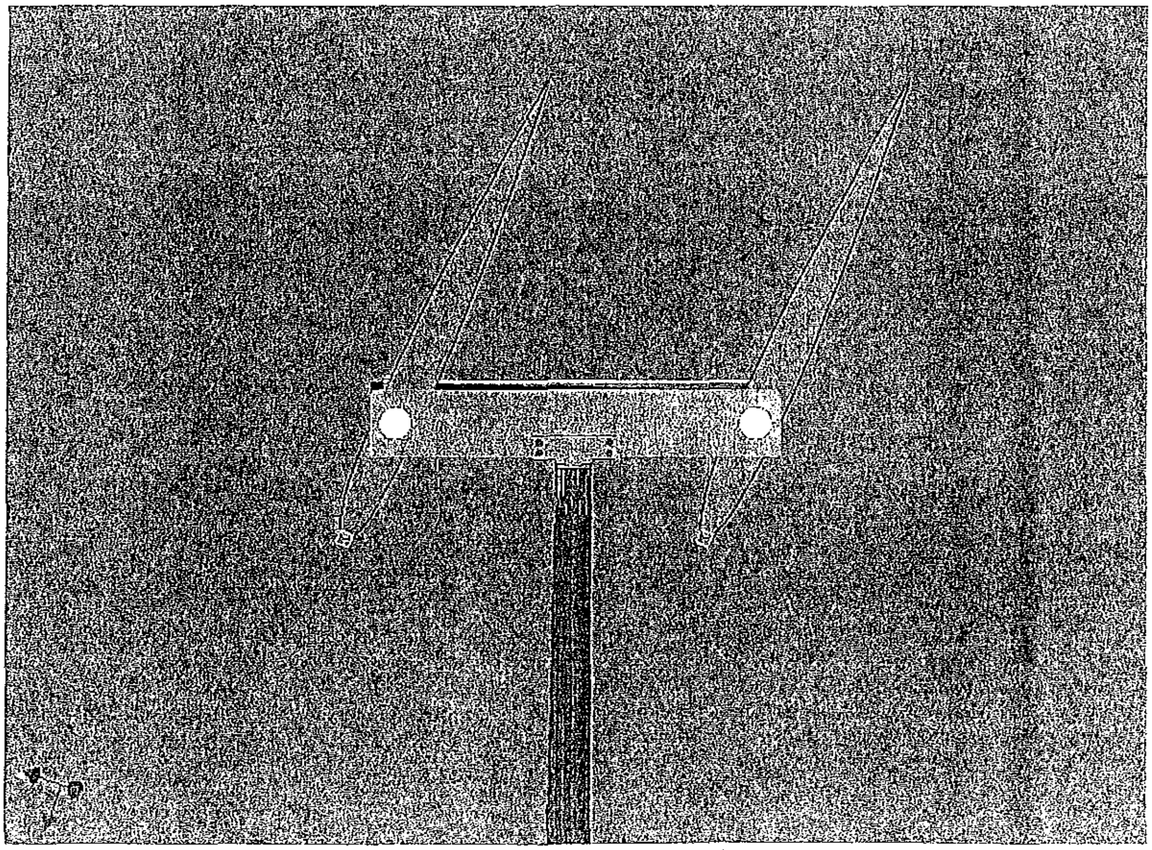


Figure 4.1: Top view of rudder pivoting at quarter chord.

The top and bottom cross plates connecting the two rudder panels could be made light and extremely strong by using a honeycomb core with several layers of carbon fiber lamina on the outside. Hard points inserted inside the honeycomb were needed to take the compressive loads caused by mounting the attach fittings to the plates. Bearings also had to be mounted inside the honeycomb to provide pivot points for the rudder panels.

The rudder initially was to attach by an aluminum channel that bolts to the rudder plates (see Figure 4.2) and glues to the main wing ribs. Standard dimensions for aluminum channel stock set the thickness of the plates and special wing ribs. Round aluminum inserts to fit in the carbon fiber tubes had to be tapered, such that the fittings would not cause stress risers at the uneven point of contact when in bending. The round inserts and aluminum channel were designed to weld together. Special care was given to the top attachments that must be welded on a slight angle of 6.6° in order to match the geometry of the original Wright Flyer.

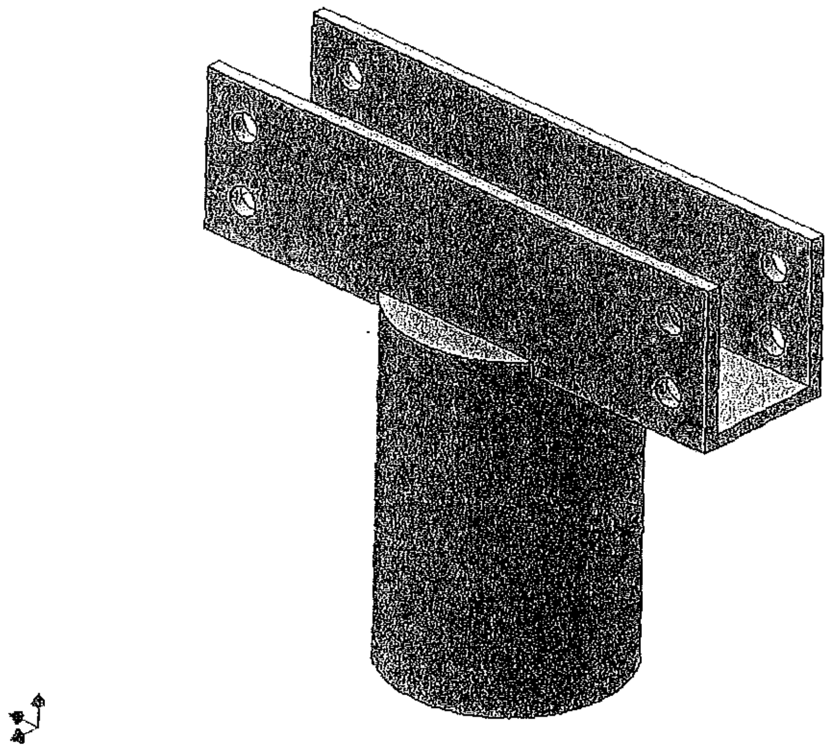


Figure 4.2: Rudder attachments that bolt to the cross plates.

Testing and Mockups

Before any testing or building of prototypes, it was decided that a solid foam core added too much weight to the rear of the aircraft, and that a rib design would be lighter. A test mockup of the rib design is still being built. Due to fabrication length constraints the C-beam and leading edge are both constructed in two sections and later glued together as shown in Figures 4.3 and 4.4. Extensive testing will be done to ensure the two sections are properly bonded together.

A working prototype of a rudder panel was fabricated. End caps were changed from half-inch plywood to half-inch honeycomb with aluminum skin, which greatly reduced the weight. It was found that the Kevlar reinforced foam leading edge could be manufactured to be a full pound lighter than predicted. The rudder panel shown in Figure 4.5 weighed 3.5 lbs.

Figure 4.3: Rudder D-tube fabricated from more than one piece of foam.

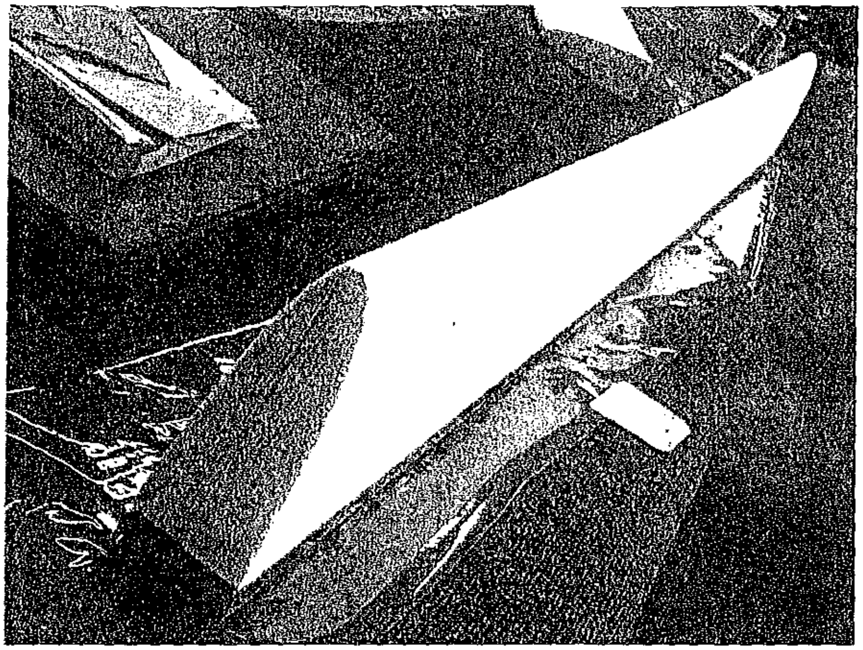


Figure 4.4: C-beam and foam leading edge being glued together using epoxy-resin mix.

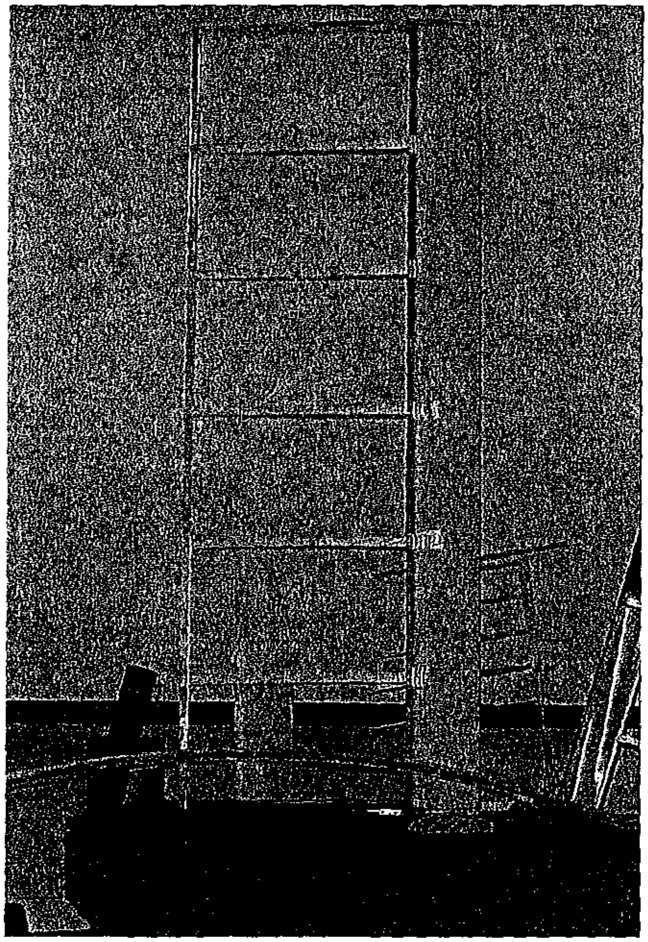


Figure 4.5: Prototype of one rudder panel that measures 81 inches in length and weighs 3.5 pounds.

Selection

Initially a large safety factor was invoked and later reduced considerably as the weight in the rear of the aircraft became the primary concern in attempting to move the center of gravity of the aircraft to a foot in front of the leading edge of the wing. Many parts were reduced in size making them lighter and weaker.

To reduce drag, support cables were initially removed from the design. The proper tube strength to hold the rudder rigid was derived such that the aero-elastic deflection was less than 4°. Sufficiently strong tubes were calculated to weigh 6 pounds at length of 9.5 ft. As prescribed by weight restrictions, this design was replaced by the use of support cables capable of withstanding the lateral forces created at maximum deflection. The support tubes are also only required to resist compressive loads, thus greatly reducing their size and weight. Included in the design selection was the shortening of the tube lengths from 9.5ft to 8 feet to aesthetically match the changes done to distance the canard is from the wing. With the thinning and the shortening of the support tubes, each tubes final predicted weight is now 1.66 lbs. A symmetric, seven layer stacking sequence of [0/±20/0/±20/0] was used in the calculation of loads with the primary concern of buckling. Later it was changed to a wavy composite.

Elaborate attach fittings that earlier served as cantilever beam-ends were reduced in size because there was no longer a need to withstand bending moment. The aluminum inserts, which were tapered to prevent a stress riser, were changed to thin steel tubing. The tubes bond to the inside of the support beams require holes to increasing the mechanical bond strength. Slits are milled in the side to allow attach plates to be welded in the tubing, see Figure 4.6. Where the support tubes attach on the wing spar, a single tab is welded to a collar that is glued and lashed to the spar. This provides ample strength and rigidity for mounting (see Figure 4.7).

Final Design

The final design consisted of a C-beam channel spar along the quarter chord that allowed one inch notched ribs to be glued to the inside of it. The ribs were made of foam covered in fiberglass or Kevlar to make them as light as possible. The C-beam consisted of two layers of bi-directional weave carbon fiber laid up inside two pieces of aluminum channel and pressed together during the curing process. The rudder endplates are made from half-inch aluminum covered honeycomb, and the pivot inserts were changed to lightweight Delrin plastic. The trailing edge could be purchased from the Spruce Aircraft catalog. Other components remain the same (see Figure 4.8).

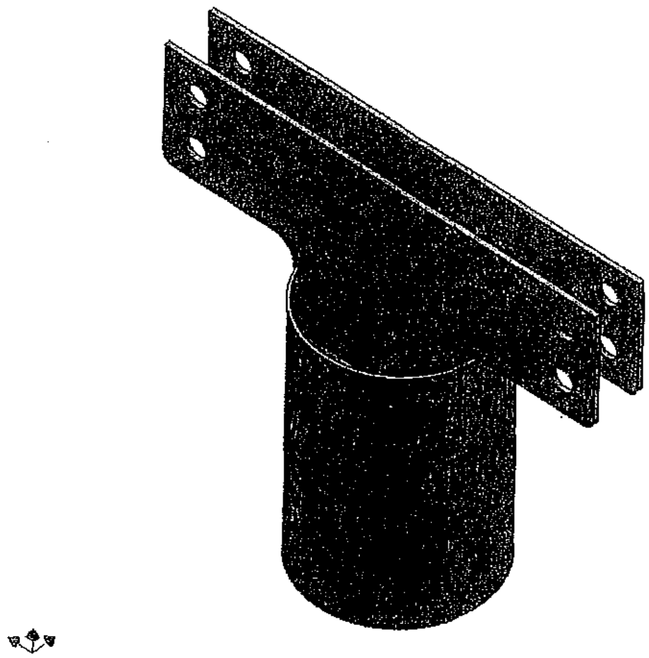


Figure 4.6: Attach fittings that bolt to the rudder cross plates.

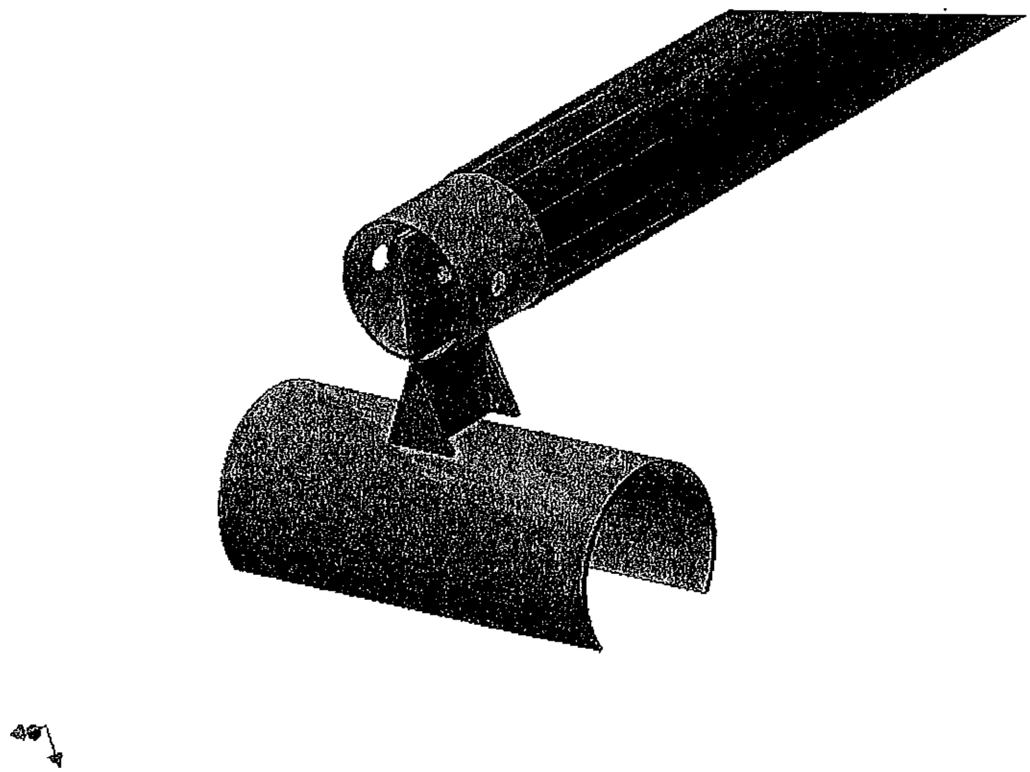


Figure 4.7: Attach fittings that mount to the rear wing spar.

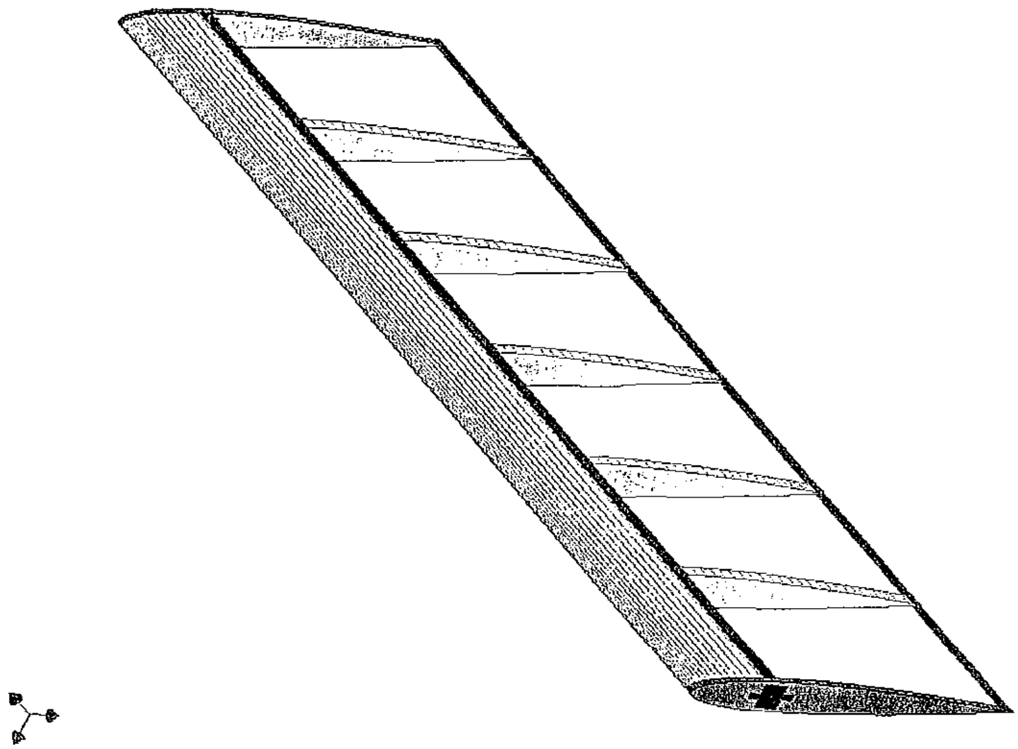
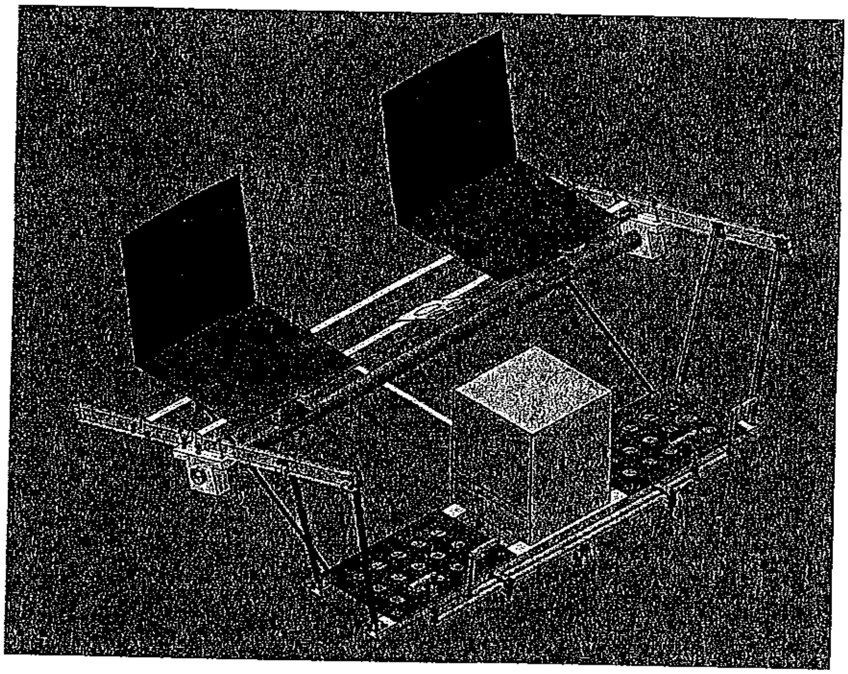


Figure 4.8: Final rudder panel assembly.

Cockpit Design



Introduction

To fly the 1905 Wright Flyer, the pilot lay prone with his head forward as shown in Figure 5.1, his left hand operating the elevator control, and his right hand operating the rudder control. Lateral control was achieved by warping the wing tips in opposite directions via wires attached to a hip cradle mounted on the lower wing. The pilot shifted his hips from side to side to operate the mechanism (Smithsonian 2002). In 1907, the Wright brothers hastily adapted their 1905 Flyer with two seats and a more powerful engine as shown in Figure 5.2, as per request of the U.S. Army and the French.

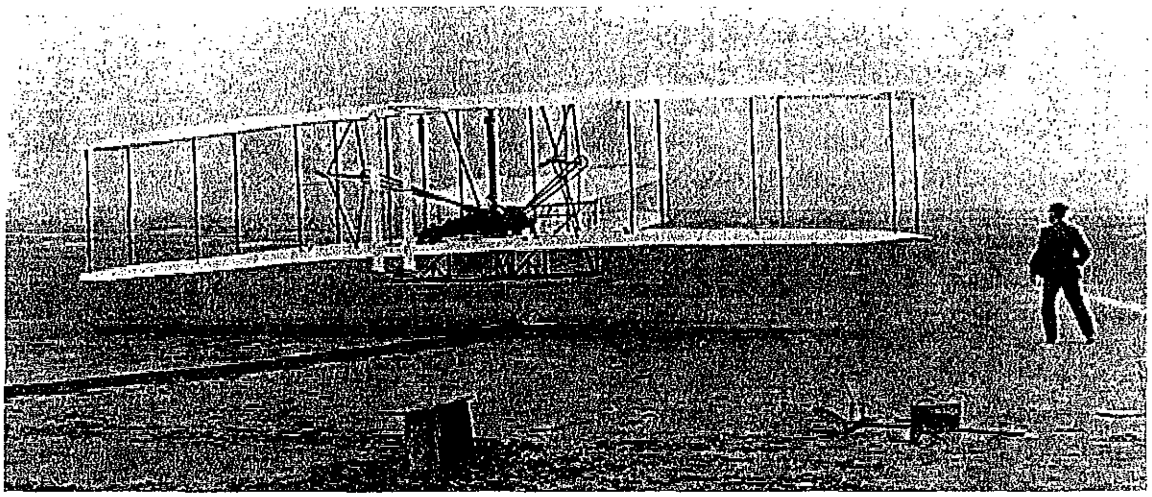


Figure 5.1: 1903, Orville Wright flying prone.

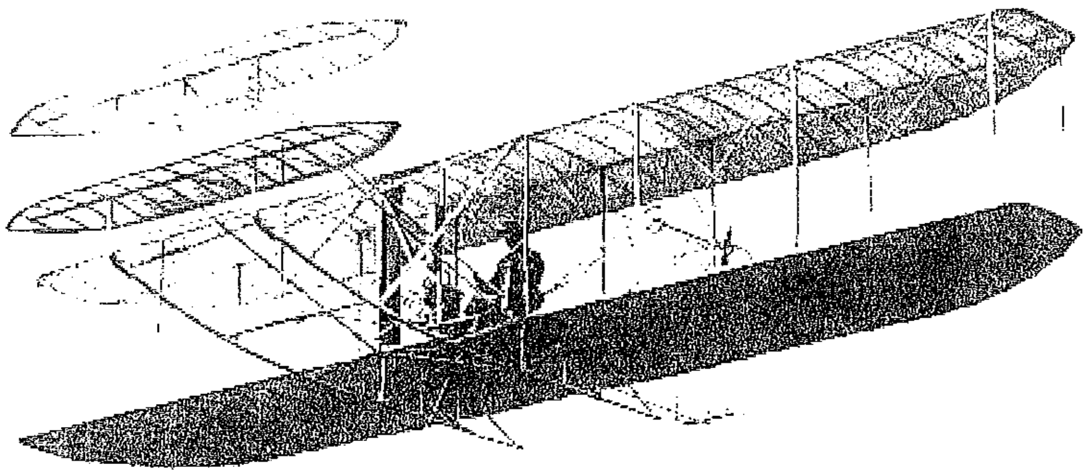


Figure 5.1: 1907, Orville Wright flying upright.

Concept

The USU Wright Flyer was in need of a cockpit design, since the 1905 edition did not incorporate a literal cockpit. The customers set up guidelines for a cockpit design. The specified guidelines to design towards included:

1. Consider pilot ergonomics
2. Implement modern control mechanisms
3. Incorporate flight instrumentation
4. Modular mounting
5. Simple maintenance
6. Accommodate two people
7. Maintain overall aesthetics

The cockpit integration into the flyer needed to be accomplished without distracting from the original aesthetics of the 1905 Flyer. Early aerodynamic analysis illustrated a prone pilot impractical for the stability of the flyer. The seats needed to be placed on the center of gravity. This allows the location of the CG to remain unchanged even with weight differences in passengers.

Preliminary Design

To begin the cockpit design initial decisions were made to direct the design of the project. One decision was an open cockpit. Another was to use mechanical control mechanisms as opposed to radio signals or electrically driven controls. These decisions were the dominating factors in the design of the cockpit.

Cockpit Frame

The frame was the first component of the cockpit to be designed. The frame was first intended for an average man of about 6'0" in height. The layout and position of the pilot was similar to a small one-seat aircraft. Initially the frame was to be manufactured from carbon fiber tubing, but the resultant frame looked like a PVC structure (as shown in Figures 5.3 and 5.4.)

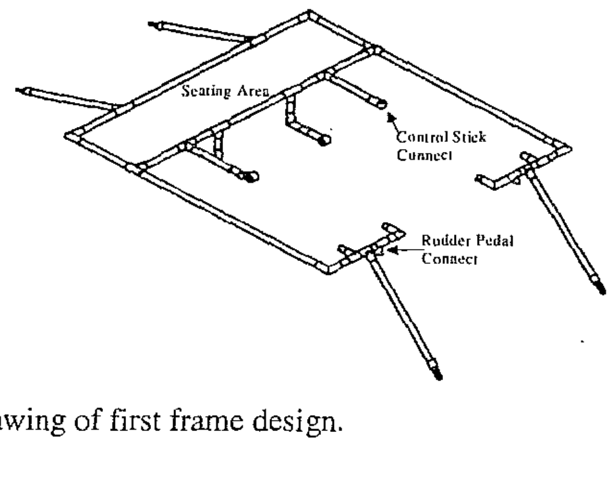


Figure 5.2: Line drawing of first frame design.

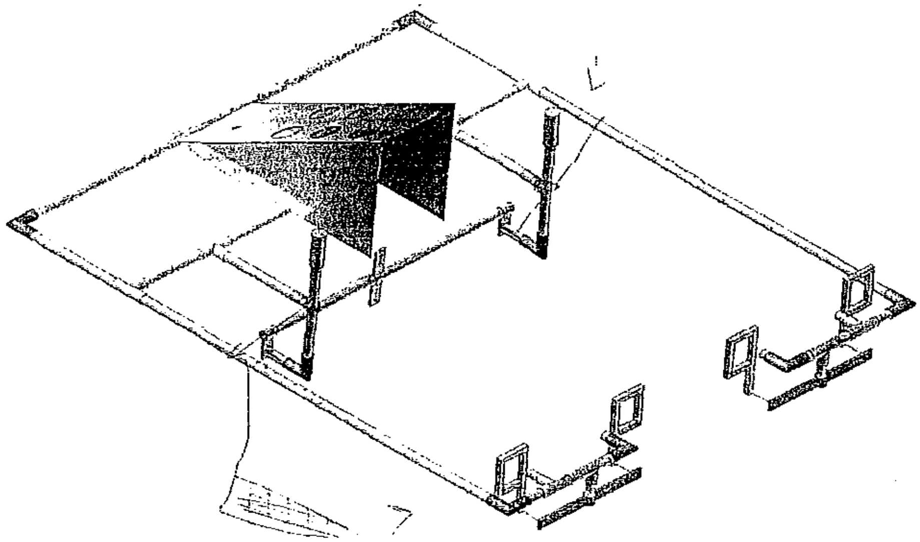


Figure 5.3: First frame design including control mechanisms.

Considering ergonomic issues, the arrangement of the pilot was changed to a more comfortable sitting position, as shown in Figure 5.5. The position change allows for a more pleasant flight for extended periods. In addition, it creates a place for the passenger to place his/her feet so interference with the rudder pedals does not occur.

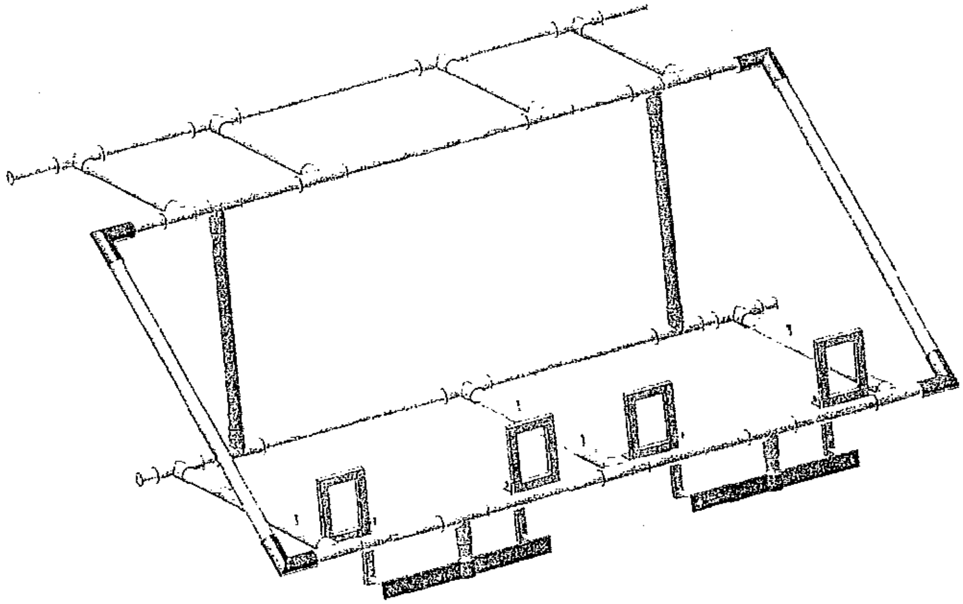


Figure 5.4: Cockpit frame with modified sitting position.

The next major design modification was the frame material. Aesthetically the frame looked like it was constructed out of PVC pipe. Structurally the cockpit would be subject to tensile, compressive, and bending stresses. Carbon Fiber exhibits high tensile strength, however the bending strength of tubular composites is very difficult to predict and model. In consideration of the manufacturability of the structure, the material type of the frame was changed to aluminum (6061) tubing stock, and high strength steel (AISI 4130), as shown in Figure 5.6. Changing the frame to isotropic, readily available materials, allowed for simpler design calculations and considerable simplification of the manufacturing plan.

Considering the stability of the USU Wright Flyer, the frame suspends between two aluminum chassis bars making the position of the travelers adjustable. Aerodynamic analysis positioned the location of the CG in front of the leading edge of the wing. To aid in moving the CG forward, the engine was proposed to mount on the cockpit structure. A practical place to mount the engine was between the pilot and passenger on the footrest plate as shown in Figure 5.7.

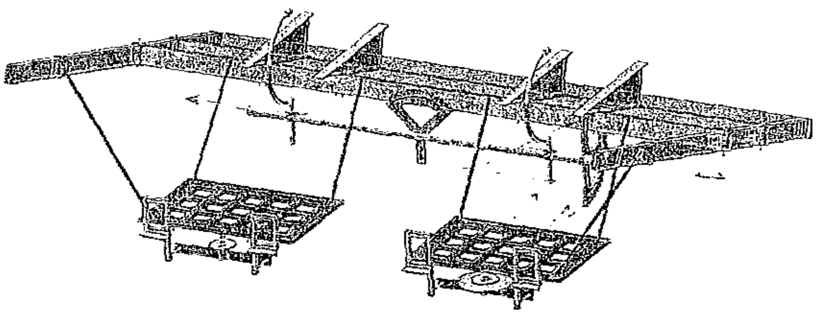


Figure 5.5: Frame designed towards manufacturability.

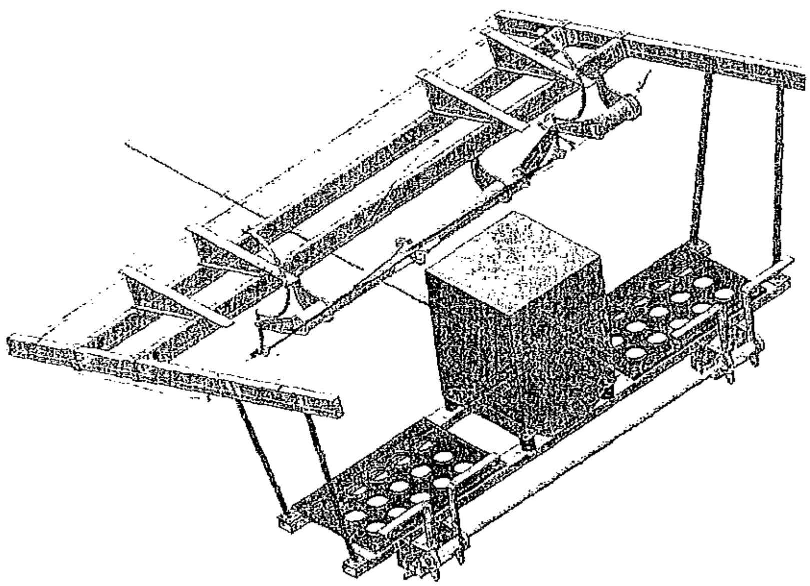


Figure 5.6: Frame including the engine position

Pitch/Roll Control System

The control stick, pitch, and roll mechanisms were the next components designed. Initial mechanism sketches were drawn as shown in Figure 5.8. The simple pitch and roll reactions were coupled, meaning that when the pitch mechanism was initiated a roll reaction occurred too. To solve the problem, the cable for the roll mechanism was placed along the center of rotation of the pitch mechanism as shown in Figure 5.9.

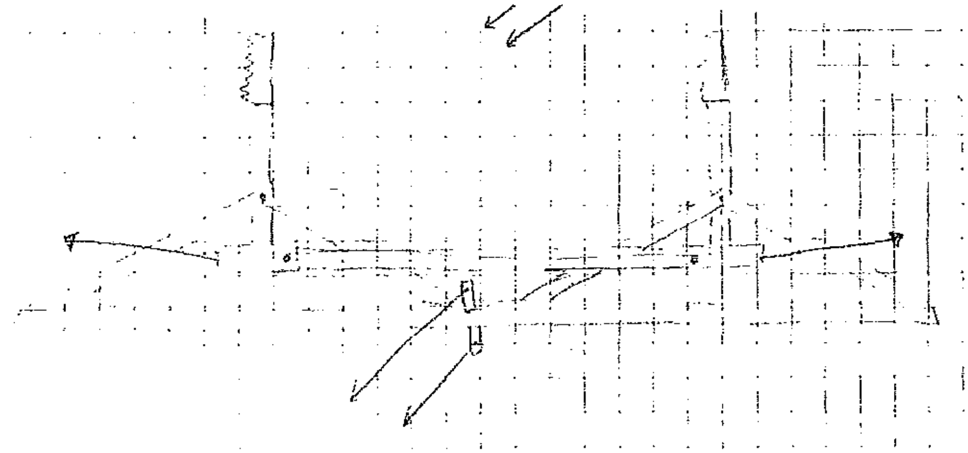


Figure 5.7: Control mechanism sketch.

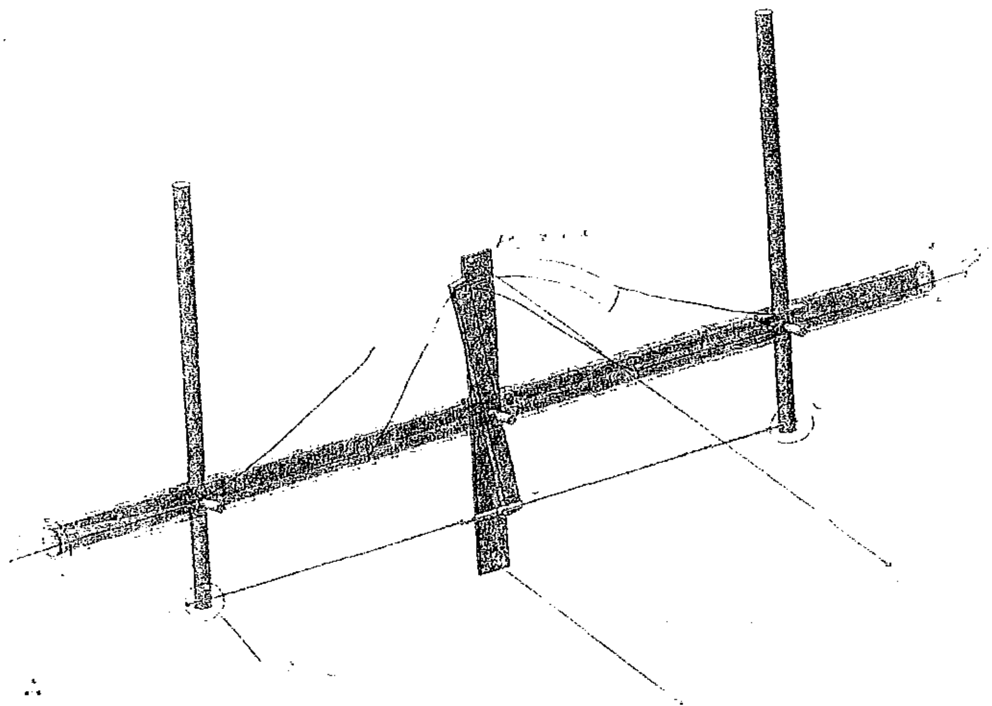


Figure 5.8: Simple representation of mechanisms needed.

Modifications were made to the original control system. Shown in Figure 5.10, the straight stick was replaced with a curved stick to eliminate seat contact when pulled inward. Placing both control differentials outside the main rotation tube further simplified the design. Shown in Figure 5.11, the bell crank for the pitch mechanism was placed in line with its connecting device on the canard. The throw differential was moved to an external position due to size restraints.

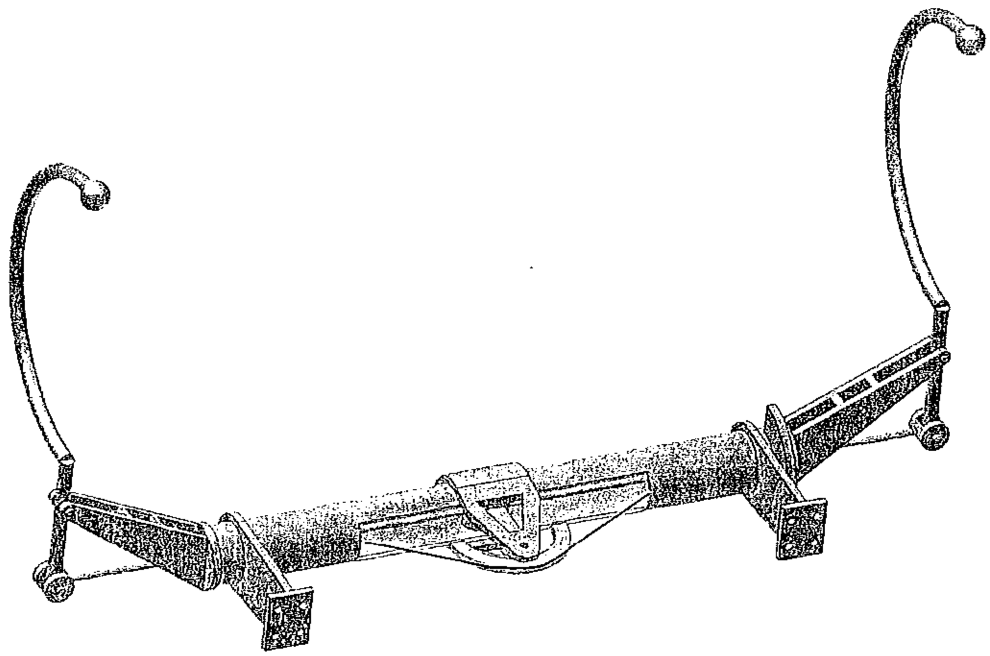


Figure 5.9: Control system.

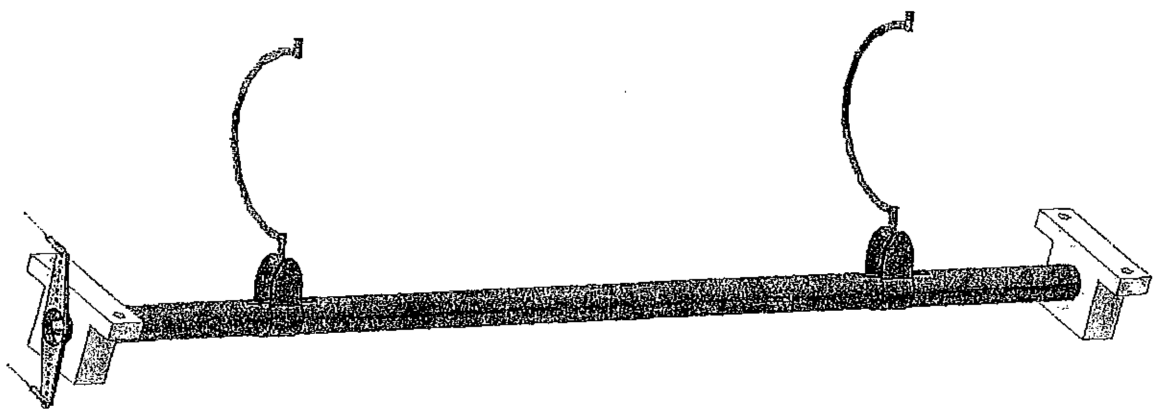


Figure 5.10: Final control system

Rudder Control System

The next component for design consideration was the rudder or yaw mechanism. An initial sketch shown in Figure 5.12 represents a possible mechanism. To bring the rotation in-house, a modular pedal set was considered. A floating bar connects the primary set to the trainees' pedal set. The pilot's pedal set incorporates the rudder control differential as shown in Figure 5.13.

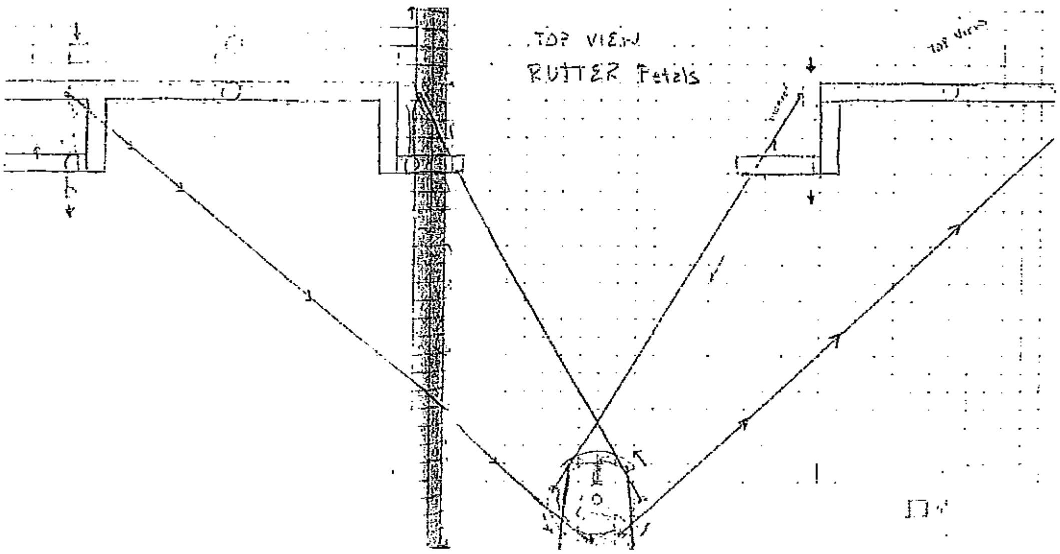


Figure 5.11: Initial rudder mechanism drawing.

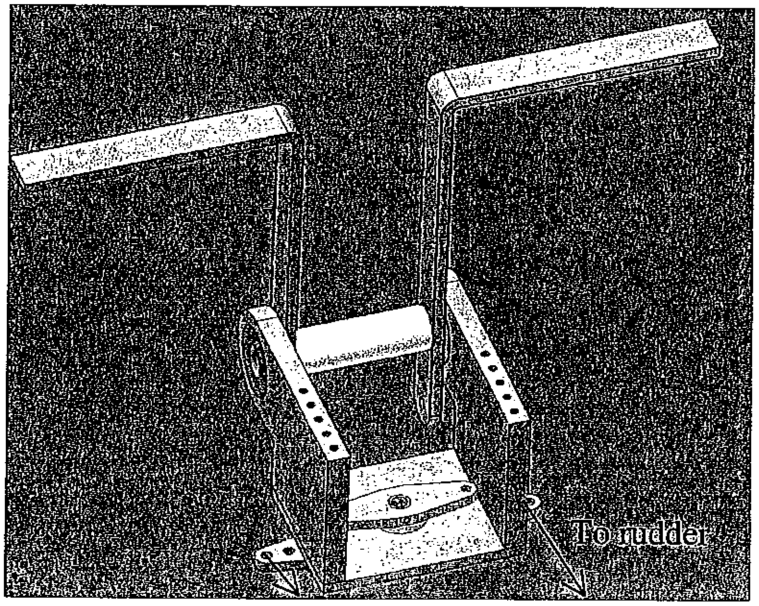


Figure 5.12: Modular rudder pedal set.

To reduce the number of parts included in the rudder pedal assembly, the system was revamped. Shown in Figure 5.14, the new configuration performs the same task as the modular set, but with simple movements and a design similar to many systems currently used in industry. The bell tabs allow for adjustable pedal movement versus rudder rotation.

Testing and Mockups

Cockpit Frame

The selection of the span bars, footrest bars, and chassis bar was based on a Microsoft Excel spreadsheet, which represents different shapes of possible stock bars and calculates maximum deflection and bar weight. To check the chosen bar geometry, a model of each worst-case scenario was performed using I-DEAS finite element method. Refer to plots in Appendix D.

The Control Systems

Throughout the cockpit design process, physical and 3-D computer models were useful design and visualization tools. Physical models brought attention to problems with actual movements. Shown in Figure 5.15 is a simple cotton swab and pin mockup of an initial design concept. The mockup illustrated coupling movements in the pitch and roll mechanism. Shown in Figure 5.16 is a balsa wood mockup of the cockpit system. The quarter scale model showed concerns with mounting the pitch and roll control assembly. The model brought attention to concerns with mounting the modular cockpit onto the chassis, and the effect of a solid footplate when flying at an angle. The computer models also illustrated physical problems such as control stick interference with the seat, size and mounting concerns.

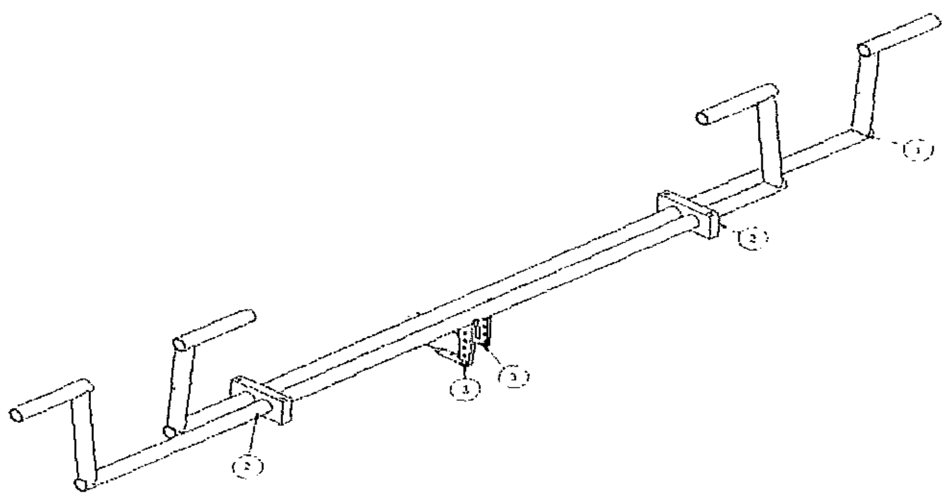


Figure 5.13: Rudder pedals.

Pitch/Roll Control System

The final design of the pitch and roll control system, shown in Figure 5.18 is easy to integrate into the main cockpit frame. To mount the system, two pillow blocks bolt onto the chassis bars. The thin walled steel rotation tube has bell crank tabs welded on one end to control the canard movement, which also couples the primary and trainee sticks. Sideways control stick movement initiates the wing warp mechanism. The trainee control stick is coupled to the primary with a push-pull rod. The control stick is fabricated from tubular steel stock. All systems use pull-pull cable response, excluding coupling devices.

Rudder Control System

The final design of the rudder control system, shown in Figure 5.19 is simple and common to industry. A steel tube connects the right pedals together and another steel tube connects the left pedals together. The right and left pedals are coupled through a bell crank. The bell crank tabs use a push-pull rod to move the bell crank that in turn pulls the cable to rotate the rudder. The bell crank is located about one foot back from the pedal assembly. The pedal assembly is mounted using pillow block type mounts with dual holes to restrain the bars.

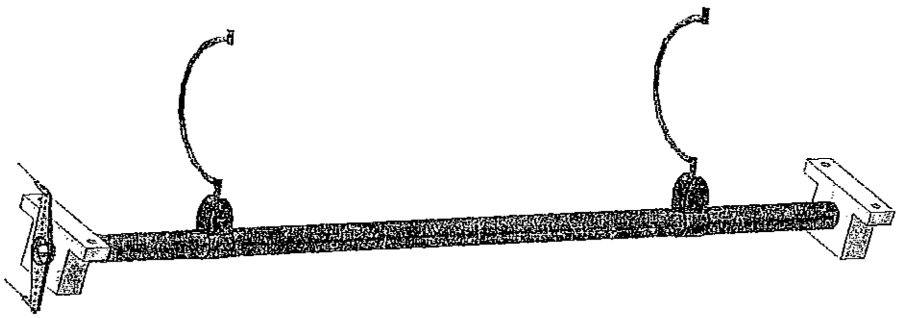


Figure 5.17: Final pitch/roll control system.

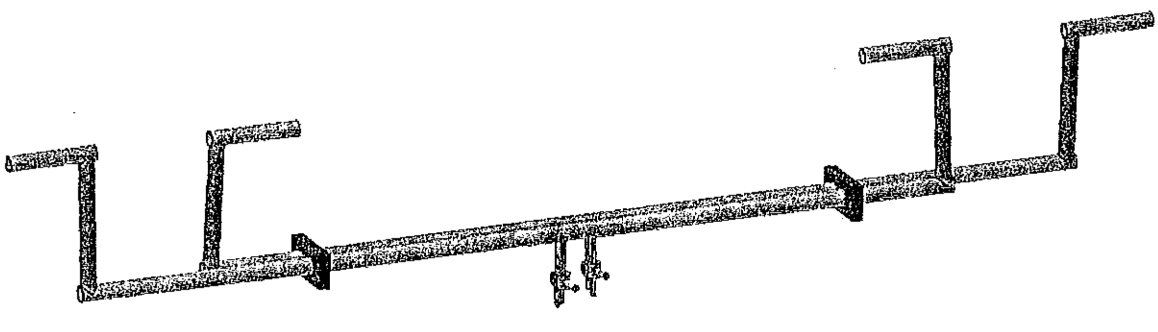
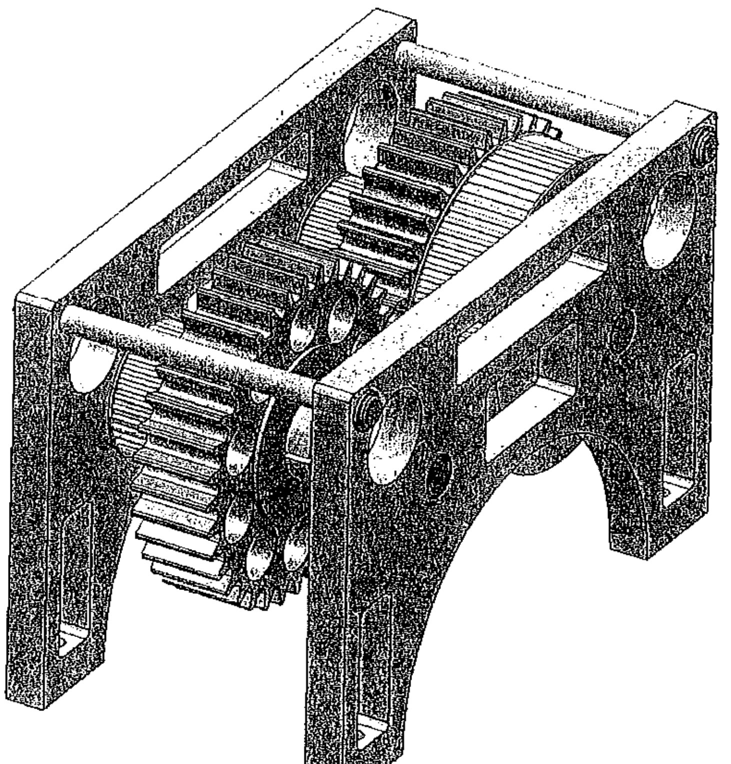


Figure 5.18: Final rudder control assembly.

Conclusion

The final cockpit design meets the criteria set by the customers. The cockpit is designed for two occupants, sitting upright. The pilot can easily reach the rudder pedals, and the footrest plate provides an area for the passenger's feet. The coupled control mechanisms are purely mechanical, and are similar to systems currently used in industry. The necessary flight instrumentation is mounted on the control panel to meet Federal Aviation Regulations for ultra-light aircraft. The cockpit frame is mounted modularly using standard bolts and materials. The incorporation of high strength steel minimizes the amount of materials used and causes less distraction from the overall flyer aesthetics. The evolution of the design produced a more efficient, manufacturable cockpit.

DRIVE TRAIN AND PROPULSION DESIGN



Propellers

Requirements

Propeller selection was based on several requirements including aesthetics and thrust production. As much as possible, the propellers needed to look just like the propellers designed by the Wright Brothers. The propellers also needed to produce enough thrust to make the plane safe under all predictable conditions. The 1905 Wright Flyer incorporated two counter-rotating propellers, with eight-foot diameters. From a photo copy of Wilbur and Orville Wright's 1908 Notebook, pg.13, the results of testing the original propellers show a static thrust between 132 and 136 pounds (for two propellers) when the propellers were turning at a speed of 350 rpm (Ash 2001).

Much has been accomplished in the development of propellers since the Wright brothers flew nearly 100 years ago, but the trends they observed are still valid today. A large diameter propeller, accelerating a large mass of air across a small velocity increment is most efficient. The Wright Brothers used the largest propeller possible considering their airframe structure. At low airspeeds, a small pitch to diameter ratio produces the most thrust per unit power: during low forward speed conditions, the rotational velocity of the blades is much larger than the forward velocity. The free stream velocity seen by the propeller blade sections is basically in the plane of propeller rotation. To keep the blades from stalling, the angle of attack of the blades must be measured relative to the direction of rotation and designed to be less than the stall angle. Since the velocity of the blade sections in the plane of rotation increases with the distance from the hub, the angle of attack of the blade sections must decrease with the distance from the hub. Stalled blade sections create large amount of drag and very little, if any, lift.

Selecting propellers for the USU Wright Flyer meant choosing propellers as close to the original eight-foot diameter as possible in order to maintain aesthetics. Minimizing forces such as P-factor and torque would require the use of counter-rotating propellers. Materials used for construction would need to be made of wood or at least finished to have the appearance of maple or mahogany. In accordance with the design goal of a lighter, stronger, more modern plane, the most modern and lightweight materials would have to be used.

Preliminary

The foremost concern with the propellers was finding a manufacturer that would build an eight-foot propeller, and do so with lightweight composite materials. Most propellers used for modern lightweight aircraft have a diameter between four and six feet and are made of heavy metals. Reducing the diameter from eight feet to six or less was strongly considered for purposes of availability.

Testing

Computer software that incorporates Propeller Blade theory and Goldstein Vortex theory was developed to further the understanding of each variable involved in propeller design. The main variables considered were diameter, pitch-to-diameter ratio, rotational speed, and desired cruise speeds. The main results considered were the power required to turn the propeller at take-off and cruise, and the thrust produced at take-off and cruise.

The advance ratio, J, is a variable that combines the forward airspeed of the plane, the rotational speed of the propeller and the propeller diameter, as shown in eq. 6.1.

[illegible] (eq. 6.1)

After experimenting with the effects of each variable, and noting how each one affected the important results, several trends were found. Figure 6.1 shows the generic trends that power and thrust coefficients follow as functions of the advance ratio. Actual values of thrust and power are directly proportional to the coefficients. Conclusions drawn from the graphs include the fact that thrust produced drops off as velocity increases, which would indicate that for a given amount of power, a propeller driven plane would have a limiting maximum velocity.

Selection

The majority of the design of the final propellers was done in conjunction with *CATTO PROPELLERS*, a propeller manufacturing and design company located in San Andreas, California. Calculations showed that the thrust produced at cruise speeds was

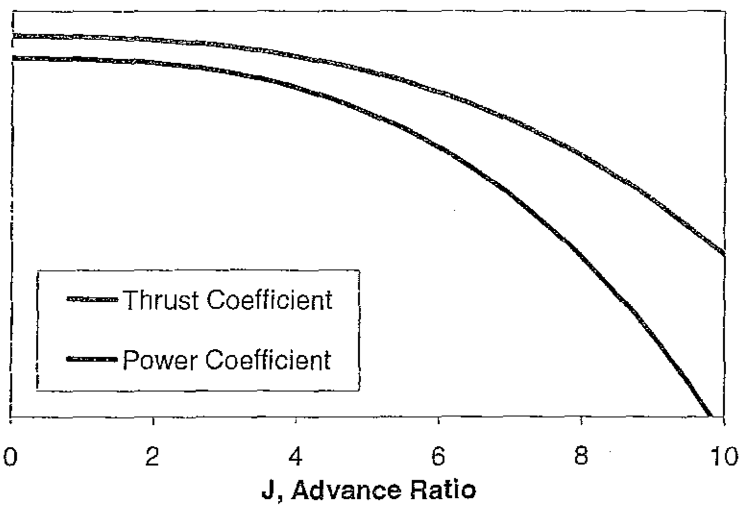


Figure 6.1: Generic curves for Thrust and Power Coefficients.

nearly independent of propeller diameter. On the other hand, for static thrust, or take off thrust, more thrust was available with larger diameters. With this information, the selection of the propeller diameter was simple. Propellers with the same eight-foot diameter that the Wright brothers used would meet constraints for both aesthetics and thrust.

With the general size of the propeller selected other specific parameters such as the pitch-to-diameter ratio, airfoil sections, and lift distribution depended mainly on the weight of the plane, the engine to be used and the desired performance of the plane. The weight of the plane was assumed to be the maximum allowable under the FAR regulations described earlier. The selection of the Rotax 277 for the engine is discussed later on. The desired performance of the plane required the propellers to produce high thrust at takeoff and sufficient thrust to overcome drag at cruising speed.

In order to match the propellers and the engine, performance curves for the Rotax 277 were generated. Figure 6.2 shows the torque and power curves for the selected engine. Additional propeller software was developed to estimate the RPM at which the engine would run, the power that it would produce and the thrust that would be available to the plane under a variety of conditions. The interaction between the engine RPM and the propellers is quite complicated. The thrust required for steady level or climbing flight depends on the airspeed, and climb angle. The power available from the engine depends on throttle setting. If the power required by the propellers is less than what the engine is able to supply at a given throttle setting, the propeller RPM will increase, accelerating the plane until the drag forces on the plane and the brake power required to turn the propellers match the engine power. The propellers and transmission would need to be designed so that the propellers could turn at the RPM necessary while the engine was turning at the RPM that could provide sufficient braking power. After a brief evaluation of the engine- propeller combinations using the software developed at USU, Catto Propellers determined the actual blade section coefficients, using a program that they had developed which incorporated years of empirical data.

A 94-inch diameter propeller with a 70-inch pitch was selected. The design rotational speed is 800 RPM. Thrust data supplied by CATTO ranges from 280 pounds at static to 70 pounds at 60 mph. A curve fit to the data points provided is shown in Figure 6.3. A quick comparison of the thrust produced by the propellers and the expected drug forces of the aircraft evidently show that the 2003 Wright Flyer will have a top speed some where around 50 mph.

The propellers will be mounted using an SAE – 1 bolt pattern that is comprised of six 3/8-inch bolts. Catto Props found that space-age materials are not always the most appropriate. Sometimes Mother Nature does a pretty good job herself. Materials used for construction of the propellers include maple and mahogany, so the appearance will be similar to the propellers used on the 1905 version. Each propeller will weigh only eight pounds: quite impressive for such a large diameter.

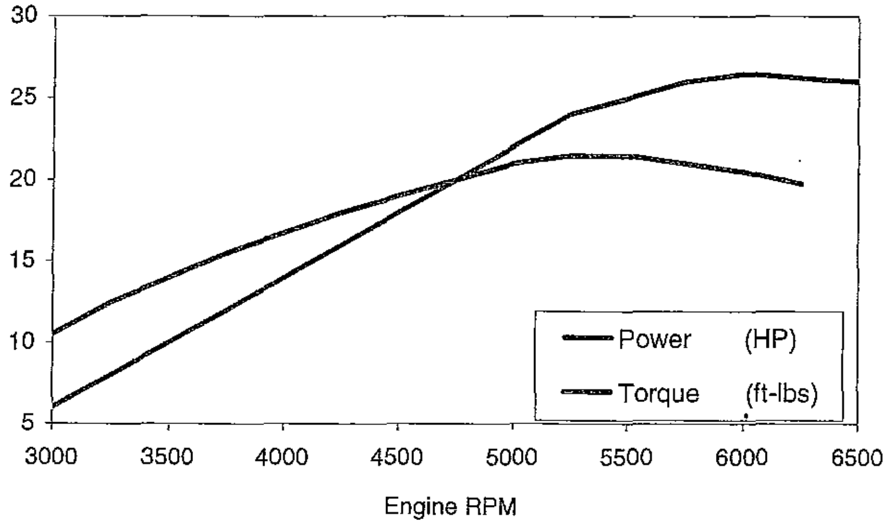


Figure 6.2: Torque and Power curves for the Rotax 277 two-stroke engine.

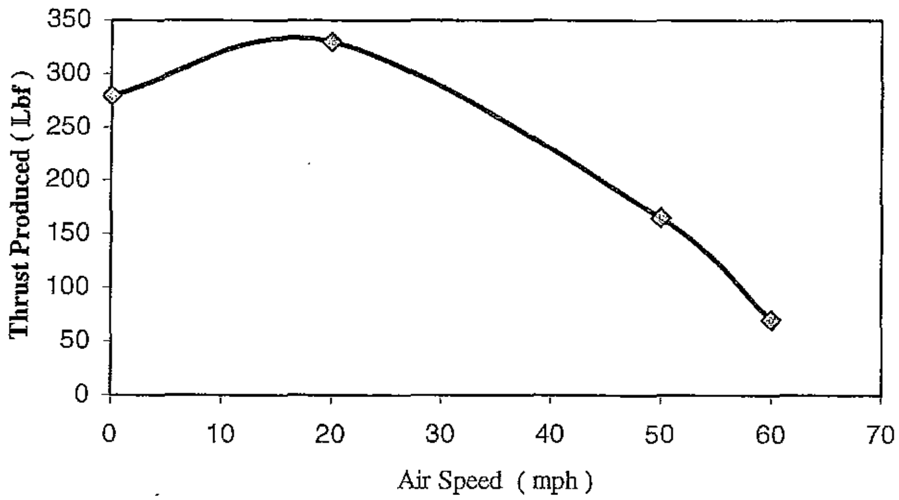


Figure 6.3: Propeller thrust produced as a function of Airspeed.

Final

Catto Propellers was selected to manufacture the propellers to be used on the USU Wright Flyer. Craig Catto's extensive experience in the design and manufacture of light aircraft propellers was the main factor in their selection as propeller supplier. He demonstrated great proficiency in adapting a propeller to the engine that had been selected and the purposes of the plane. As a wonderful benefit, Craig Catto offered to donate everything needed to design and build the propellers.

Transmission

Concept

The two main requirements of the transmission assembly were speed reduction and the ability to counter rotate the propellers. In order for the propellers to rotate at 800 rpm, a seven to one speed reduction was necessary. The 1905 Wright Flyer used bicycle chains to transmit power from the engine to the prop shafts. One chain was twisted to achieve counter-rotation of one prop. The transmission needed to accomplish the same objective, without use of the twisted bicycle chain. The maximum weight of the transmission was limited to 30 pounds.

Preliminary

Drive belts were first considered as an alternative to chains. By using belts, efficiency could be increased while reducing noise and overall weight. Both toothed timing belts and grooved V-belts were taken into consideration. Other ideas for transmitting power from the transmission to the prop shafts included drive shafts with bevel gears on each end, cogged V-belts and serpentine belts.

Counter-rotation of props using belts of any kind left only two options. The first was to twist one of the belts over itself between the transmission and the prop shaft. The other was incorporate the use of an idler gear built into the transmission assembly as shown in Figure 6.4. The use of belts to transmit power would allow the use different sheave diameters to obtain the necessary gear reduction for the system.

Testing

Testing and analysis were conducted using belt design software provided by Gates Rubber Company. This design program provided several belt options, and illustrated their respective advantages and disadvantages. The program accounted for the design horsepower, maximum rpm of the smallest sheave, center-to-center distance between shafts and the type of leading. After reading these inputs, the program recommends a belt type, length, width and appropriate tension.

Selection

Poly-Chain toothed belts were selected to transmit power to the propeller shafts. Poly-Chain belts, shown in Figure 6.5, are timing type belts manufactured by Gates Rubber Company. While they require approximately 30 percent more tensioning force than standard V- belts, tensioned properly they can provide the safest power transmission possible.

After determining the horsepower that would be transmitted through the transmission, Rush Gears proved to be the best vendor for the gears needed to accommodate the necessary counter-rotation of the props.

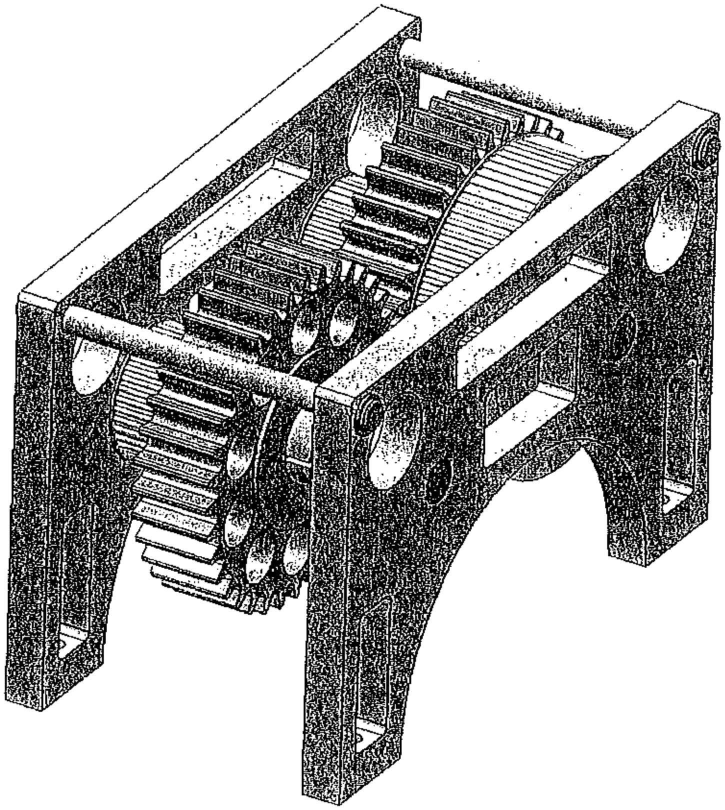


Figure 6.4: Transmission assembly with toothed sheaves and gear assembly.

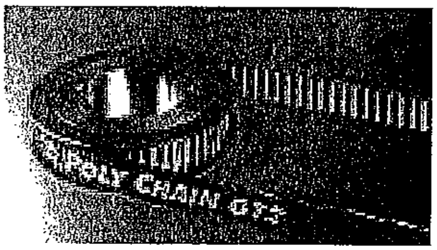


Figure 6.5: Poly-Chain used for power transmission to prop shafts.

Engine

Concept

The power plant selected would need to generate enough thrust to fly the plane at least 50 mph. The motor needed to have a high power to weight ratio and excellent reliability. The Wright Brothers flew the 1905 version on a 12 horsepower engine that weighed over 100 pounds. The USU Wright Flyer required an engine that could provide at least 25 horsepower and weigh half as much as the original.

Preliminary

Simple lightweight two-stroke engines power most aircraft in the ultralight category today. Because of this, first consideration was given to use of a Rotax two-cycle engine. The Rotax 277 provided 28 horsepower while weighing only 74 pounds, making it a viable option (see Figure 6.6). A fuel consumption rate of 1.8 gallons per hour would allow for a one-hour flight on less than two-gallons of fuel, as shown in Table 6.1. The availability and relatively low cost of this engine seemed to make it a practical choice.

Powering the USU Wright Flyer via electric motors was also strongly considered. The high efficiency, lightweight motors available today could provide the needed power to fly the airplane but weigh less than two-stroke engines in the same power range. By using electric motors, the transmission could be eliminated by attaching a motor directly to the prop shaft. This would also eliminate the need for belts and pulleys. Other advantages included increased reliability and noise reduction. The disadvantages of using electric motors were the high cost of the new technology and the reduction of flight duration. Even with the best available batteries, flight times would be reduced to around 25 minutes.

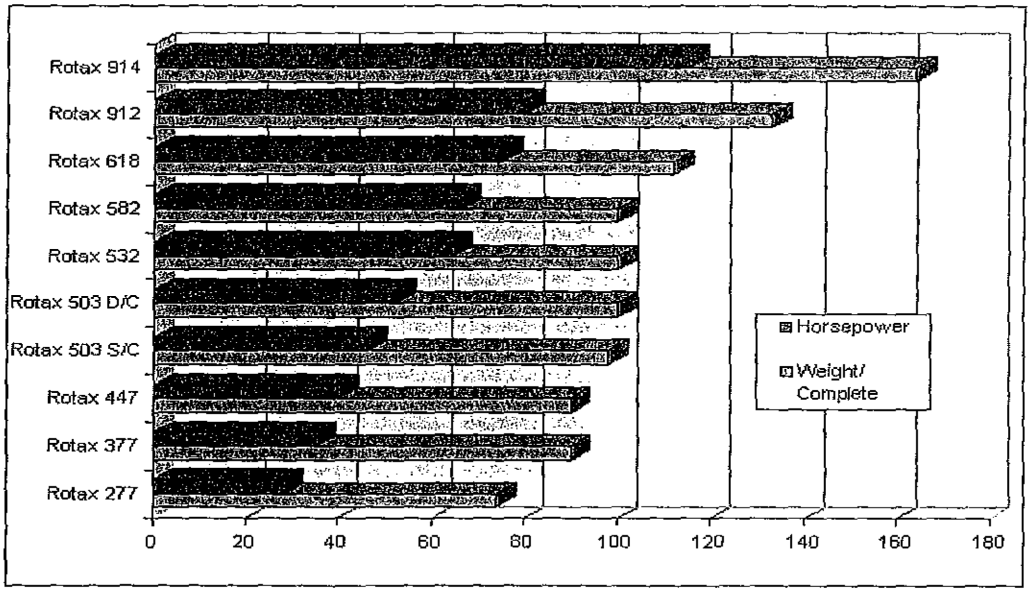


Figure 6.6: Horsepower and weight comparisons of various Rotax engines.

	A	B	C	D	E	F	G	H	I	J	K	L
Engine Type	Fuel Consumption	Weight/ Complete	Max RPM	Horsepower	Specific Fuel Consumption lbs/hp/hour	TBO Rebuild Cost	Weight/ Block	Displacement	Retail Price	Fuel Cost/hr.	TBO Cost/hr.	Total Cost/hr.
Rotax 277	1.8	74	6400	28	0.7	600	42.5	268	14.99	3.51	2	5.51

Table 6.1: Complete data for Rotax 277 two-cycle engine.

Final

After weighing the options, the Rotax 277 was selected as the best choice for the USU Wright Flyer. The Rotax 277 has been proven reliable in the ultralight industry. The high availability of this engine and its parts was also taken into consideration during the selection process. The analysis and modeling of the USU Wright Flyer showed that the Rotax 277 could provide sufficient power to propel the aircraft.

Support Structure

Concept

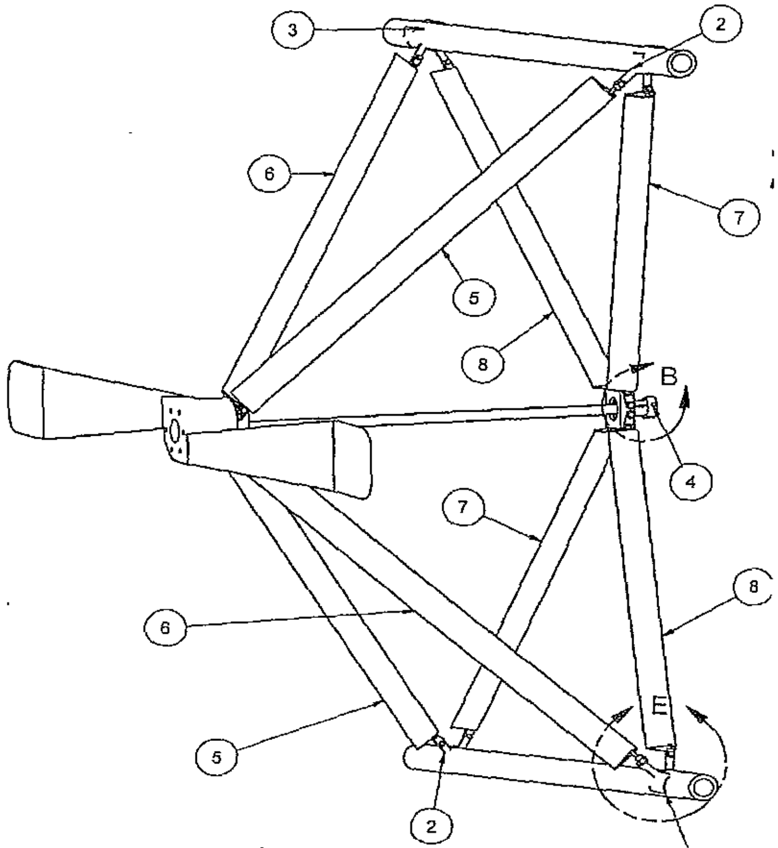
The support structure would need to provide support to the propeller drive shafts, transmission, and engine. The Wright Brothers used a system of four rods and eight cables to support each propeller drive shaft. Due to the high drag caused by cables, eliminating as much cabling as possible was an immediate consideration for the USU Wright Flyer. The main force the propeller support structure would have to withstand would be the axial force along the shaft. Other minor forces included drive belts turning the shaft producing lateral forces and vibrations. Any eccentricity in the propellers would also induce lateral forces. Due to the size of the propellers, excessive lateral motion could result in the propellers colliding with the main wing. Transmission and engine support systems would not only support their respective components, but also add rigidity to the wing and cockpit assemblies.

Preliminary

From the thrust curves of the propellers, the maximum expected thrust each would produce would be around 175 lb. The tension in the drive belts would be less than 150 lb. In order to support these loads, the system shown in Figure 6.7 was developed. Four rods support the thrust from the propellers while four other rods support the end of the shaft where the drive belts will be pulling and vibrating. In order to reduce the drag on the entire structure, a streamlined cross-section would be needed for the support shafts. The use of carbon fiber would allow for a larger streamlined cross-section while still keeping the weight low.

Transmission support could be provided by the strengthened wing ribs or by adding structural tubing between the front and rear spar. Early consideration was given to using tubing because of the high tension in the belts.

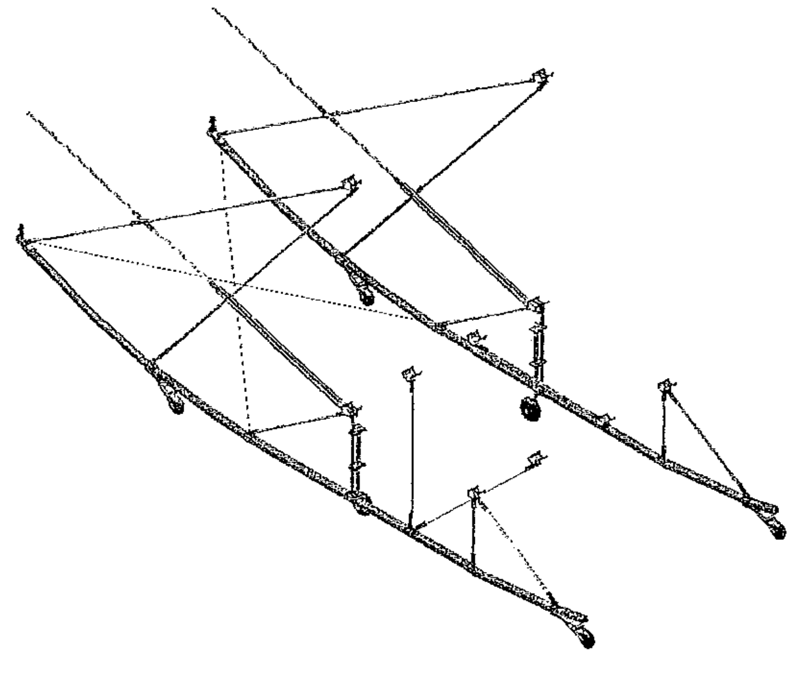
Engine support and placement varied throughout the design in order to accommodate proper placement of the center of gravity of the aircraft. Originally, the idea was to place the engine on the quarter chord of the main wing and support it and the transmission with the same structure. This location was gradually moved forward onto the floor of the cockpit to move the center of gravity forward.



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	Spar Assm	
2	2	WF-40-002-507A	Mounting Assembly
3	2	WF-40-002-507B	Mounting Assembly
4	1	WF-40-002-503	Shaft Support Assm
5	2	WF-40-002-505A	Rear Support Assm - A
6	2	WF-40-002-505B	Rear Support Assm - B
7	2	WF-40-002-506A	Front Support Assm - A
8	2	WF-40-002-506B	Front Support Assm - B
9	1	WF-40-003 Propeller	Designed by CATT O PROPS

Figure 6.7: Drawing of the Propeller support and drive system

CHASSIS DESIGN



Introduction

The 1905 Flyer incorporated a chassis made up of spruce struts and skids assembled with bolts, screws and sheet metal fittings. The skids provided a large contact area, stabilizing the 1905 Flyer while on the ground. The chassis was interfaced with a track system that guided the plane during takeoff. When the Wright Brothers relocated their proving grounds away from the ceaseless winds of Kitty Hawk, North Carolina, the chassis-track takeoff system was reintegrated with a catapult system to obtain the needed airspeed required for lift off. The challenge of the USU Wright Flyer redesign was to incorporate space age materials in order to avoid, undoubtedly, the strut repairs made by the Wright Brothers in between flights. Also, the chassis needed to aesthetically look like the 1905 Flyer, but allow the USU Wright Flyer to take off and land like a conventional aircraft.

Concept

Aesthetics

In keeping with the aesthetics requirement for the overall look of the plane, the chassis design needed to keep the skids as part of the design. However, the geometry of the structural tubing attaching the skids to the rest of the USU Wright Flyer was largely unspecified. It was requested that the USU Wright Flyer incorporate composite tubing as the main component of construction.

Landing Gear

It was also determined in the early conceptual phase of the project that wheels would also need to be incorporated into the design of the new Flyer. Originally, the 1905 Flyer used the heavy winds at Kitty Hawk, North Carolina to create the needed lift as a man on each wing guided the Flyer down its track with the skids sliding across the sand. Later, when the Wright Brothers relocated their experimental proving grounds to a remote field near Dayton, Ohio, the Wright Brothers constructed a catapult system to give the Flyer the needed velocity to create the necessary lift for take off. Heavy winds and a catapult would not be available in takeoff of the USU Wright Flyer. The USU Wright Flyer would need to be able to take off on asphalt or cement and possibly a manicured grassy lawn. This would not be possible if the plane had to overcome the sliding friction of skids on any of the proposed take off surfaces. It was determined that the appearance of the USU Wright Flyer would need to suffer the addition of wheels.

Early flights of the 1905 Flyer undoubtedly saw the failure of many struts upon landing. The experiments at Kitty Hawk especially saw many broken components when the Flyer would execute improper landings, as well as perfect landings. This was due largely to the lack of any suspension system absorbing the impact forces during landings. It was also decided early in the conceptual phase that some sort of landing gear suspension system would be critical in extending the life of the USU Wright Flyer, as well as avoiding embarrassing and timely repairs during the tour of the aircraft on its way to Dayton, Ohio for the 2003 festivities.

Disassembly

As part of a USU Outreach Program, the USU Wright Flyer needed to be disassembled for transport in semi-truck trailer. Using nylon locking bolts to attach the skids to the canard and wing would quite easily accommodate this requirement. The USU Wright Flyer would most likely be broken down into five pieces consisting of wings, rudder, canard and two skids.

Preliminary Design

From the beginning, emphasis was placed on interchangeability of parts. This was a lesson learned by Henry Ford and adopted since by all of manufacturing. Interchangeability would ease in the manufacturing of the parts as well as the assembly of the components during construction. Emphasis was also placed on adjustability, understanding that the scope of a systems integration project such as this one would, undoubtedly, lead to tolerances quickly stacking up and leading to inevitable conflicts. However, the built in adjustabilities of the design created their own unique complexities that further created problems for manufacturability and cost of construction. Early possibilities of solving the suspension problem included using a lightweight mountain bike shock in conjunction with a composite leaf spring. This was an impressive solution that included sliding linkages and hinged joints that would allow the rear part of the skid to compress upward independent of the wings and canard. Figure 7.1 below shows a conceptualization of the shocks and spring and the two-piece nature of the skid. A diagram of the sliding mechanism of the composite spring is also included.

Developing an accurate model of the mechanics of such a large composite spring proved inconsistent with the intuition of the team. Curved beam theory was the model equation used. This was found in Mechanical Engineering Design, Shigley, Mischke, pages 138, 140-142, 200-202.

$$\delta \approx \frac{\pi F R^3}{2EI} = 382.8\ in$$

F= landing force, 1000 lb
R= centerline radius of spring, 90.47 in.
E= smeared modulus of elasticity for fiber lay-up, 12.2 E6 psi
I= moment of inertia, 0.25 in^4

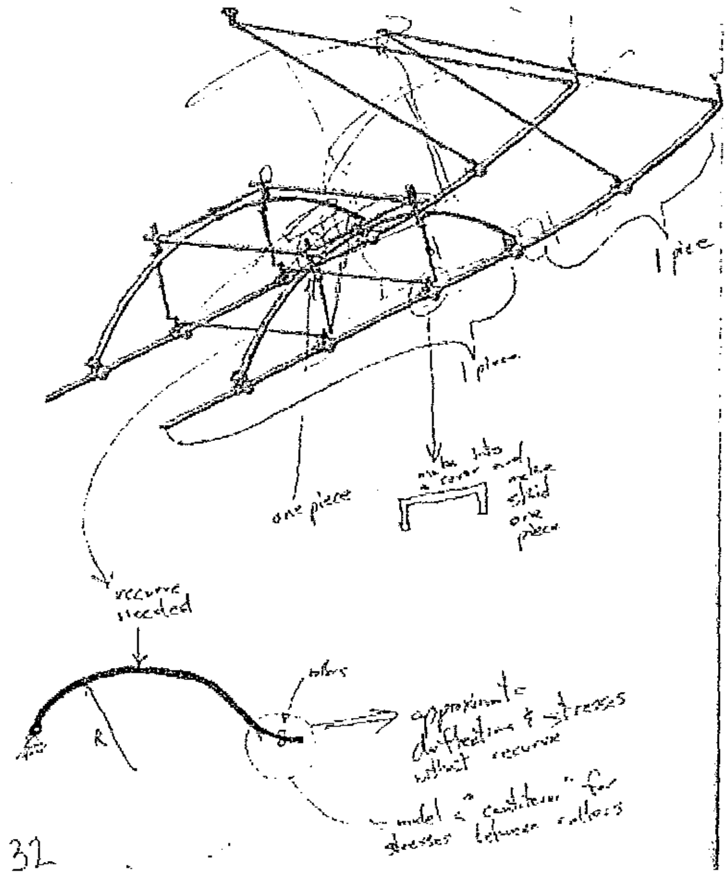


Figure 7.1: Spring/shock conceptualization.

The smeared modulus of elasticity was taken from a program that calculated the value for different fiber orientations. A $[0/90]_s$ gave the highest value that most closely resembled an isotropic material. The characteristics of an isotropic material would be desirable, given the possible angles at which the Flyer might land. The spring should behave the same regardless of the angle of impact. This value was used in the calculation. As demonstrated, the value of 382.8 in of deflection was quite inconsistent with design requirements. A finite element analysis of the design gave a deflection of 1040 in. Either the science was demonstrating the complete lack of feasibility of the design, or the science could not accurately model the unique characteristics of the composite design. It was determined that a mock up would need to be made to determine "hands-on" the true mechanics of the design.

Preliminary design showed that, unlike the Wright Brothers who flew their 1905 Flyer with the pilot lying prone on the wing, the USU Wright Flyer would require the pilots to be situated in a "cockpit" forward of the main wing. This arrangement would allow for correct placement of the center of gravity. Due to this new design requirement, some of the chassis struts would require being directly attached to the cockpit components. Struts that had previously been subjected to only "historical" loading, would now need to be reexamined for the additional loading of the weight of the cockpit itself, as well as a possible loading of 500 lb of pilot and passenger.

The preliminary design phase involved drawing early concepts in the Inventor CAD program. This allowed for a visual of conceptual designs in a real-life scale. Many early designs were plagued with complexity as might be expected, and later refined into simpler ideas as the team made suggestions. A good example of a part evolution in the chassis design involves the skid hard-point. This was a fitting to be attached to the skid on which to attach the struts. Figures 7.2, 7.3, and 7.4 show how the part went from a heavily machined design, to a lightweight cut and welded design.

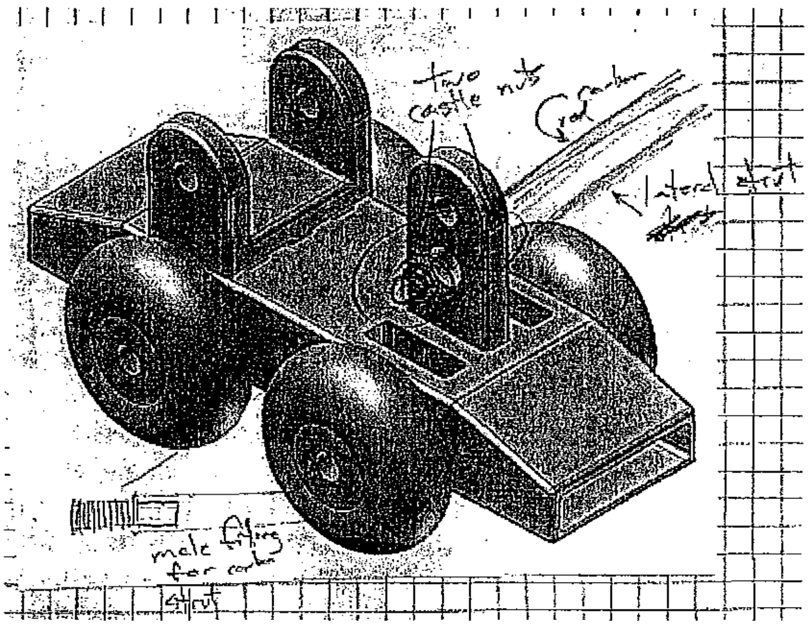


Figure 7.2: Early hard-point design, note intense machining requirements.

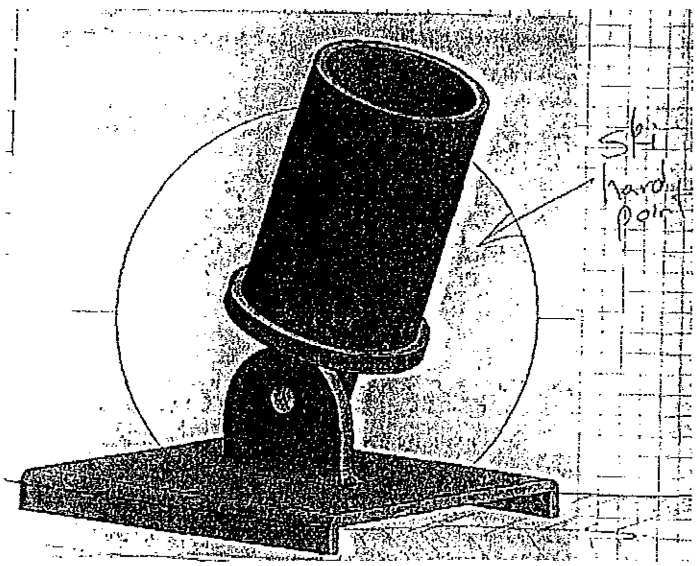


Figure 7.3: Progressed hard-point design, note intense welding requirements.

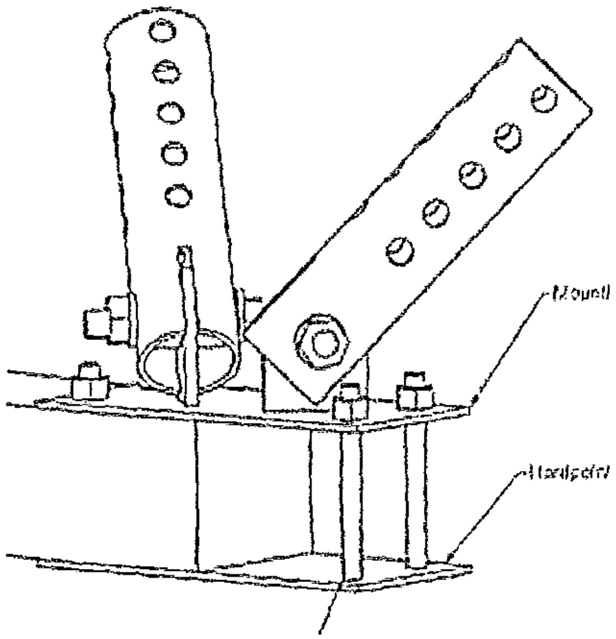


Figure 7.4: Final hard-point design, note little welding, mostly drilling and milling.

During the preliminary design phase, much thought was given to the construction of the skids. Initially it was thought that the skids could be made out of space-age composites like the struts of the USU Wright Flyer. It was also considered that the hard-points might be "splices" for different sections of the skid. Thought was given to covering the bottom of the skids with P-Tex, a material used to repair the bottom of skis and snowboards. The desire for a straight, stiff skid began to weed out the ideas of a multi-piece design. It was determined that each skid would at the most be made up of two pieces in order to facilitate the leaf spring linkage concept for the USU Wright Flyer suspension. However, before a final decision could be reached, a proof of concept mock-up of the composite spring would need to be made.

Testing and Mockups

Composite Spring

A mock up of the composite spring was constructed out of less expensive glass fibers. The spring was laid up in excess of 20 layers in a $[0,90]_s$ configuration. During the curing of the spring the vacuum pump failed to work properly and the spring cured with serious spaces and voids. However, the mock up did demonstrate that the springs would be too heavy to be considered for the final design, and the mathematical models were showing serious problems in the rigidity of the structure subjected to our anticipated maximum landing loads. Figure 7.5 is a picture of the mock up leaf spring with a span near 100 in.

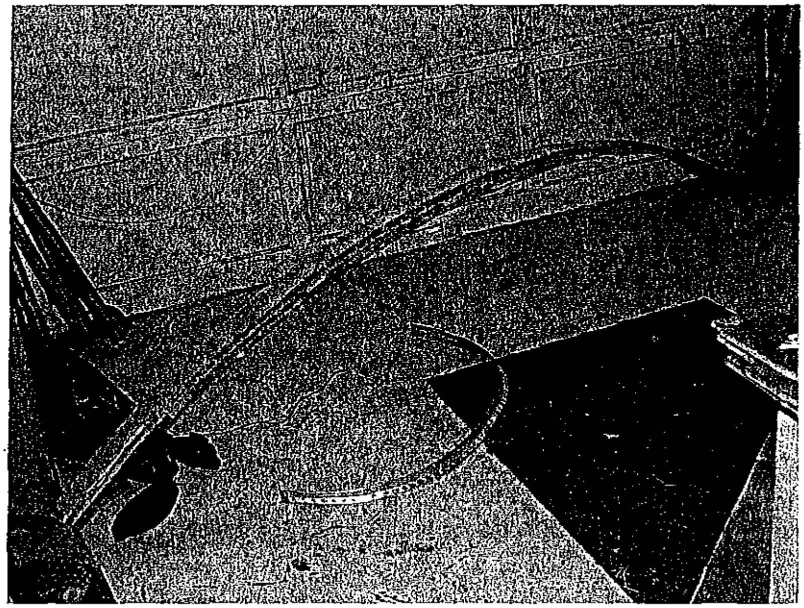


Figure 7.5: Mock up composite spring made of glass fibers.

Composite Structural Tubing

The application of composite materials is generally for tension and torsion. The USU Wright Flyer would require most of the composite structural tubing to undergo compressive loading, magnified greatly during landing. Traditionally composite materials are not used in compressive loading applications because of the inaccurate predictability of the behavior of a composite member in compression. Analysis of such compressive loading was beyond the scope of a student engineer, and doctoral assistance was not readily available. Intuitively the ITE professors felt that their experience with composite materials warranted their use in the USU Wright Flyer. In order to back up a decision to use composite tubing in the strut structures of the USU Wright Flyer, three composite tubes of different geometries where tested in compression.

It was determined that the worst case scenario for the loading on one of the tube struts would be a fully loaded plane at 1000 pounds landing at two times the acceleration of gravity. This would cause the landing load of 2000 pounds to be distributed at 1000 pounds per skid assembly. If the entire load were taken by one strut, then it would need to be able to withstand 1000 pounds. The composite tubes to be used in the project are constructed of a "wavy" fiber made by Wavy Composites, Provo, Utah. Due to the nature of the even more unpredictable wavy composite construction, tests were invaluable. The three test specimens were fitted with steel pipe plugs that where glued in place with epoxy in order to be placed in the compression test cell. The three specimens were each loaded at a displacement rate of 0.0816 in /min. The tests were only limited by the failure of the epoxy bonds on the fittings. None of the tubes failed in the tests. Table 7.1 and Figure 7.6 give the specifications of each tube and the loading at which the epoxy bonds of the fittings failed.

Tube Description	I.D.	O.D.	Maximum Load
Thin-walled	.882 in	.928 in	891 lb
Thicker-walled	.875 in	.945 in	689 lb
Damped	.875 in	.980 in	470 lb

Table 7.1: The three tubes placed in compressive testing.

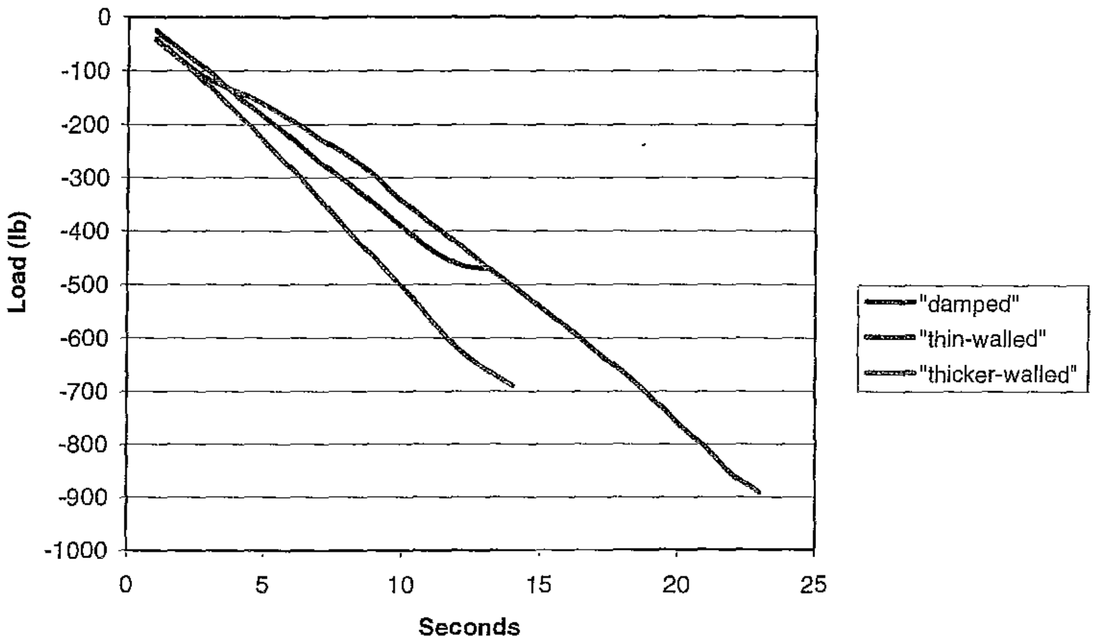


Figure 7.6: Compressive loads in three dissimilar wavy composite tubes.

Although tests were only conducted on three dissimilar specimens, the results were very encouraging. As stated earlier, none of the tubes failed at the loads indicated, and each tube appeared quite intact upon later inspection. Later inspection also showed that the epoxy had only adhered to only 1/4 in of the fitting at the end of the tube and that the "swiss-cheese" feature of the fitting had not been properly "gooped" with epoxy.

Steel Structural Tubing

Using the AISC specifications for allowable loads in structural columns referenced in Mechanics of Materials, Timoshenko, pages 775-782, analysis was performed on the longest steel tube to be used in the chassis struts. Below are the equations used to calculate the allowable loads on a 46 in steel tube with a 1/16 in wall thickness.

$$A_{cross-sectional} = \pi(r_o^2 - r_i^2) = 0.1841\ in^2$$

$$E = 29{,}000\ ksi$$

$$\sigma_{allow} = \frac{12\pi^2 E}{23(KL/r)^2} = 17{,}643\ psi$$

$$F_{allow} = \sigma_{allow} * A_{cross-sectional} = 3{,}248\ lb$$

With an allowable load of 3,248 pound, the steel struts are well suited for the design. As discussed earlier, it was assumed that in a worst case scenario a single strut might be subjected to a 1000 pound loading. The allowable load on the steel struts gives added security in the cockpit support areas where the struts will be applied.

Weldaments

No physical tests of weldaments were performed, however theoretical calculations were made. The smallest, simplest weld on the skid hard point was analyzed under a worst-case scenario to determine the overall integrity of the USU Wright Flyer's structural welds. A worst-case scenario would again involve a possible 2.0g landing. At 1000 pounds per skid assembly, it is assumed that the most a single weldament would have to take would be 500 pounds in bending. Below is a string of calculations to determine the nominal throat shear stress in bending, with a rectangular weld 1/8 in x 1 in. The equations were taken from Mechanical Engineering Design, Shigley, Mischke, pages 540-544.

$$b = 0.125\ in$$

$$d = 1\ in$$

$$h = 0.0625\ in$$

$$c = \frac{d}{2} = 0.5\ in$$

$$F = 500\ lb$$

$$X = 0.75\ in$$

$$M = FX = 375\ lb*in$$

$$I_u = \frac{d^2}{6}(3b + d) = .229\ in^3$$

$$I = 0.707 h I_u = .010\ in^3$$

$$\tau = \frac{Mc}{I} = 18.52\ kpsi$$

Using fillet welds, the permissible stress in the AISC Code for weld metal using an AWS electrode number E60XX in shear loading is 18.6 kpsi. Compared to the shear stress value of 18.52 kpsi found in the above equations, this gives a safety factor of 0.996 in a worst-case scenario. This is an acceptable design, and despite theoretical calculations that sometimes don't correctly model real-life situations, welding a 1/8 in steel plate to a 1/16 in steel plate is intuitively strong enough for this lightweight aircraft.

Selection

It was determined that the structural tubing of the project would be a mix of wavy composite tubes, steel tubes and rectangular aluminum tubes. The selection was due to several factors.

First, using steel tubing in areas that would directly support the weight of the cockpit during landing was preferred because of the strength of steel needed in these critical areas. Next, the steel and aluminum tubes allowed for conventional drilling and mounting with nuts and bolts. This allowed for secure placement of cockpit elements. Composite tubes do not lend themselves to be drilled through and bolted without placing a wood core inside the tube in areas to be mounted in order to take the compressive hoop stresses. Such fabrication details did not mesh well with overall ease in manufacturing. Finally, the use of wavy composite tubing in the remaining struts of the chassis was preferred for weight savings as well as their demonstrated compressive strength.

The tubes that were tested had an approximate outside diameter of 7/8 in. The final tubes to be used in construction of the plane would be 1 40/1000 I.D. with approximately 40/1000 in gluing tolerance. The wall thickness on the final tubes was specified at 1/16 in. This diameter will still allow for streamlining later if the need to cut wind resistance is great enough. This decision is in stark contrast to an original proposal to have the tubes 2 I.D.

It was decided that all hardware and fittings, except for the cockpit aluminum tube, would be made out of steel. In general, steel is easier to weld than aluminum. The strength of steel in the heat-affected zone of the welds is not as affected as it is in the case of aluminum. Aluminum was chosen for the cockpit mounting tubes because of the weight savings over steel due to the size of the tube.

The desire to use composites for the skids, allowing the USU Wright Flyer to leave the wooden legacy of 1905 Flyer behind, was outweighed by the inability of composites to resist impact and abrasion well. The Wright Brothers had it "right" in selecting spruce for the skid material. Wood has great strength to weight ratio as well as good impact and abrasion resistance. The USU Wright Flyer skids, however, would be beefed up just a touch by adding in layers of Kevlar during the spruce laminating process. This will indeed add a touch of space-age design desired in the project as a whole.

All joints of the chassis were designed to incorporate a double-shear property allowing the maximum shear in the bolts to be doubled. The bolts specified have a 125,000 psi tensile rating. Generally, the maximum shear in metals is half the tensile strength. With the double shear property of the joints the shearing force in the bolts becomes approximately 125,000 psi, well over-designed for the application.

Conclusion

The final design (see Figures 7.6 and 7.7) is indeed somewhat along the lines of the New VW Beetle. It successfully pays homage to its predecessor, yet it exhibits the vast improvements that years of technological innovation have spawned. Indeed, the final chassis design most closely resembles the geometry and look of the original 1905 Flyer chassis better than any other component of the USU Wright Flyer. This is due largely in part to the lack of a need to improve its function. The chassis of the 1905 Flyer functioned well for its intended purpose, to hold the canard and wing together in flight and provide an aircraft to ground interface when taking off or landing. The wing, canard, and rudder design of the 1905 Flyer did not function well. The cockpit was poorly designed from a practical standpoint, and the motor was primitive to say the least. Hence these components saw a more serious overhaul in the USU Wright Flyer design than that of the chassis.

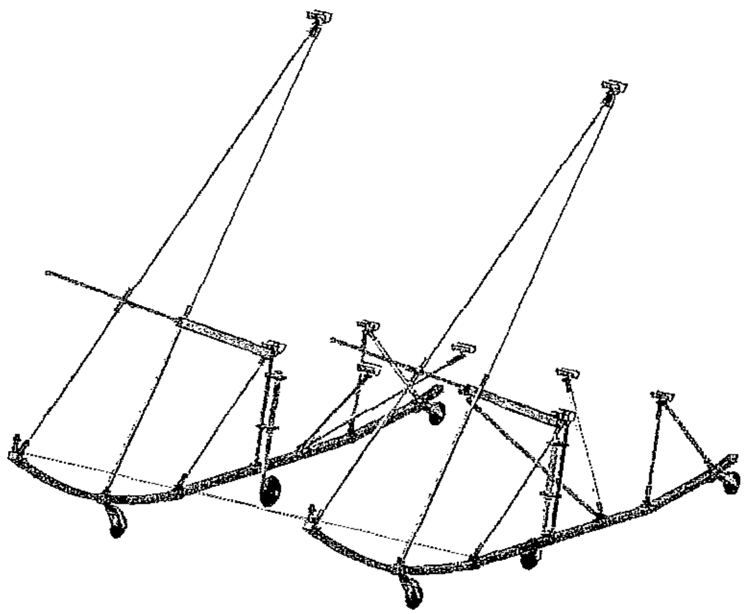


Figure 7.6: Final chassis design.

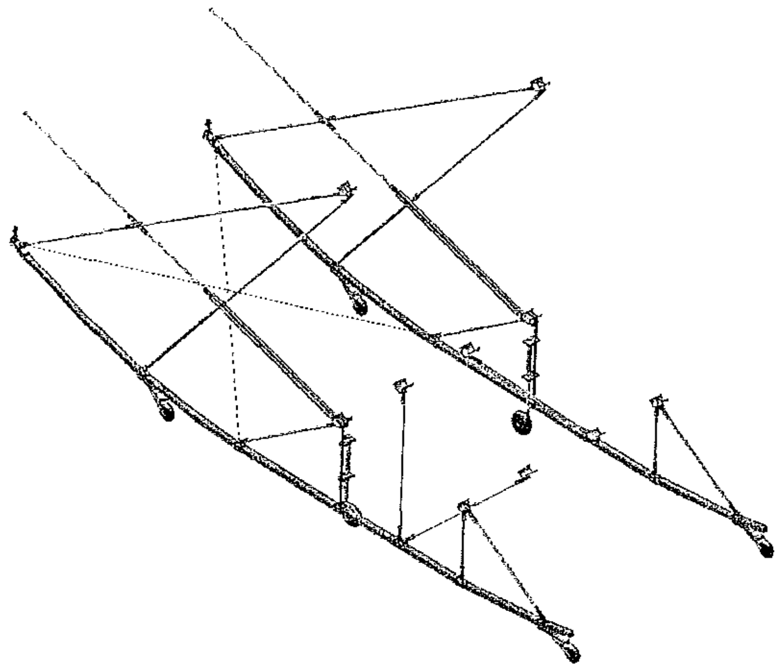
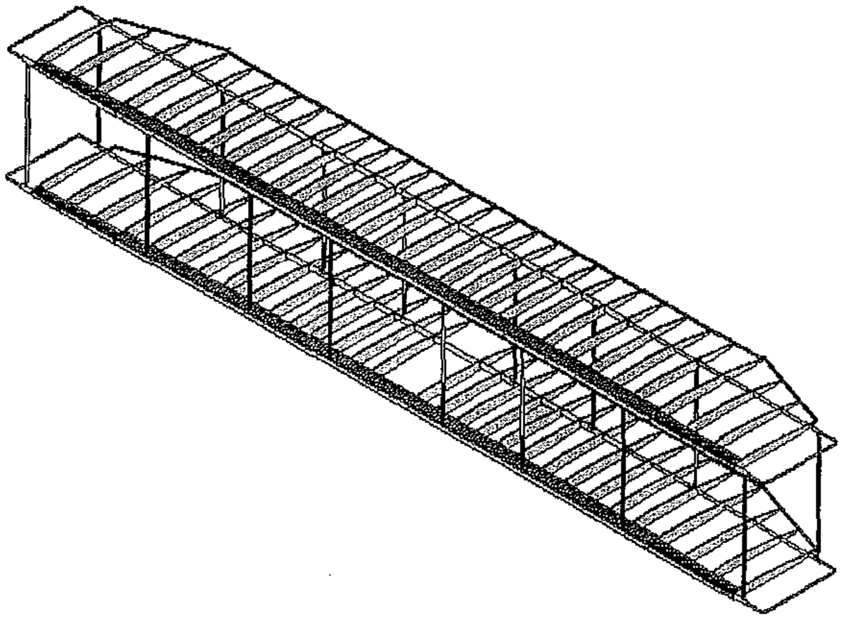


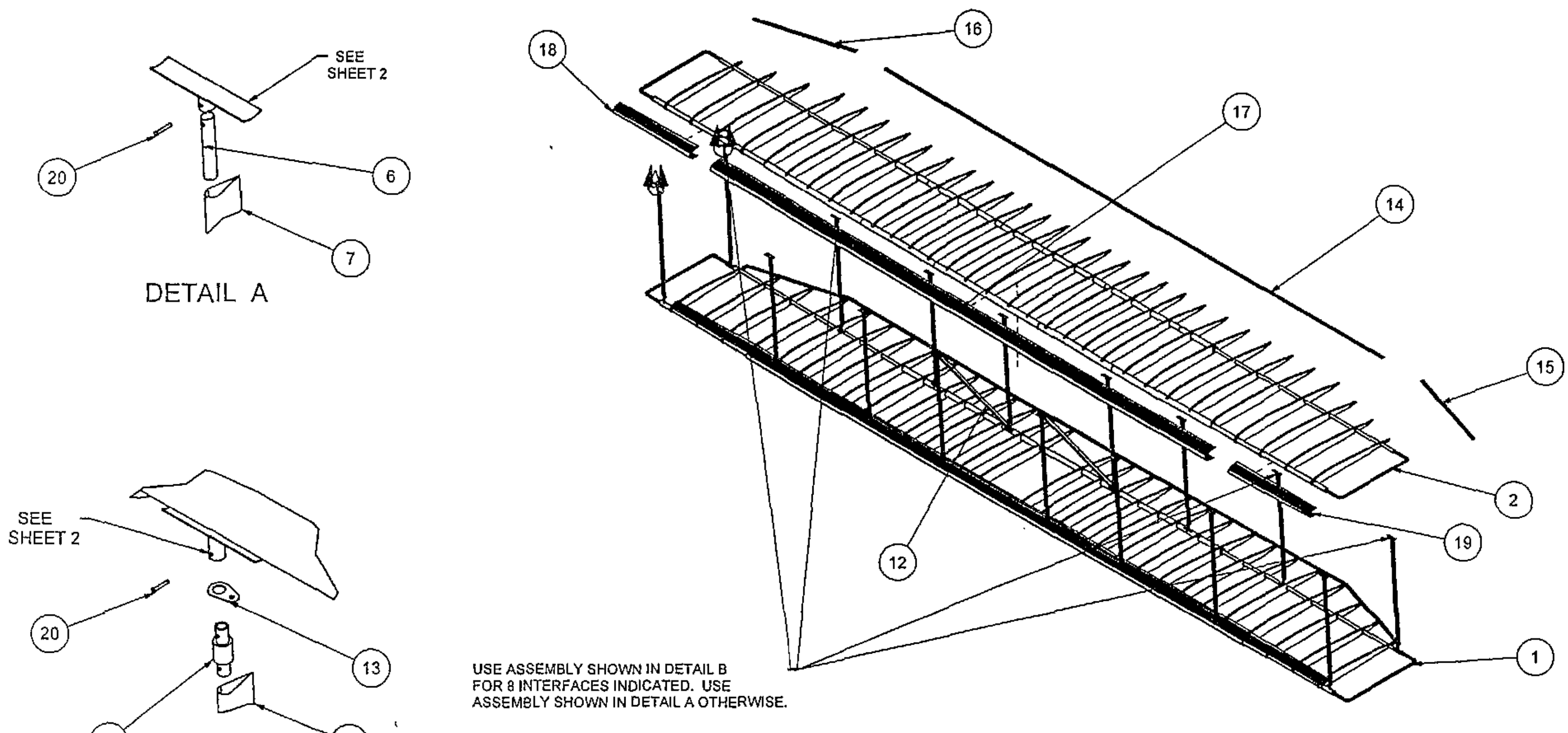
Figure 7.7: Final chassis design.

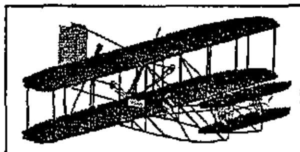
Utah State University

2003 USU Wright Flyer Drawing Package

Wing Assembly







Utah State University Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: CKESPLINI				
MATERIAL:	PART DESCRIPTION: WING ASSY		PART NUMBER: WF-10-000A	REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 4	

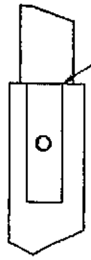
Materials List for Wings

ck spc= check drawing specifications

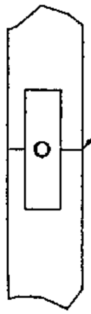
Item/Material	Description	Qty	Part #	Supplier
Aluminum Plate	.04" thick	ck spc		Aircraft Spruce
Aluminum Tube		ck spc		Aircraft Spruce
Universal Joint		ck spc		Aircraft Spruce
Clevis Pin		ck spc		Aircraft Spruce
Trailing Edge		ck spc		Aircraft Spruce

Parts List for Wings

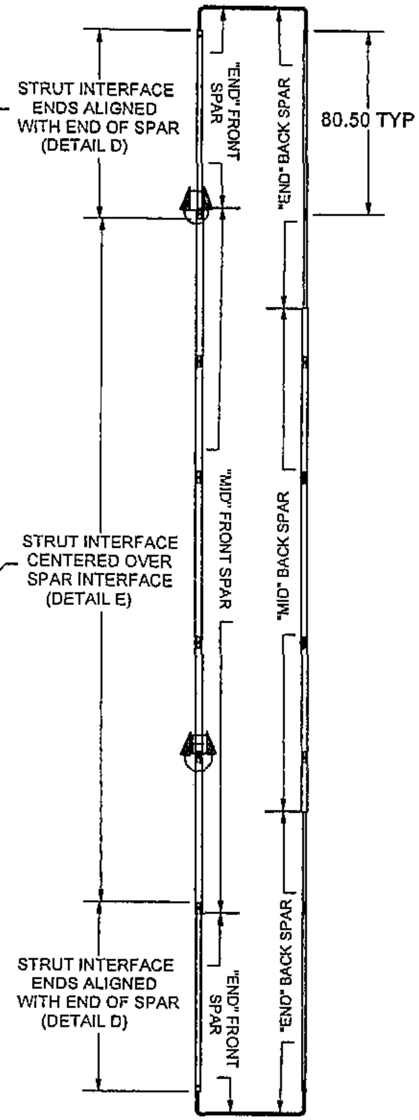
Part Number	Description	Qty	Type
WF-10-000	Assy, Wing	1	top assembly
WF-10-200	Sub-assy, Lower Wing Planform	1	assembly/adhered
WF-10-201	Sub-assy, Upper Wing Planform	1	assembly/adhered
WF-10-202	Sub-assy, Back Mid Strut Interface	10	assembly/weldament
WF-10-203	Sub-assy, Back End Strut Interface	8	assembly/weldament
WF-10-204	Sub-assy, Front Mid Strut Interface	14	assembly/weldament
WF-10-205	Sub-assy, Front End Strut Interface	4	assembly/weldament
WF-10-220	Assy, Pulley	6	assembly/bolt
WF-10-206	Strut	16	laid up & cut
WF-10-207	Cable Plate, 2-Prong	TBD	cut & drilled
WF-10-208	Cable Plate, 1-Prong	TBD	cut & drilled
WF-10-213	Leading Edge, Inner	2	laid up & cut
WF-10-214	Leading Edge, Outer Left	2	laid up & cut
WF-10-215	Leading Edge, Outer Right	2	laid up & cut
WF-10-216	Trailing Edge, Inner	2	cut from stock
WF-10-217	Trailing Edge, Outer Left	2	cut from stock
WF-10-218	Trailing Edge, Outer Right	2	cut from stock
WF-10-219	Pulley Plate	12	cut & drilled
WF-10-221	Strut Cap	28	cut and adhered
WF-10-222	X-Strut	2	laid up & cut
WF-10-300	Sub-Assy, Front Spar	2	assembly/adhered
WF-10-301	Sub-Assy, Back Spar	2	assembly/adhered
WF-10-302	Interface Plate, Back Outer	8	cut
WF-10-303	Interface Plate, Back Inner	8	cut
WF-10-304	Interface Plate, Front Inner	12	cut
WF-10-305	Interface Plate, Front Outer	4	cut
WF-10-306	Interface Tube, Strut/Spar, Front	16	cut
WF-10-307	Interface Tube, Strut/Spar, Back	16	cut
WF-10-308	Wingtip	4	cut & bent
WF-10-309	Cap, Wingtip/Front Spar	2	cut
WF-10-310	Cap, Wingtip/Back Spar	2	cut
WF-10-312	Rib, Main, Structural	34	cut & laid up
WF-10-313	Rib A	4	cut & laid up
WF-10-314	Rib B	4	cut & laid up
WF-10-316	Rib C	4	cut & laid up
WF-10-318	Rib D	4	cut & laid up
WF-10-315	Rib, Main	12	cut & laid up
WF-10-400	Spar, Front, Middle	2	laid up
WF-10-401	Spar, Front, First Outer	4	laid up
WF-10-402	Spar, Front, Second Outer	4	laid up
WF-10-403	Spar, Front, Third Outer	4	laid up
WF-10-404	Spar, Back, Middle	2	laid up
WF-10-405	Spar, Back, First Outer	4	laid up
WF-10-406	Spar, Back, Second Outer	4	laid up
WF-10-407	Spar, Back, Third Outer	4	laid up
WF-10-408	Spar Interface, Front Inner	12	laid up
WF-10-409	Spar Interface, Back Inner	8	laid up
WF-10-410	Spar Interface, Front Outer	4	cut & adhered
WF-10-411	Spar Interface, Back Outer	8	cut & adhered

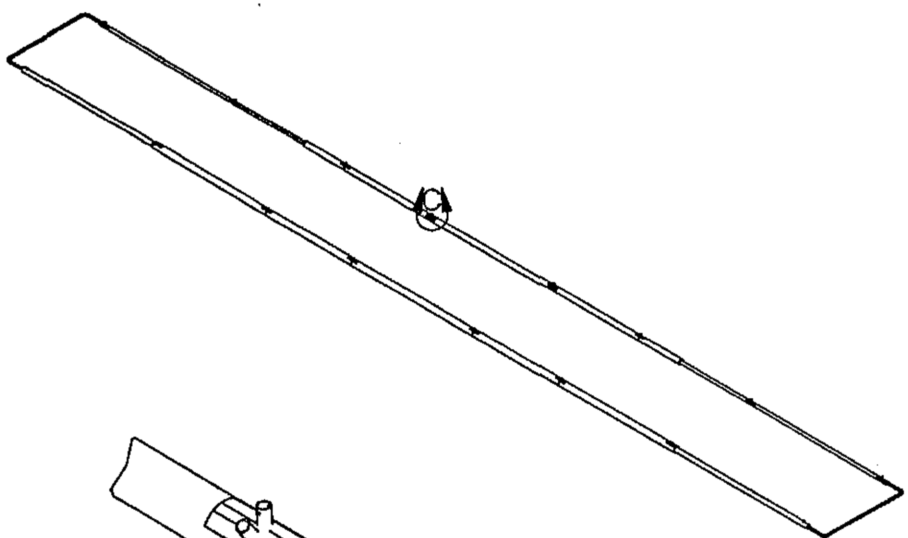


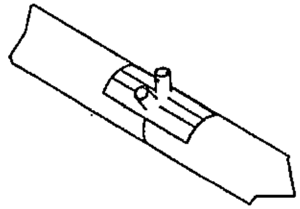
DETAIL D



DETAIL E
(NOTE 3)

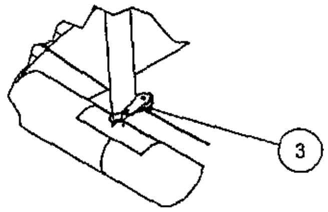




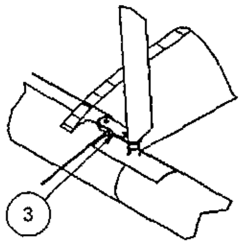


DETAIL C
(NOTE 7)

DRAWN BY: CKESPLINI	**USU WRIGHT FLYER 1903-2003**			
MATERIAL:	**PART DESCRIPTION:** WING ASSY		**PART NUMBER:** WF-10-000A	**REV** A
DATE: 2/17/2002	**SCALE:**	**SIZE:** B	**SHEET** 2 of 4	

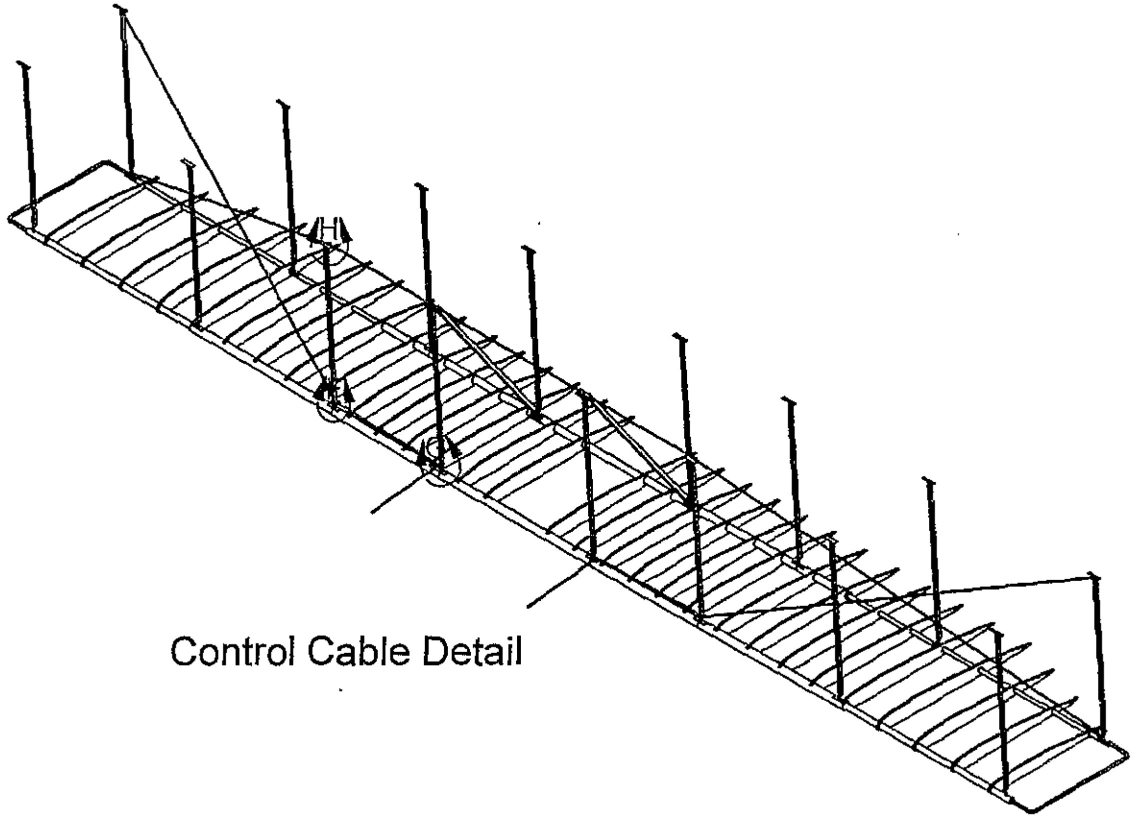


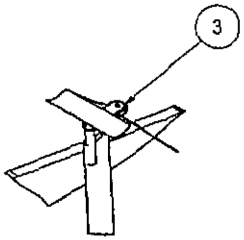
DETAIL F



DETAIL G

(NOTE 5)





DETAIL H

DRAWN BY: CKESPLIN!	USU WRIGHT FLYER 1903-2003
MATERIAL:	PART DESCRIPTION: WING ASSY — PART NUMBER: WF-10-000A — REV A
DATE: 2/17/2002	SCALE: — SIZE: B — SHEET 3 of 4

NOTES

1. GENERAL STRUT/SPAR INTERFACE ASSEMBLY REPRESENTED IN DETAIL A AND B. USE ON ALL SUCH ASSEMBLIES

2. ADHERE SPAR/STRUT INTERFACE PLATES TO SPAR WITH EPOXY AND ONE LAYYER OF EPOXIED GRAPHITE AROUND THE FLANGES

3. REFERENCE AREAS TO ATTACH INTERFACE PLATES ACCORDING TO NAME. (EX. "FRONT MID STRUT INTERFACE SUB-ASSY" (ITEM 5) WOULD BE ADHERED IN THE "MID" SPAR/STRUT REGION ON THE FRONT SPAR)

4. BOND LEADING EDGE TO SPAR AND RIBS EVERWHERE EXCEPT THE OUTER SEVEN RIBS WHERE IT IS ONLY BONDED TO THE RIBS.

5. USE ATTACHING HARDWARE AS NEEDED ON PULLEY ASSEMBLY. BEND 1-PRONG PLATE TO APPROPRIATE ANGLE TO PREVENT CABLE FROM SLIPPING OFF OF THE PULLEYS.

6. USE CABLES AND CABLE PLATES TO CREATE A STRUCTURAL CABLE SETUP THAT WILL CREATE 2° OF DIHEDRAL. ATTACHING HARDWARE AS REQUIRED.

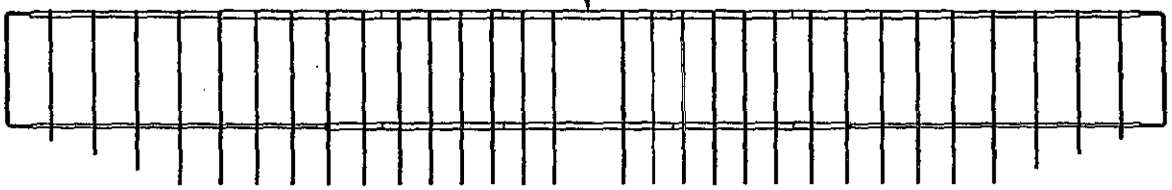
Parts List

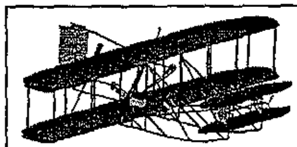
ITEM	QTY	PART NUMBER	DESCRIPTION
5	14	WF-10-204A	SUB-ASSY, FRONT MID STRUT INTERFACE
6	28	WF-10-221A	STRUT CAP
7	16	WF-10-206A	STRUT
8	4	WF-10-205A	SUB-ASSY, FRONT END STRUT INTERFACE
9	8	WF-10-203A	SUB-ASSY, BACK END STRUT INTERFACE
10	8	MS20271-B12	UNIVERSAL JOINT
11	10	WF-10-202A	SUB-ASSY, BACK MID STRUT INTERFACE
12	2	WF-10-222A	X-STRUT
13	4	WF-10-208A	CABLE PLATE, 1-PRONG
14	2	WF-10-216A	TRAILING EDGE, INNER
15	2	WF-10-217A	TRAILING EDGE, OUTER LEFT
16	2	WF-10-218A	TRAILING EDGE, OUTER RIGHT
17	2	WF-10-213A	LEADING EDGE, INNER
18	2	WF-10-215A	LEADING EDGE, OUTER RIGHT
19	2	WF-10-214A	LEADING EDGE, OUTER LEFT
20	32	AN392-21	CLEVIS PIN
21	1	05-04300	CONTROL CABLE
22	1	05-03500	STRUCTURAL CABLE
1	1	WF-10-200A	SUB-ASSY, LOWER WING PLANFORM
2	1	WF-10-201A	SUB-ASSY, UPPER WING PLANFORM
3	6	WF-10-220A	ASSY, PULLEY

USU WRIGHT FLYER 1903-2003

DRAWN BY:			
MATERIAL:	***PART DESCRIPTION:***	***PART NUMBER:***	***REV***
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 4 ***of*** 4

ASSEMBLY IS IDENTICAL TO WF-10-201 EXCEPT THAT CENTER RIB IS OMMITTED





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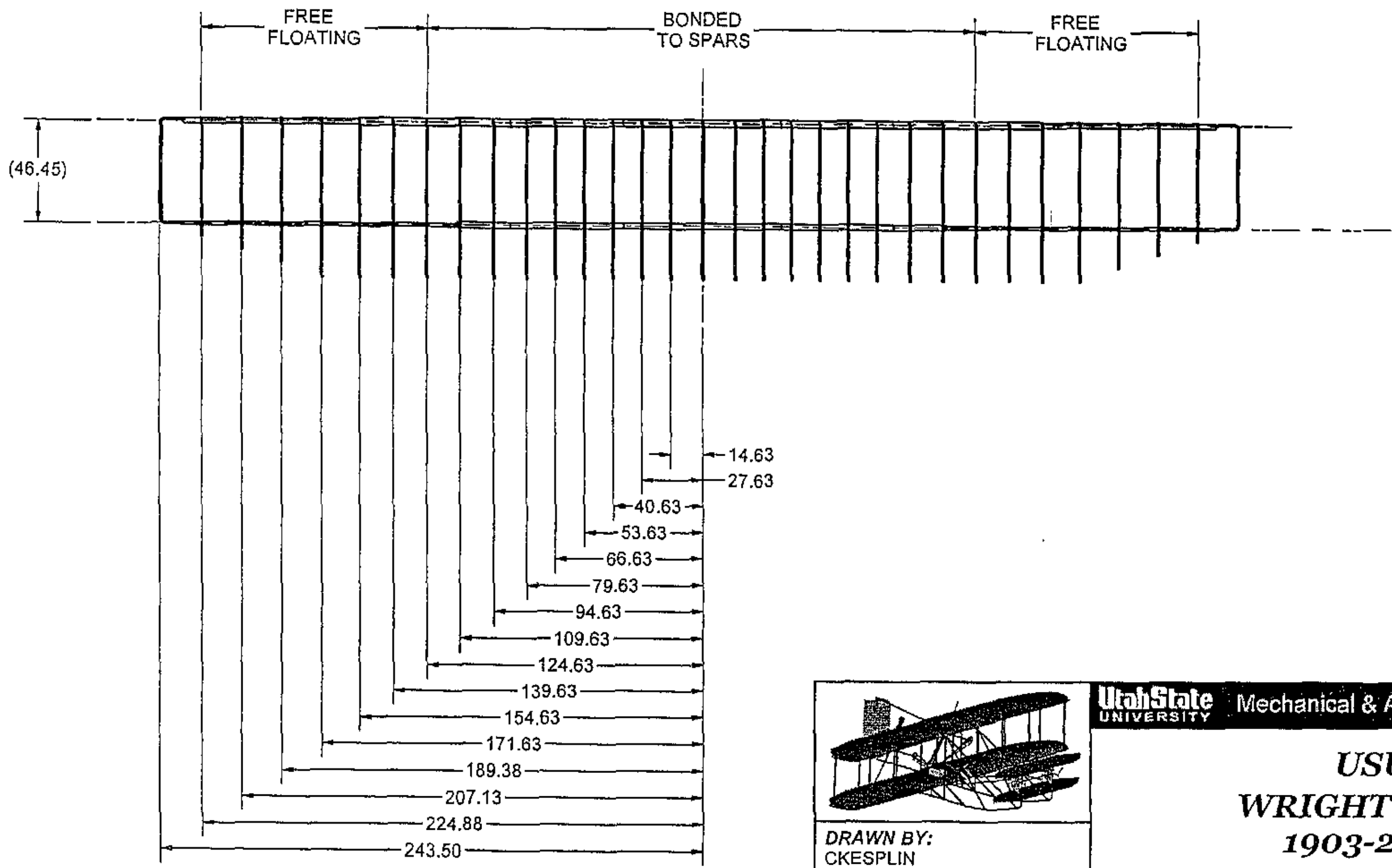
USU
WRIGHT FLYER
1903-2003

DRAWN BY: CKESPLIN				
MATERIAL:	PART DESCRIPTION: SUB-ASSY, LOWER WING PLANFORM		PART NUMBER: WF-10-200A	REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	

DETAIL A : RIB PLACEMENT *(NOTE 1)*



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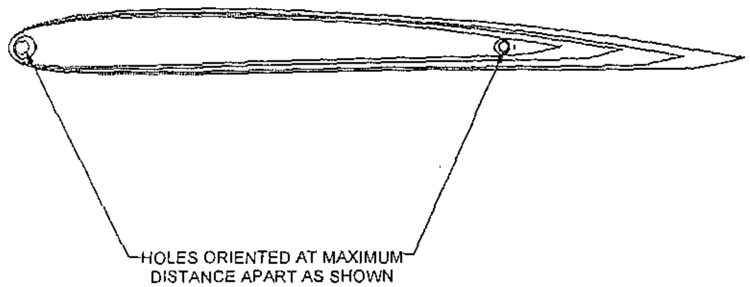
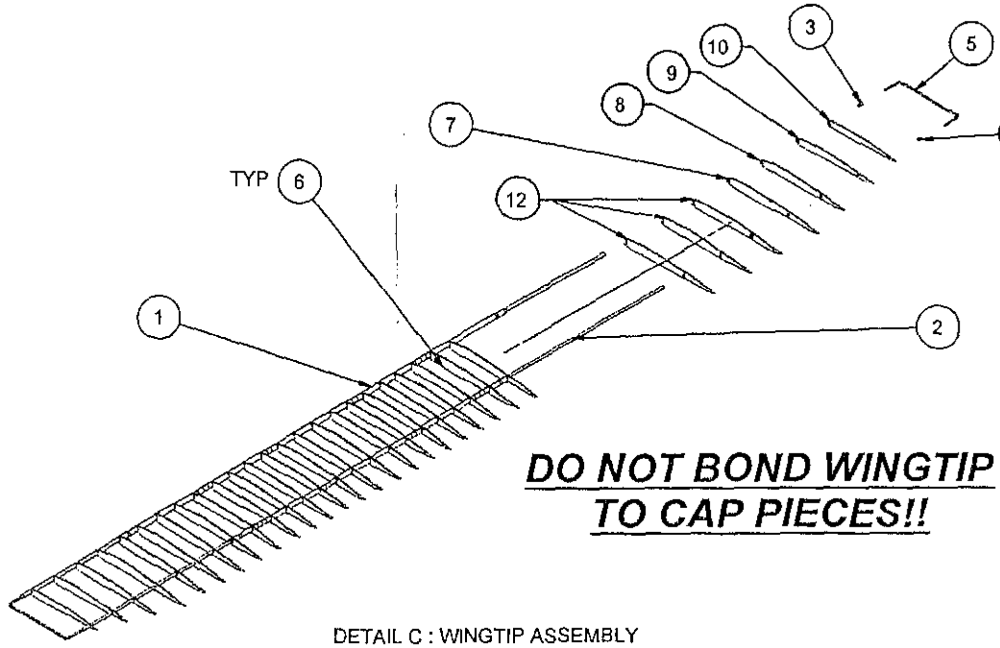
USU WRIGHT FLYER 1903-2003

DRAWN BY: CKESPLIN			
MATERIAL:	*PART DESCRIPTION:* SUB-ASSY, UPPER WING PLANFORM	*PART NUMBER:* [illegible]-201A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 of 4

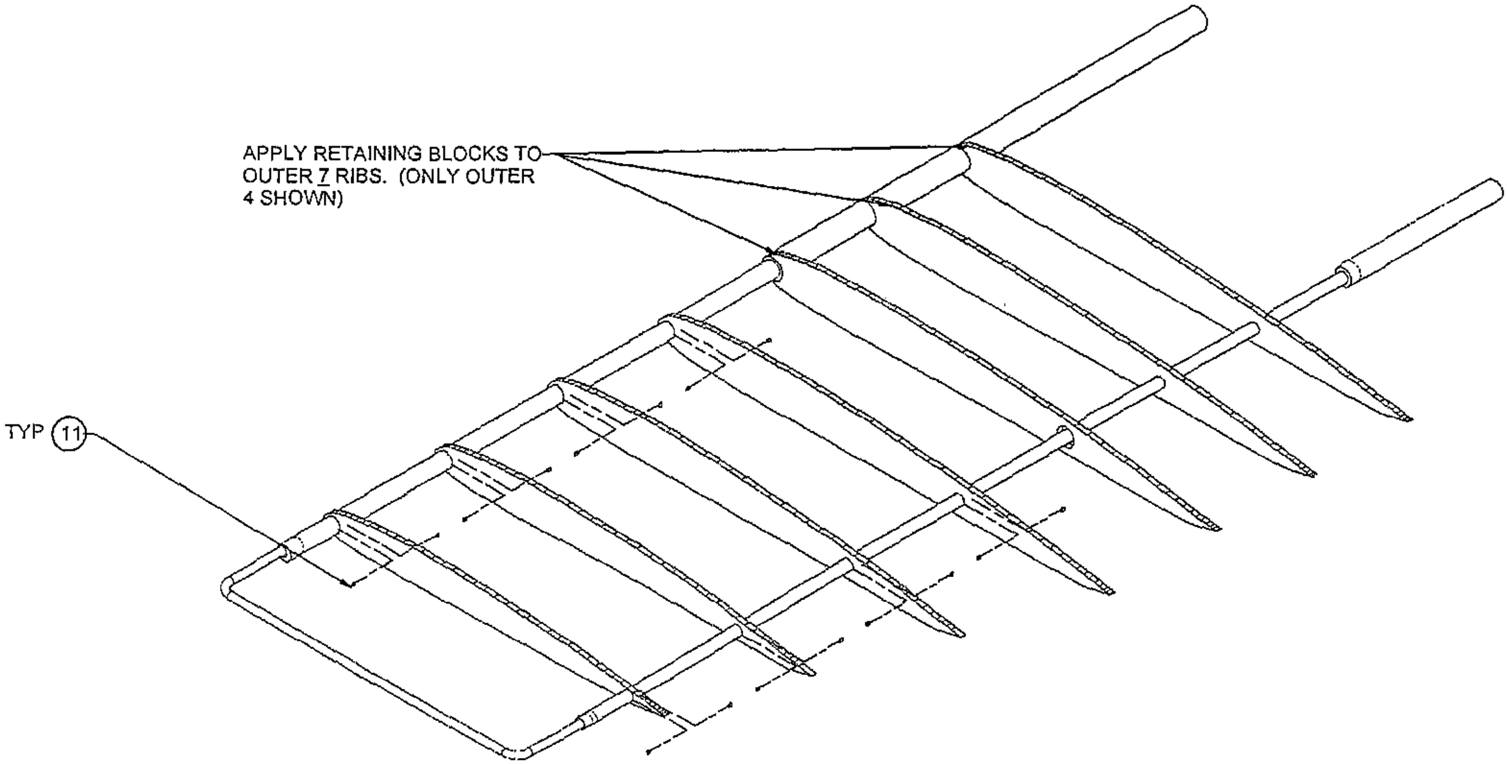


DETAIL B : SPAR CAP ALIGNMENT
(NOTE 2)



DETAIL C : WINGTIP ASSEMBLY
(NOTE 3)

DRAWN BY: CKESPLIN	**USU WRIGHT FLYER 1903-2003**			
MATERIAL:	**PART DESCRIPTION:** SUB-ASSY, UPPER WING PLA[illegible]		**PART NUMBER:** [illegible]-201A	**REV** A
DATE: 2/17/2002	**SCALE:**	**SIZE:** B	**SHEET** 2 **of** 4	



DETAIL D : RIB RETAINING BLOCK ASSEMBLY
(NOTE 4)

DRAWN BY: CKESPLIN	USU WRIGHT FLYER 1903-2003			
MATERIAL:	PART DESCRIPTION: SUB-ASSY, UPPER WING PLANFORM		PART NUMBER: [illegible]-201A	REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 3 of 4	

4 | 3 | 2 | 1

NOTES

1. BOND RIBS TO SPARS WITH STRUCTURAL ADHESIVE AS REQUIRED
2. BOND CAPS WITH STRUCTURAL ADHESIVE IN ORIENTATION AS SHOWN
3. OUTER 7 RIBS AND THE WINGTIP ARE FREE FLOATING. THE RIBS WILL BE RETAINED BY THE LEADING EDGE AND RETAINING BLOCKS. THE WINGTIP WILL BE RETAINED BY THE SKIN TENSION. PERFORM ON BOTH WINGTIPS.
4. BOND BLOCKS ON SPAR ONLY TO HOLD RIBS IN LOCATIONS SHOWN IN DETAIL A. MAKE BLOCKS TO FIT SPAR (BUILDER'S DISCRESSION).

Parts List

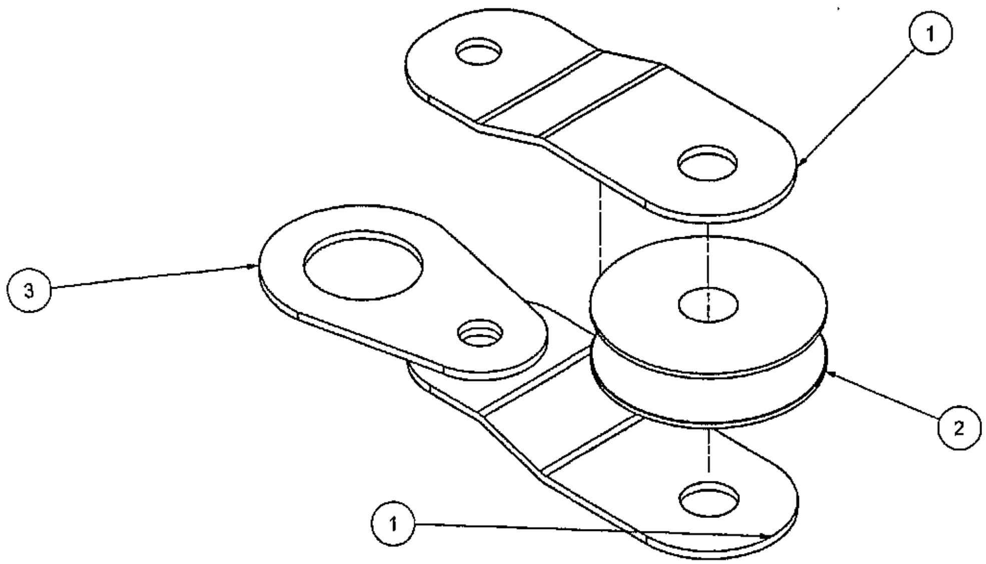
ITEM	QTY	PART NUMBER	DESCRIPTION
3	2	WF-10-309A	CAP, WINGTIP-FRONT SPAR
4	2	WF-10-310A	CAP, WINGTIP-BACK SPAR
5	2	WF-10-308A	WINGTIP
6	18	WF-10-312A	RIB, MAIN, STRUCTURAL
7	2	WF-10-313A	RIB, A
8	1	WF-10-314A	RIB, B
9	1	WF-10-318A	RIB, D
10	1	WF-10-317A	RIB, C
11	44	NONE	RIB RETAINING BLOCK
12	4	WF-10-315A	RIB, MAIN
1	1	WF-10-300A	SUB-ASSY, FRONT SPAR
2	1	WF-10-301A	SUB-ASSY, BACK SPAR

USU
WRIGHT FLYER
1903-2003

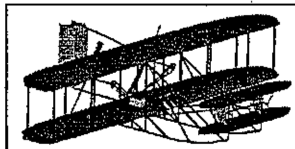
DRAWN BY:			
MATERIAL:	*PART DESCRIPTION:*	*PART NUMBER:*	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 4 *of* 4

4 | 3 | 2 | 1

NOTES
1. ATTACHING HARDWARE AS REQUIRED



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	WF-10-219A	PULLEY PLATE
2	1	A-223	PULLEY
3	1	WF-10-208A	CABLE PLATE, 1-PRONG



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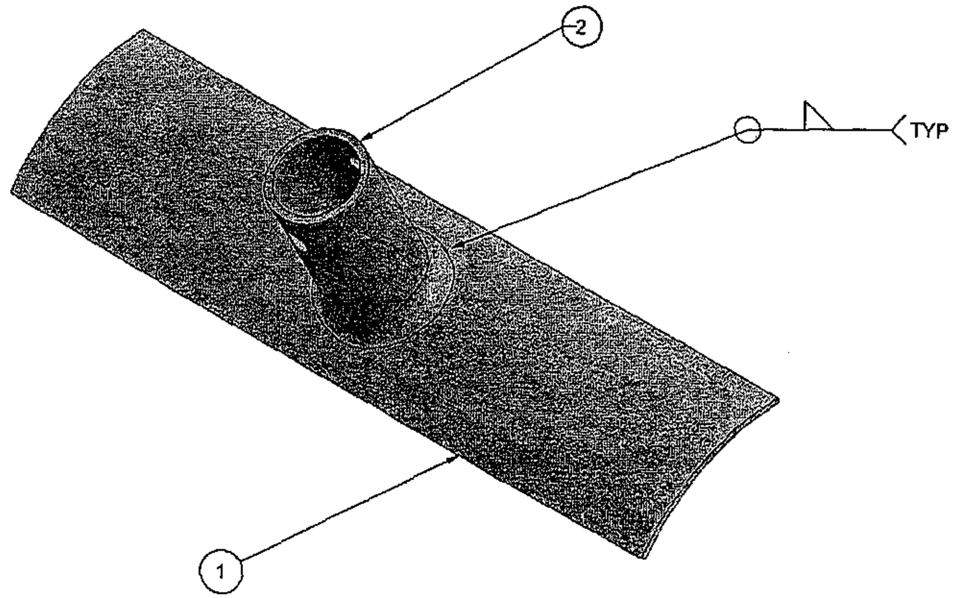
USU WRIGHT FLYER 1903-2003

DRAWN BY: CKESPLIN			
MATERIAL:	PART DESCRIPTION: ASSY, PULLEY	PART NUMBER: WF-10-220A	REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1

NOTES
1. ASSEMBLE ACCORDING TO TABLE BELOW



ASSEMBLY NUMBER	PLATE OF ASSEMBLY	TUBE OF ASSEMBLY
WF-10-202	WF-10-303	WF-10-307
WF-10-203	WF-10-302	WF-10-307
WF-10-204	WF-10-304	WF-10-306
WF-10-205	WF-10-305	WF-10-306

Parts List

ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	SEE TABLE	INTERFACE PLATE
2	1	SEE TABLE	INTERFACE TUBE

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1903-2003

DRAWN BY: CKESPLIN

MATERIAL: Aluminum-6061

PART DESCRIPTION: STRUT INTERFACE PLATES

PART NUMBER: SEE TABLE

REV A

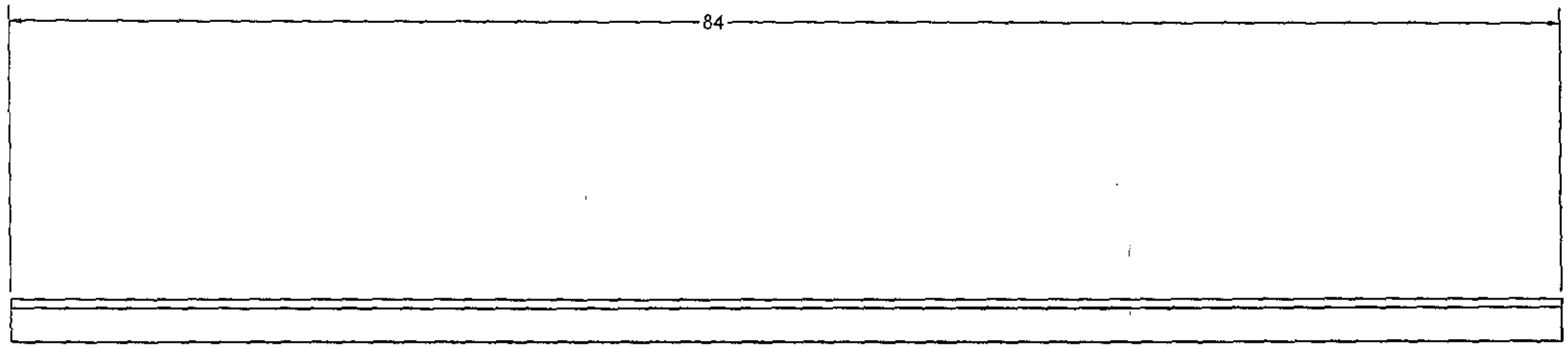
DATE: 2/17/2002

SCALE:

SIZE: B

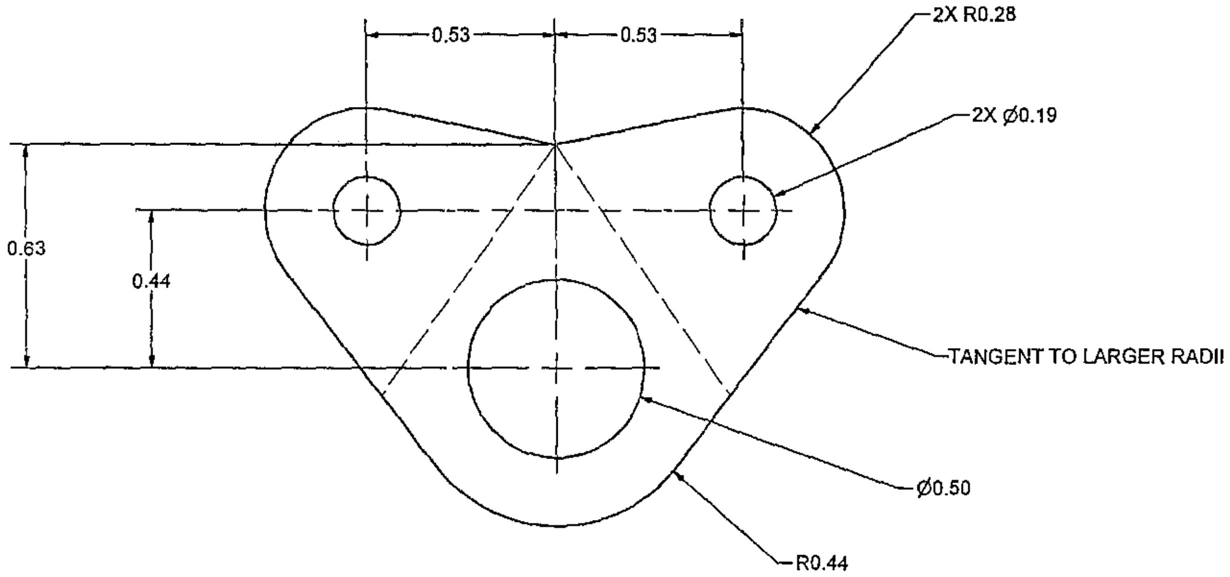
SHEET 1 ***of*** 1

1. USE MADREL AND BUILDING METHOD THAT CHUCK LARSEN WILL PROVIDE
2. LAYUP: 4/WAVY
3. NOMINAL SIZE SHOWN. CUT TO BEST FIT.



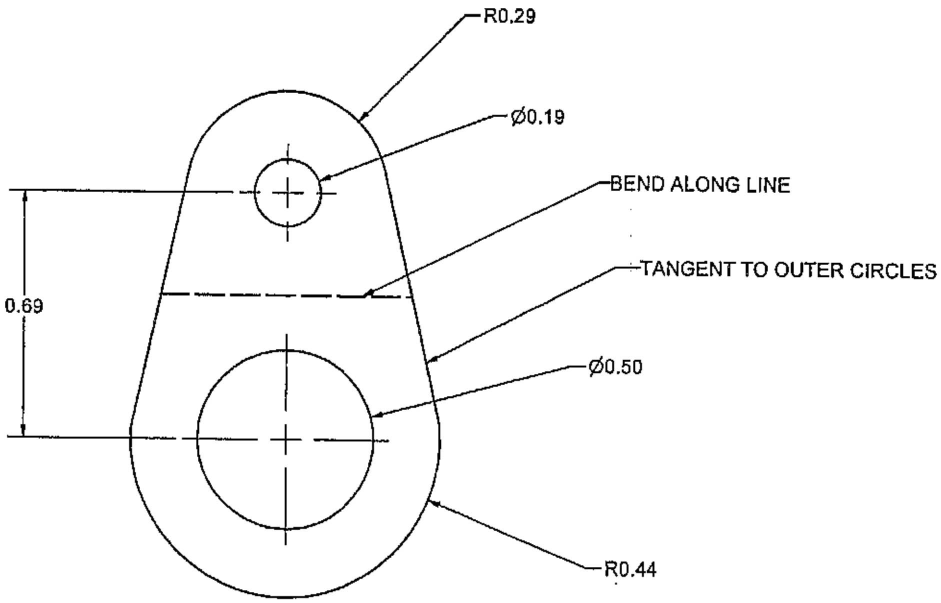
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*			
DRAWN BY: ERIC PETERSON				
MATERIAL: Graphite	*PART DESCRIPTION:* X-STRUT		*PART NUMBER:* WF-10-209A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	

1. CUT FROM .04" THICK PLATE (AIRCRAFT SPRUCE & CO. P.N. 03-31150)
2. PUNCH HOLES



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003			
DRAWN BY: CKESPLIN				
MATERIAL: Aluminum-6061	*PART DESCRIPTION:* CABLE PLATE, 2-PRONG		*PART NUMBER:* WF-10-207A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	

1. CUT FROM .04" THICK PLATE (AIRCRAFT SPRUCE & CO. P.N. 03-31150)
2. PUNCH HOLES



ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XX = ± .010
ANGLES ± 1°

DRAWN BY: CKESPLIN

MATERIAL: Aluminum-6061

DATE: 2/17/2002

UtahState UNIVERSITY Mechanical & Aerospace Engineering

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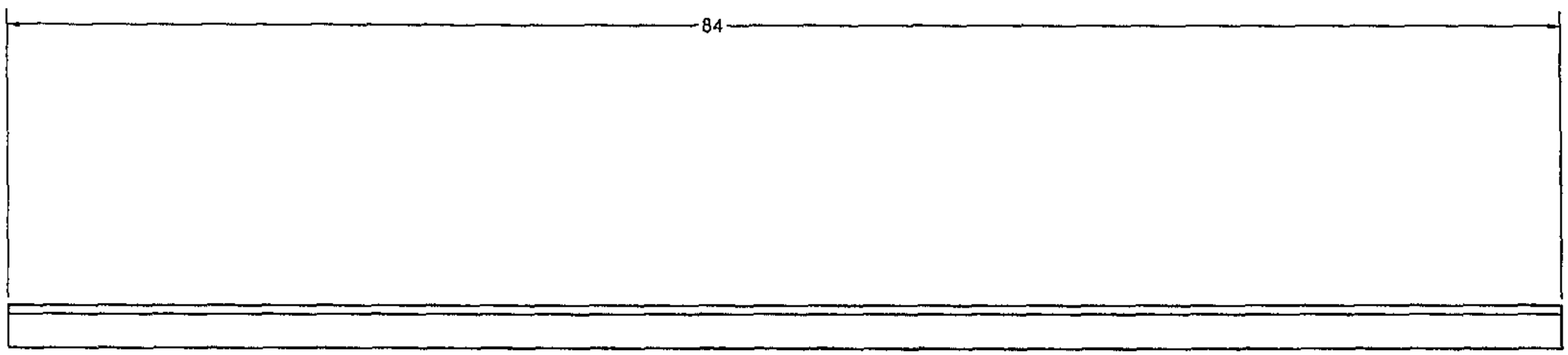
WRIGHT FLYER
1903-2003

PART DESCRIPTION:	PART NUMBER:	REV
CABLE PLATE, 1-PRONG	WF-10-208A	A

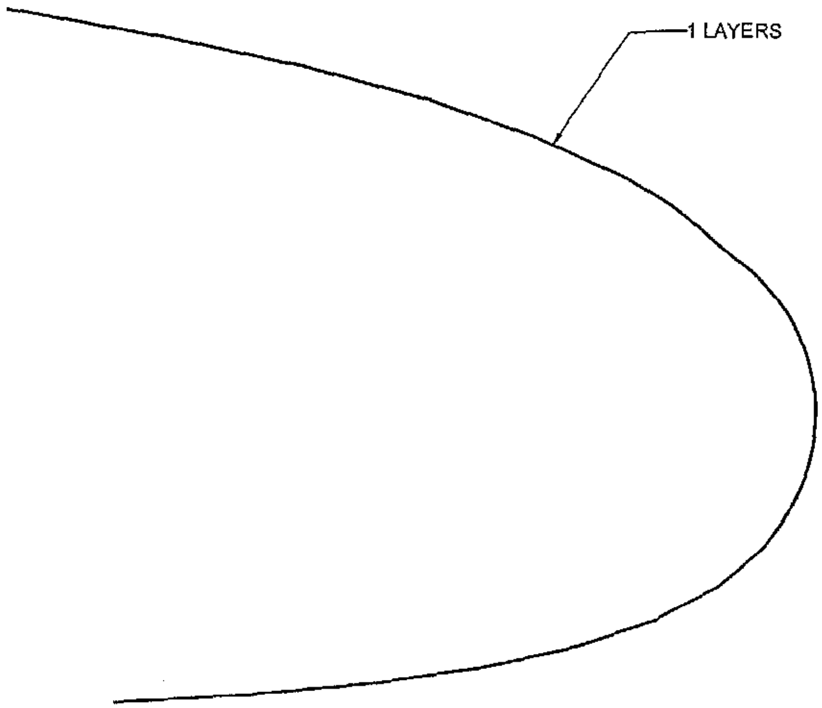
SCALE: | SIZE: B | SHEET 1 of 1

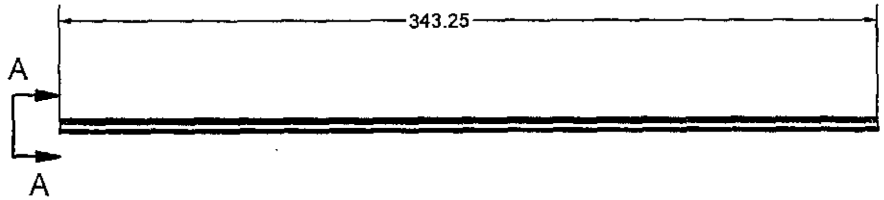
1. USE MADREL AND BUILDING METHOD THAT CHUCK LARSEN WILL PROVIDE
2. LAYUP: 4/WAVY
3. NOMINAL SIZE SHOWN. CUT TO BEST FIT.



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*			
DRAWN BY: ERIC PETERSON				
MATERIAL: Graphite	*PART DESCRIPTION:* STRUT		*PART NUMBER:* WF-10-206A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 of 1	

1. USE LEADING EDGE OF RIBS AND SPAR AS A TEMPLATE FOR PIECE
2. USE WOVEN GRAPHITE AT A 45° LAYUP

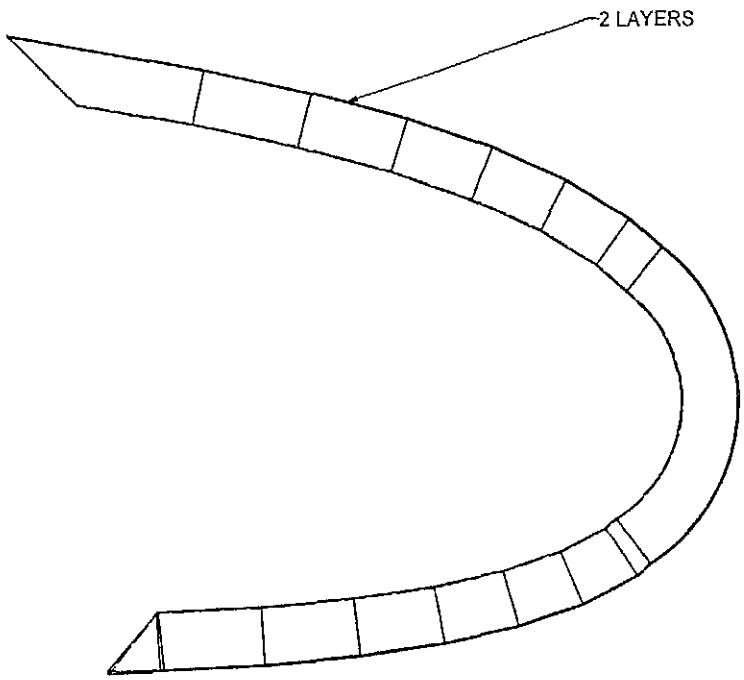




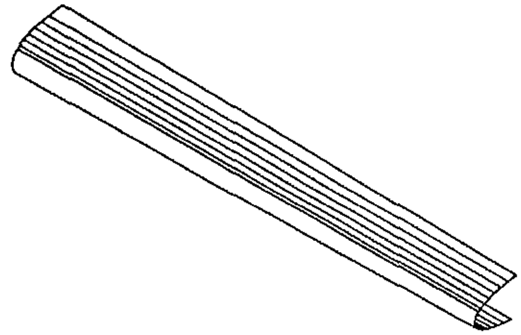
VIEW A-A
SCALE 1 : 1

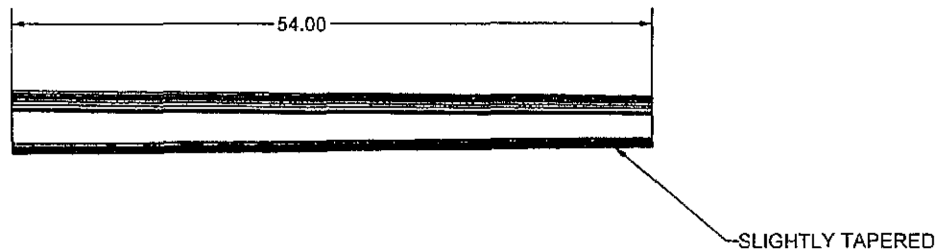
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	Utah State University Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*			
DRAWN BY: ERIC PETERSON				
MATERIAL: graphite	*PART DESCRIPTION:* LEADING EDGE, INNER		*PART NUMBER:* WF-10-213AA	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	

1. USE OUTER 54 INCHES OF WING RIBS AND SPAR TO CREATE A TEMPLATE FOR PART
2. USE WOVEN GRAPHITE AT A 45° LAYUP



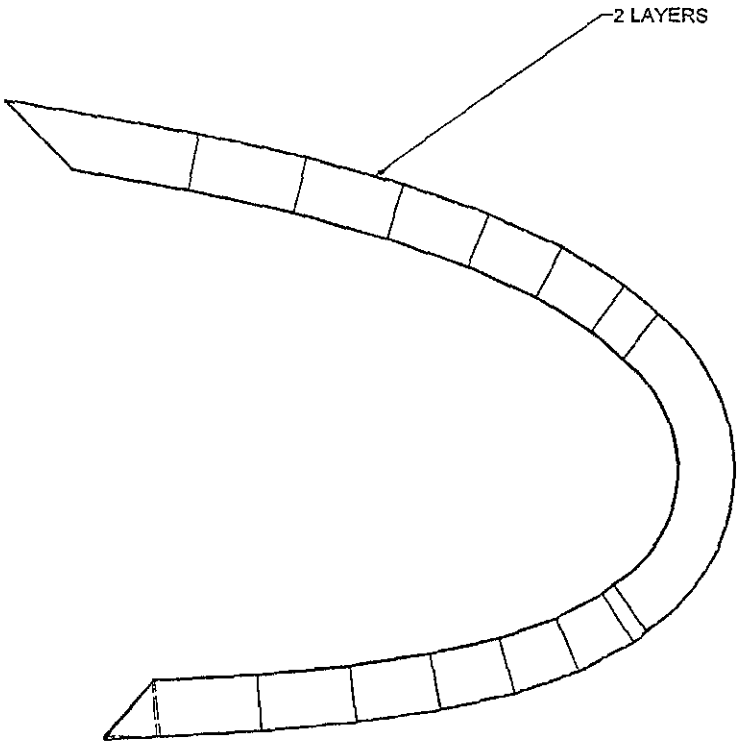
SCALE 1 : 1

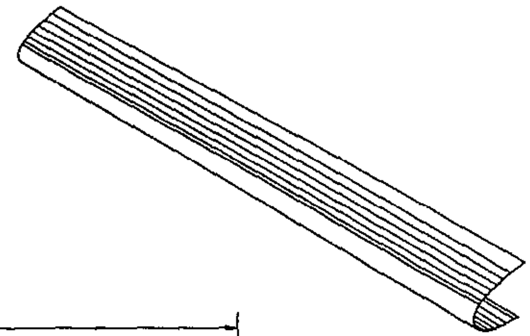


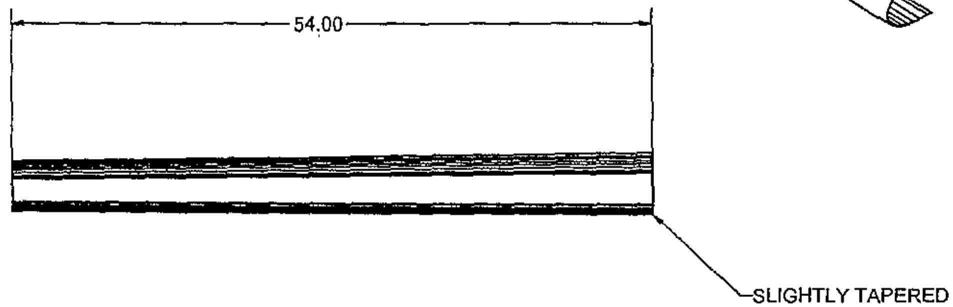


ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering			
DRAWN BY: ERIC PETERSON	USU WRIGHT FLYER 1903-2003			
MATERIAL: graphite	PART DESCRIPTION: LEADING EDGE, OUTER LEFT	PART NUMBER: WF-10-214A		REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	

1. USE OUTER 54 INCHES OF WING RIBS AND SPAR TO CREATE A TEMPLATE FOR PART
2. USE WOVEN GRAPHITE ON A 45° LAYUP



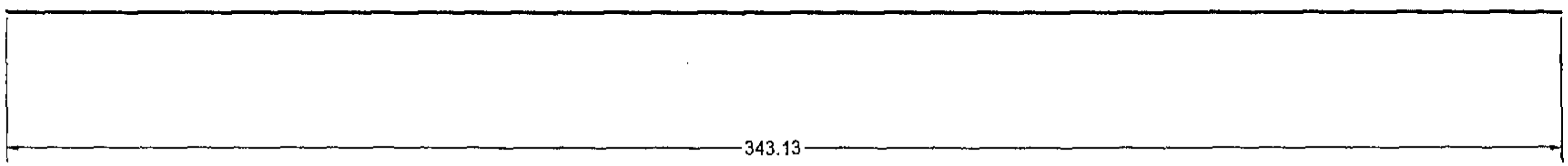




SCALE 1 : 1

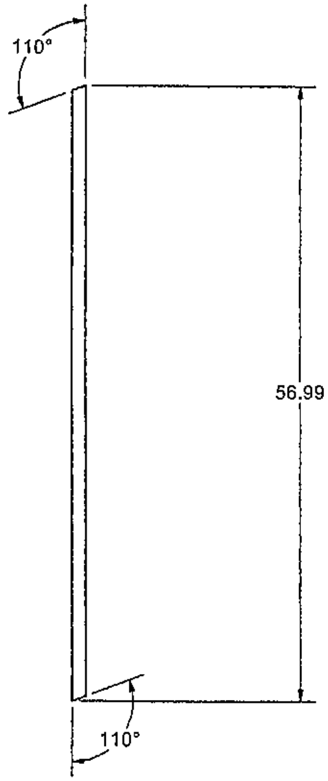
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering		
DRAWN BY: ERIC PETERSON	USU WRIGHT FLYER 1903-2003		
MATERIAL: graphite	PART DESCRIPTION: LEADING EDGE, OUTER RIGH	PART NUMBER: TWF-10-215A	REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1

1. CUT FROM AIRCRAFT SPRUCE & SPECIALTY CO. PN 03-48900
2. BEND AND CUT TO FIT TRAILING EDGE



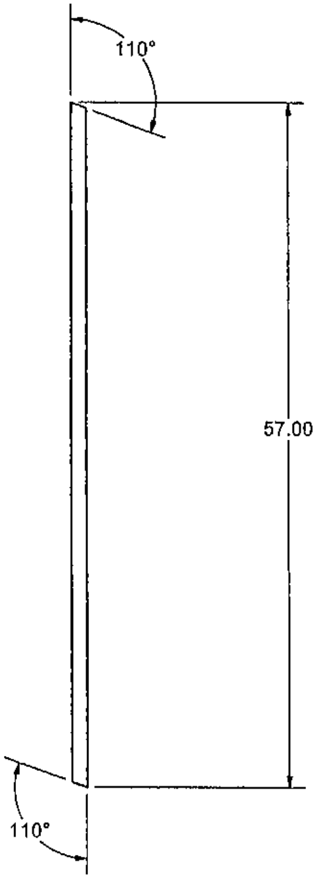
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*			
DRAWN BY: ERIC PETERSON				
MATERIAL: Trailing Edge	*PART DESCRIPTION:* TRAILING EDGE, INNER		*PART NUMBER:* WF-10-216A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	

1. CUT FROM AIRCRAFT SPRUCE & SPECIALTY CO. PN 03-48900
2. BEND AND CUT TO FIT TRAILING EDGE

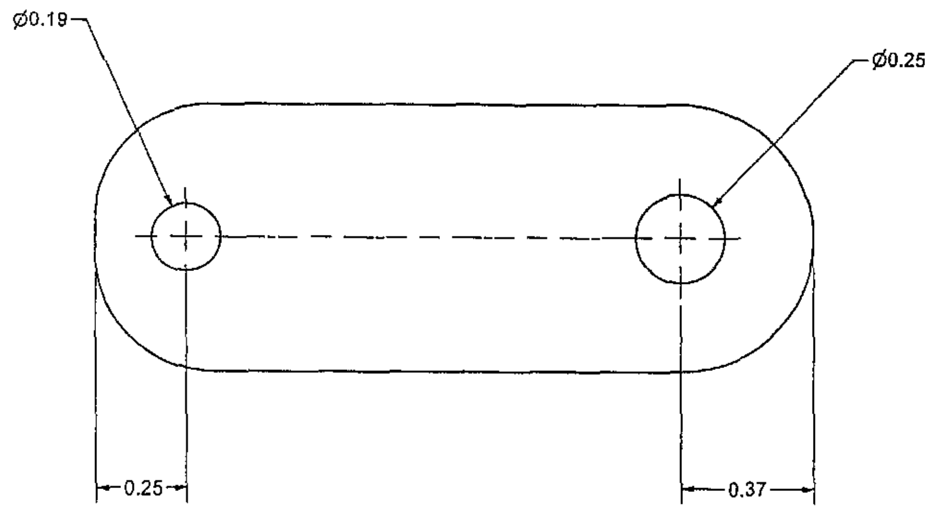


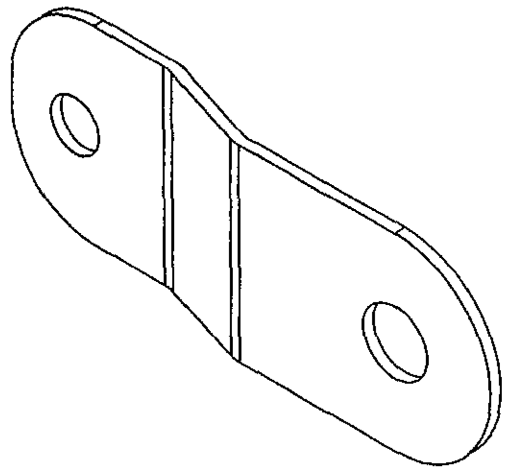
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XX = ± .010 ANGLES ± 1'	UtahState University Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003			
DRAWN BY: ERIC PETERSON				
MATERIAL: Trailing Edge	PART DESCRIPTION: TRAILING EDGE, OUTER LEFT		PART NUMBER: WF-10-217A	REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	

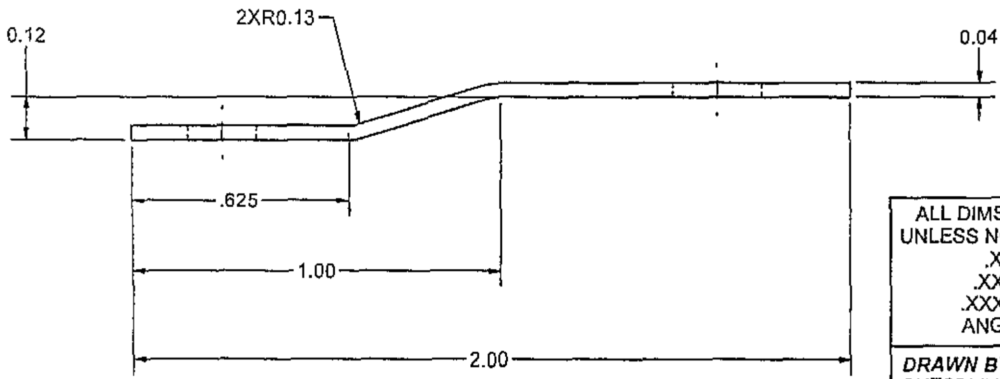
1. CUT FROM AIRCRAFT SPRUCE & SPECIALTY CO. PN 03-48900
2. BEND AND CUT TO FIT TRAILING EDGE



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003	
DRAWN BY: ERIC PETERSON		
MATERIAL:	PART DESCRIPTION: TRAILING EDGE, OUTER RIGH	PART NUMBER: WF-10-218A — REV A
DATE: 2/17/2002	SCALE:	SIZE: B — SHEET 1 of 1







ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

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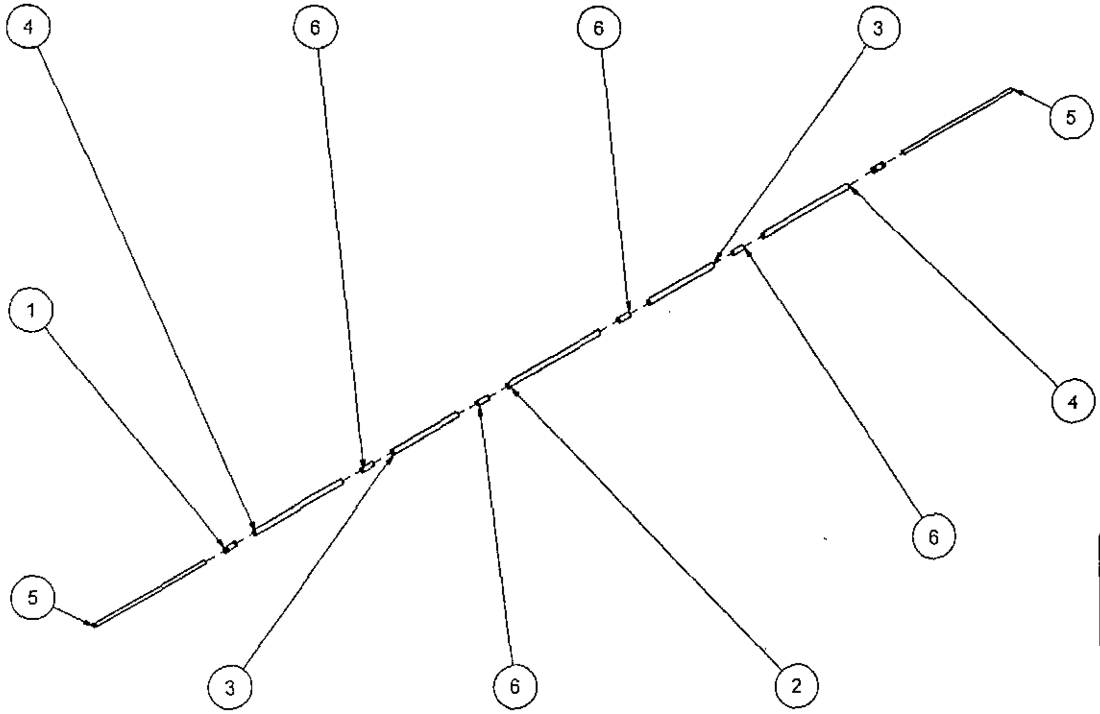
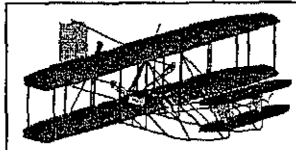
1903-2003

DRAWN BY: CKESPLIN			
MATERIAL: Aluminum-6061	PART DESCRIPTION: PULLEY PLATE	PART NUMBER: WF-10-219A	REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	WF-10-410A	SPAR INTERFACE, FRONT OUTER
2	1	WF-10-400A	SPAR, FRONT MIDDLE
3	2	WF-10-401A	SPAR, FRONT, FIRST OUTER
4	2	WF-10-402A	SPAR, FRONT, SECOND OUTER
5	2	WF-10-403A	SPAR, FRONT, THIRD OUTER
6	4	WF-10-408A	SPAR INTERFACE, FRONT INNER



UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: CKESPLIN

MATERIAL:

PART DESCRIPTION: SUB-ASSY, FRONT SPAR

PART NUMBER: WF-10-300A

REV A

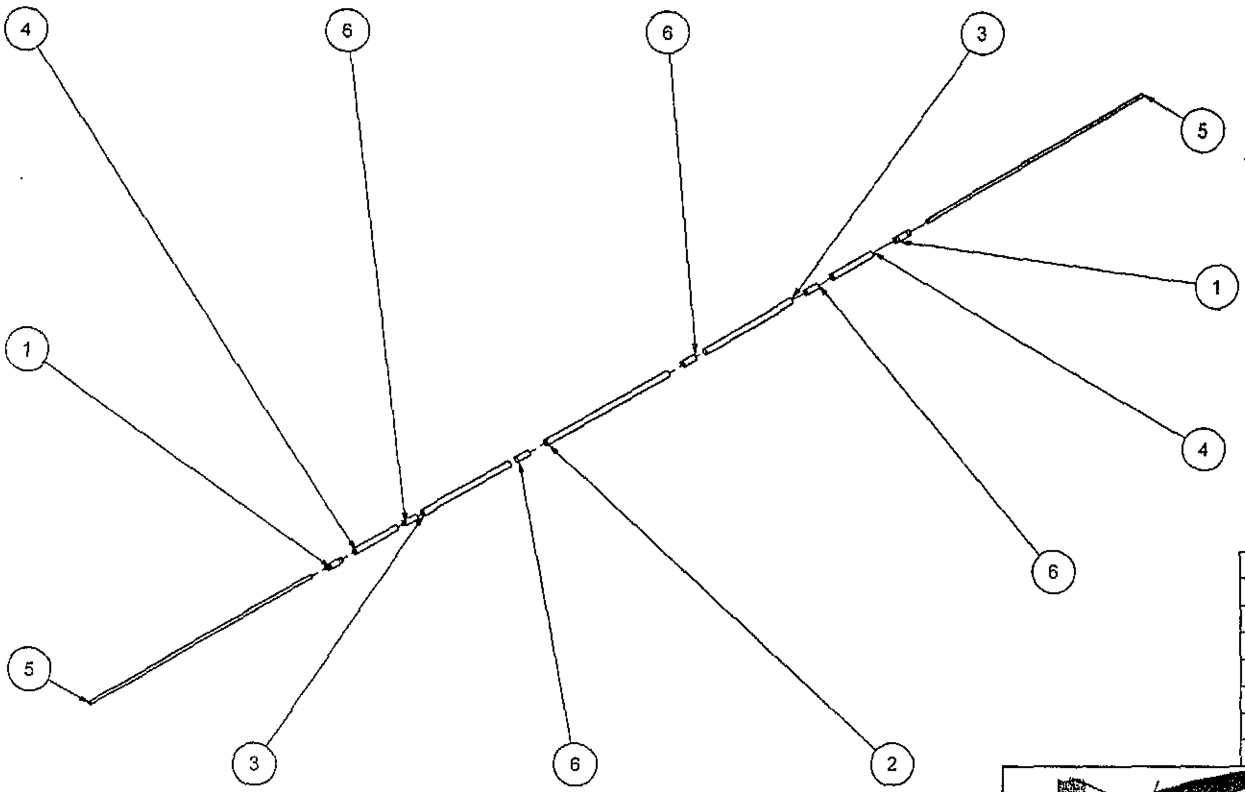
DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 *of* 1

1. ADHERE WITH STUCTURAL EPOXY



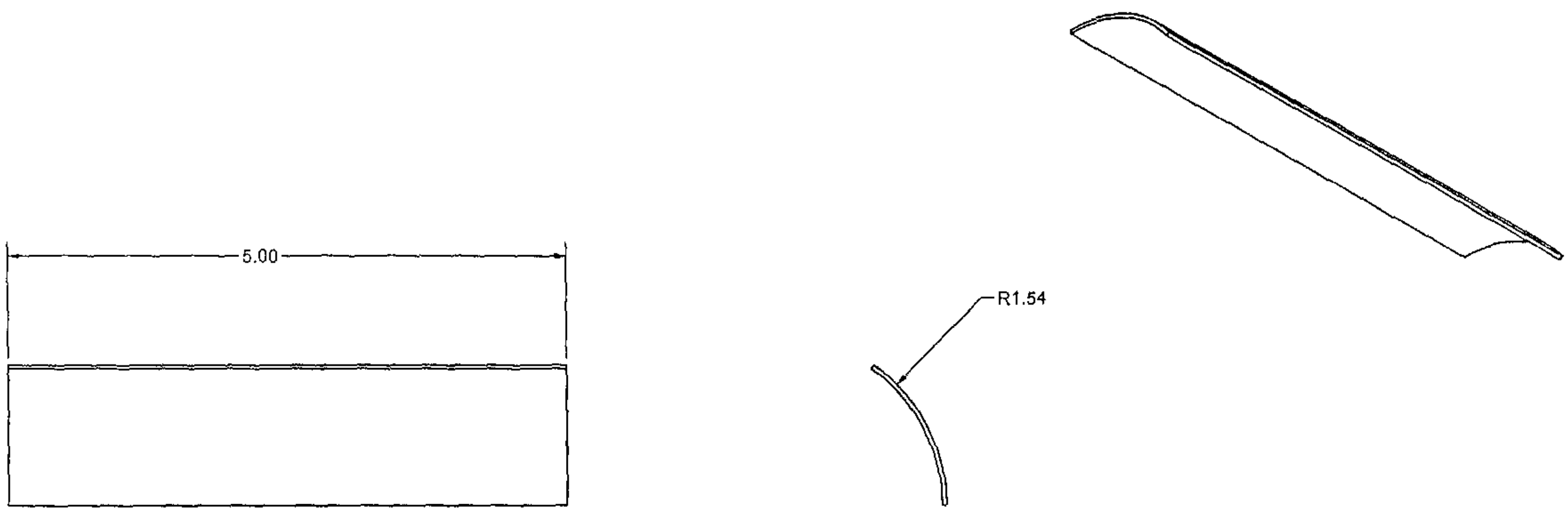
Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	WF-10-411A	SPAR INTERFACE, BACK OUTER
2	1	WF-10-404A	SPAR, BACK, MIDDLE
3	2	WF-10-405A	SPAR, BACK, FIRST OUTER
4	2	WF-10-406A	SPAR, BACK, SECOND OUTER
5	2	WF-10-407A	SPAR, BACK, THIRD OUTER
6	4	WF-10-409A	SPAR INTERFACE, BACK INNER

Utah State University Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

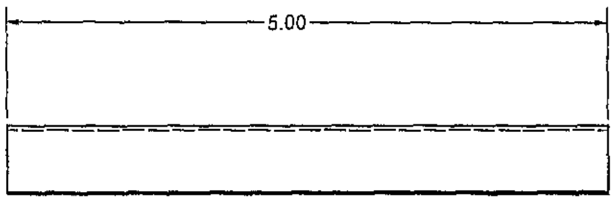
DRAWN BY: CKESPLIN			
MATERIAL:	*PART DESCRIPTION:* SUB-ASSY, BACK SPAR	*PART NUMBER:* WF-10-301A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1

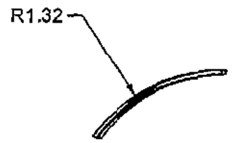
1. CUT PART FROM 5"x1.5" PLATE   AIRCRAFT SPRUCE & SPECIALTY CO. PN 03-31150
2. BEND PLATE TO RADIUS

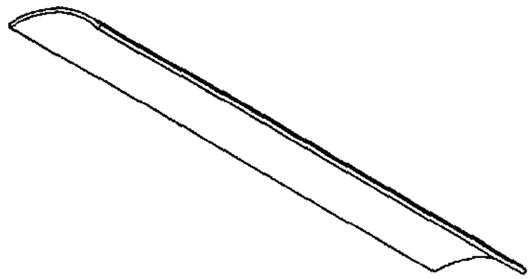


ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*		
DRAWN BY: CKESPLIN			
MATERIAL:	*PART DESCRIPTION:* INTERFACE PLATE, BACK OUTER	*PART NUMBER:* WF-10-302A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1

1. CUT PART FROM 5"x1.5" PLATE AIRCRAFT SPRUCE & SPECIALTY CO. PN 03-31150
2. BEND PLATE TO RADIUS

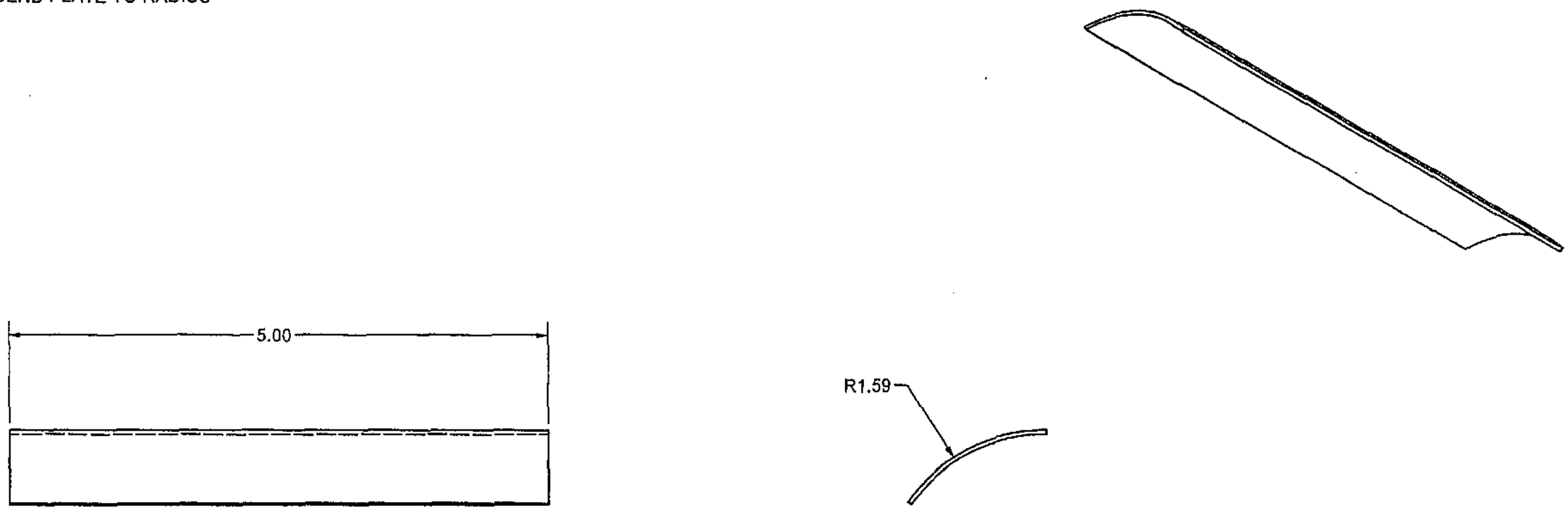






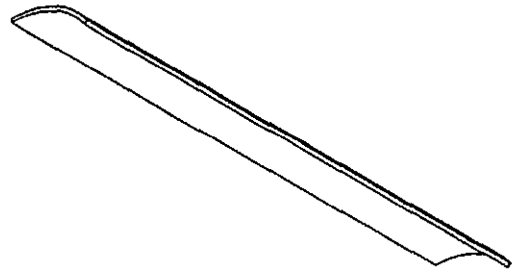
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003
DRAWN BY: CKESPLIN	
MATERIAL: Aluminum-6061	PART DESCRIPTION: INTERFACE PLATE, FRONT OUTER — PART NUMBER: WR10-303A — REV A
DATE: 2/17/2002	SCALE: — SIZE: B — SHEET 1 of 1

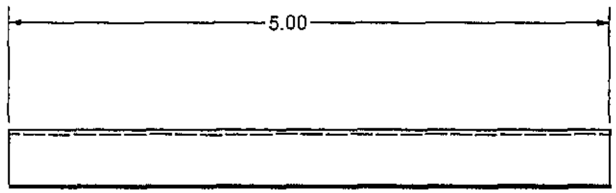
1. CUT PART FROM 5"x1.5" PLATE AIRCRAFT SPRUCE & SPECIALTY CO. PN 03-31150
2. BEND PLATE TO RADIUS

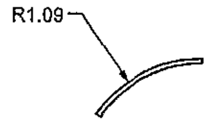


ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	UtahState University Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*			
DRAWN BY: CKESPLIN				
MATERIAL: Aluminum-6061	*PART DESCRIPTION:* INTERFACE PLATE, INNER		*PART NUMBER:* WF-10-304A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	

1. CUT PART FROM 5"x1.5" PLATE   AIRCRAFT SPRUCE & SPECIALTY CO. PN 03-31150
2. BEND PLATE TO RADIUS

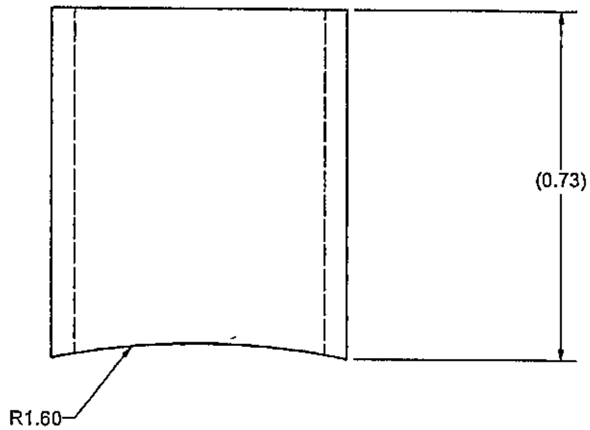






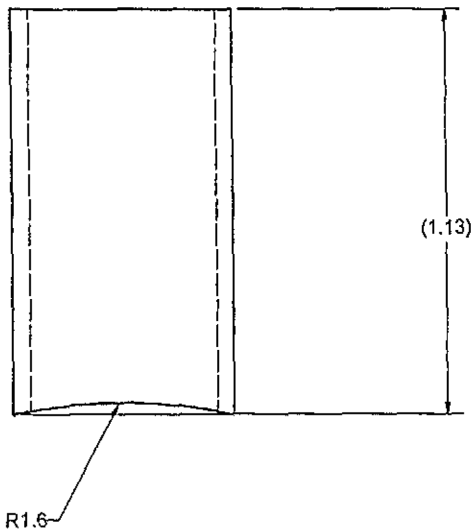
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	Utah State University · Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*	
DRAWN BY: CKESPLIN		
MATERIAL:	*PART DESCRIPTION:* INTERFACE PLATE, FRONT OUTER *PART NUMBER:* WF10-305A	*REV* A
DATE: 2/17/2002	*SCALE:* · *SIZE:* B	*SHEET* 1 of 1

1. CUT FROM TUBE STOCK (AIRCRAFT SPRUCE & CO. P.N. 03-36400)



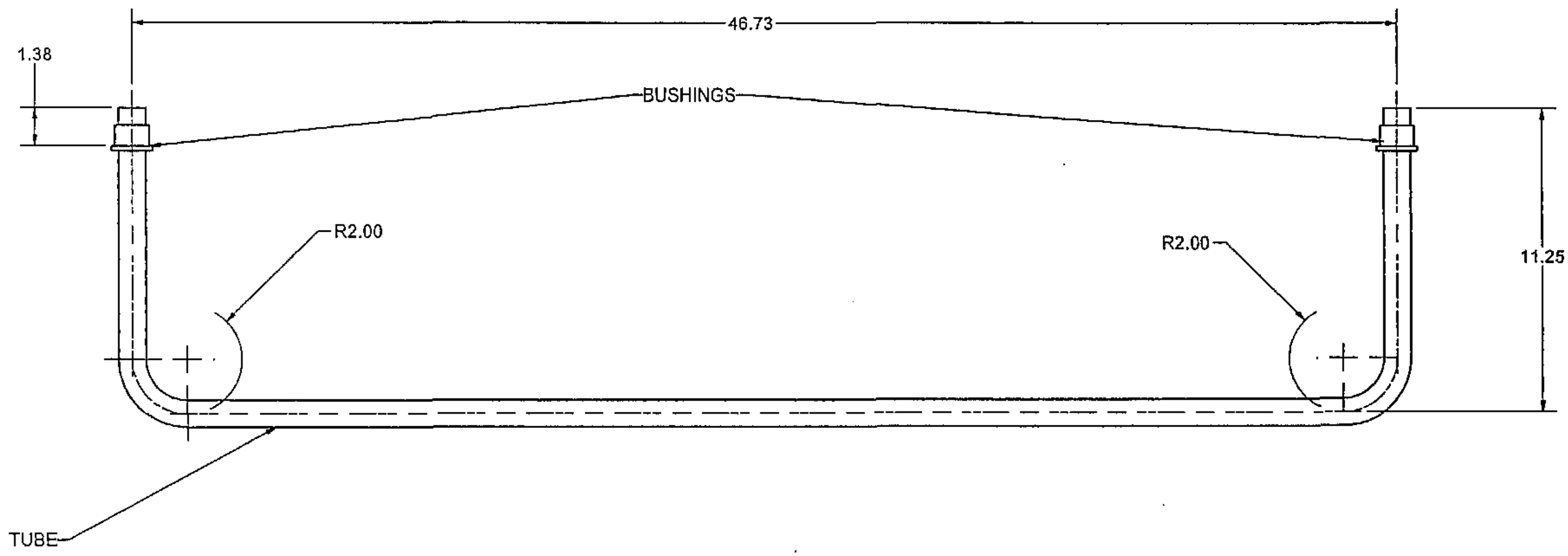
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XX = ± .010 ANGLES ± 1°	UtahState University Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*			
DRAWN BY: CKESPLIN				
MATERIAL: Aluminum-6061	*PART DESCRIPTION:* INTERFACE TUBE, FRONT		*PART NUMBER:* WF-10-306A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	

1. CUT FROM TUBE STOCK (AIRCRAFT SPRUCE & CO. P.N. 03-36400)

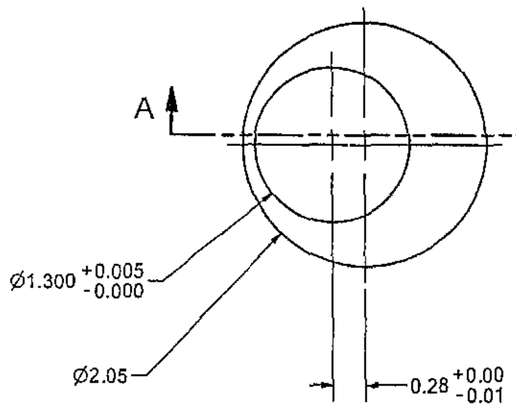


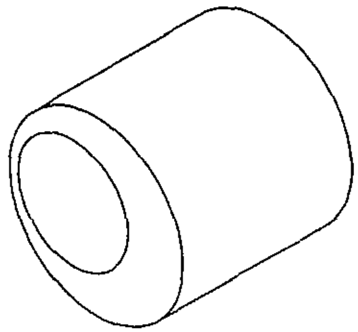
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XX = ± .010 ANGLES ± 1'	Utah State University Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003				
DRAWN BY: CKESPLIN					
MATERIAL: Aluminum-6061	PART DESCRIPTION: INTERFACE TUBE, BACK		PART NUMBER: WF-10-307A		REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1		

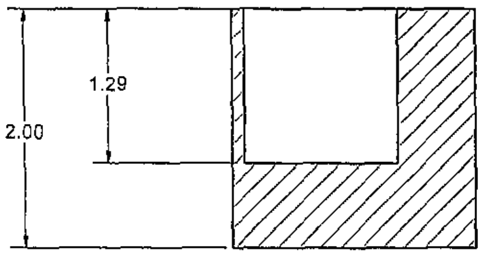
1. USE 1" TUBE AIRCRAFT SPRUCE & SPECIALTY CO. PN 03-36600
2. BUSHING, AIRCRAFT SPRUCE & SPECIALTY CO. PN: FB1620-06



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XX = ± .010 ANGLES ± 1°	Utah State University Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003			
DRAWN BY: CKESPLIN				
MATERIAL:	PART DESCRIPTION: WINGTIP		PART NUMBER: WF-10-308A	REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	

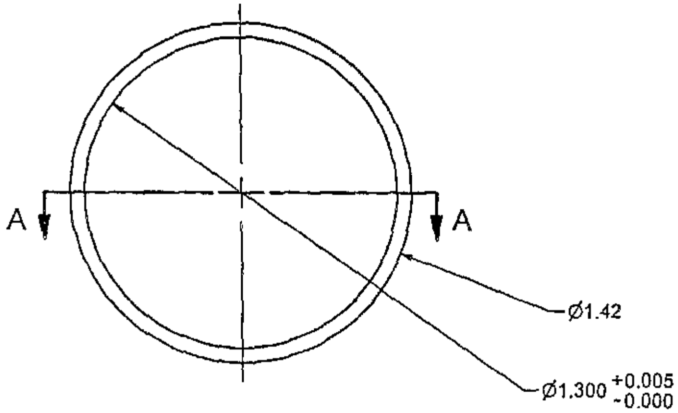


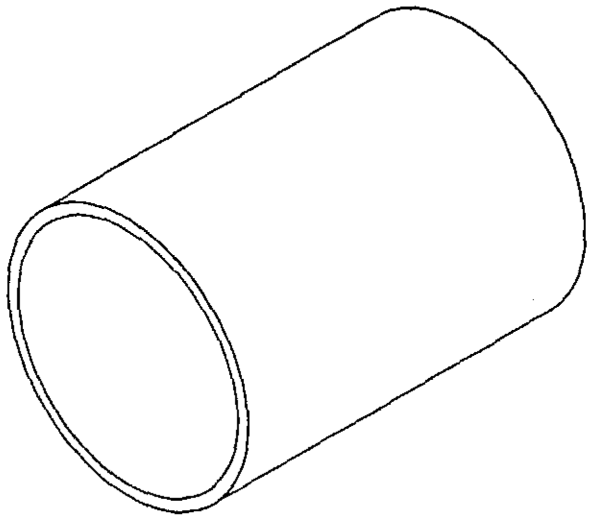


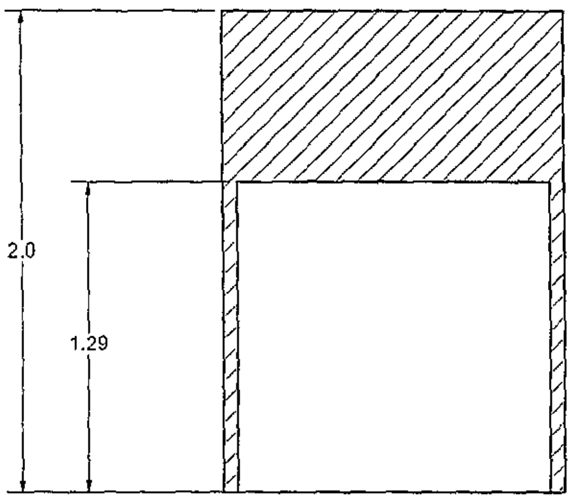


SECTION A-A

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003			
DRAWN BY: CKESPLIN				
MATERIAL: SPRUCE	*PART DESCRIPTION:* CAP, WINGTIP-FRONT SPAR		*PART NUMBER:* WF-10-309A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



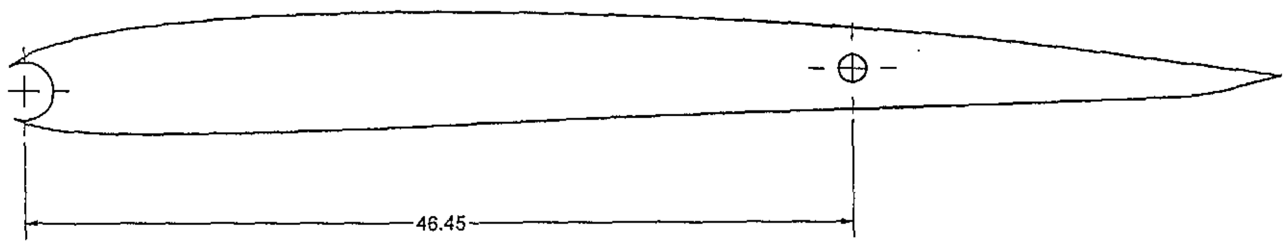




SECTION A-A

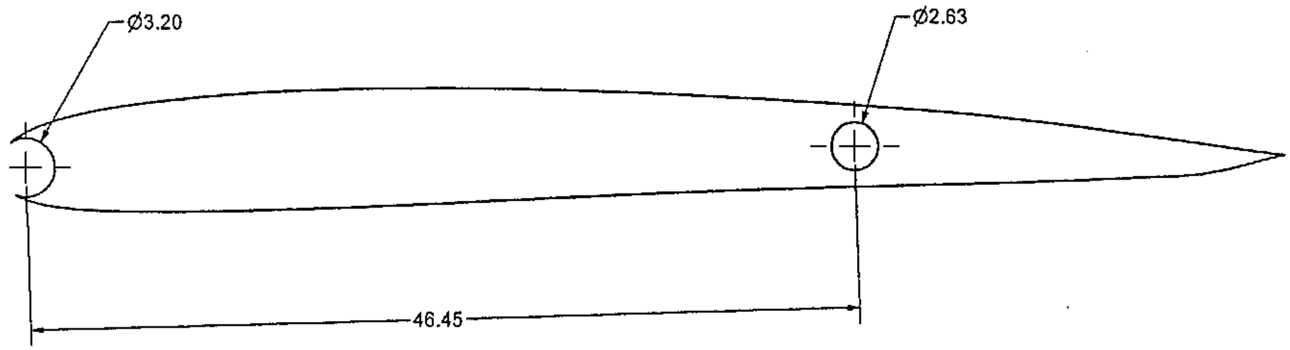
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*		
DRAWN BY: CKESPLIN			
MATERIAL: SPRUCE	*PART DESCRIPTION:* CAP, WINGTIP-BACK SPAR	*PART NUMBER:* WF-10-310A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1

1. CUT PATTERN FROM 1" FOAM USING TEMPLATE WF-10-311-T1
2. COVER FOAM WITH 1 LAYER KEVLAR
3. FINAL WEIGHT MUST NOT EXCEED 0.45 LB



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	Utah State University — Mechanical & Aerospace Engineering			
DRAWN BY: CKESPLIN	***USU WRIGHT FLYER 1903-2003***			
MATERIAL: FoamComposite	*PART DESCRIPTION:* RIB, MAIN		*PART NUMBER:* WF-10-311A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	

1. CUT PATTERN FROM 1" FOAM USING TEMPLATE WF-10-312-T1
2. COVER FOAM WITH 1 LAYER KEVLAR
3. FINAL WEIGHT MUST NOT EXCEED 0.45 LB



ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: CKESPLIN

MATERIAL: FoamComposite

PART DESCRIPTION: RIB, MAIN

PART NUMBER: WF-10-312A

REV A

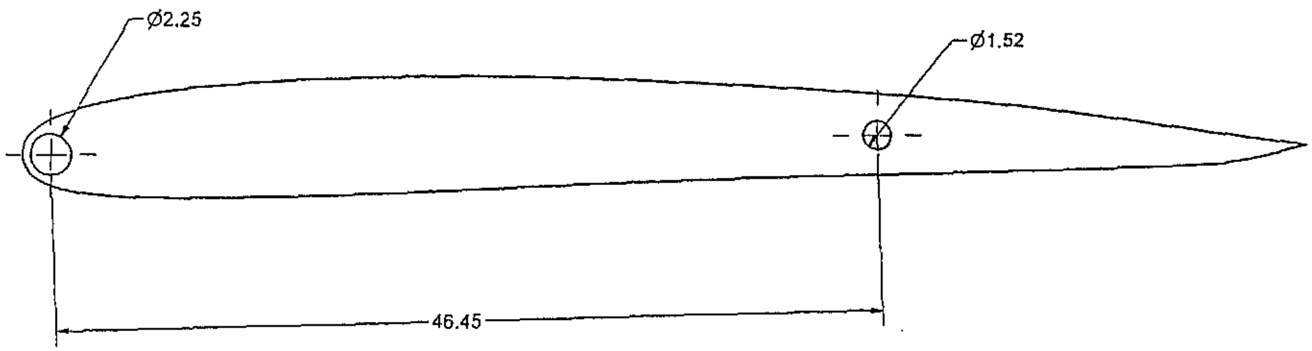
DATE: 2/17/2002

SCALE:

SIZE: B

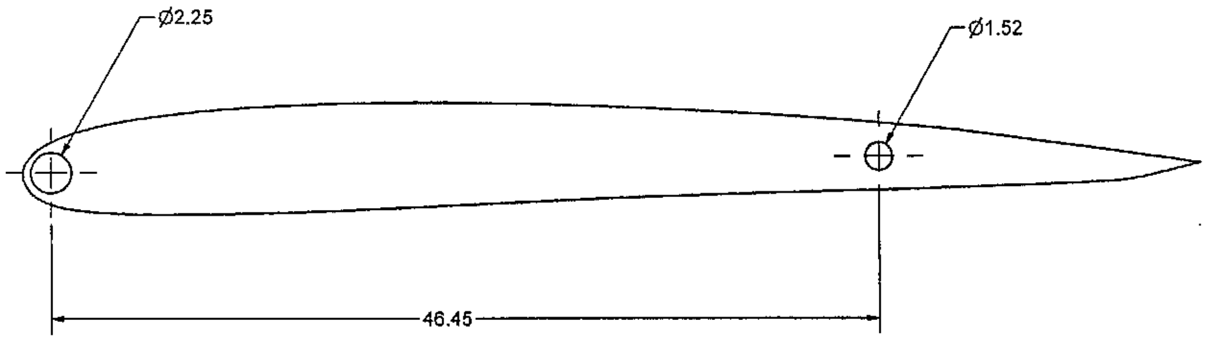
SHEET 1 *of* 1

1. CUT PATTERN FROM 1" FOAM USING TEMPLATE WF-10-313-T1
2. COVER FOAM WITH 1 LAYER KEVLAR
3. FINAL WEIGHT MUST NOT EXCEED 0.45 LB



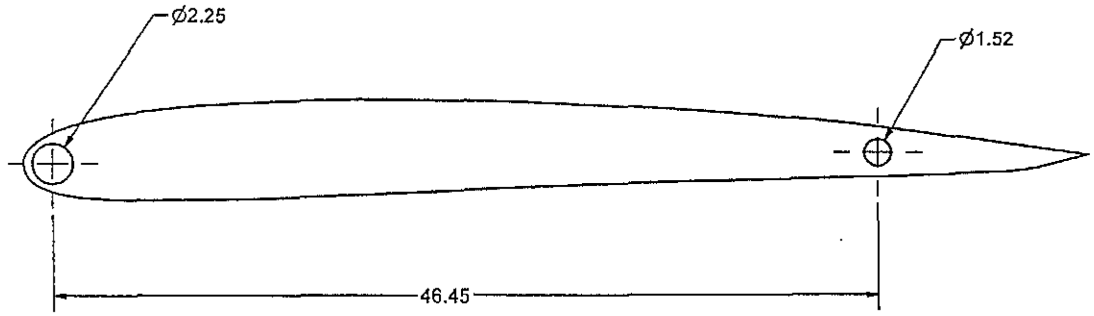
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*			
DRAWN BY: ERIC PETERSON				
MATERIAL: FOAM COMPOSITE	*PART DESCRIPTION:* RIB, OUTER A		*PART NUMBER:* WF-10-313A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	

1. CUT PATTERN FROM 1" FOAM USING TEMPLATES WF-10-314-T1
2. COVER FOAM WITH 1 LAYER KEVLAR
3. FINAL WEIGHT MUST NOT EXCEED 0.4 LB



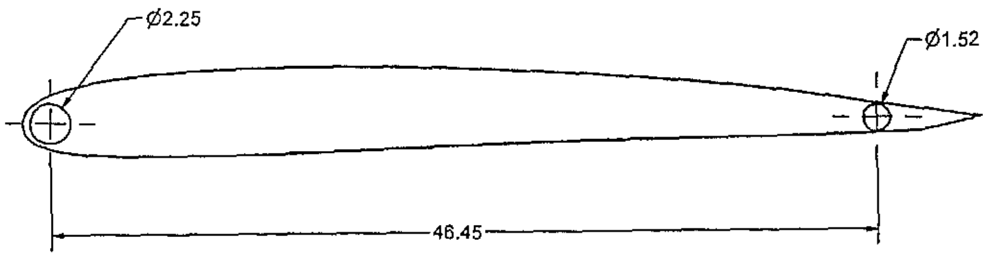
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	Utah State University Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003			
DRAWN BY: CKESPLIN				
MATERIAL: FOAM COMPOSITE	PART DESCRIPTION: RIB, B		PART NUMBER: WF-10-314A	REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	

1. CUT PATTERN FROM 1" FOAM USING TEMPLATES WF-10-316-T1
2. COVER FOAM WITH 1 LAYER KEVLAR
3. FINAL WEIGHT MUST NOT EXCEED 0.35 LB



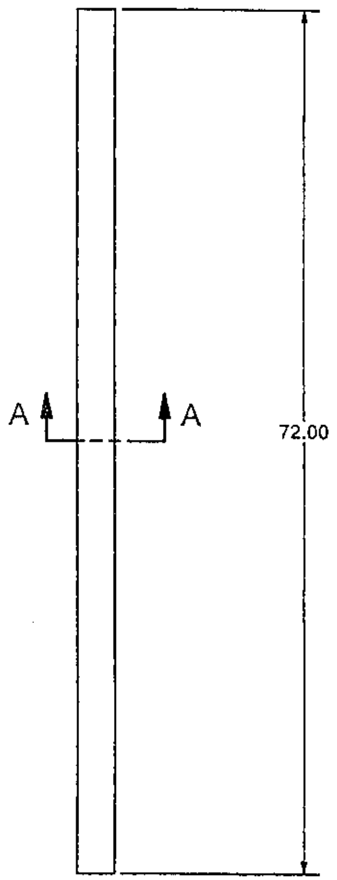
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	UtahState University Mechanical & Aerospace Engineering			
DRAWN BY: ERIC PETERSON	USU WRIGHT FLYER 1903-2003			
MATERIAL: FOAM COMPOSITE	**PART DESCRIPTION:** RIB, C		**PART NUMBER:** WF-10-316A	**REV** A
DATE: 2/17/2002	**SCALE:**	**SIZE:** B	**SHEET** 1 of 1	

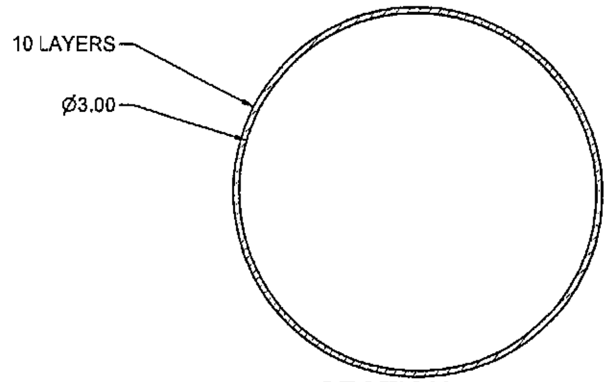
1. CUT PATTERN FROM 1" FOAM USING TEMPLATES WF-10-318-T1
2. COVER FOAM WITH 1 LAYER KEVLAR
3. FINAL WEIGHT MUST NOT EXCEED 0.3 LB



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	Utah State University — Mechanical & Aerospace Engineering			
DRAWN BY: ERIC PETERSON	***USU WRIGHT FLYER 1903-2003***			
MATERIAL: FOAM COMPOSITE	*PART DESCRIPTION:* RIB, D		*PART NUMBER:* WF-10-318A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	

LAYUP: 4/WAVY, 2/0°, 4/WAVY

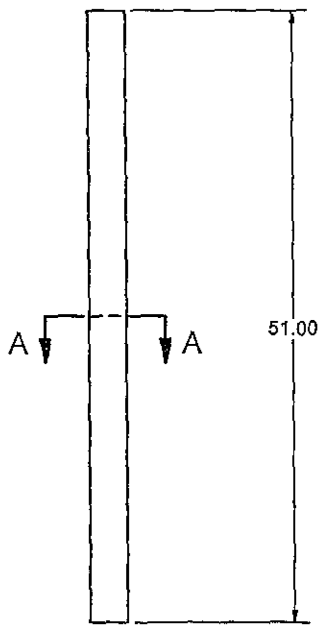


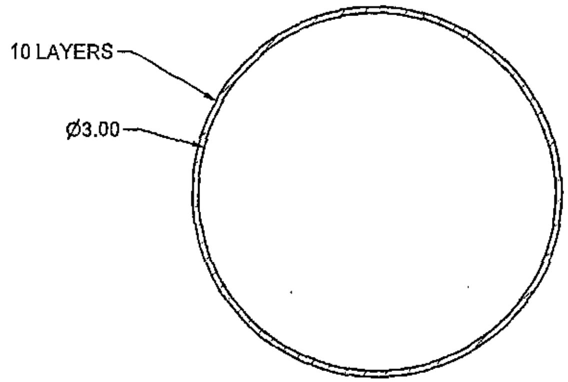


SECTION A-A
SCALE 1 : 1

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*			
DRAWN BY: ERIC PETERSON				
MATERIAL: Graphite	***PART DESCRIPTION:*** SPAR, FRONT MIDDLE		***PART NUMBER:*** WF-10-400A	***REV***
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 ***of*** 1	

LAYUP: 4/WAVY, 2/0°, 4/WAVY

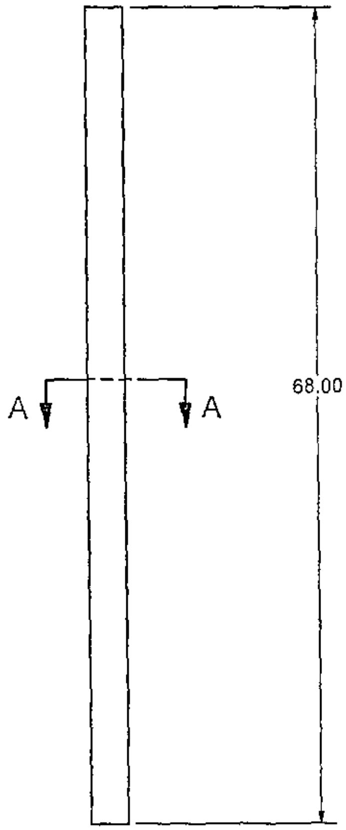


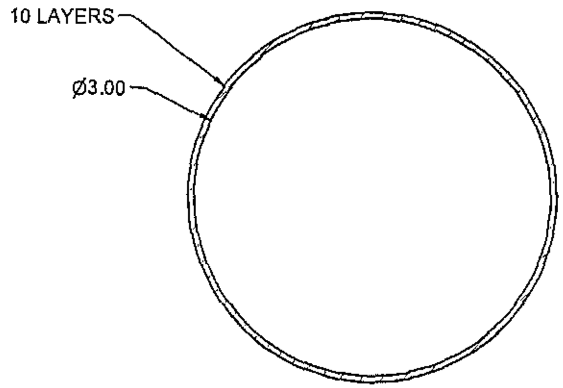


SECTION A-A
SCALE 1 : 1

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*		
DRAWN BY: ERIC PETERSON			
MATERIAL: Graphite	*PART DESCRIPTION:* SPAR, FRONT, FIRST OUTER	*PART NUMBER:* WF-10-401A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1

1. LAYUP: 4/WAVY, 2/0˚, 4/WAVY





SECTION A-A
SCALE 1 : 1

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XX = ± .010
ANGLES ± 1˚

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: ERIC PETERSON

MATERIAL: Graphite

PART DESCRIPTION: SPAR, FRONT, SECOND OUTER

PART NUMBER: WF-10-402A

REV A

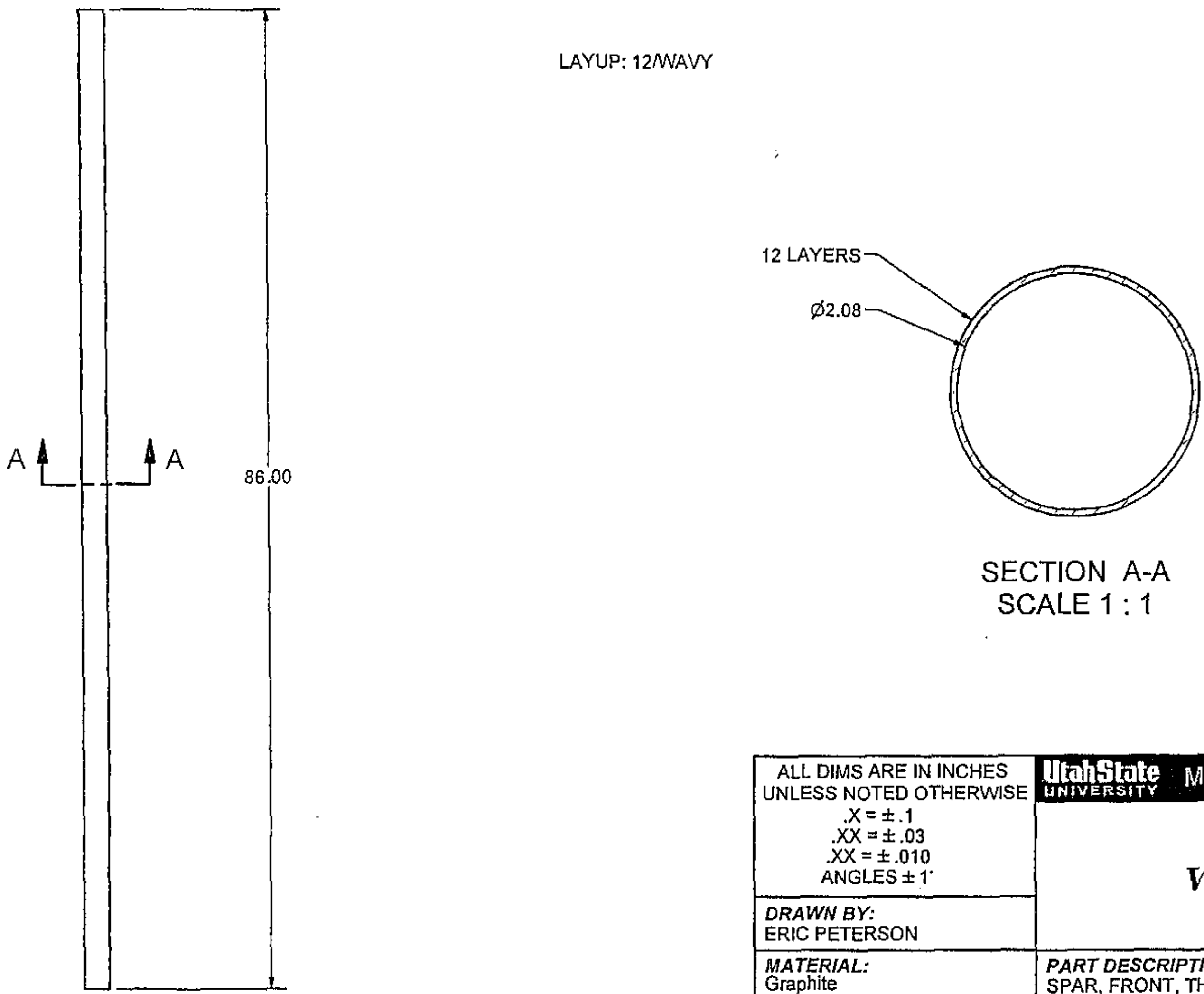
DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 of 1

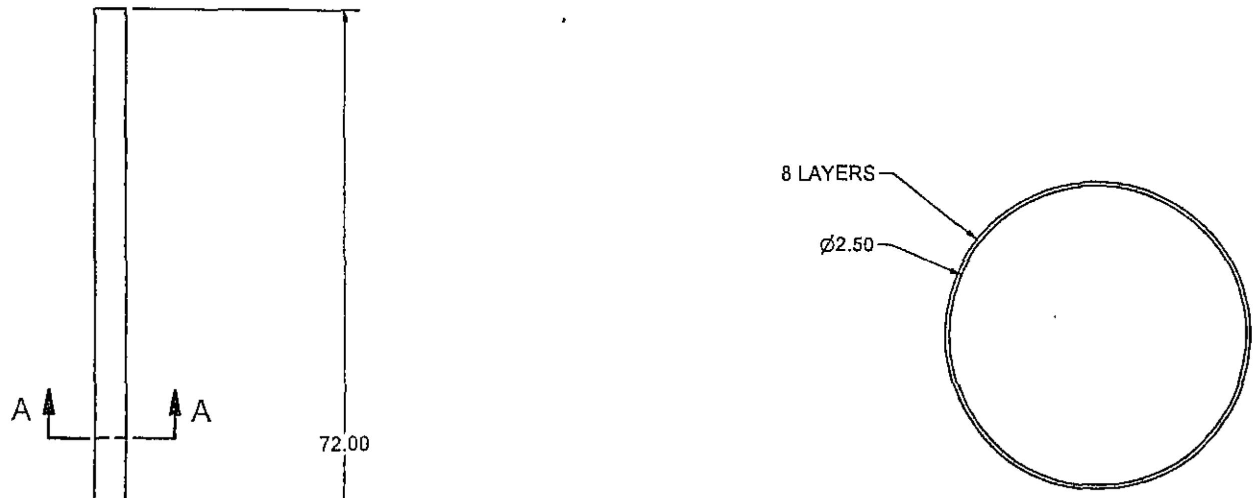
LAYUP: 12/WAVY



SECTION A-A
SCALE 1 : 1

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*		
DRAWN BY: ERIC PETERSON			
MATERIAL: Graphite	*PART DESCRIPTION:* SPAR, FRONT, THIRD OUTER	*PART NUMBER:* WF-10-403A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1

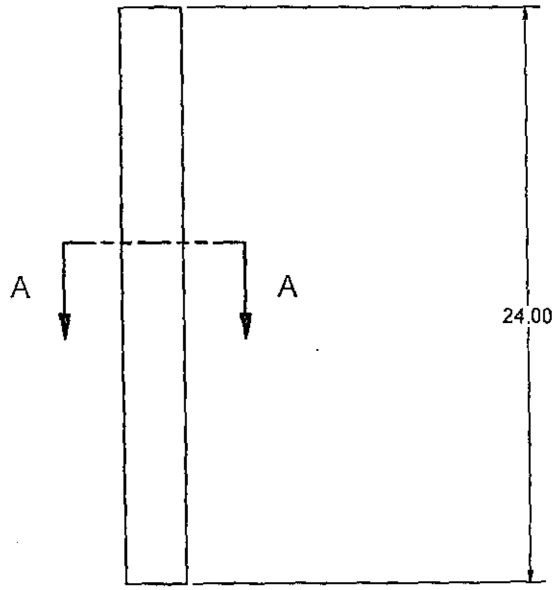
LAYUP: 8/WAVY

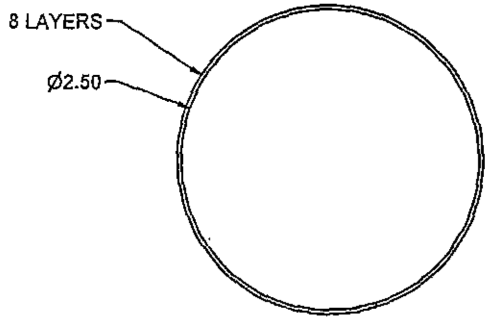


SECTION A-A
SCALE 1 : 1

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XX = ± .010 ANGLES ± 1°	Utah State University — Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*		
DRAWN BY: ERIC PETERSON			
MATERIAL: Graphite	*PART DESCRIPTION:* SPAR, BACK, MIDDLE	*PART NUMBER:* WF-10-404A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1

LAYUP: 8/WAVY





SECTION A-A
SCALE 1 : 1

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XX = ± .010
ANGLES ± 1°

DRAWN BY: ERIC PETERSON

MATERIAL: Graphite

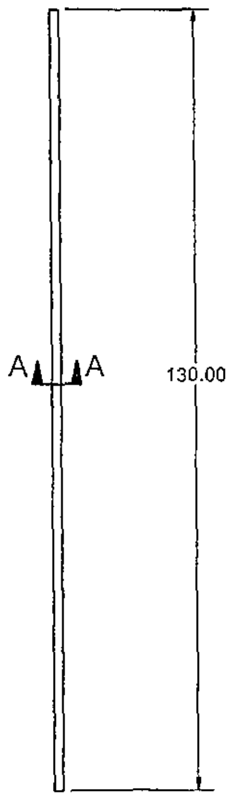
DATE: 2/17/2002

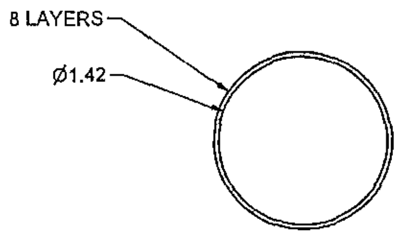
Utah State University Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

PART DESCRIPTION:	PART NUMBER:	REV
SPAR, BACK, SECOND OUTER	WF-10-406A	A

SCALE:	SIZE: B	SHEET 1 of 1

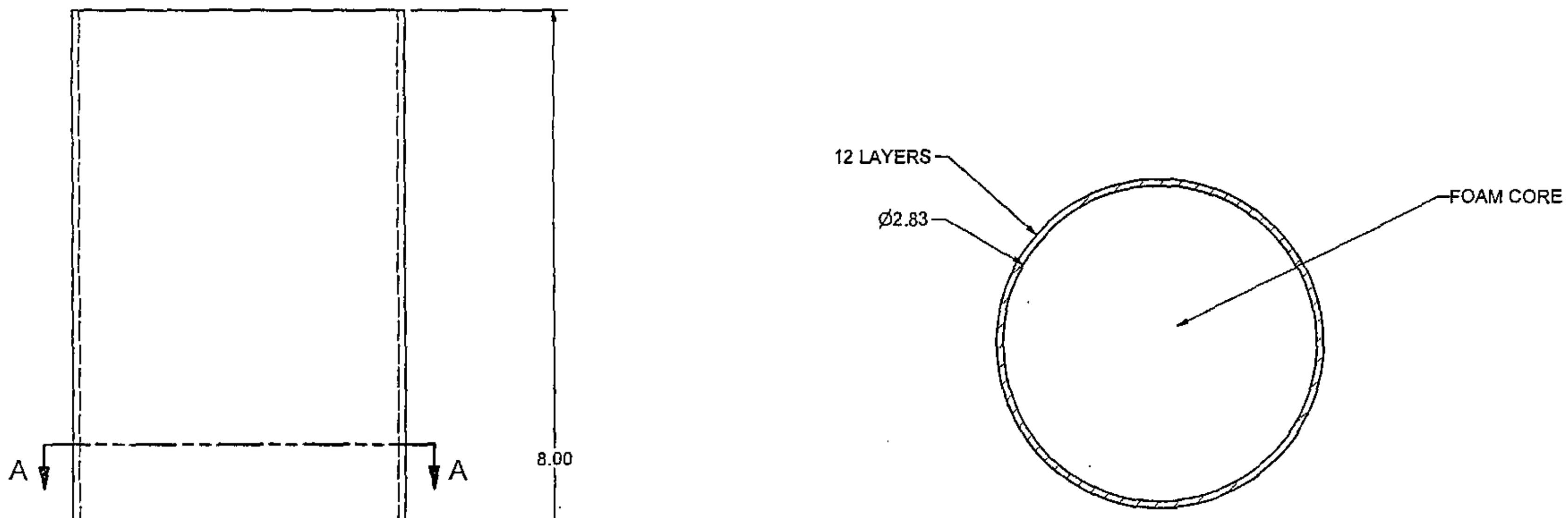




SECTION A-A
SCALE 1 : 1

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*			
DRAWN BY: ERIC PETERSON				
MATERIAL: Graphite	*PART DESCRIPTION:* SPAR, BACK, THIRD OUTER		*PART NUMBER:* WF-10-407A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	

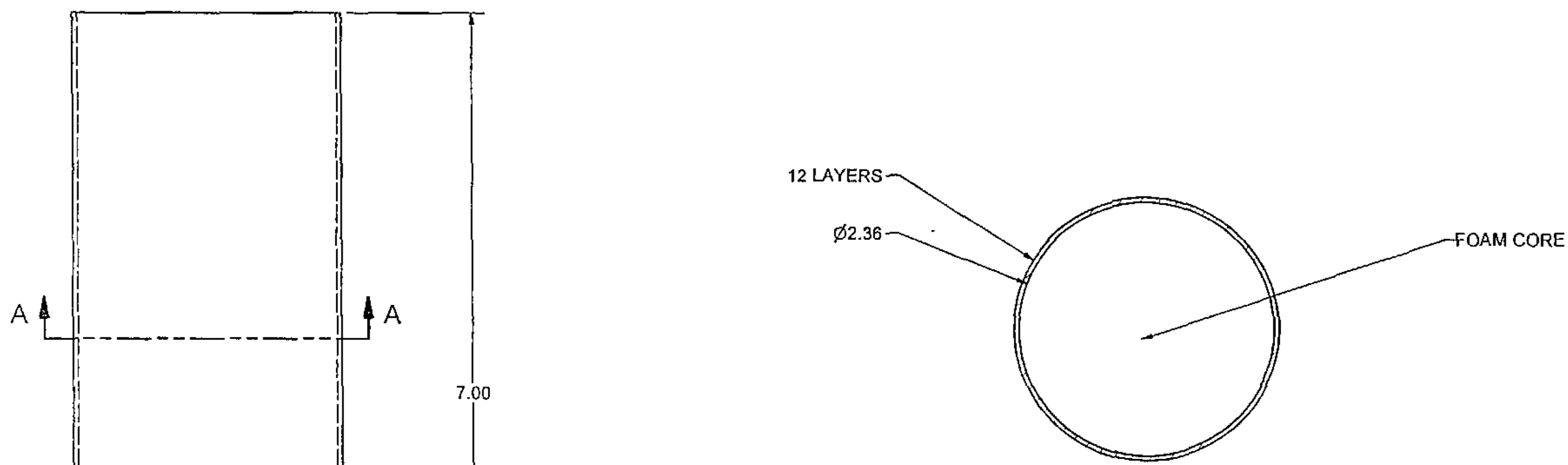
LAYUP: 12/WAVY



SECTION A-A
SCALE 1 : 1

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*			
DRAWN BY: ERIC PETERSON				
MATERIAL: Graphite	*PART DESCRIPTION:* SPAR INTERFACE, FRONT INNER	*PART NUMBER:* WF-10-408A		*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	

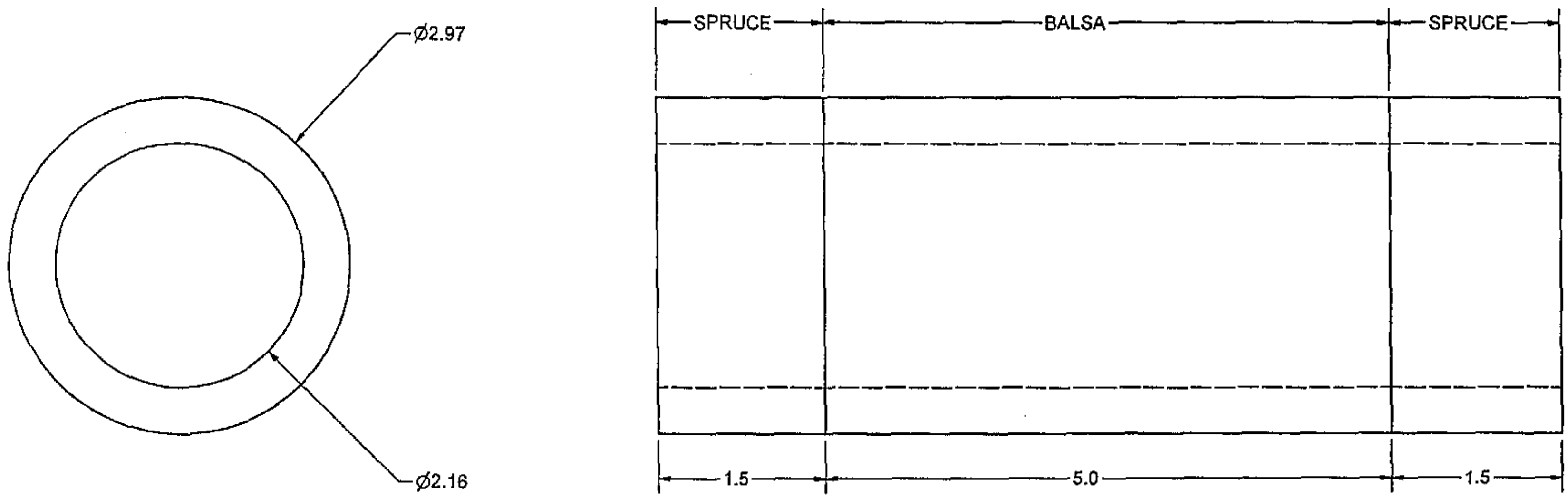
LAYUP: 12/WAVY



SECTION A-A
SCALE 1 : 1

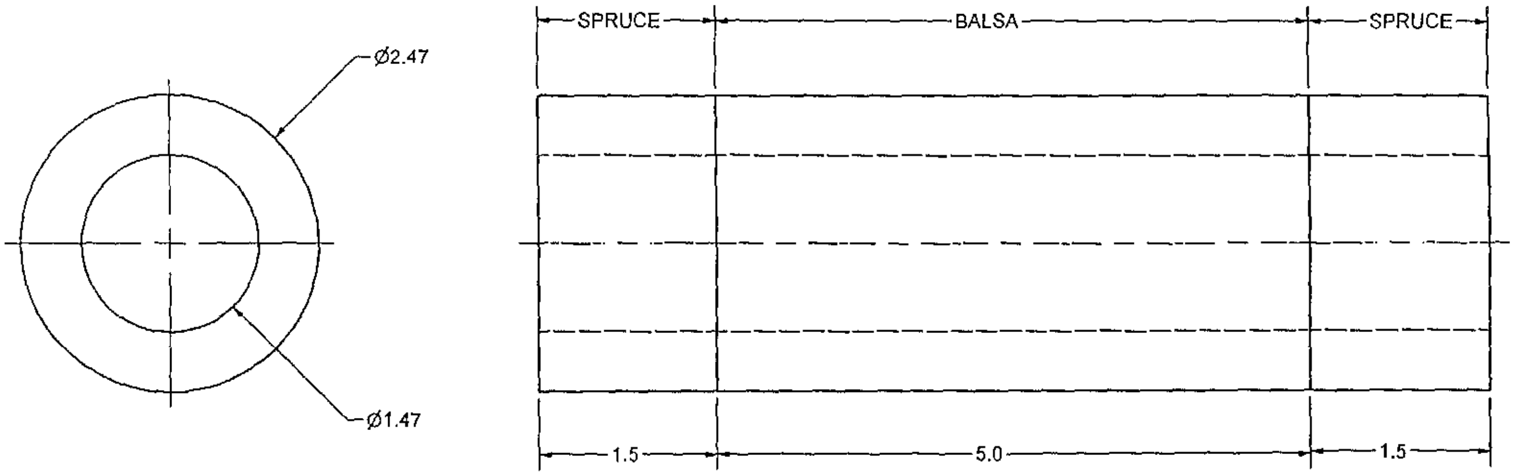
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XX = ± .010 ANGLES ± 1'	Utah State University Mechanical & Aerospace Engineering			
DRAWN BY: ERIC PETERSON	***USU WRIGHT FLYER 1903-2003***			
MATERIAL: Graphite	*PART DESCRIPTION:* SPAR INTERFACE, BACK INNER		*PART NUMBER:* WF-10-409A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	

1. MATERIAL : PER DRAWING
2. ADHERE JOINTS WITH STRUCTURAL WOOD ADHESIVE



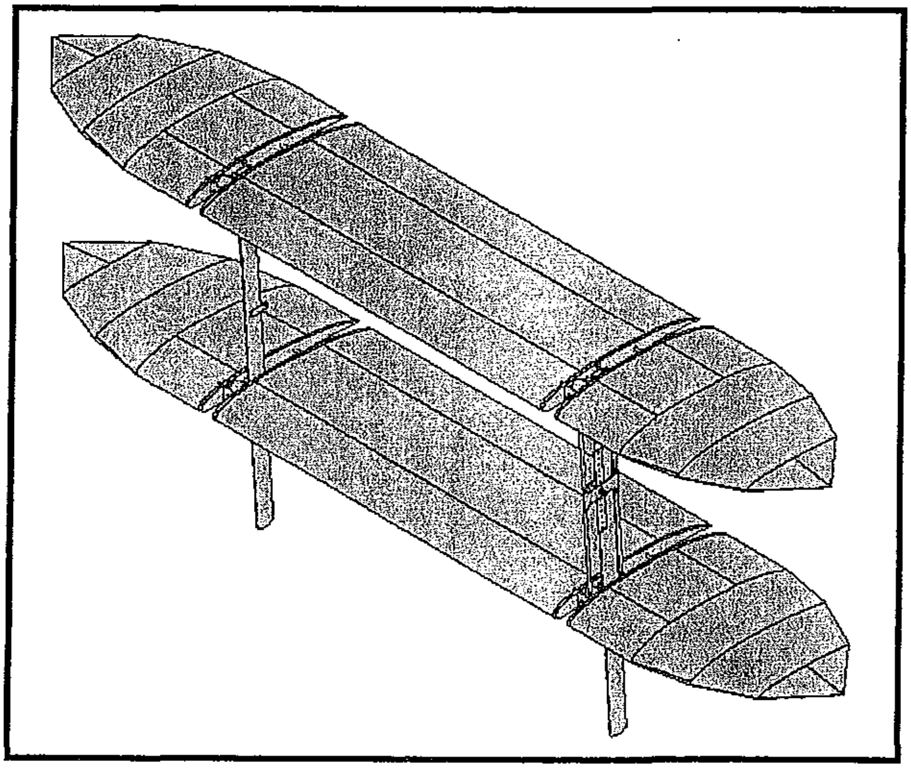
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003	
DRAWN BY: CKESPLIN		
MATERIAL:	PART DESCRIPTION: SPAR INTERFACE, FRONT OUTER	PART NUMBER: WR-10-410A REV A
DATE: 2/17/2002	SCALE: SIZE: B	SHEET 1 of 1

1. MATERIAL AS SHOWN
2. ADHERE JOINTS WITH GENERAL STUCTURAL WOOD ADHESIVE



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*
DRAWN BY: CKESPLIN	
MATERIAL:	*PART DESCRIPTION:* SPAR INTERFACE, BACK OUTER · *PART NUMBER:* WF-10-411A · *REV* A
DATE: 2/17/2002	*SCALE:* · *SIZE:* B · *SHEET* 1 *of* 1

Canard Assembly



Materials List for Canard

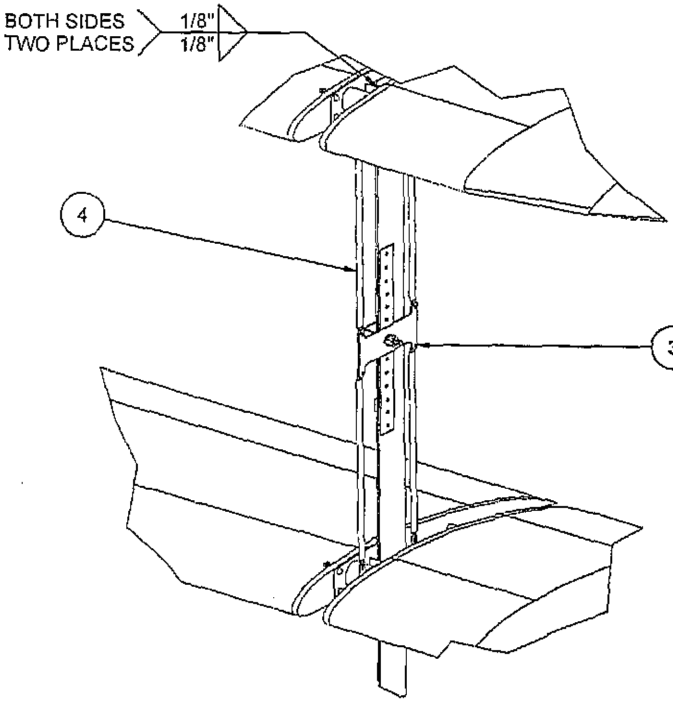
ck spc= check drawing specifications

Item/Material	Description	Qty	Part #	Supplier
Control Rod		4	AN673AC-1475	Aircraft Spruce Co.
Terminal Assembly		8	AN665-21(R/L)	Aircraft Spruce Co.
Rear Spar (4130 tube)	2 x 9ft	1	03-02300	Aircraft Spruce Co.
Main Spar (4130 tube)	2 x 9ft	1	03-09100	Aircraft Spruce Co.
10-32 Bolts		32	AN526-1032R16	Aircraft Spruce Co.
10-32 Nuts		32	AN365-1032A	Aircraft Spruce Co.
Clevis Pin		4	AN396-81	Aircraft Spruce Co.
3/8-24 Bolt		1	AN6-24	Aircraft Spruce Co.
3/8-24 Stop Nut		1	AN365-624A	Aircraft Spruce Co.
Bearing		1	KS6A-AN200	Aircraft Spruce Co.

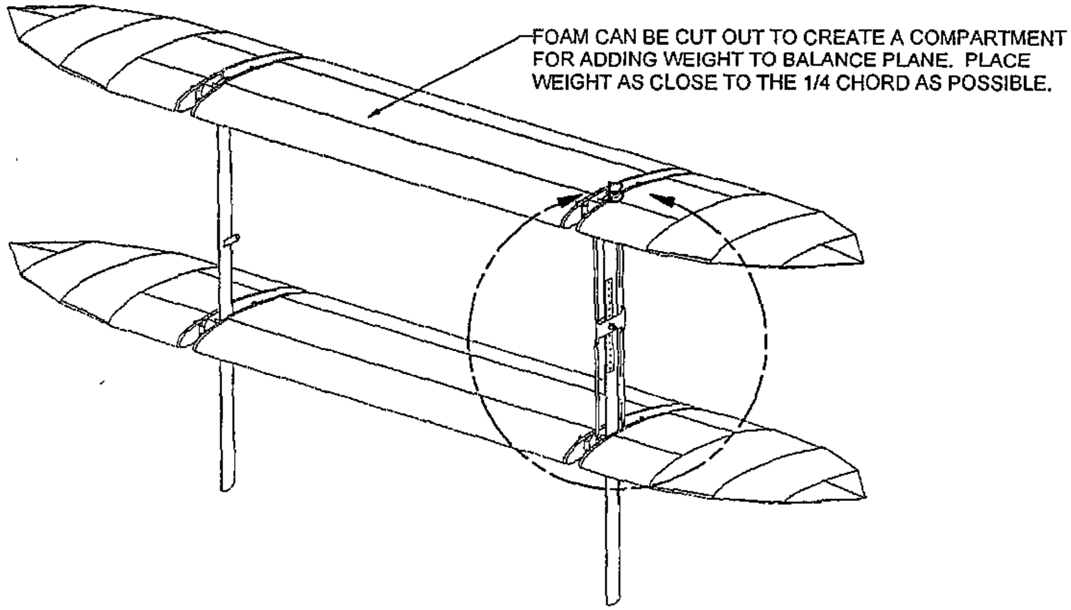
Parts List for Canard

Part Number	Description	Qty	Type
WF-20-050	Control Adjust	1	cut & drilled
WF-20-033	Linkage Mount	1	cut & drilled
WF-20-030	Chassis Connect	2	cut & drilled
WF-20-028	Control Mount	1	cut & drilled
WF-20-025	Canard Supports	2	cut & drilled
WF-20-022	Hinge Pin Shaft	12	cut & drilled
WF-20-021	Spar Hinge Shaft	4	cut & drilled
WF-20-020	Strut Hinge Plate	4	cut
WF-20-018	Hinge Bracket	6	cut & drilled
WF-20-017	Linkage Bracket	2	cut & drilled
WF-20-016	Canard Surface Right	2	hot wired,glued,shaped,layed up
WF-20-015	Canard Surface Left	2	hot wired,glued,shaped,layed up
WF-20-014	Canard Surface Center	2	hot wired,glued,shaped,layed up
WF-20-013	Canard Rib	8	cut, drilled, & sanded
WF-20-007	Spar Hinge Assembly	4	weldament
WF-20-006	Strut Hinge Assembly	4	weldament
WF-20-005	Hinge Assembly Right	2	weldament
WF-20-004	Hinge Assembly Bottom	1	weldament
WF-20-003	Hinge Assembly Top	1	weldament
WF-20-027	Control Sub-Assembly	1	weld and bolt
WF-20-040	Canard Sub-Assembly	1	weld and bolt
WF-20-001	Top Surface Assembly	1	bolt
WF-20-002	Bottom Surface Assembly	1	bolt
WF-20-000	Canard Assembly	1	weld and bolt

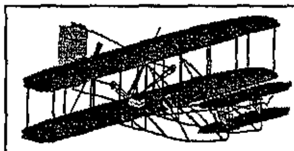
Note: Weld Hinge Plates tangent to leading edge of supports and flush with top of supports.



DETAIL B
SCALE 0.12 : 1



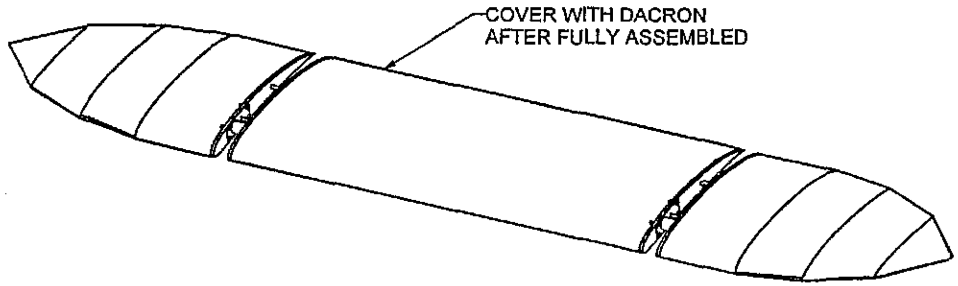
Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
3	8	AN665-21(R/L)	Terminal Assembly
4	4	AN673AC-1475	Control Rod
5	1	WF-20-040	Canard Sub-Assembly
6	1	WF-20-001	Canard Surface Assembly Top

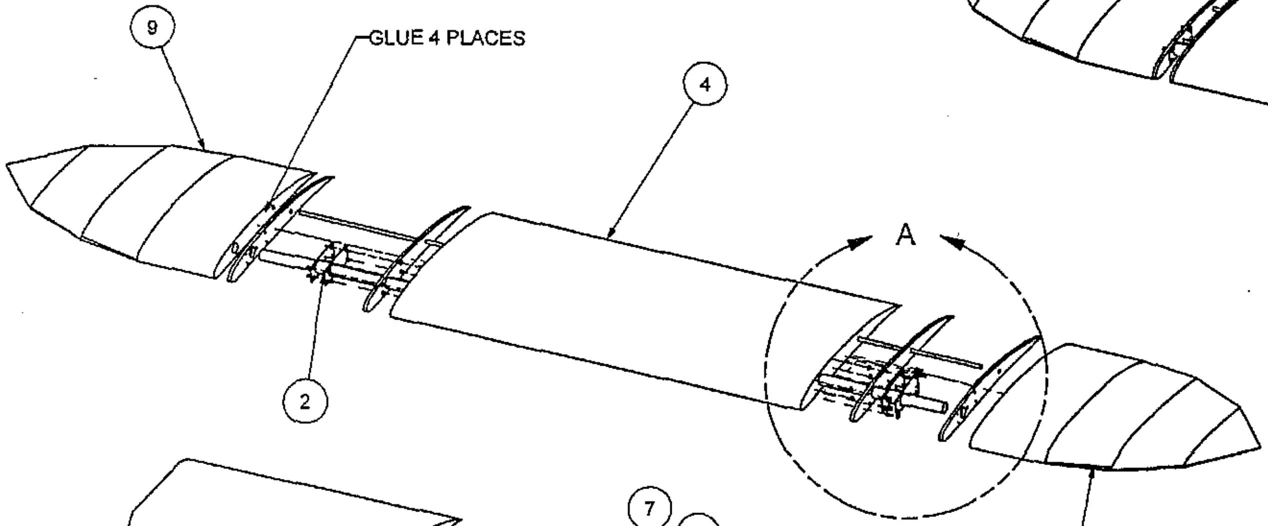


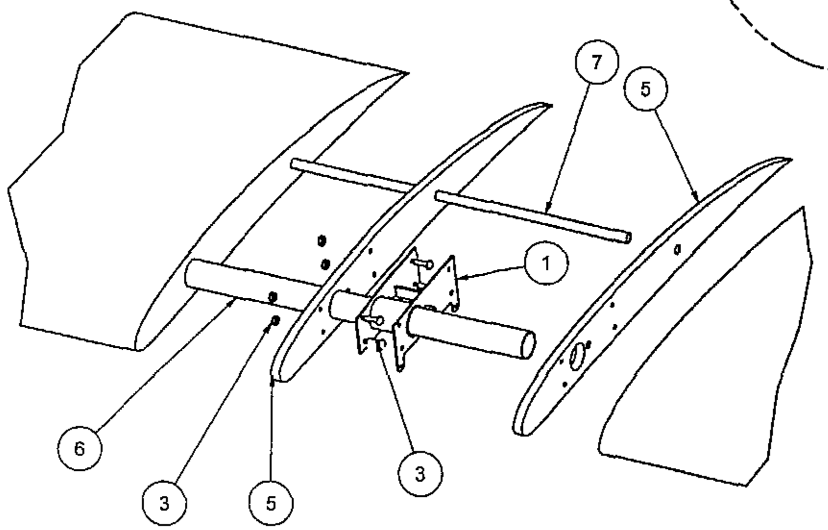
UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: N. Holman				
MATERIAL:	PART DESCRIPTION: Canard Assembly		PART NUMBER: WF-20-000	REV
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	

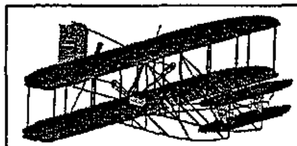






DETAIL A
SCALE 0.16 : 1

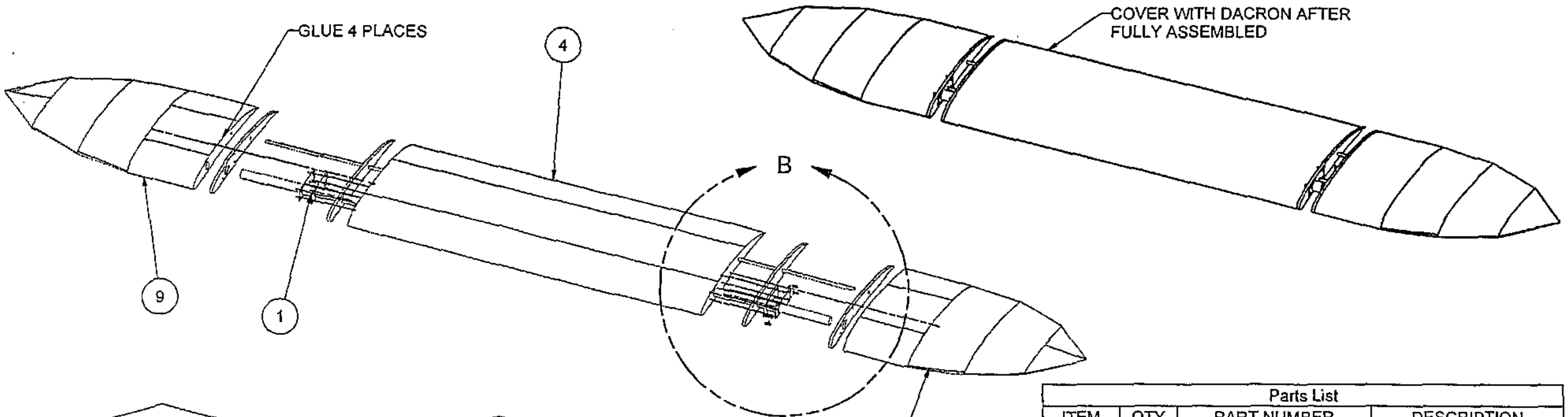
Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-20-003	Hinge Assembly Top
2	1	WF-20-005	Hinge Assembly Right
3	16	AN526-1032R16 / AN365-1032A	10-32 Screws and Nuts
4	1	WF-20-014	Canard Center Surface
5	4	WF-20-013	Canard Rib
6	1	03-09100	Main Spar
7	1	03-02300	Rear Spar
8	1	WF-20-015	Canard Surface Left
9	1	WF-20-016	Canard Surface Right

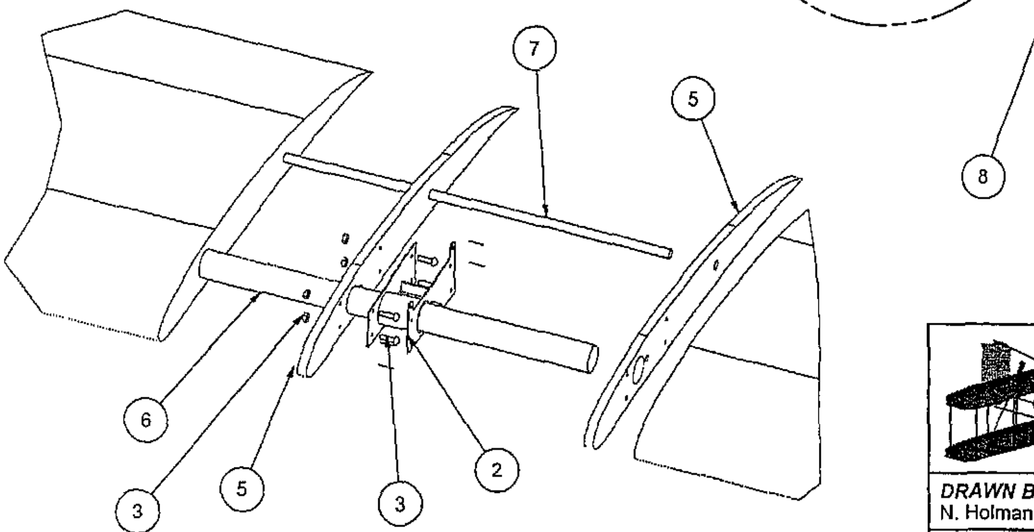


Utah State University — Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

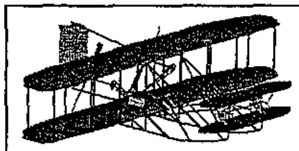
DRAWN BY: N. Holman			
MATERIAL:	*PART DESCRIPTION:* Canard Surface Assembly Top	*PART NUMBER:* WF-20-001	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 of 1





DETAIL B
SCALE 0.16 : 1

Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-20-005	Hinge Assembly Right
2	1	WF-20-004	Hinge Assembly Bottom
3	16	AN526-1032R16 / AN365-1032A	10-32 Screws and Nuts
4	1	WF-20-014	Canard Center Surface
5	4	WF-20-013	Canard Rib
6	1	03-09100	Main Spar
7	1	03-02300	Rear Spar
8	1	WF-20-015	Canard Surface Left
9	1	WF-20-016	Canard Surface Right



UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: N. Holman

MATERIAL:

PART DESCRIPTION: Canard Surface Assembly Bottom

PART NUMBER: WF-20-002

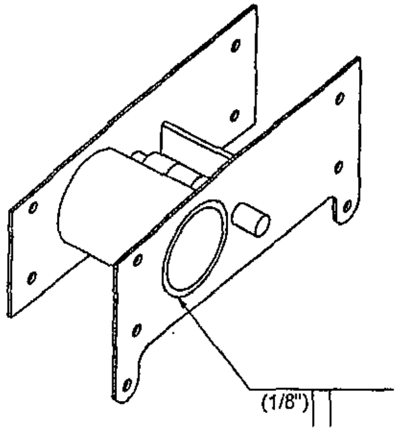
REV

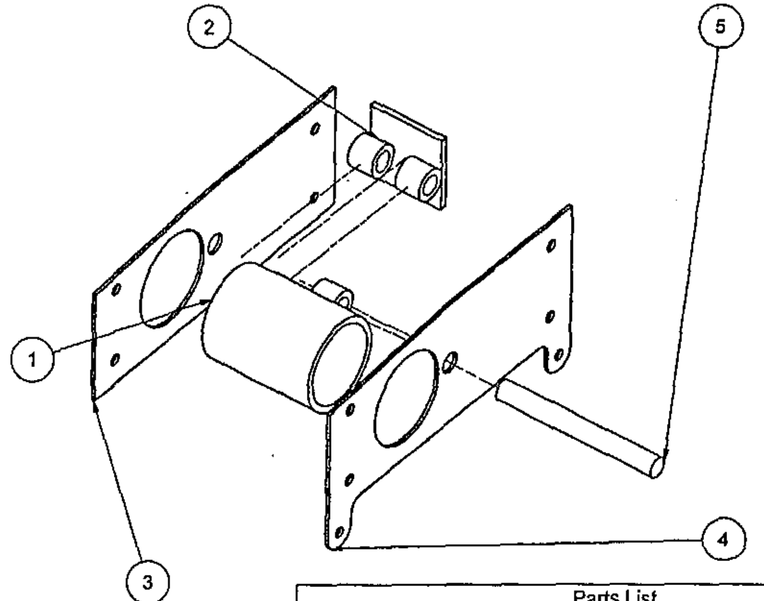
DATE: 2/17/2002

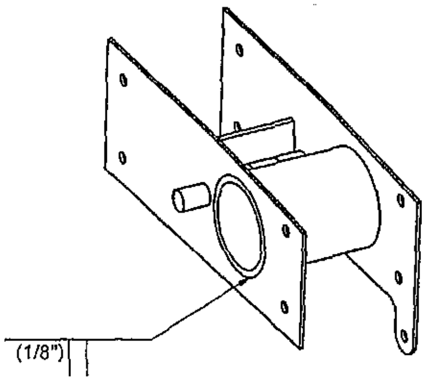
SCALE:

SIZE: B

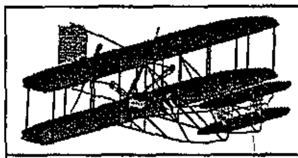
SHEET 1 *of* 1







Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-20-007	Spar Hinge Assembly
2	1	WF-20-006	Strut Hinge Assembly
3	1	WF-20-018	Hinge Bracket
4	1	WF-20-017	Linkage Bracket
5	1	AN396-81	Hinge Clevis Pin



Utah State University — Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: N. Holman

MATERIAL:

PART DESCRIPTION: Hinge Assembly Top

PART NUMBER: WF-20-003

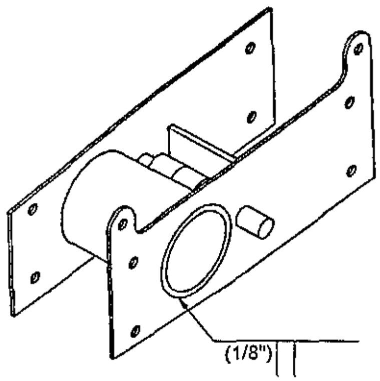
REV

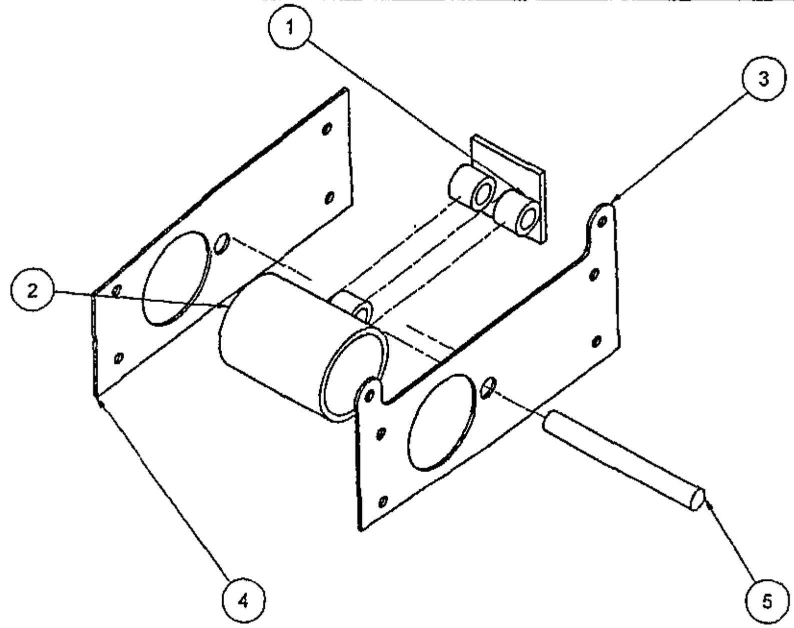
DATE: 2/17/2002

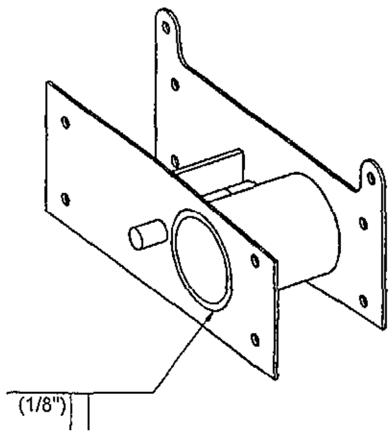
SCALE:

SIZE: B

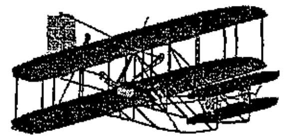
SHEET 1 ***of*** 1







Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-20-006	Strut Hinge Assembly
2	1	WF-20-007	Spar Hinge Assembly
3	1	WF-20-017	Linkage Bracket
4	1	WF-20-018	Hinge Bracket
5	1	AN396-81	Hinge Clevis Pin



UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: N. Holman

MATERIAL:

PART DESCRIPTION: Hinge Assembly Bottom

PART NUMBER: WF-20-004

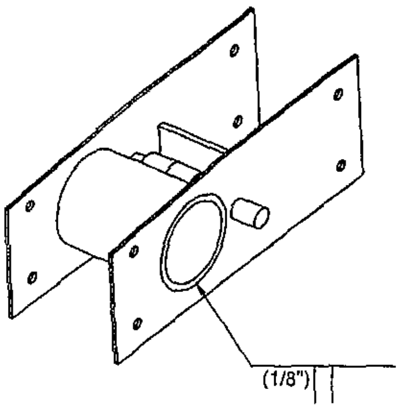
REV

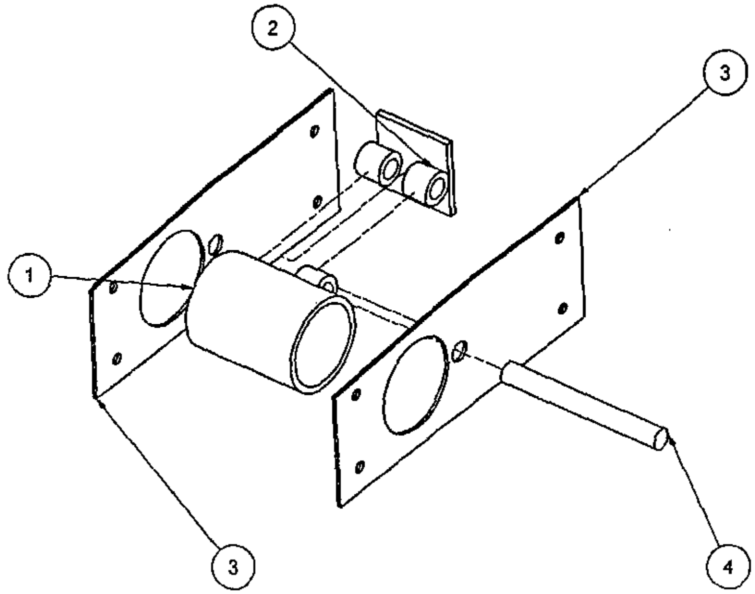
DATE: 2/17/2002

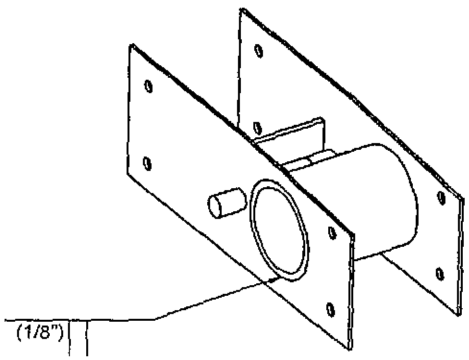
SCALE:

SIZE: B

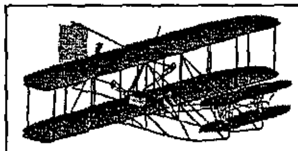
SHEET 1 **of** 1







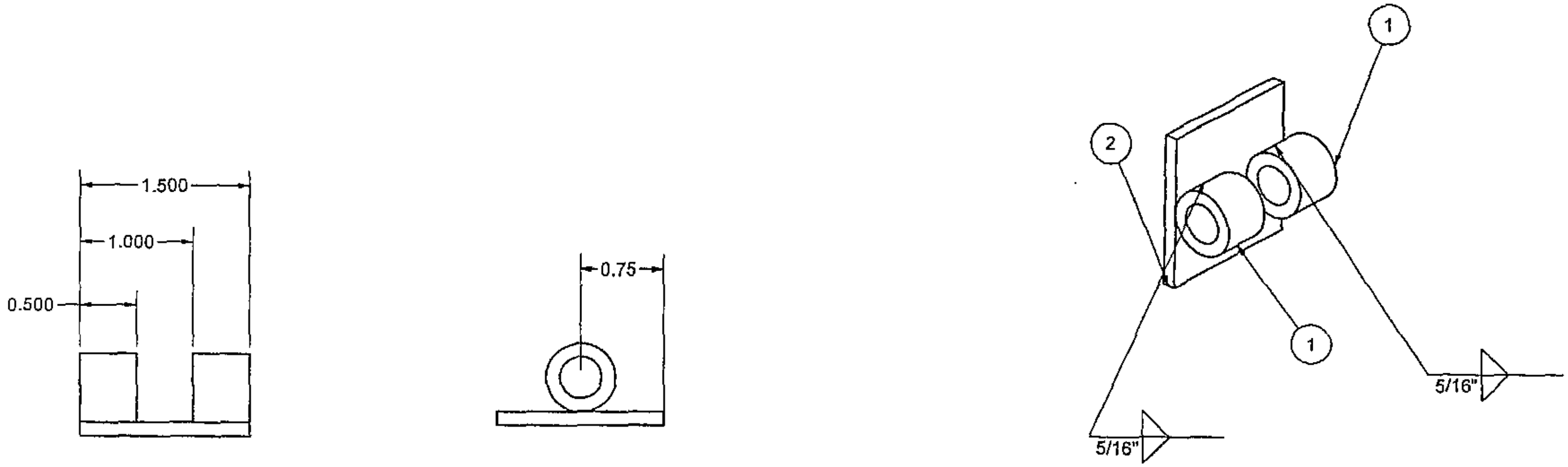
Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-20-007	Spar Hinge Assembly
2	1	WF-20-006	Strut Hinge Assembly
3	2	WF-20-018	Hinge Bracket
4	1	AN396-81	Hinge Clevis Pin



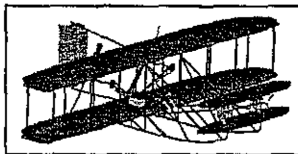
UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: N. Holman			
MATERIAL:	***PART DESCRIPTION:*** Hinge Assembly Right	***PART NUMBER:*** WF-20-005	***REV***
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 ***of*** 1



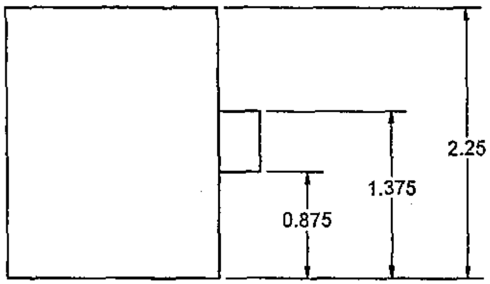
Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	WF-20-022	Hinge Pin Shaft
2	1	WF-20-020	Strut Hinge Plate

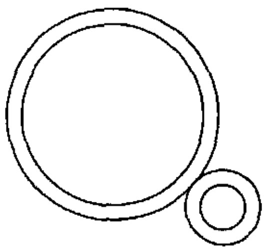


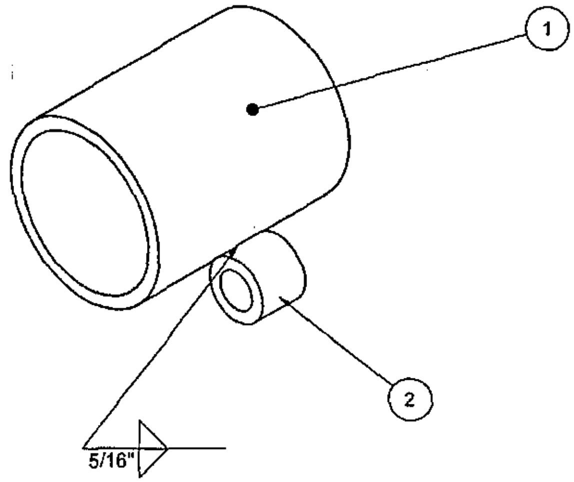
UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

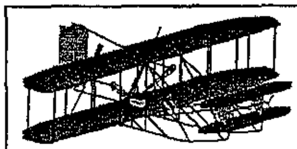
DRAWN BY: N. Holman				
MATERIAL:	PART DESCRIPTION: Strut Hinge Assembly		PART NUMBER: WF-20-006	REV
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	







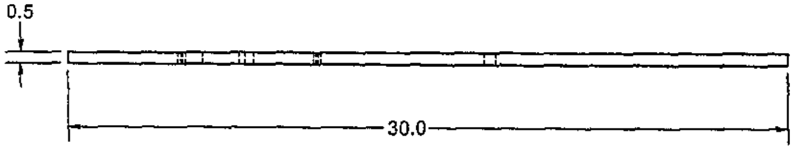
Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-20-021	Spar Hinge Shaft
2	1	WF-20-022	Hinge Pin Shaft

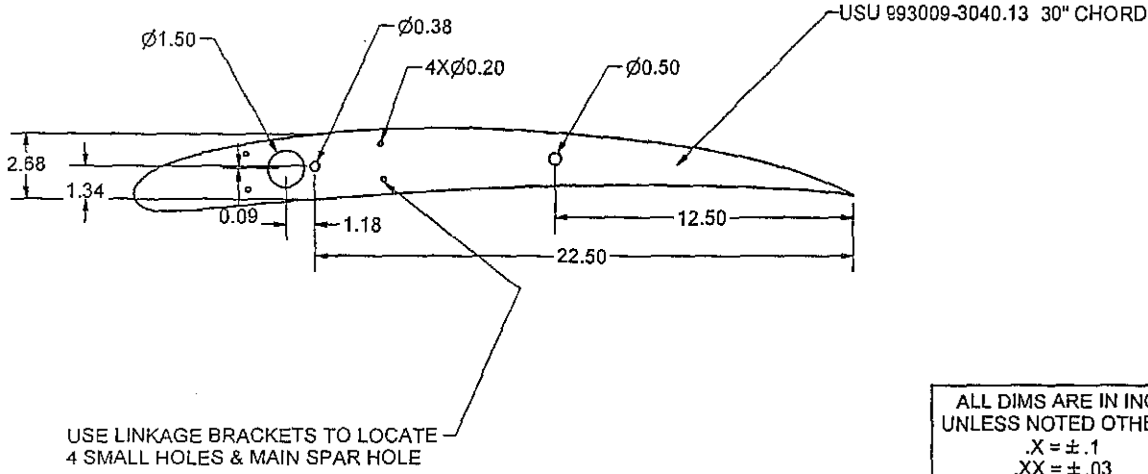


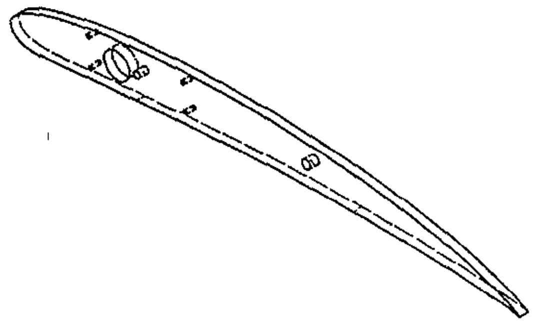
UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: N. Holman			
MATERIAL:	*PART DESCRIPTION:* Spar Hinge Assembly	*PART NUMBER:* WF-20-007	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1





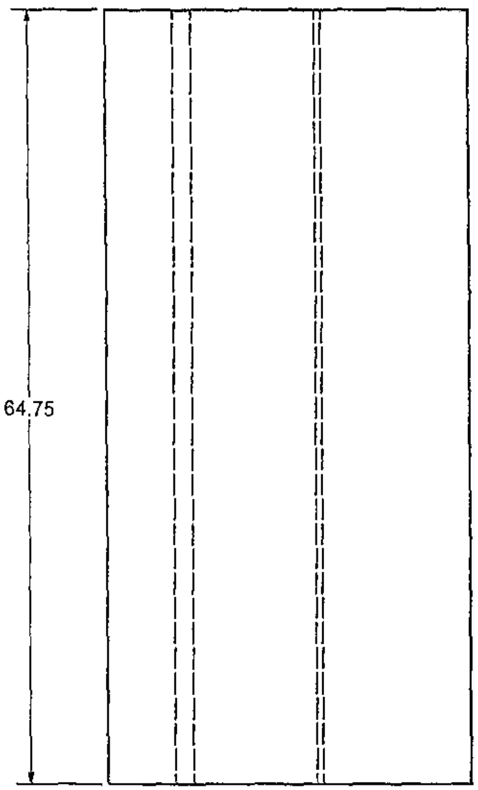


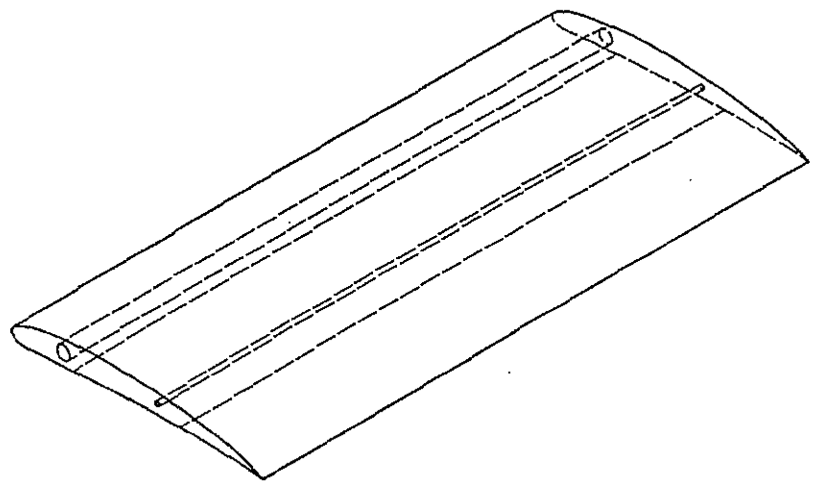
ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

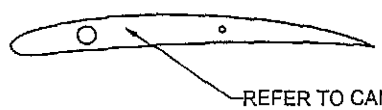
USU
WRIGHT FLYER
1903-2003

DRAWN BY: N. Holman			
MATERIAL: Ply-Wood	*PART DESCRIPTION:* Canard Rib	*PART NUMBER:* WF-20-013	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1



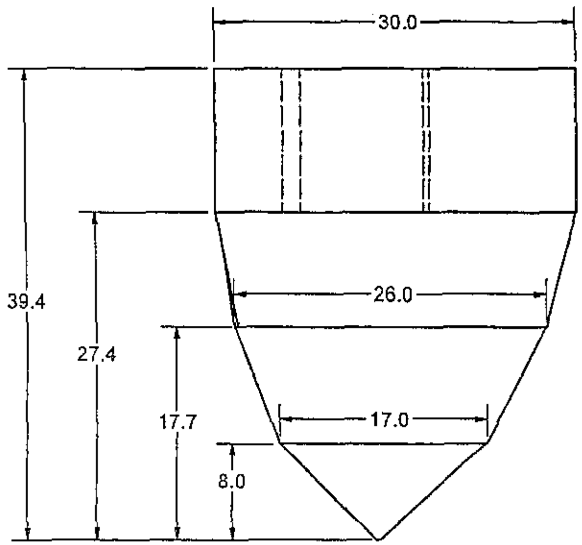


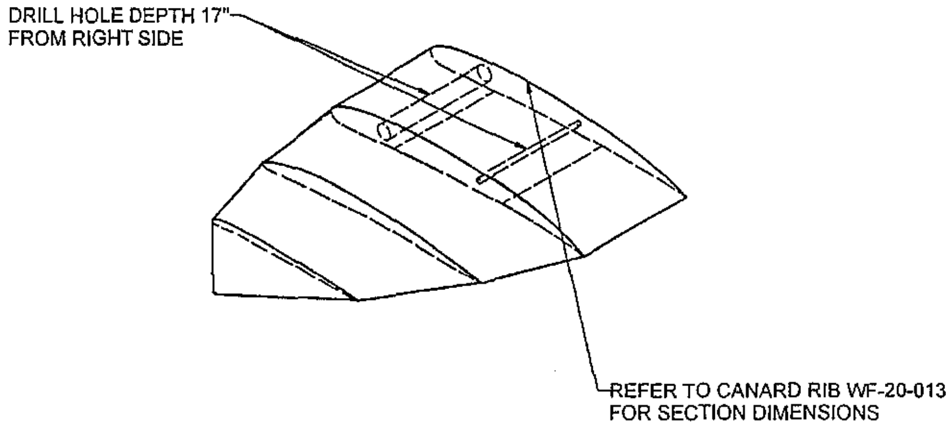
NOTE: FOAM CAN BE CUT INTO CONVIENIENT PIECES IN ORDER TO CREATE HOLES FOR SPARS. REASSEMBLE PIECES WITH APPROPRIATE GLUE. COVER FOAM WITH FIBERGLASS FOR ADDED STRENGTH.

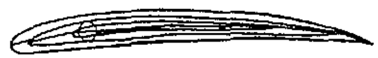


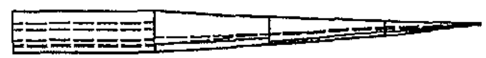
REFER TO CANARD RIB WF-20-013
FOR SECTION DIMENSIONS

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering **USU WRIGHT FLYER 1903-2003**			
DRAWN BY: N. Holman				
MATERIAL: 4 Lb Foam	*PART DESCRIPTION:* Canard Center Surface		*PART NUMBER:* WF-20-014	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	









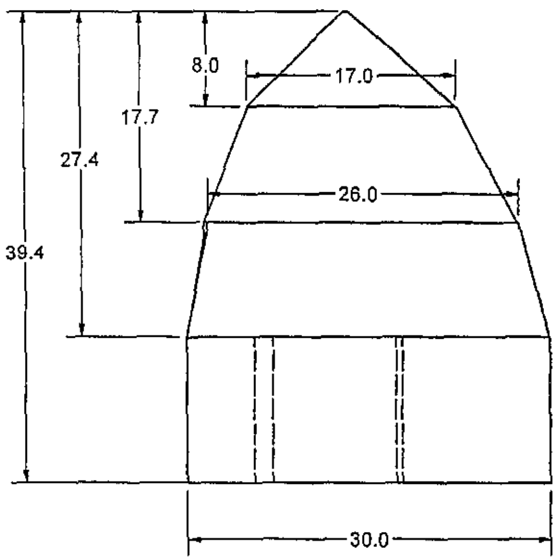
NOTE: TEMPLATE WILL BE PROVIDED FOR CHORDS OF 30", 26", & 17" TO CHECK AIRFOIL SHAPE. SAND A SMOOTH TRANSITION BETWEEN SECTIONS. COVER FOAM WITH FIBERGLASS FOR ADDED STRENGTH.

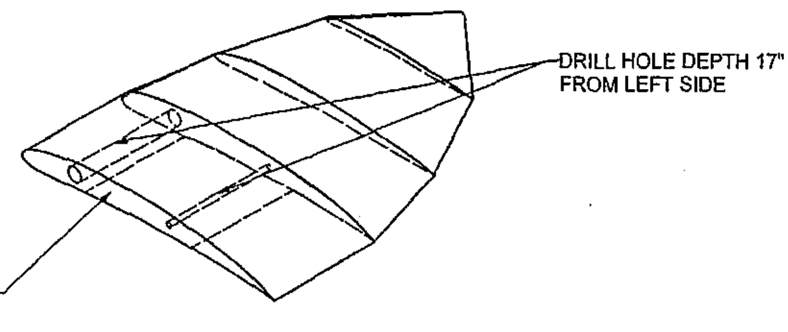
ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

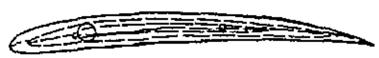
Utah State University — Mechanical & Aerospace Engineering

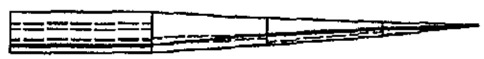
USU
WRIGHT FLYER
1903-2003

DRAWN BY: N. Holman			
MATERIAL: 4 Lb Foam	*PART DESCRIPTION:* Canard Surface Left	*PART NUMBER:* WF-20-015	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1



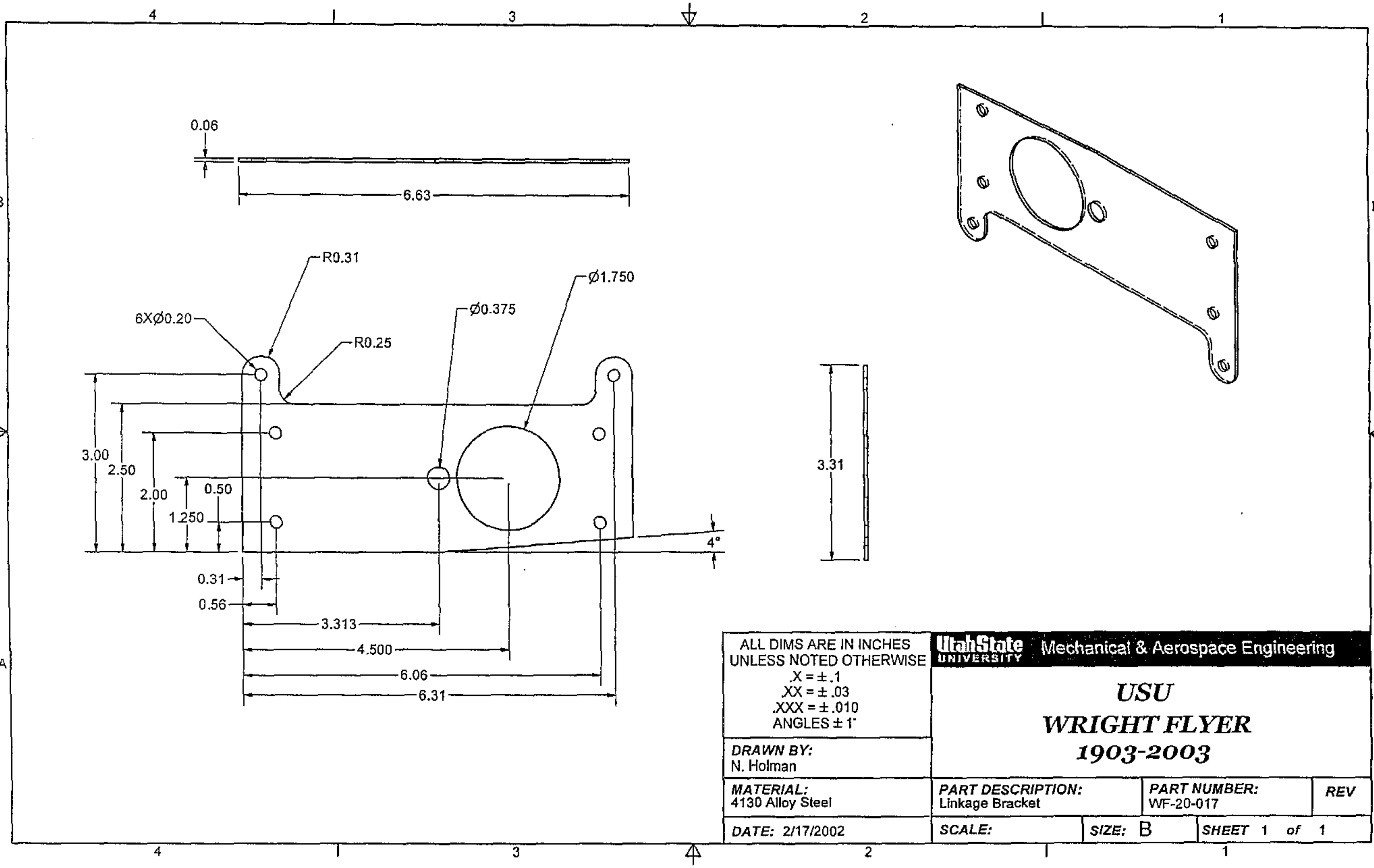


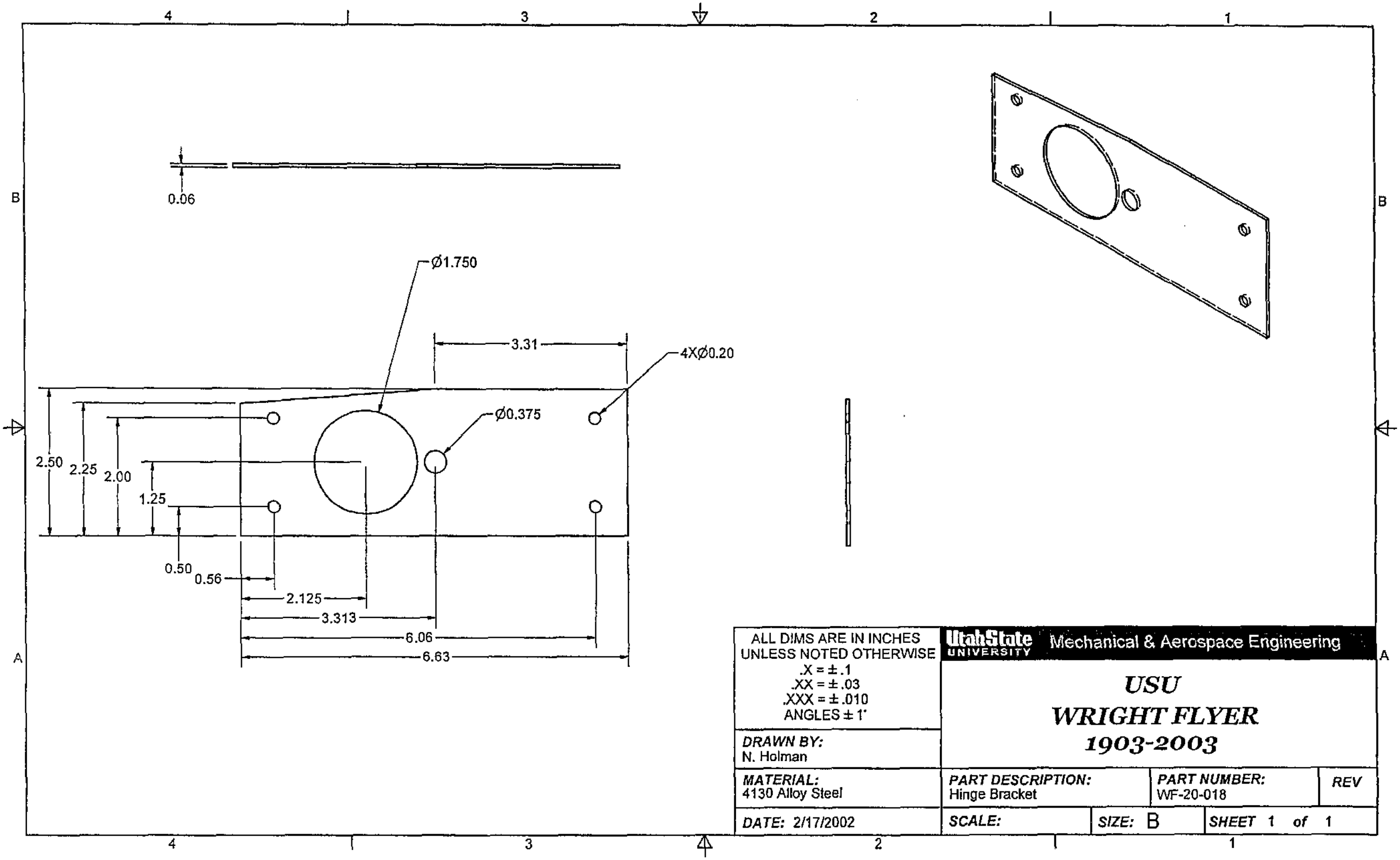




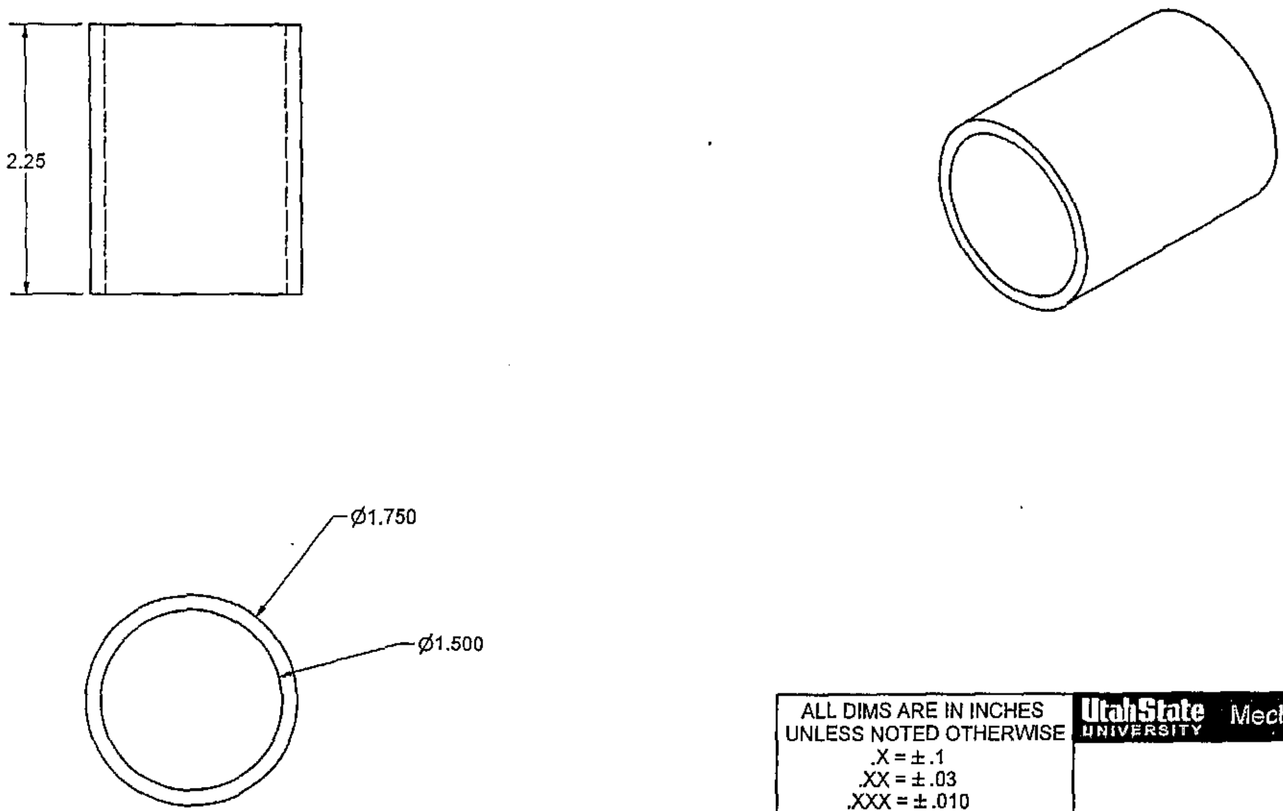
NOTE: TEMPLATE WILL BE PROVIDED FOR CHORDS OF 30", 26", & 17" TO CHECK AIRFOIL SHAPE. SAND A SMOOTH TRANSITION BETWEEN SECTIONS. COVER FOAM WITH FIBERGLASS FOR ADDED STRENGTH.

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1˚	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*		
DRAWN BY: N. Holman			
MATERIAL: 4 Lb Foam	*PART DESCRIPTION:* Canard Surface Right	*PART NUMBER:* WF-20-016	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1

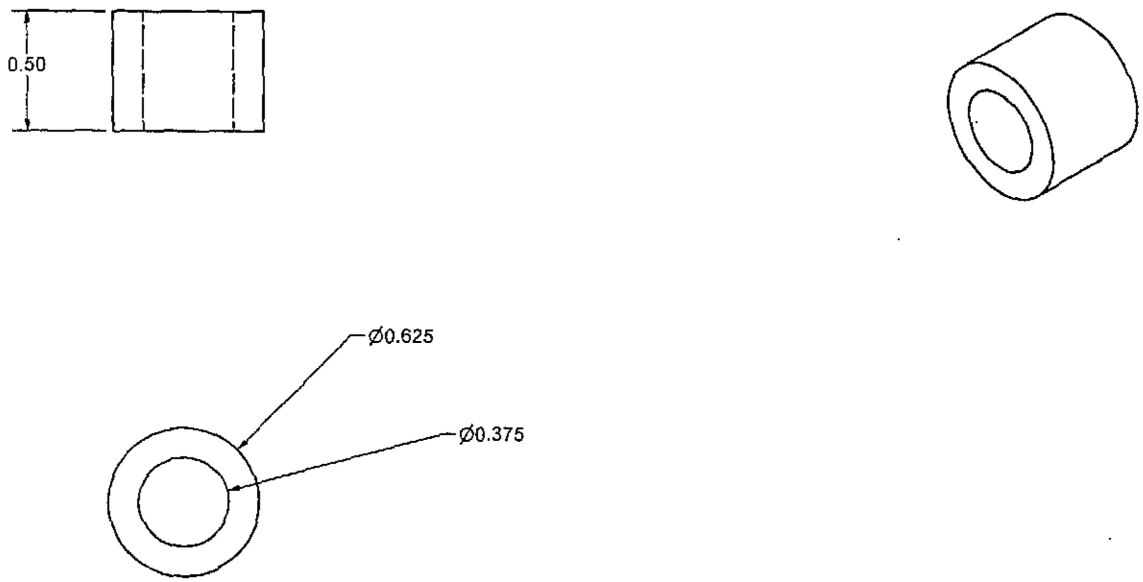

0.06
6.63
R0.31
Ø1.750
Ø0.375
6XØ0.20
R0.25
3.00
2.50
2.00
0.50
1.250
4°
0.31
0.56
3.313
4.500
6.06
6.31
3.31
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°
UtahState UNIVERSITY
Mechanical & Aerospace Engineering
USU
WRIGHT FLYER
1903-2003
DRAWN BY: N. Holman
MATERIAL: 4130 Alloy Steel
PART DESCRIPTION: Linkage Bracket
PART NUMBER: WF-20-017
REV
DATE: 2/17/2002
SCALE:
SIZE: B
SHEET 1 of 1


4
3
2
1
B
A
0.06
Ø1.750
3.31
4XØ0.20
Ø0.375
2.50
2.25
2.00
1.25
0.50
0.56
2.125
3.313
6.06
6.63
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°
UtahState UNIVERSITY Mechanical & Aerospace Engineering
USU
WRIGHT FLYER
1903-2003
DRAWN BY: N. Holman
MATERIAL: 4130 Alloy Steel
PART DESCRIPTION: Hinge Bracket
PART NUMBER: WF-20-018
REV
DATE: 2/17/2002
SCALE:
SIZE: B
SHEET 1 of 1

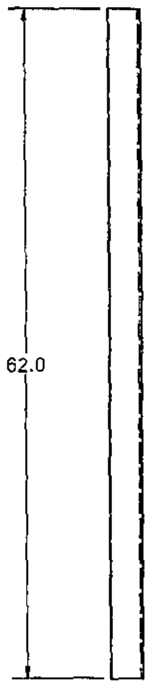
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState University — Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003		
DRAWN BY: N. Holman			
MATERIAL: 4130 Alloy Steel	PART DESCRIPTION: Strut Hinge Plate	PART NUMBER: WF-20-020	REV
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1

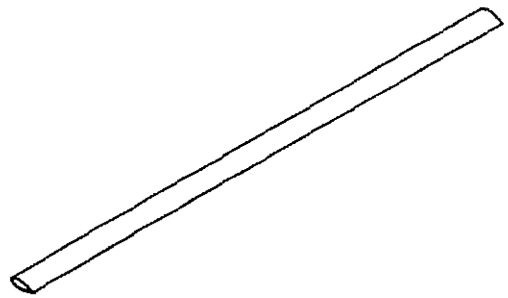


ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering			
	USU WRIGHT FLYER 1903-2003			
DRAWN BY: N. Holman				
MATERIAL: 4130 Alloy Steel	***PART DESCRIPTION:*** Spar Hinge Shaft		***PART NUMBER:*** WF-20-021	***REV***
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 ***of*** 1	

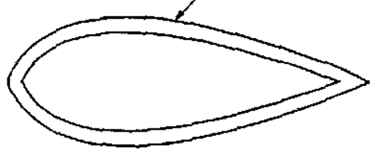


ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	Utah State University — Mechanical & Aerospace Engineering			
DRAWN BY: N. Holman	***USU WRIGHT FLYER 1903-2003***			
MATERIAL: 4130 Alloy Steel	**PART DESCRIPTION:** Hinge Pin Shaft		**PART NUMBER:** WF-20-022	**REV**
DATE: 2/17/2002	**SCALE:**	**SIZE:** B	**SHEET** 1 **of** 1	





USE MATERIAL ALL READY AVAILABLE.



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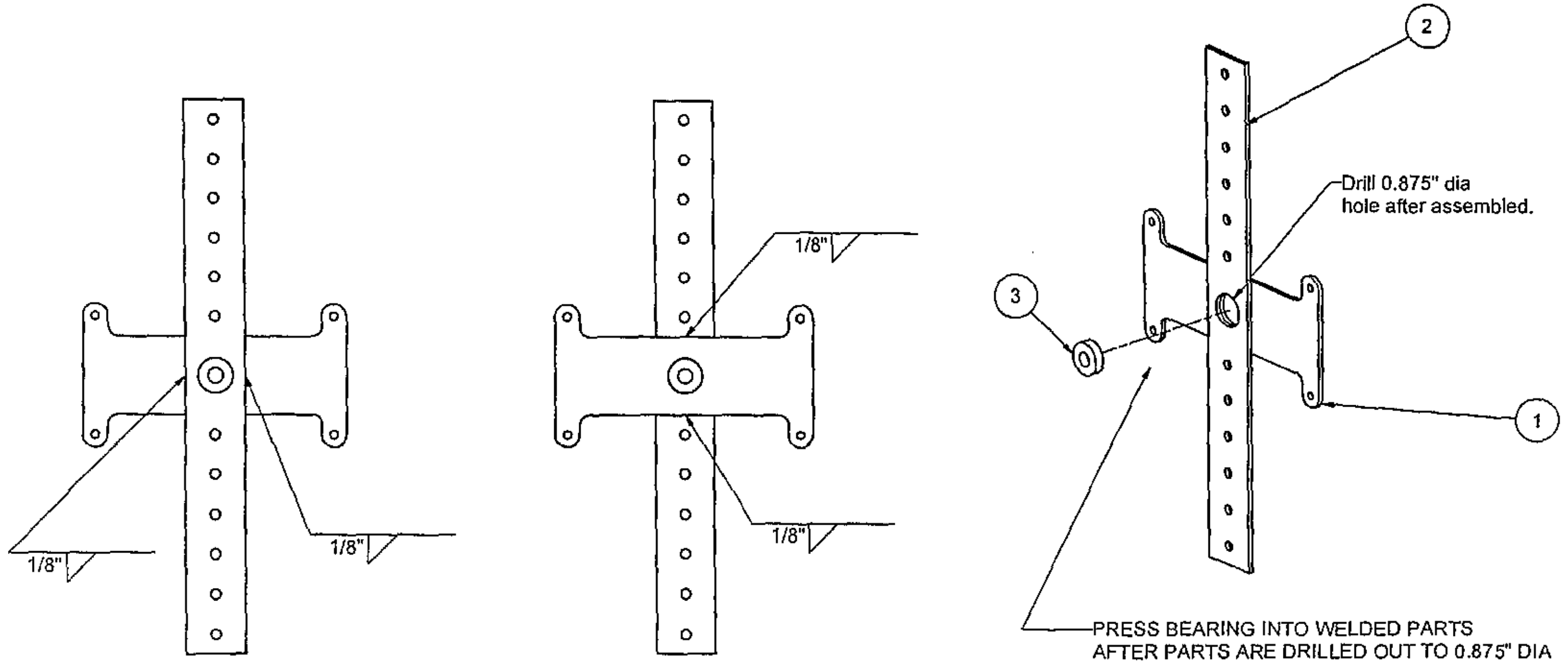
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

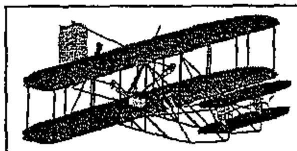
UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: N. Holman			
MATERIAL: Gold	*PART DESCRIPTION:* Streamline Canard Supports	*PART NUMBER:* WF-20-025	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1



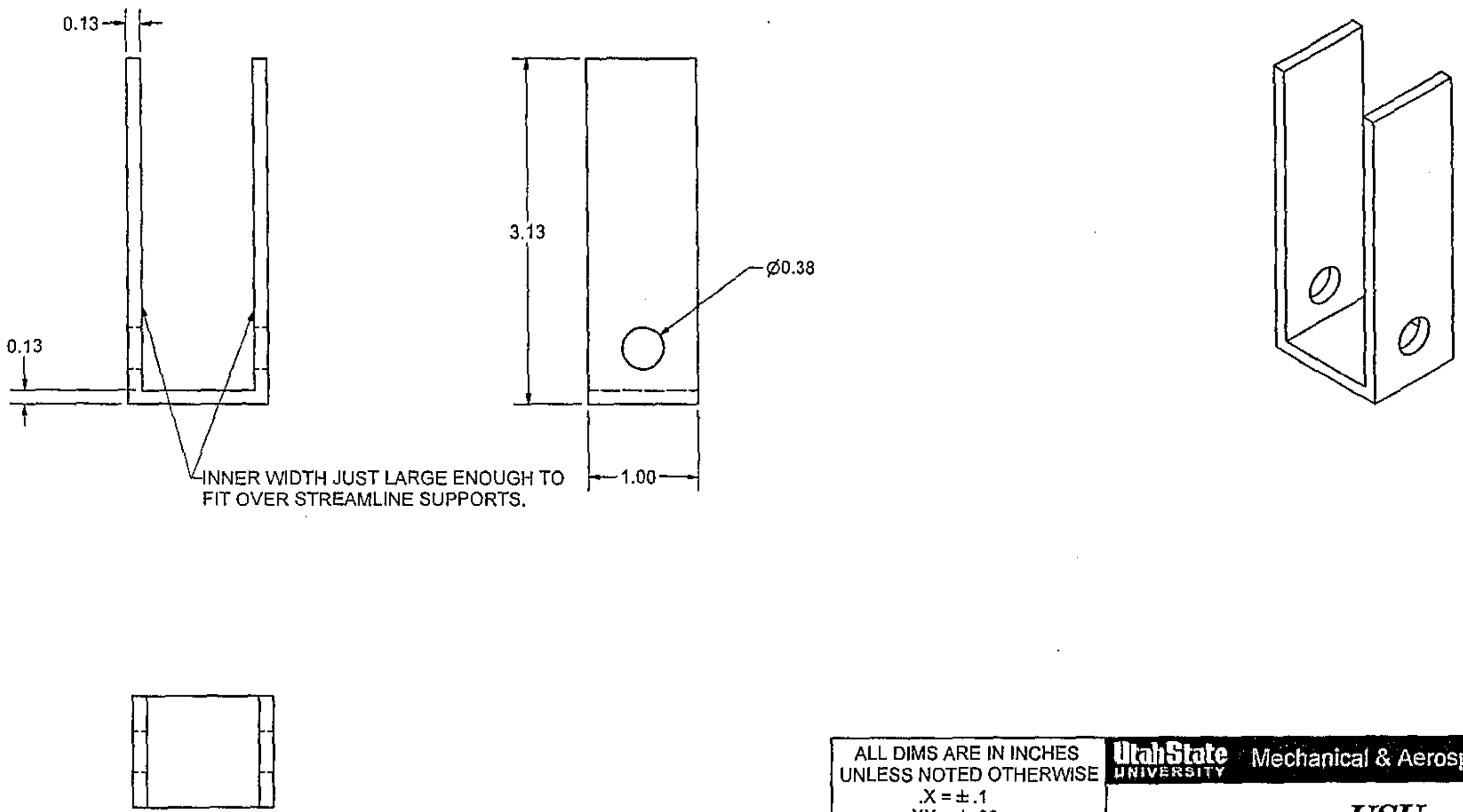
Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-20-033	Linkage Mount
2	1	WF-20-050	Control Adjust
3	1	KS6A-AN200	Canard Controls Bearing



UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: N. Holman				
MATERIAL:	*PART DESCRIPTION:* Control Sub-Assembly		*PART NUMBER:* WF-20-027	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	

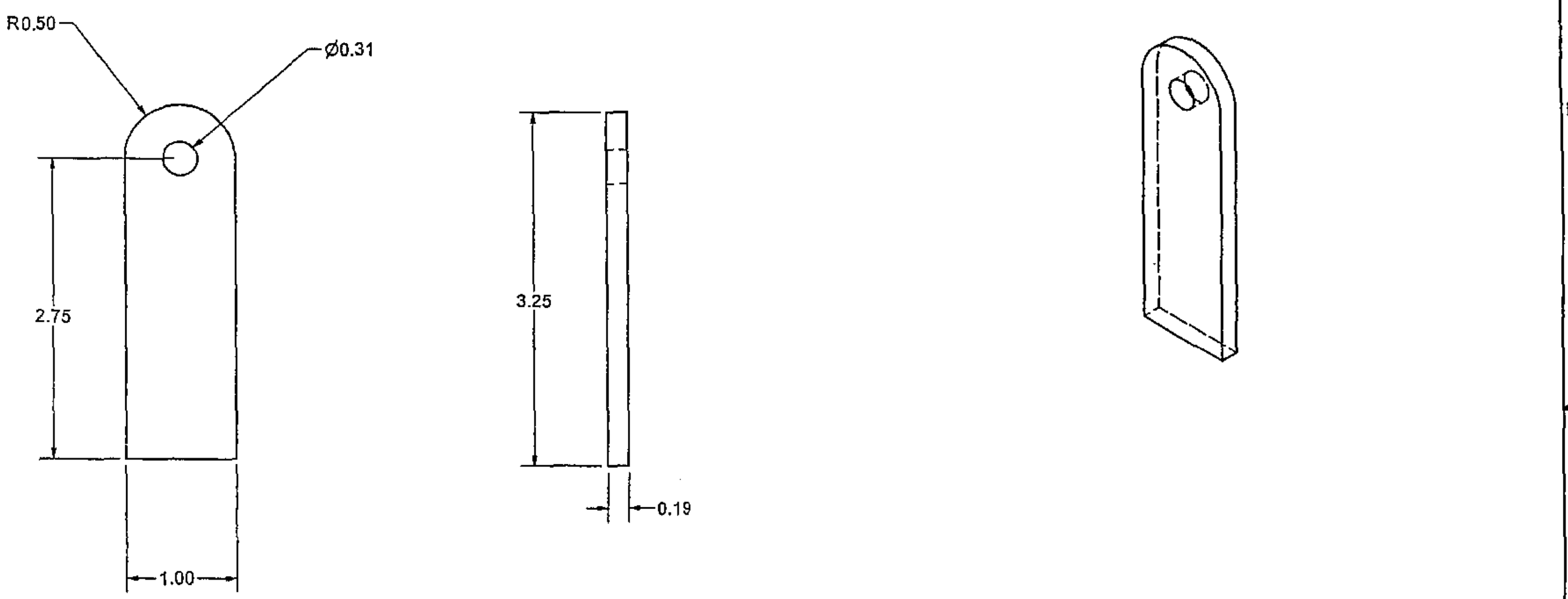


ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: N. Holman			
MATERIAL: 4130 Alloy Steel	*PART DESCRIPTION:* Control Mount	*PART NUMBER:* WF-20-028	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1



ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

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WRIGHT FLYER
1903-2003

DRAWN BY: N. Holman

MATERIAL: 4130 Alloy Steel

PART DESCRIPTION: Chassis Connect

PART NUMBER: WF-20-030

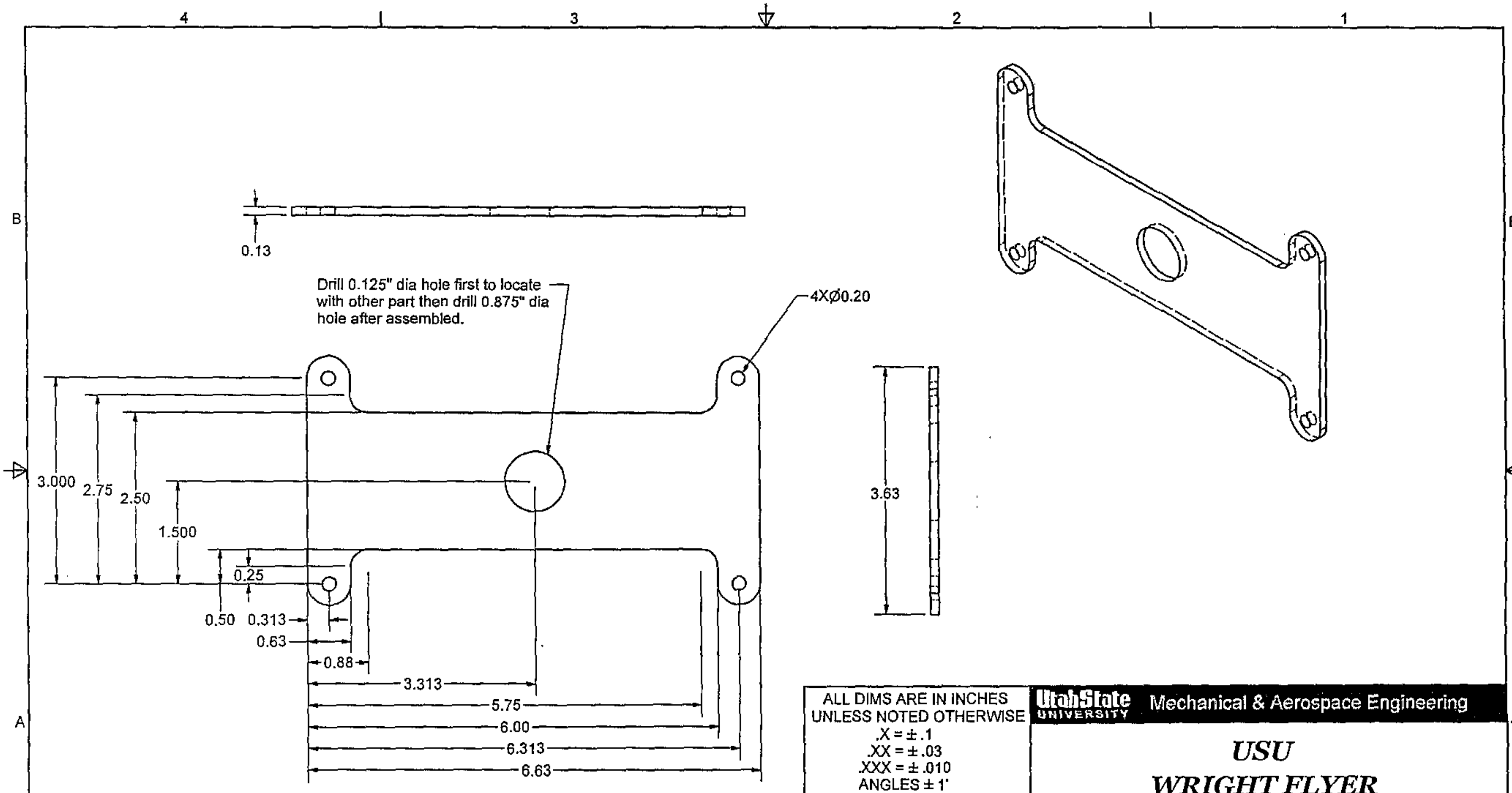
REV

DATE: 2/17/2002

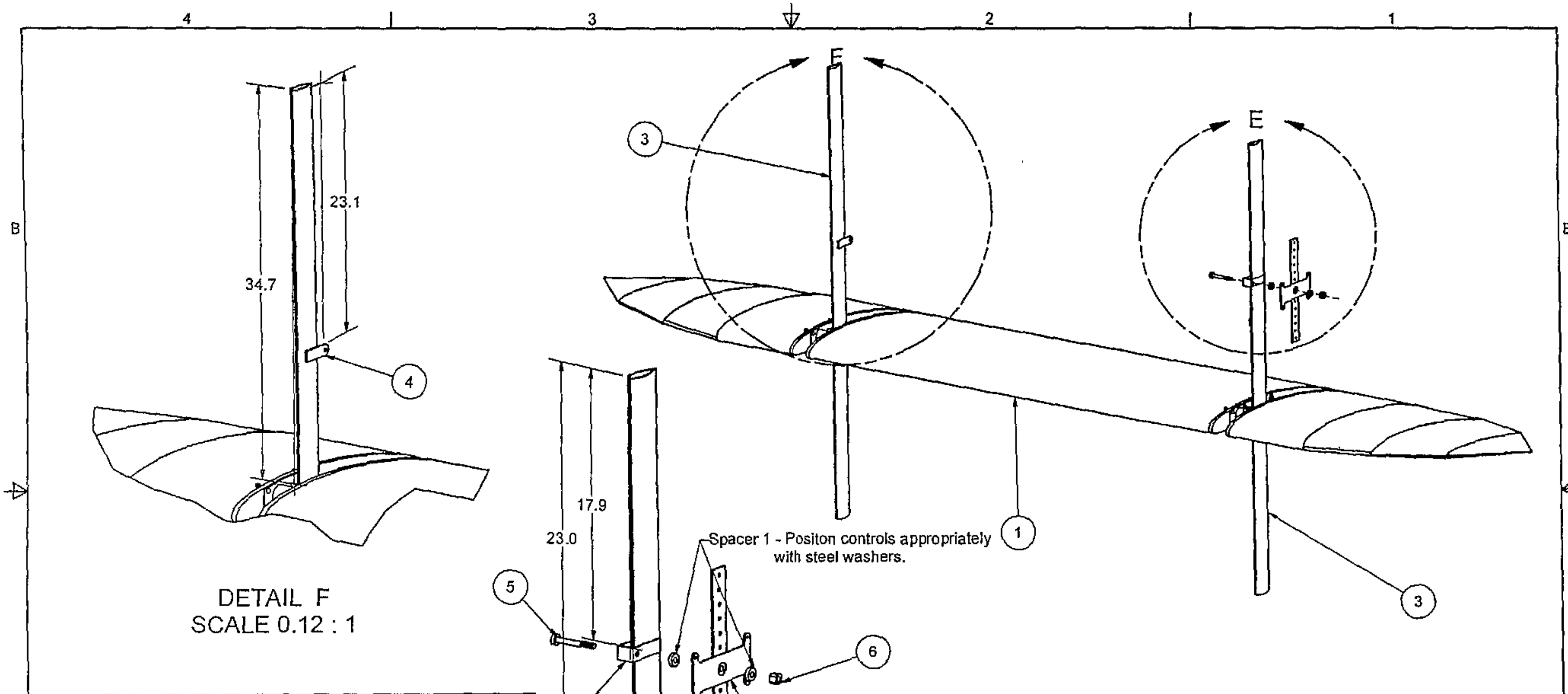
SCALE:

SIZE: B

SHEET 1 *of* 1

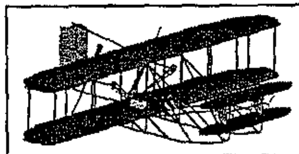


ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*			
DRAWN BY: N. Holman				
MATERIAL: 4130 Alloy Steel	*PART DESCRIPTION:* Linkage Mount		*PART NUMBER:* WF-20-033	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



Parts List

ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-20-002	Canard Surface Assembly Bottom
2	1	WF-20-027	Control Sub-Assembly
3	2	WF-20-025	Streamline Canard Supports
4	2	WF-20-030	Chassis Connect
5	1	AN6-24	Control Mount Shaft
6	1	AN365-624A	3/8-24 Stop Nut
7	2	Spacer 1	Spacer 1
8	1	WF-20-028	Control Mount



UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: N. Holman

MATERIAL:

DATE: 2/17/2002

PART DESCRIPTION: Canard Sub-Assembly

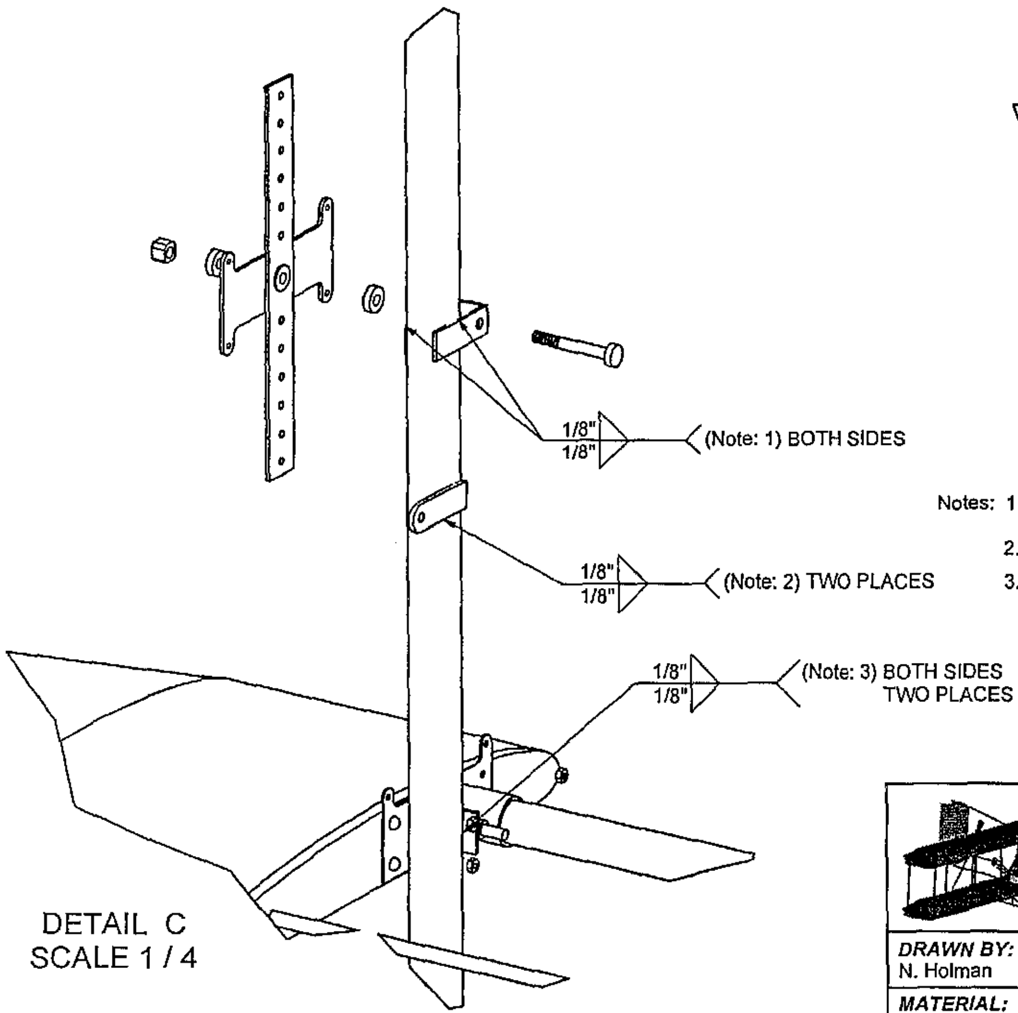
PART NUMBER: WF-20-040

REV

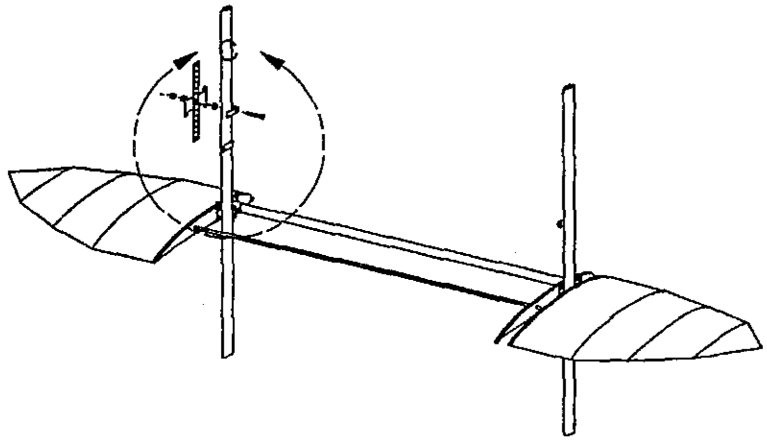
SCALE:

SIZE: B

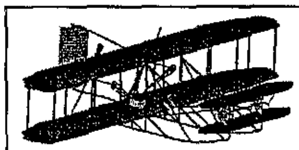
SHEET 1 *of* 1



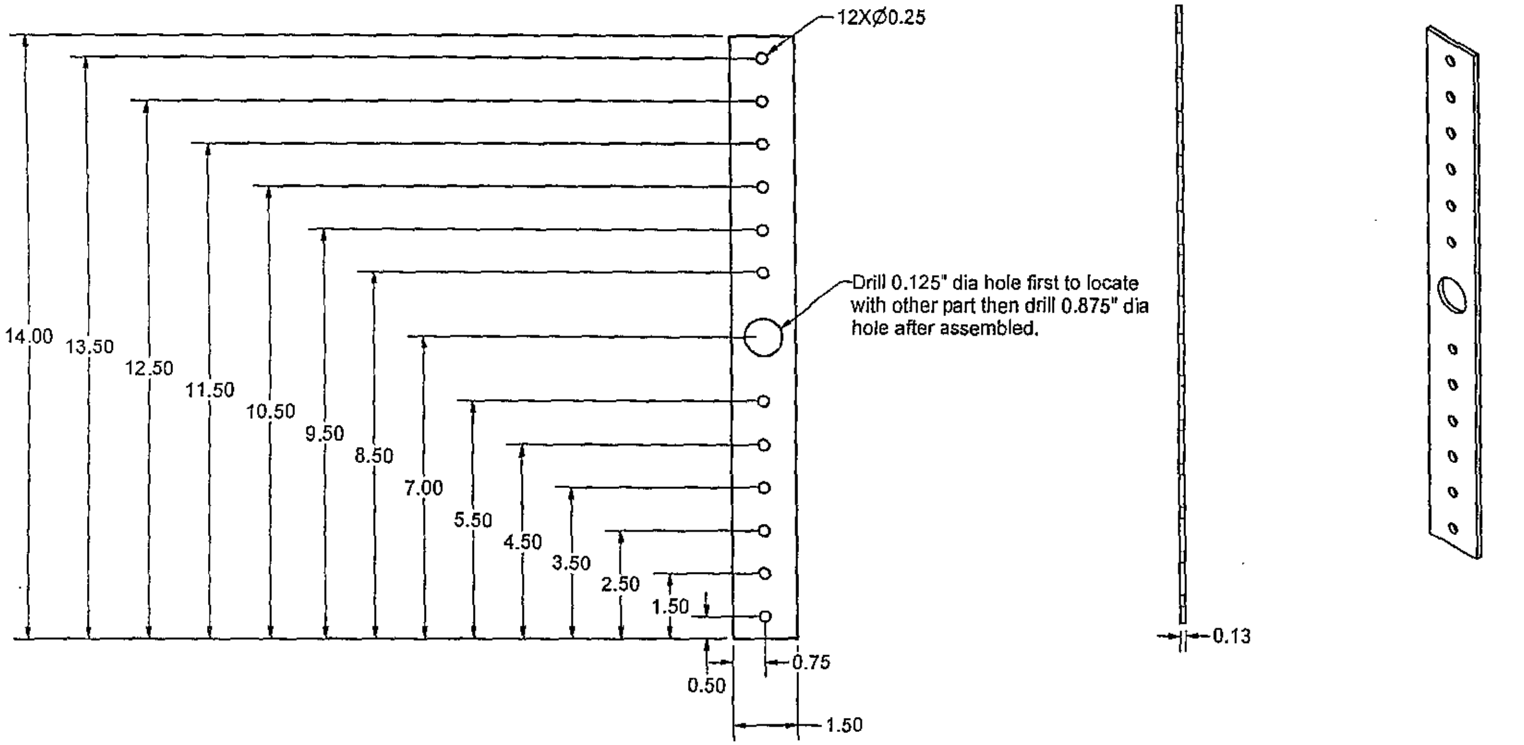
DETAIL C
SCALE 1 / 4



Notes:
1. Control Mount - Position for best alignment with controls and weld tangent to 1/4 chord of supports.
2. Support Mounts - Position for best alignment and weld tangent to 1/4 chord of supports.
3. Hinge Mount Plates - Weld tangent to leading edge of supports.'



	UtahState UNIVERSITY Mechanical & Aerospace Engineering			
DRAWN BY: N. Holman	USU WRIGHT FLYER 1903-2003			
MATERIAL:	PART DESCRIPTION: Canard Sub-Assembly	PART NUMBER: WF-20-040		REV
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	



ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
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.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: N. Holman

MATERIAL: 4130 Alloy Steel

PART DESCRIPTION: Control Adjust

PART NUMBER: WF-20-050

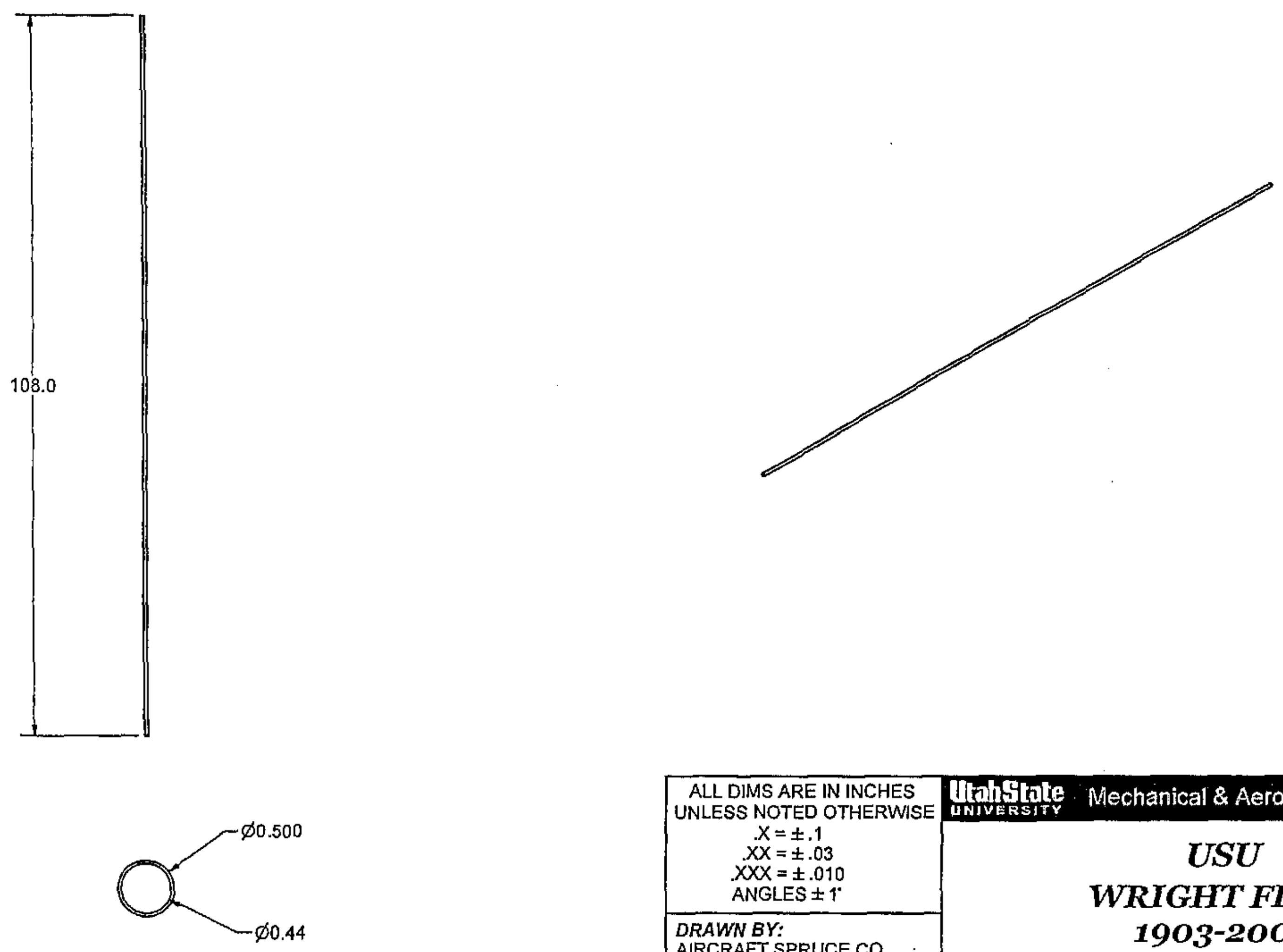
REV

DATE: 2/17/2002

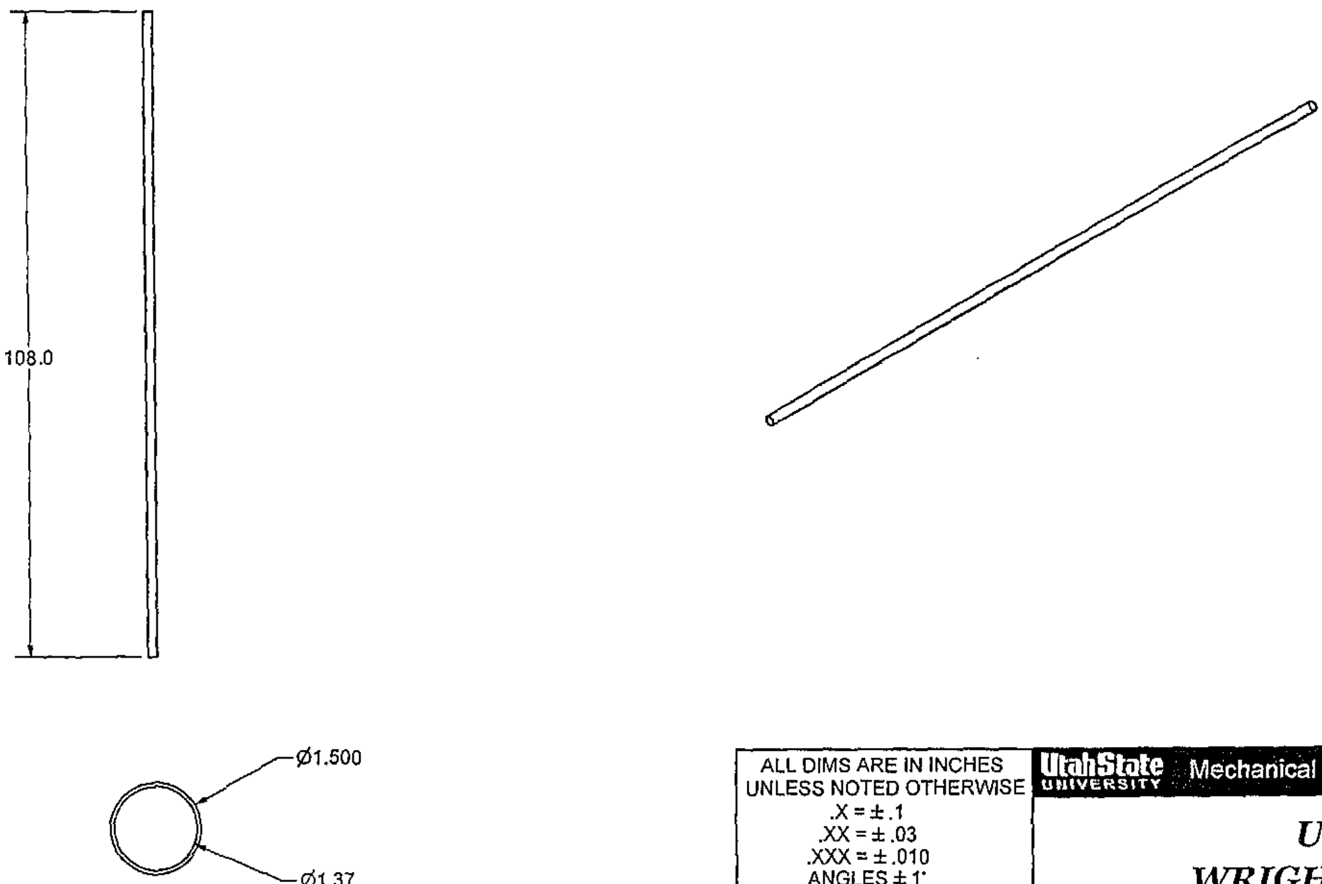
SCALE:

SIZE: B

SHEET 1 *of* 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003			
DRAWN BY: AIRCRAFT SPRUCE CO.				
MATERIAL: 4130 Alloy Steel	PART DESCRIPTION: Rear Spar		PART NUMBER: 03-02300	REV
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	



ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: AIRCRAFT SPRUCE CO.

MATERIAL: 4130 Alloy Steel

PART DESCRIPTION: Main Spar

PART NUMBER: 03-09100

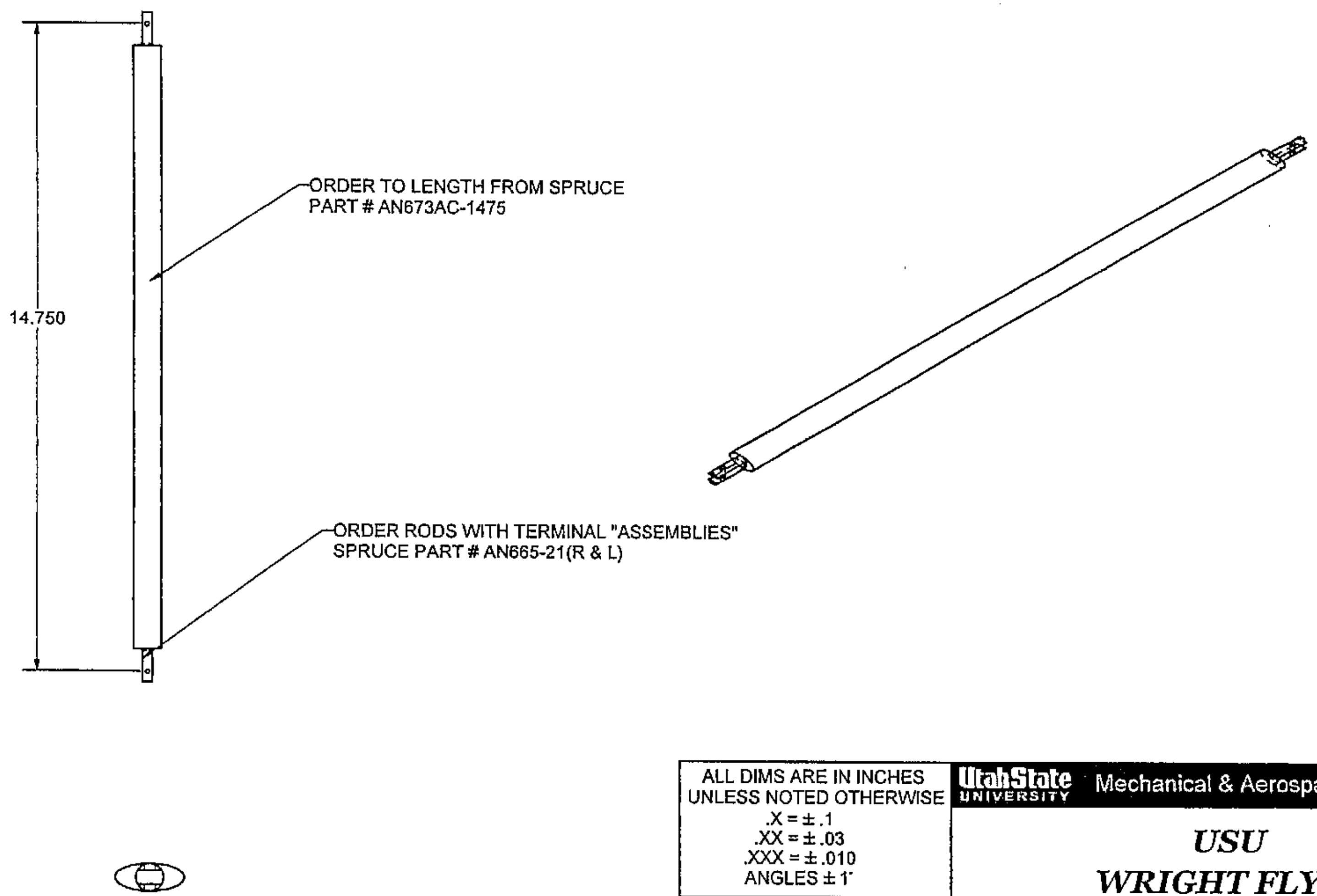
REV

DATE: 2/17/2002

SCALE:

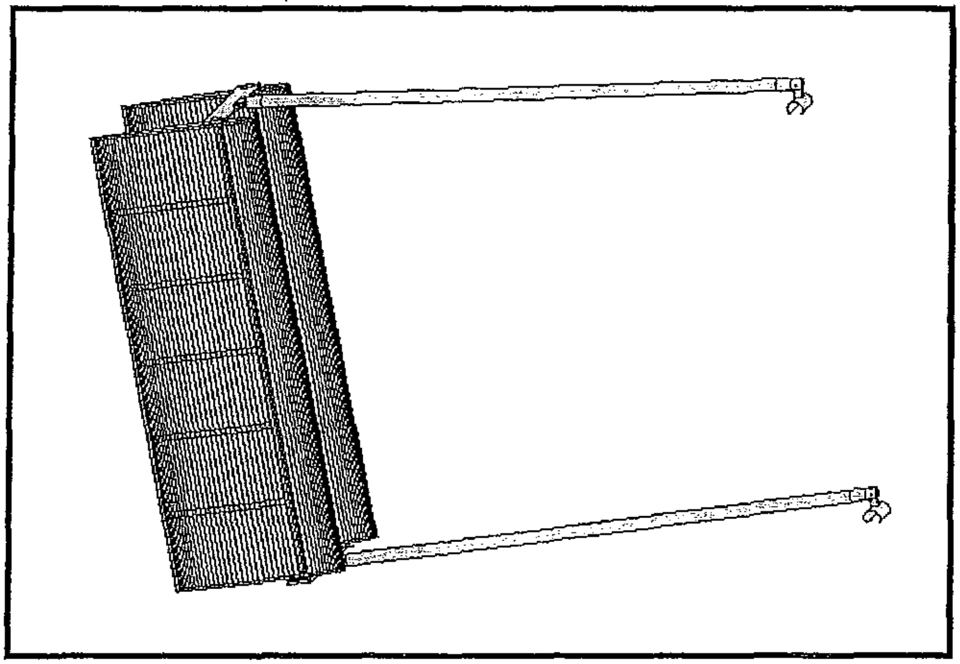
SIZE: B

SHEET 1 *of* 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState University — Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*		
DRAWN BY: AIRCRAFT SPRUCE & CO.			
MATERIAL: Stainless Steel, Austenitic	**PART DESCRIPTION:** Control Rod	**PART NUMBER:** AN673AC-1475	**REV**
DATE: 2/17/2002	**SCALE:**	**SIZE:** B	**SHEET** 1 of 1

Rudder Assembly



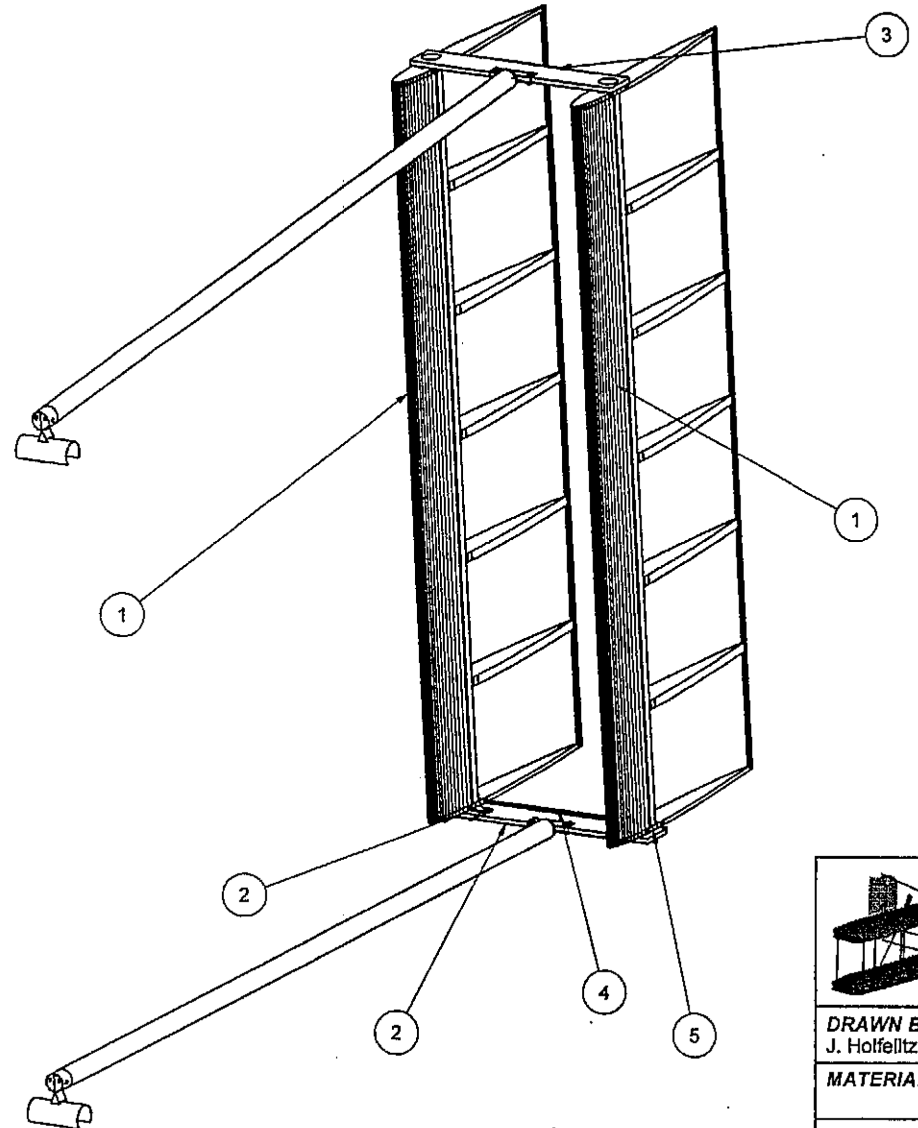
Materials List for Rudder

ck spc= check drawing specifications

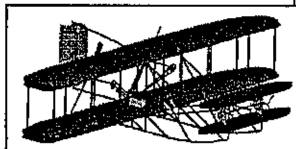
Item/Material	Description	Qty	Part #	Supplier
Foam	1"X30", 2" sheets	ck spc		Hardware store
Kevlar	7' length	ck spc		?
Aluminum Skin Honeycomb	12" X 30"			ITE Dept.
Wood	1/2" X 1 1/4" X 5"	2		ITE Dept.
Wood	1/2" X 2" diameter	4		ITE Dept.
Carbon Tubes	2"X8'	2		ITE Dept.
Steel Tubing	2" O.D. x 0.035" wall	2 ft		ITE/IPACO
Steel Pins	3/8"	1 ft		?
Plate Steel	5" x 1/16"	2 ft		ITE/IPACO
Plate Steel	4" x 1/16"	1 ft		ITE/IPACO
Plate Steel	3" x 0.10"	1 ft		ITE/IPACO
Aluminum Plate	1/8" X 4" X 4"	2		ITE/IPACO
Push/Pull Control Rod				ITE/Aircraft Spruce
Bolt and Nut 1/4"		8		ITE
Bolt and Nut 10-32		2		ITE
Bolt (machine screw)		8		ITE
Nylon Washer	3/8" hole	8	NW 2061	ITE/Aircraft Spruce
Delrin Stock	1/2" X 2" X 4"	4		?
Nylon Stock	1/4" X 2" X 2"	2		?
Trailing Edge	1"	14 ft	pg. 72	ITE/Aircraft Spruce
Dacron Covering	28 sq ft			ITE/Aircraft Spruce

Parts List for Rudder

Part Number	Description	Qty	Type
WF-20-100	Rudder Assembly	1	assembly
WF-20-101	Rudder Surface Assembly	2	assembly
WF-20-103	Bottom Plate Assembly	1	assembly
WF-20-104	Top Plate Assembly	1	assembly
WF-20-105	Control Linkage Assembly	1	assembly
WF-20-130	Push/Pull Rod (round)	1	fit
WF-20-131	Control Plate	2	cut & drilled
WF-20-141	Rudder Spacer Plate (bottom)	2	cut & drilled
	Hardware		attach
WF-20-111	Rudder D Tube	2	foam lay-up
WF-20-112	Rudder C Beam	2	bi-dir weave lay-up
WF-20-113	Rudder Hard Plate	4	cut, mill & finish
WF-20-114	Rudder Ribs	10	foam lay-up
WF-20-115	Rudder Trailing Edge	2	cut & attach
WF-20-116	Rudder Pivot Block Insert	2	mill & bond
WF-20-140	Rudder Pivot Block Insert Pins	4	cut & bond
	Hardware		
	Glue		
	Covering Material		attach
WF-20-117	Cross Support	2	honeycomb lay-up
WF-20-118	Bearing Assy	4	press-fit & bond
WF-20-130	Steel Shaft	4	cut & drilled
WF-20-131	Wood Circle	4	cut & drilled
WF-20-119	Mount Point	2	cut
WF-20-120	Support Cables	4	attach fit
NW 2061	Nylon Washers	6	drill
WF-20-122	Bottom Beam Support	1	wavy comp. lay-up
WF-20-126	Top Beam Support	1	wavy comp. lay-up
WF-20-123	Wing Spar Mount Assy	2	weldment
WF-20-142	Wing Spar Mount Tube	2	rolled
WF-20-145	Wing Spar Mount Brace	4	weldment
WF-20-124a	Beam Attach Insert	2	cut & milled
WF-20-125	Bot Rud Attach Assy	1	weldment
WF-20-135	Bot Rud Tube	1	milled
WF-20-129	Top Rudattach Assy	1	weldment
WF-20-136	Top Rud Tube	1	milled
WF-20-137	Rud Attach Plate	4	milled



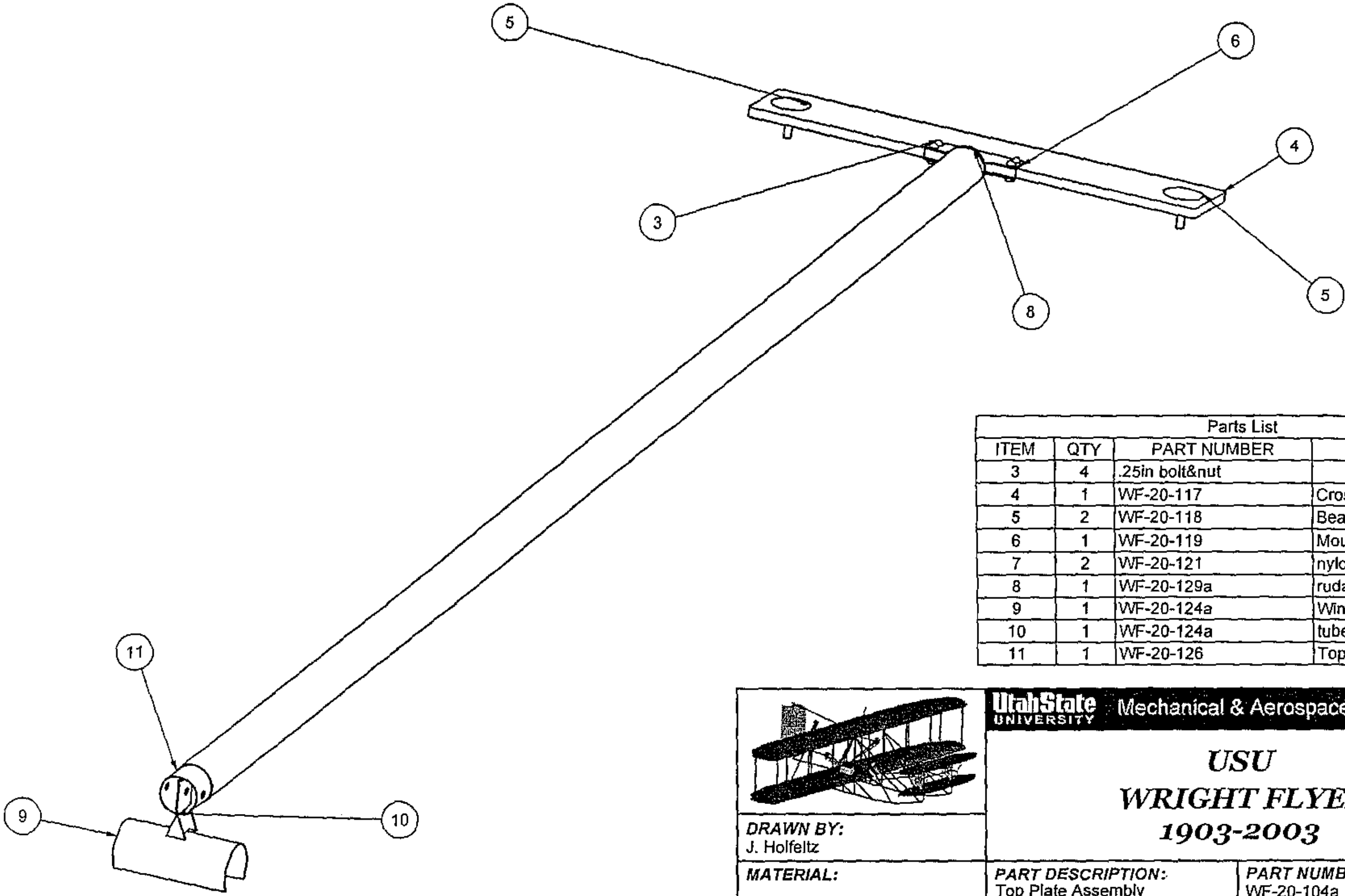
Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	WF-20-101	Rudder Surface Assembl y
2	1	WF-20-103	Bottom Plate Assembly
3	1	WF-20-104	Top Plate Assembly
4	1	WF-20-105	Linkage Assembly
5	2	WF-20-141	Rudder Spacer Plate (bot tom)



UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: J. Holfelltz			
MATERIAL:	PART DESCRIPTION: Rudder Assembly	PART NUMBER: WF-20-100a	REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
3	4	.25in bolt&nut	
4	1	WF-20-117	Cross Support
5	2	WF-20-118	Bearing
6	1	WF-20-119	Mount Point
7	2	WF-20-121	nylon washers
8	1	WF-20-129a	rudattachassy2a
9	1	WF-20-124a	Wing Spar Mount Bottom
10	1	WF-20-124a	tube cnt
11	1	WF-20-126	Top Beam Support

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: J. Holfeltz

MATERIAL:

PART DESCRIPTION: Top Plate Assembly

PART NUMBER: WF-20-104a

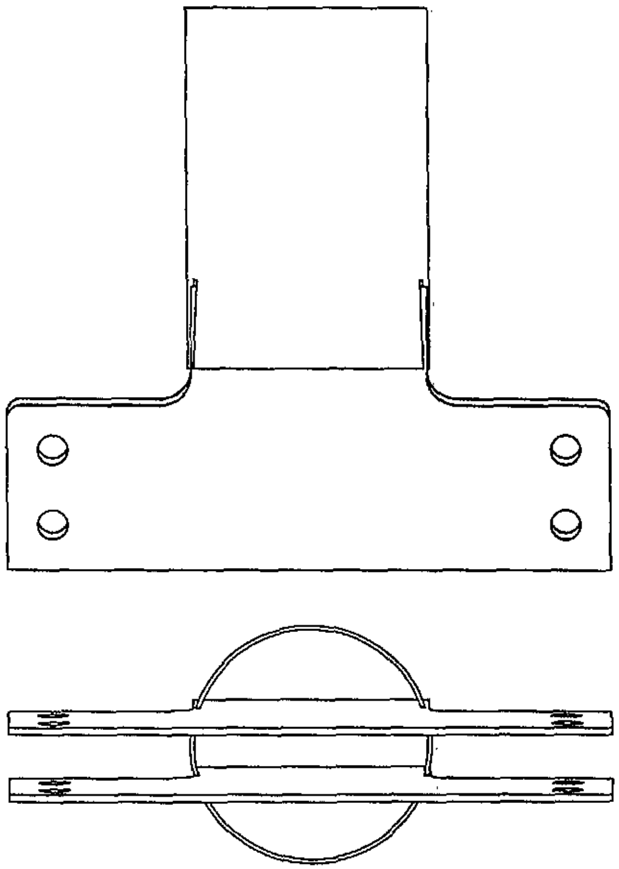
REV A

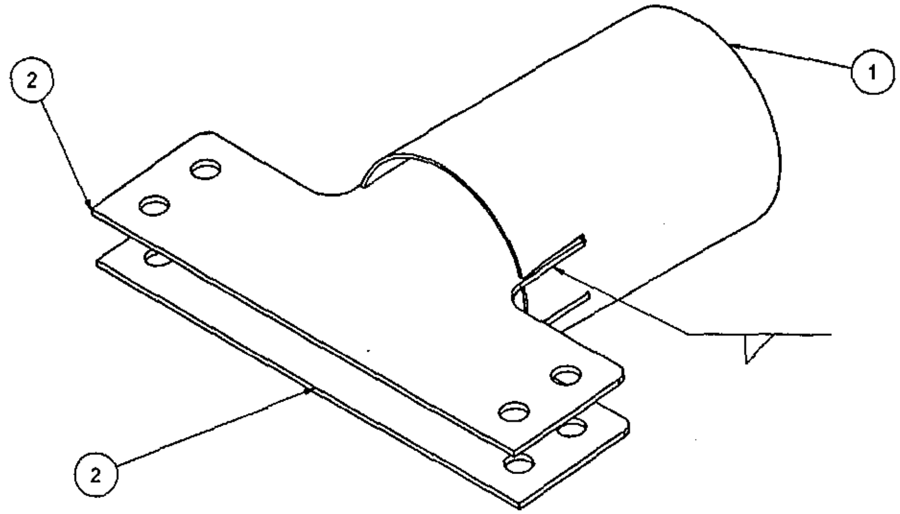
DATE: 2/17/2002

SCALE:

SIZE: B

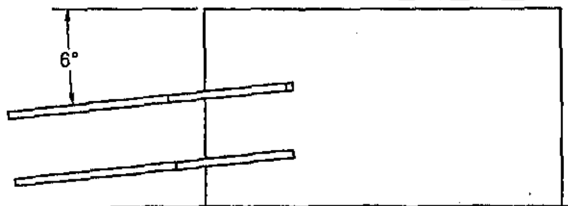
SHEET 1 *of* 1





Parts List

ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-20-136	top2 rud tube
2	2	WF-20-137	rud attach plate



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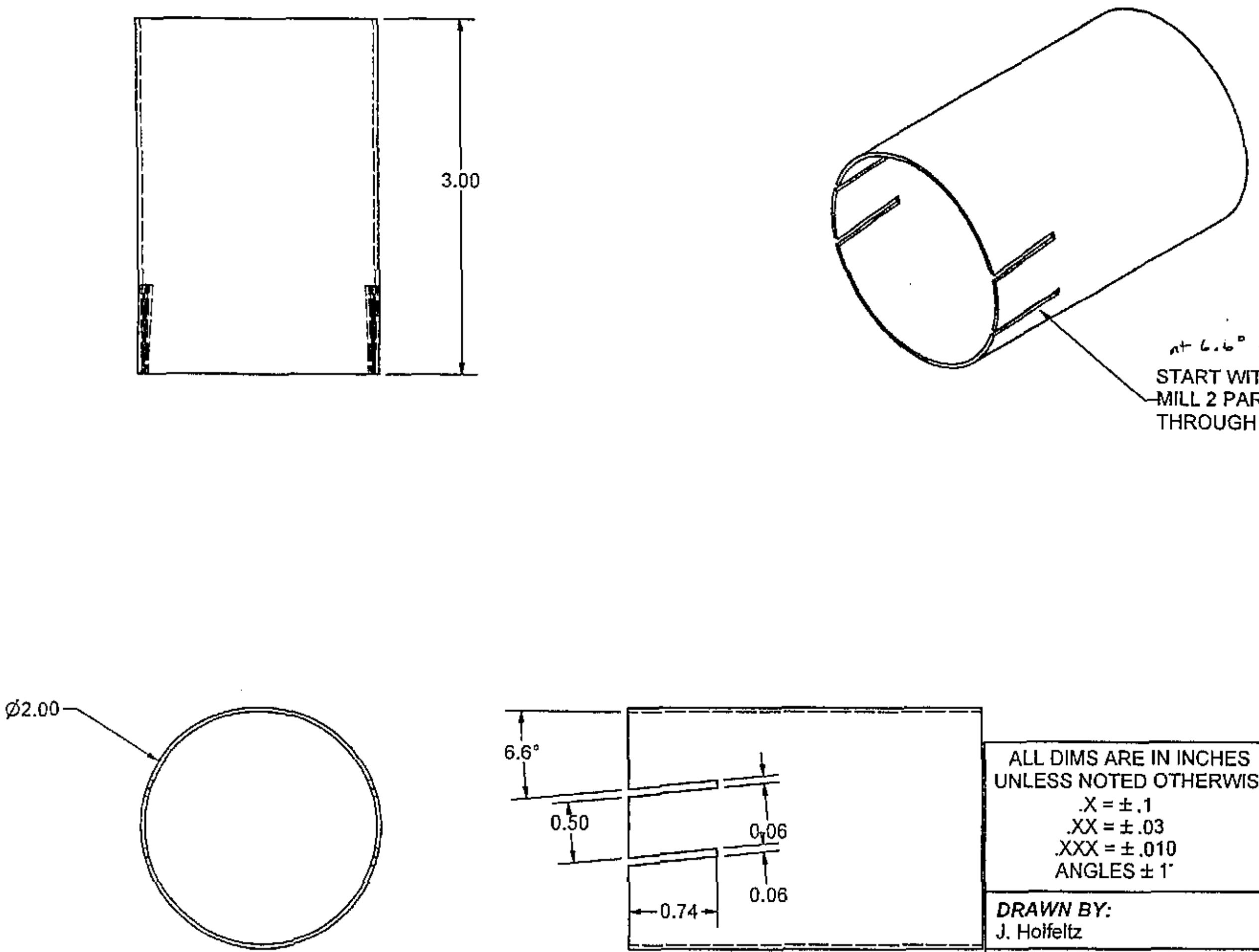
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

Utah State University — Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: J. Holfeltz			
MATERIAL:	PART DESCRIPTION: rudattachassy2a	PART NUMBER: WF-20-129	REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1



at 6.6° from ℄

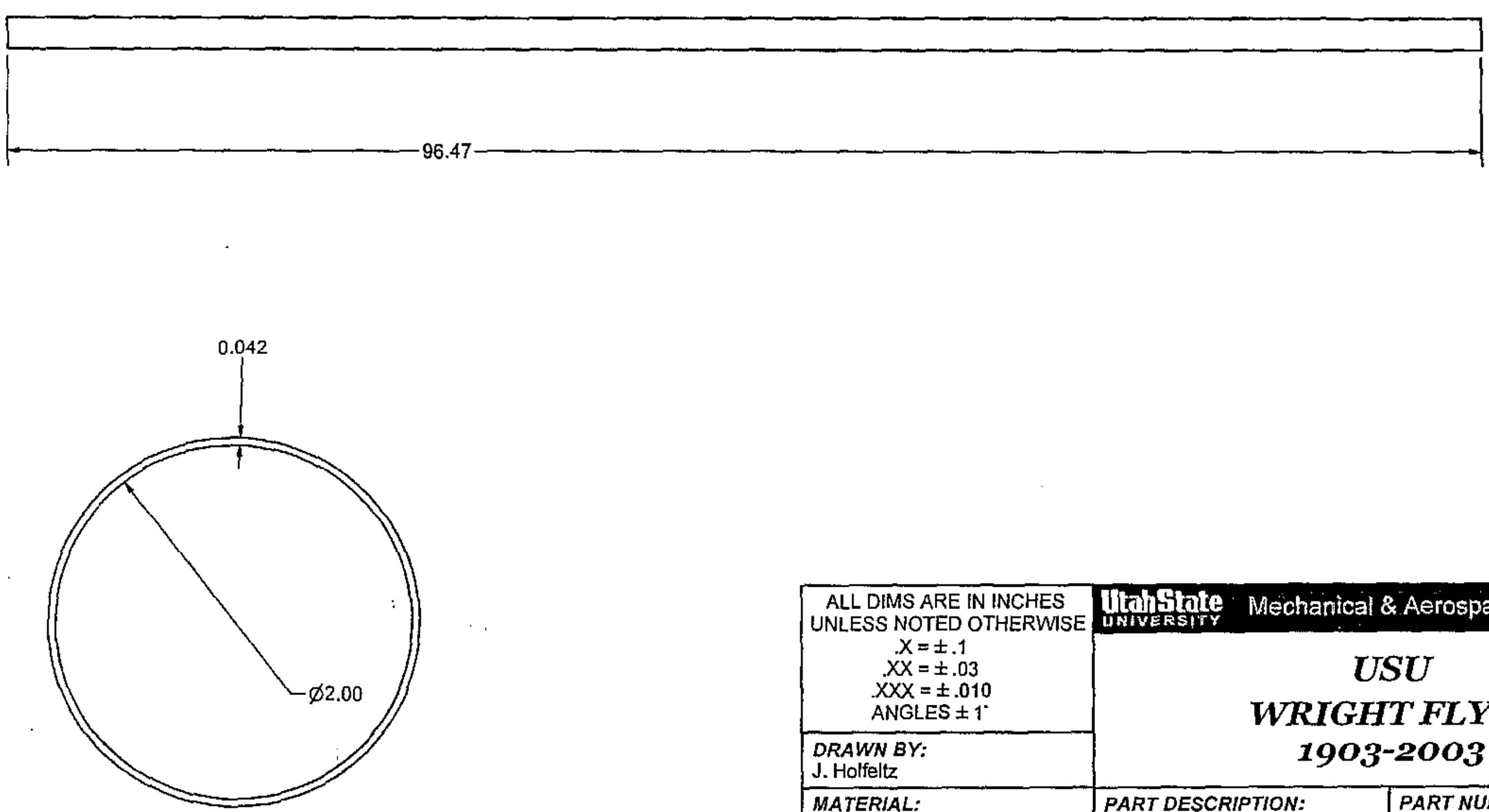
START WITH 3" LONG PIECE OF 2"DIA PIPE 0.035" THICK
MILL 2 PARALLEL 1/16" SLITS, 3/4" LONG, 1/2" APART
THROUGH MIDDLE, DRILL HOLES FOR BONDING

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

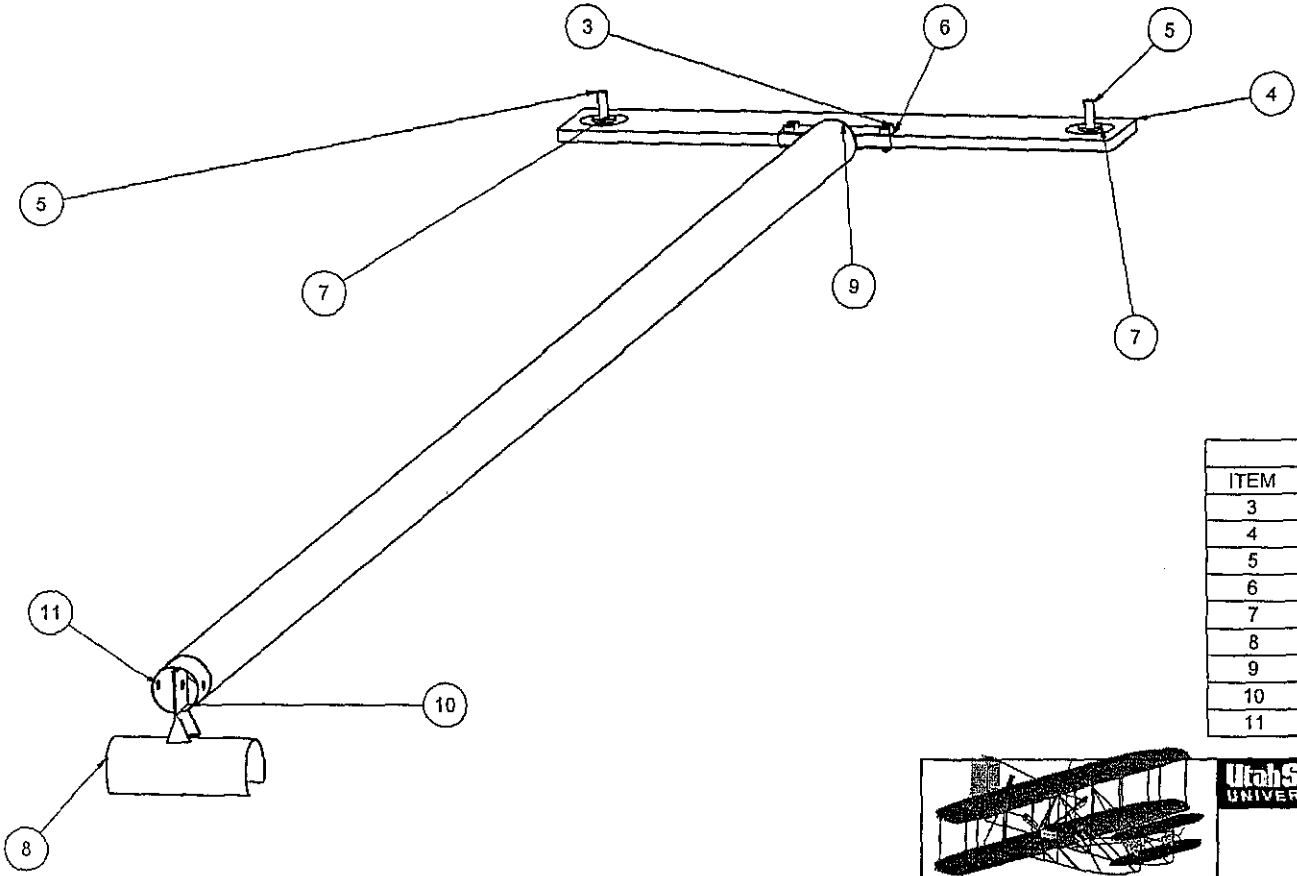
UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: J. Holfeltz			
MATERIAL: Steel, High Strength Low Alloy	*PART DESCRIPTION:* top2 rud tube	*PART NUMBER:* WF-20-136	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	Utah State University — Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*
DRAWN BY: J. Holfeltz	
MATERIAL: carbon fiber	*PART DESCRIPTION:* Top Beam Support | *PART NUMBER:* WF-20-126 | *REV*
DATE: 2/17/2002	*SCALE:* | *SIZE:* B | *SHEET* 1 *of* 1

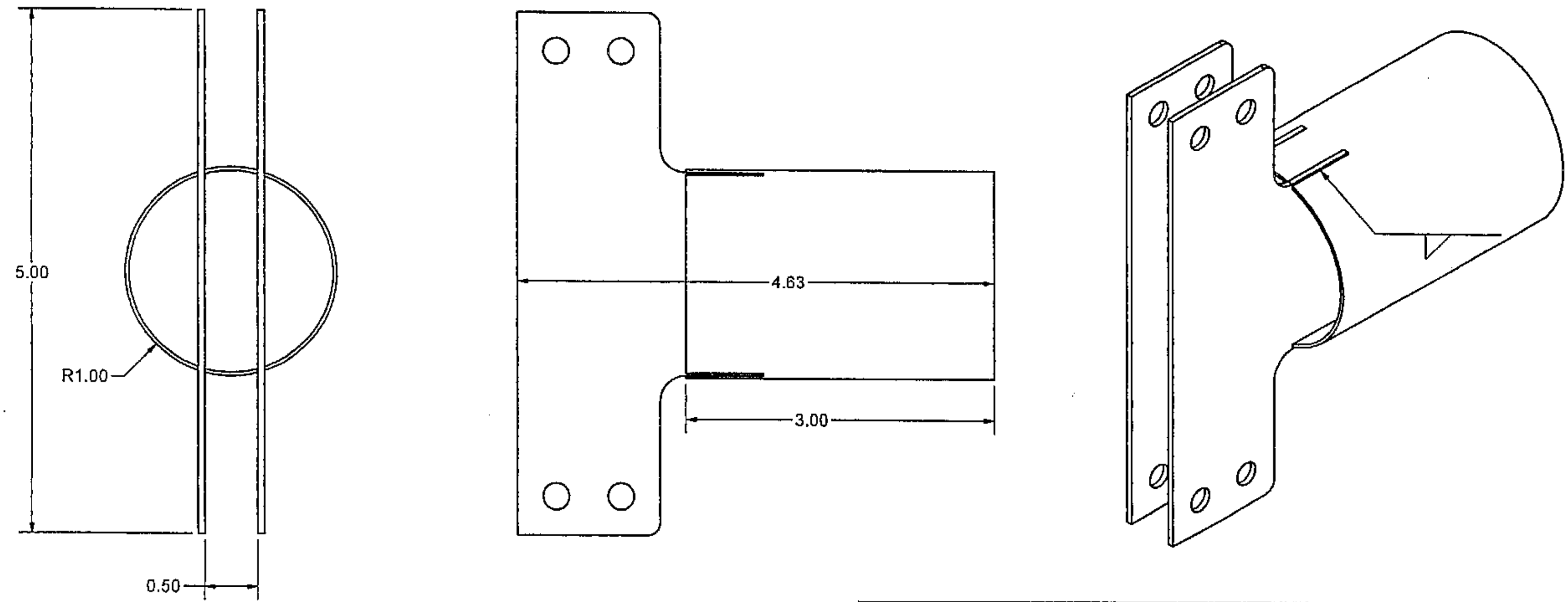


Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
3	4	.25in bolt&nut	
4	1	WF-20-117	Cross Support
5	2	WF-20-118	Bearing
6	1	WF-20-119	Mount Point
7	2	WF-20-121	nylon washers
8	1	WF-20-124a	Wing Spar Mount Bottom
9	1	WF-20-125a	rudattachassy1a
10	1	WF-20-122	Botton Beam Support
11	1	WF-20-124a	tube cnt

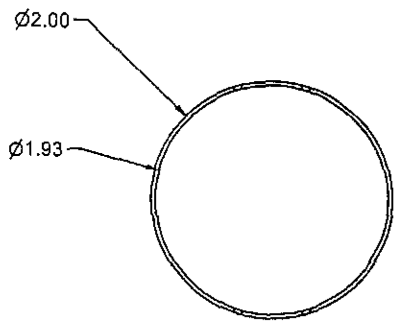
Utah State University — Mechanical & Aerospace Engineering

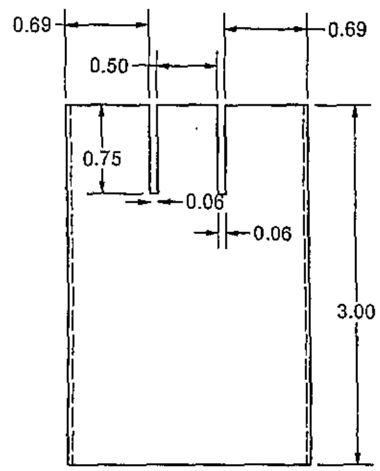
USU WRIGHT FLYER 1903-2003

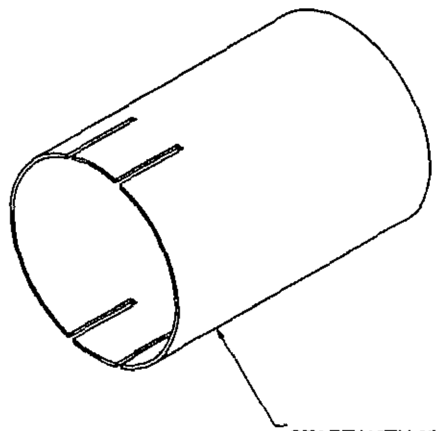
DRAWN BY: J. Holfeltz				
MATERIAL:	PART DESCRIPTION: Bottom Plate Assembly		PART NUMBER: WF-20-103a	REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*
DRAWN BY: J. Holfeltz	
MATERIAL:	*PART DESCRIPTION:* rudattachassy1a / *PART NUMBER:* WF-20-125. / *REV* A
DATE: 2/17/2002	*SCALE:* / *SIZE:* B / *SHEET* 1 *of* 1







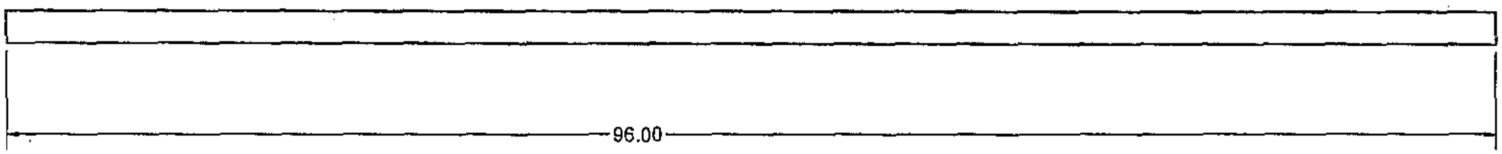
START WITH 3" LONG PIECE OF 2"DIA PIPE 0.035" THICK
MILL 2 PARALLEL WITH CENTERLINE 1/16" SLITS,
3/4" LONG, 1/2" APART
THROUGH MIDDLE, DRILL HOLES FOR BONDING

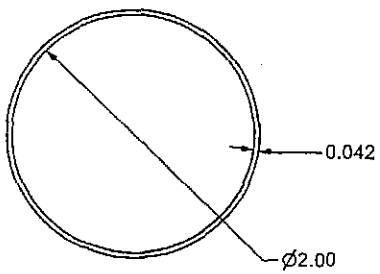
ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: J. Holfeltz				
MATERIAL: Steel, High Strength Low Alloy	*PART DESCRIPTION:* bot rud tube		*PART NUMBER:* WF-20-135	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	





ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

Utah State University — Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: J. Holfeltz

MATERIAL: carbon fiber

DATE: 2/17/2002

PART DESCRIPTION: Botton Beam Support

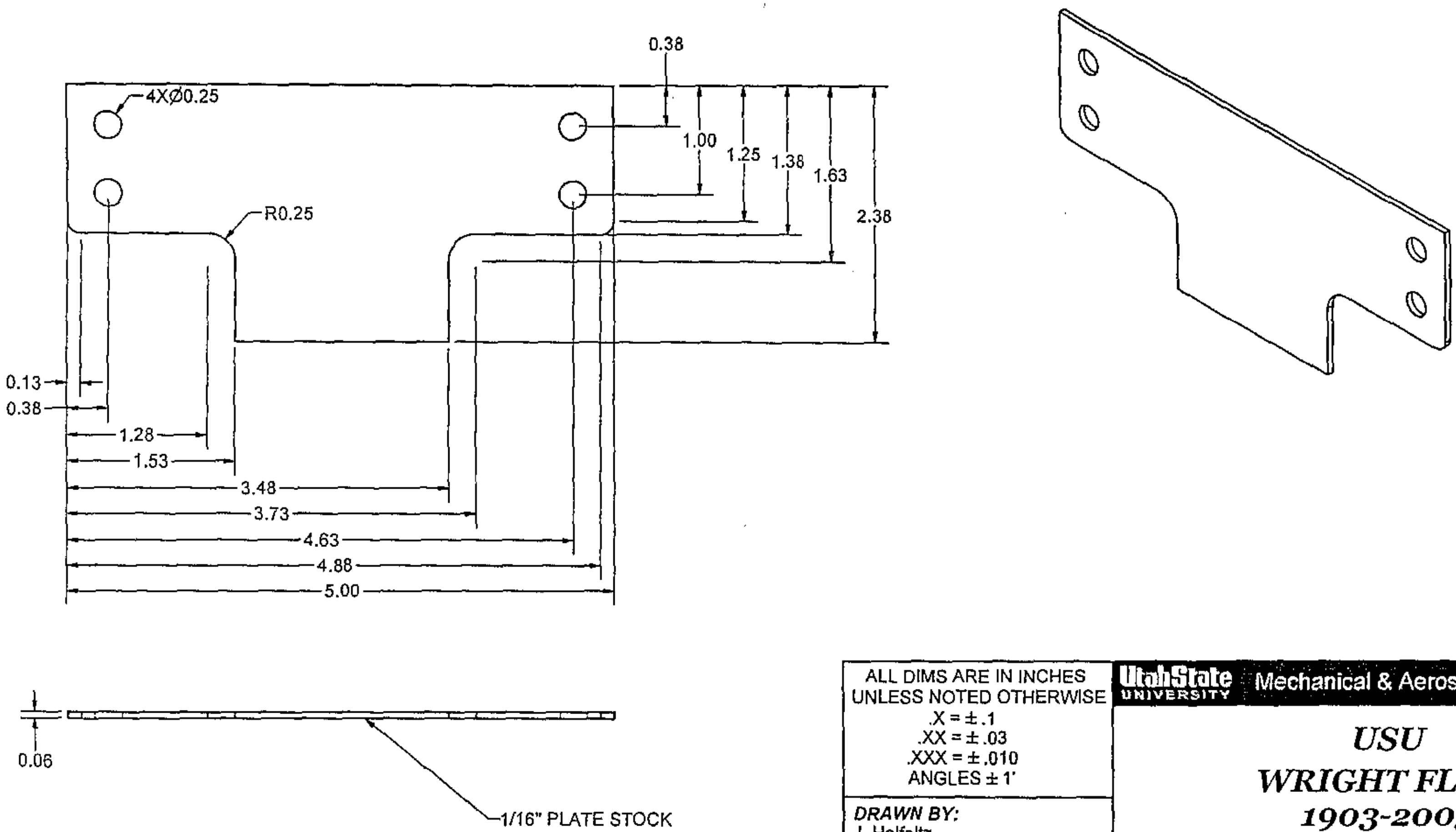
PART NUMBER: WF-20-122

REV

SCALE:

SIZE: B

SHEET 1 ***of*** 1



ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

Utah State University — Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: J. Holfeltz

MATERIAL: Steel, High Strength Low Alloy

PART DESCRIPTION: rud attach plate

PART NUMBER: WF-20-137

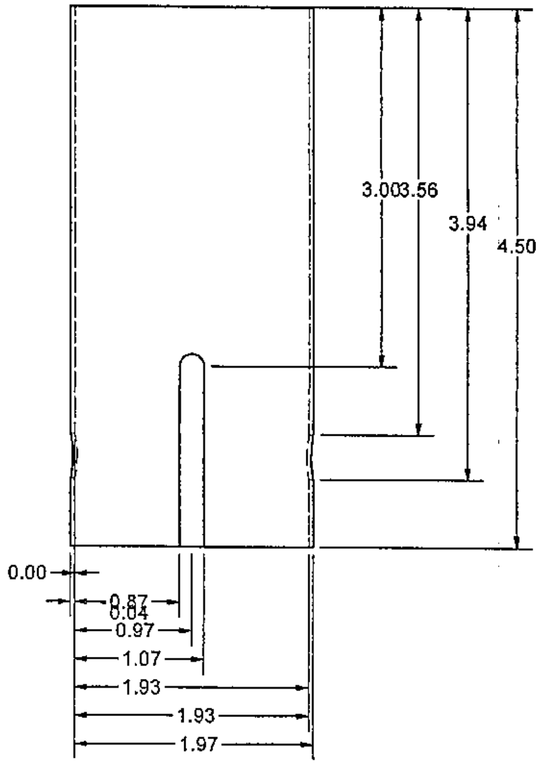
REV

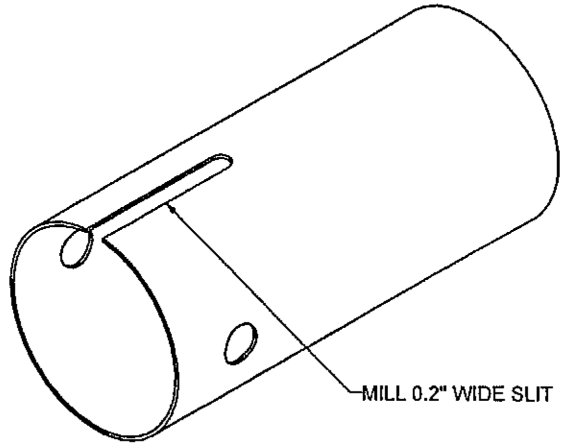
DATE: 2/17/2002

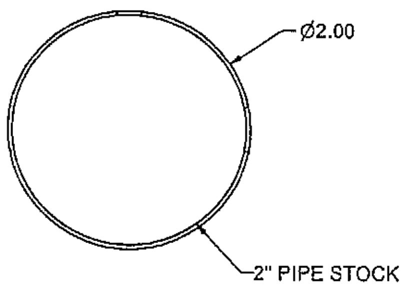
SCALE:

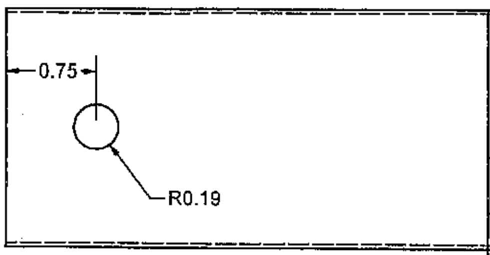
SIZE: B

SHEET 1 *of* 1







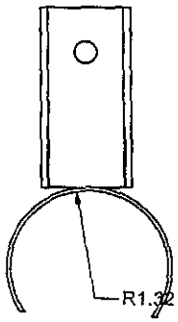


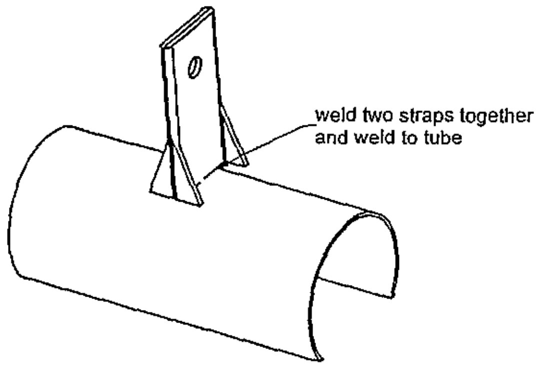
ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

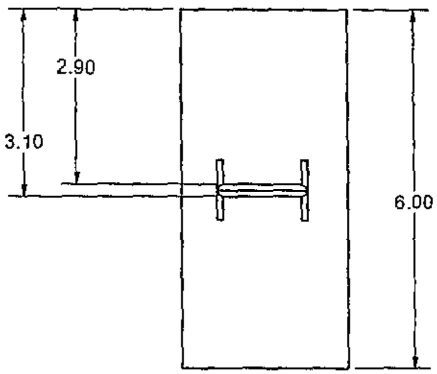
UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: J. Holfeltz			
MATERIAL: Steel, High Strength Low Alloy	*PART DESCRIPTION:* tube cnt	*PART NUMBER:* WF-20-124a	*REV* a
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1







Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-20-142	BSSA Tube
4	2	WF-20-145	strap

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: J. Holfeltz

MATERIAL:

PART DESCRIPTION: Wing Spar Mount Bottom

PART NUMBER: WF-20-123

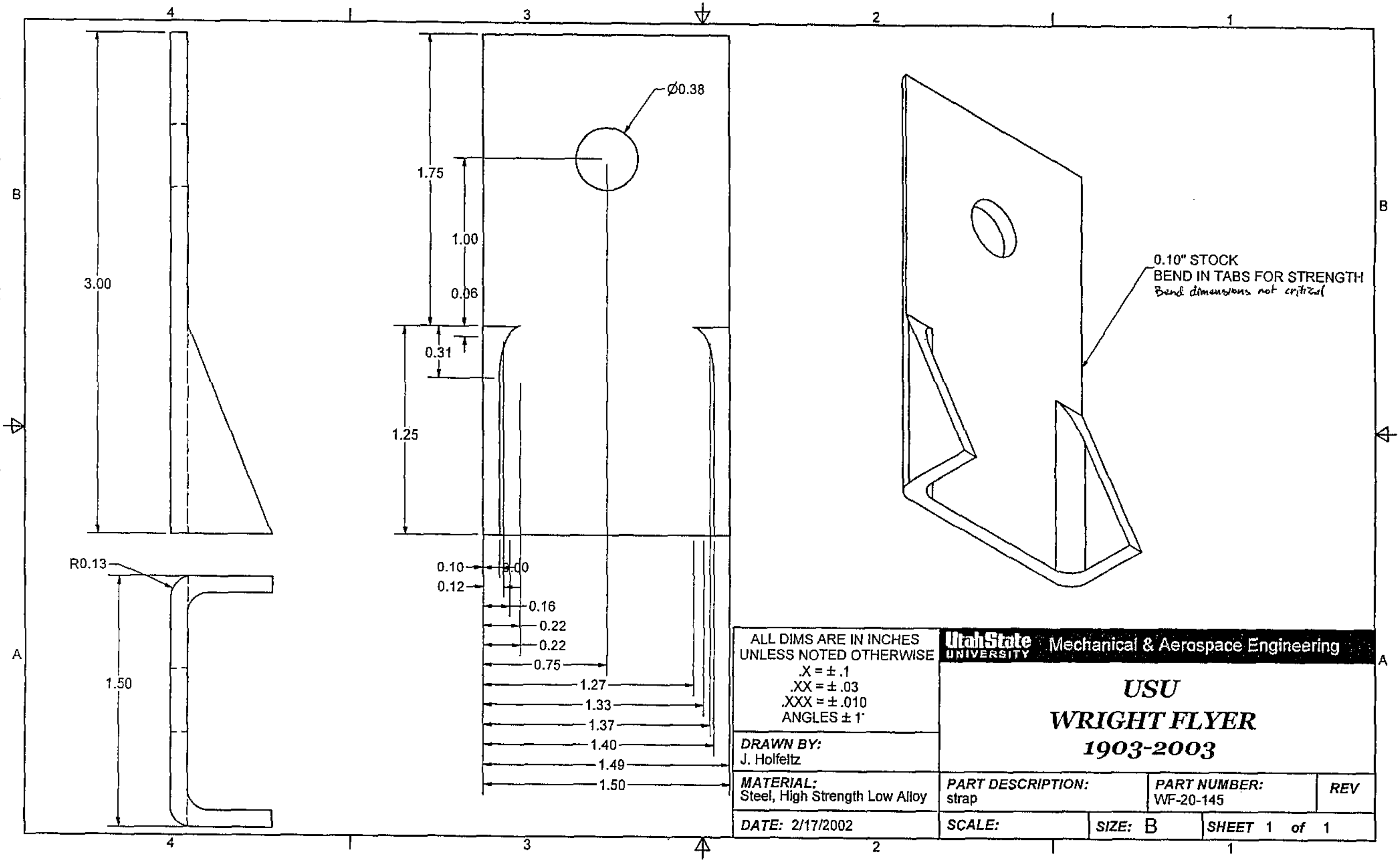
REV

DATE: 2/17/2002

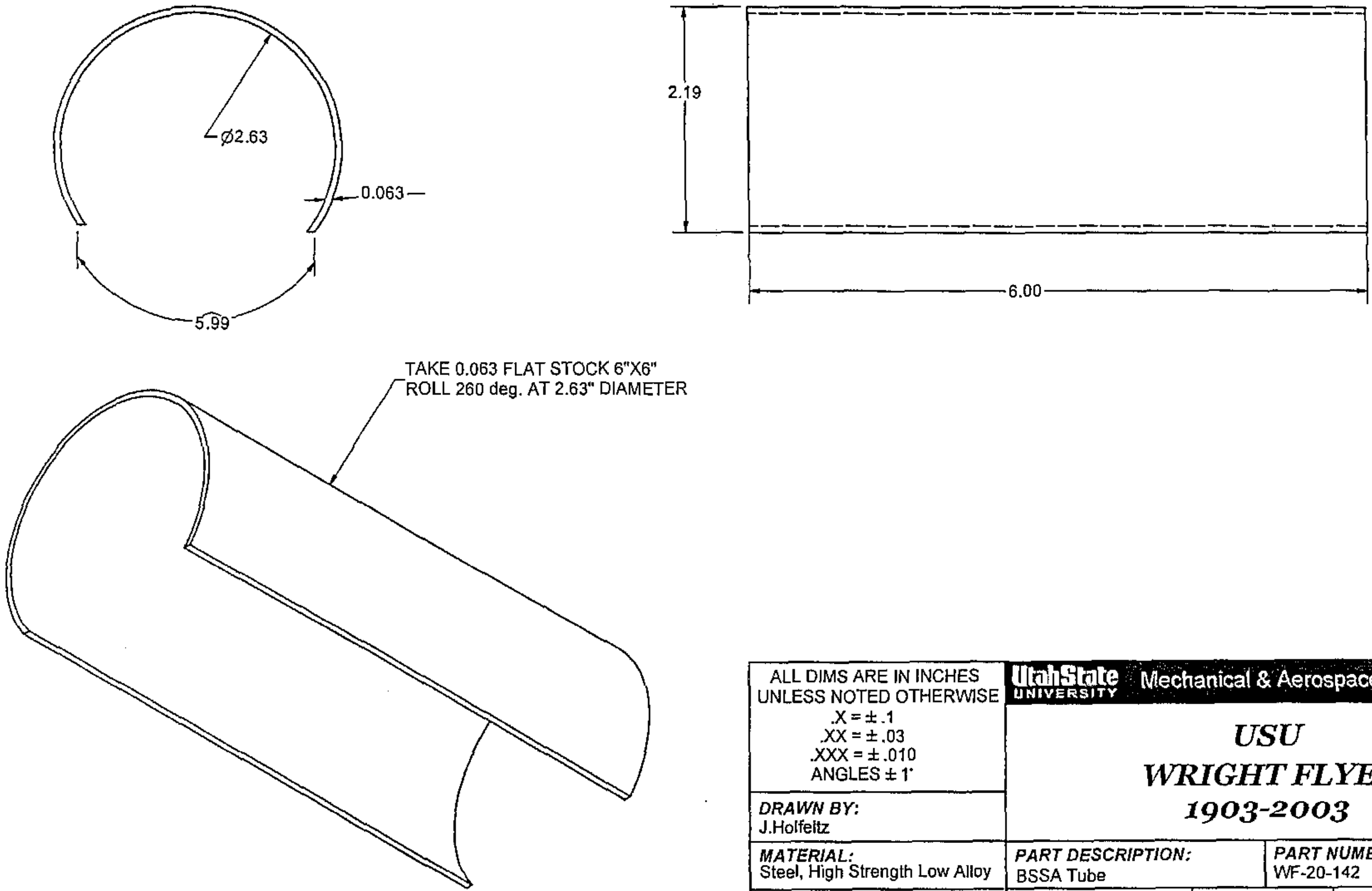
SCALE:

SIZE: B

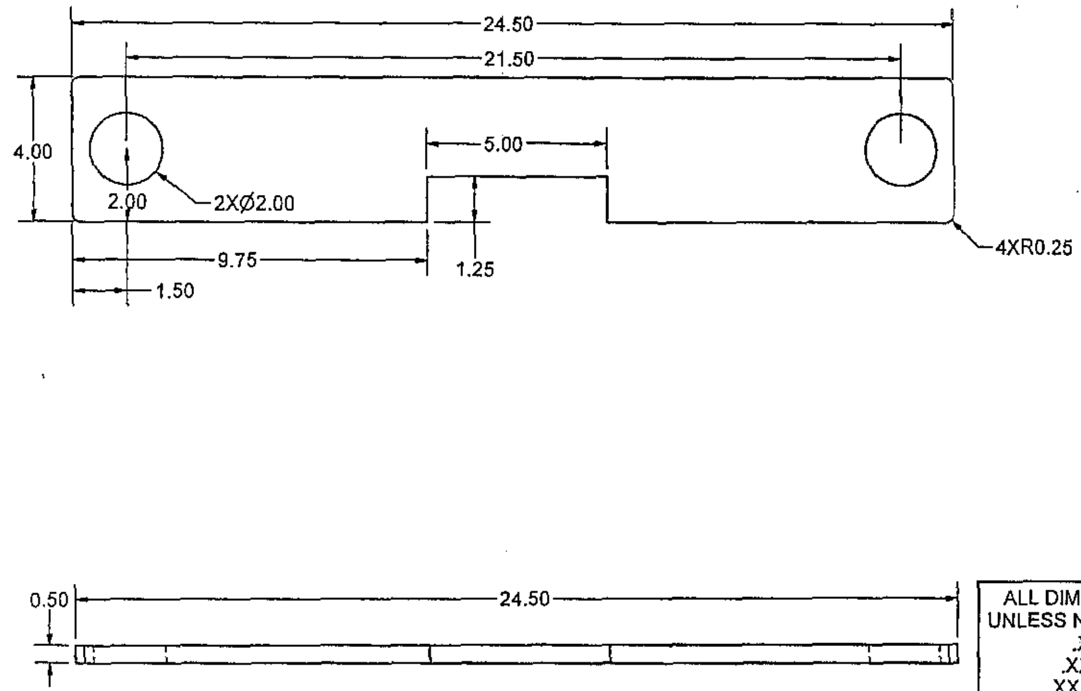
SHEET 1 *of* 1

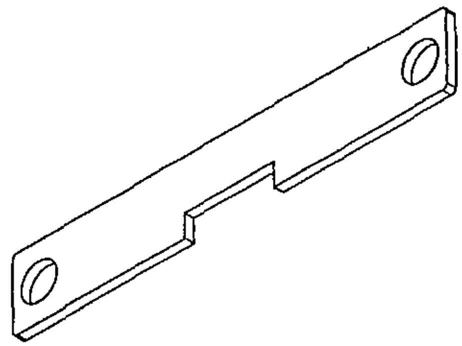


3.00
R0.13
1.50
1.75
1.00
0.06
0.31
1.25
Ø0.38
0.10
0.00
0.12
0.16
0.22
0.22
0.75
1.27
1.33
1.37
1.40
1.49
1.50
0.10" STOCK
BEND IN TABS FOR STRENGTH
Bend dimensions not critical
ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°
UtahState UNIVERSITY
Mechanical & Aerospace Engineering
USU
WRIGHT FLYER
1903-2003
DRAWN BY:
J. Holfeltz
MATERIAL:
Steel, High Strength Low Alloy
PART DESCRIPTION:
strap
PART NUMBER:
WF-20-145
REV
DATE: 2/17/2002
SCALE:
SIZE: B
SHEET 1 of 1

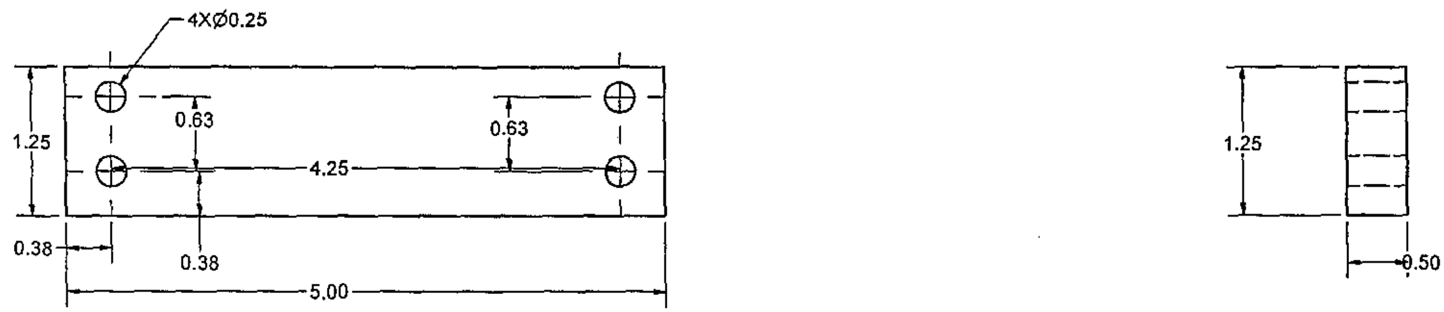


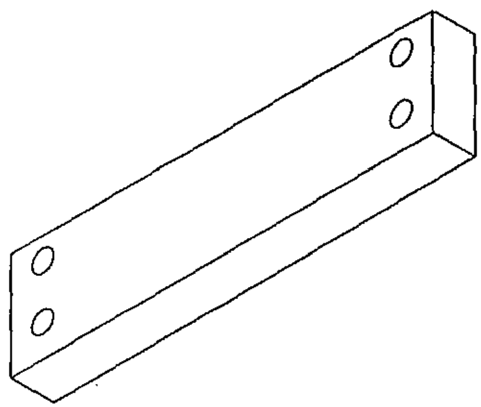
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003		
DRAWN BY: J.Holfeltz			
MATERIAL: Steel, High Strength Low Alloy	PART DESCRIPTION: BSSA Tube	PART NUMBER: WF-20-142	REV
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1



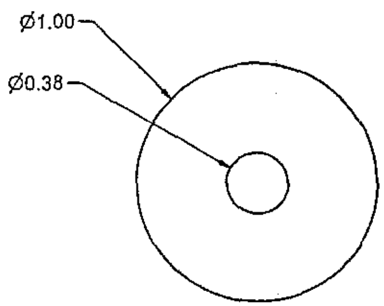


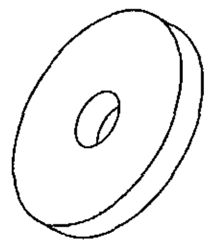
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*			
DRAWN BY: J. Holfeltz				
MATERIAL: honeycomb, graphite skin	*PART DESCRIPTION:* Cross Support		*PART NUMBER:* WF-20-117	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 of 1	

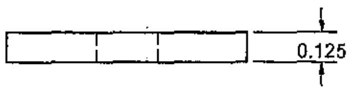




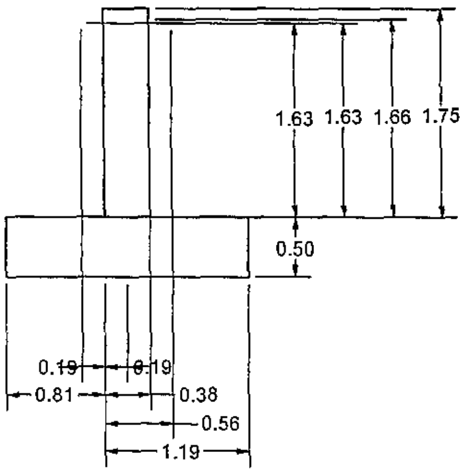
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	Utah State University Mechanical & Aerospace Engineering			
DRAWN BY: J. Holfeltz	**USU WRIGHT FLYER 1903-2003**			
MATERIAL: wood	**PART DESCRIPTION:** Mount Point		**PART NUMBER:** WF-20-119	**REV**
DATE: 2/17/2002	**SCALE:**	**SIZE:** B	**SHEET** 1 of 1	

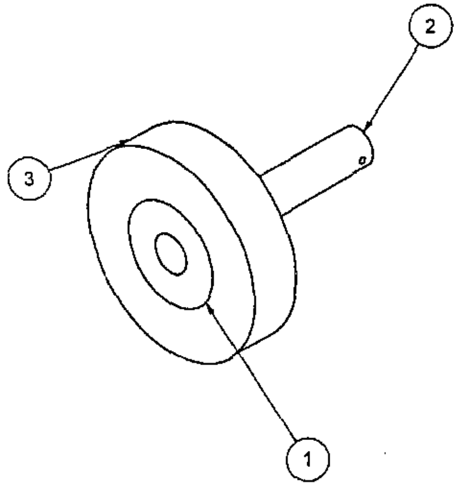


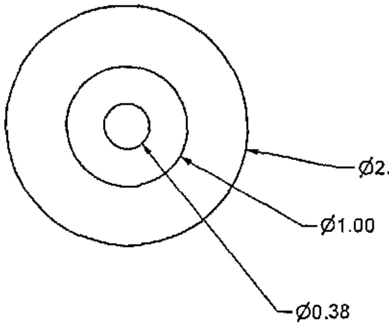




ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*			
DRAWN BY: J. Holfeltz				
MATERIAL: Nylon-6/6	*PART DESCRIPTION:* nylon washers	*PART NUMBER:* NW2061 Spruce p. 134		*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	







Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	LS 6 bearing	
2	1	steel pin	
3	1	wood insert	

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: J. Holfeltz

MATERIAL:

PART DESCRIPTION: bearing assy

PART NUMBER: WF-20-118

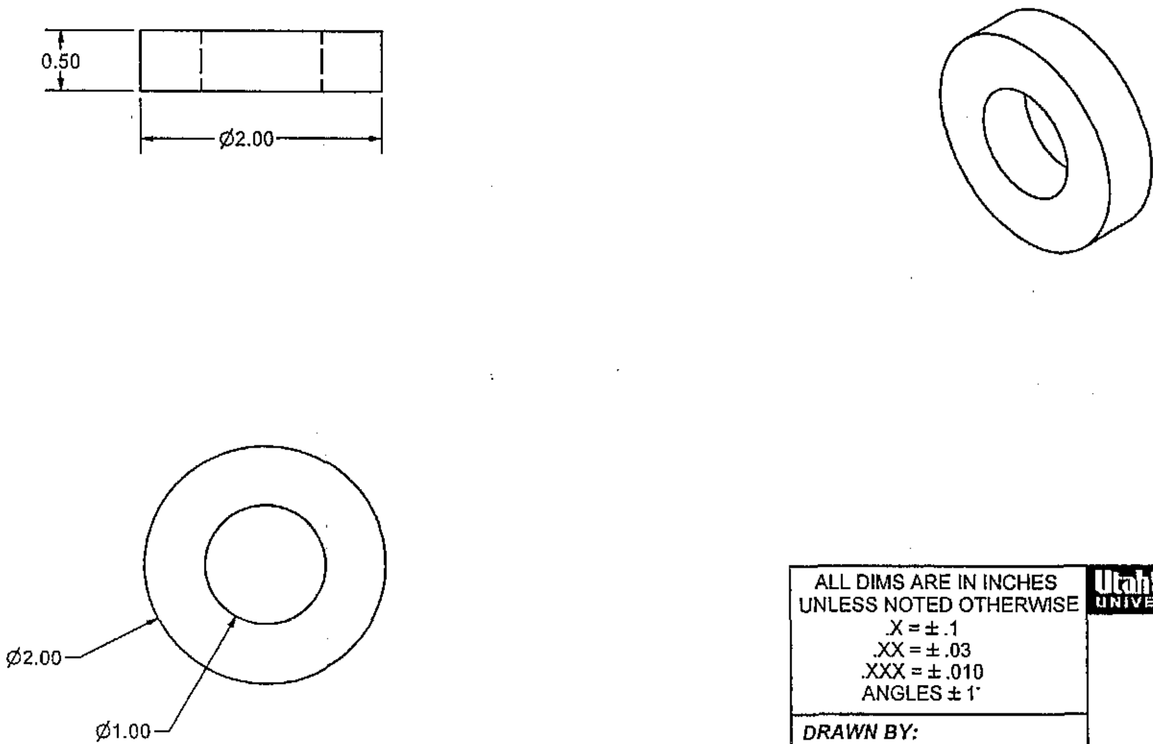
REV

DATE: 2/17/2002

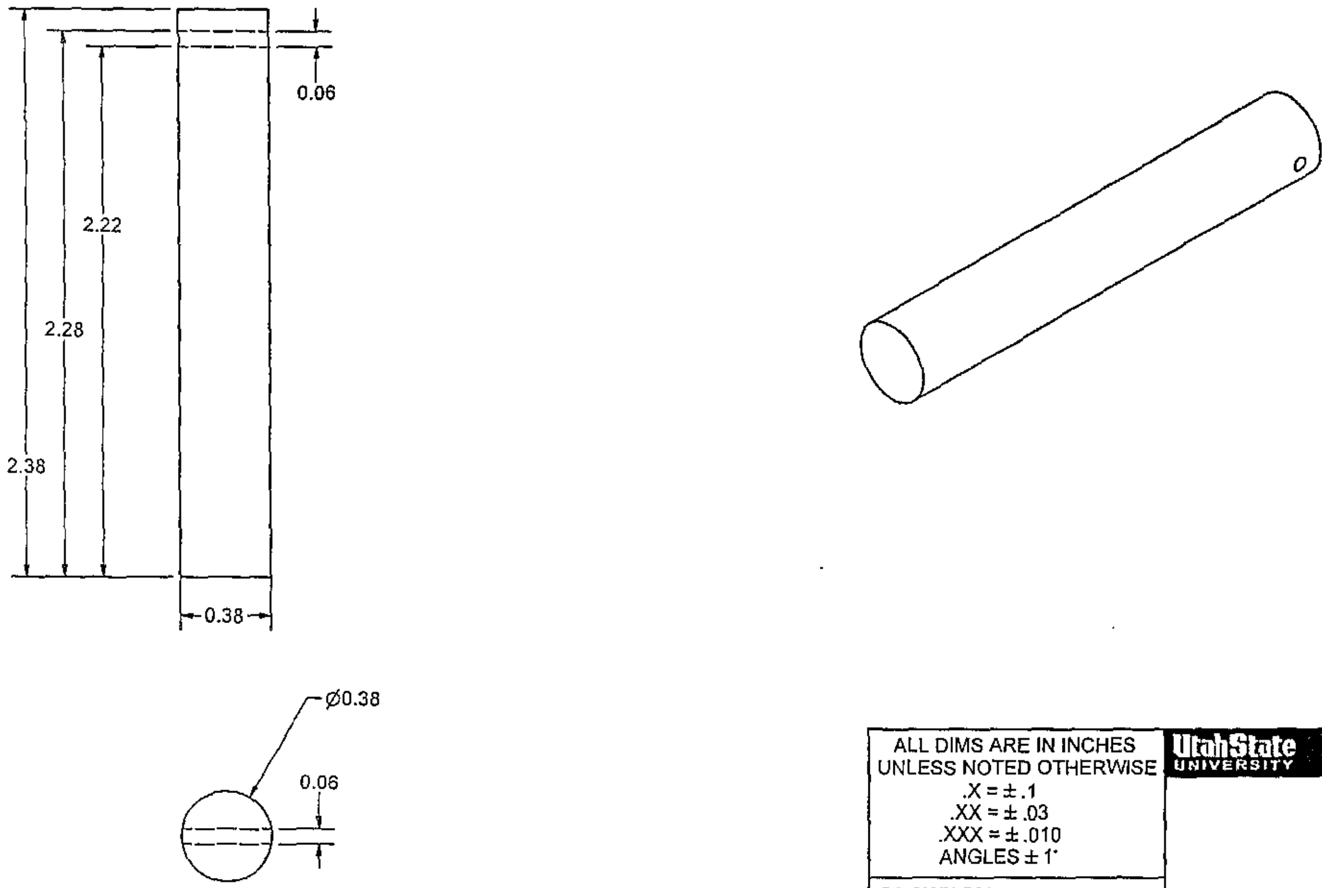
SCALE:

SIZE: B

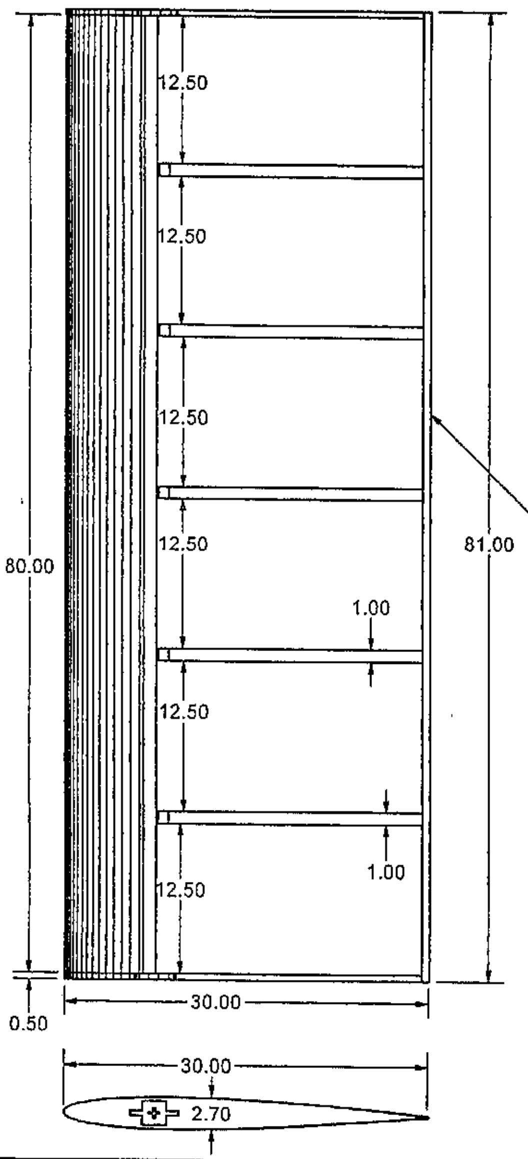
SHEET 1 *of* 1

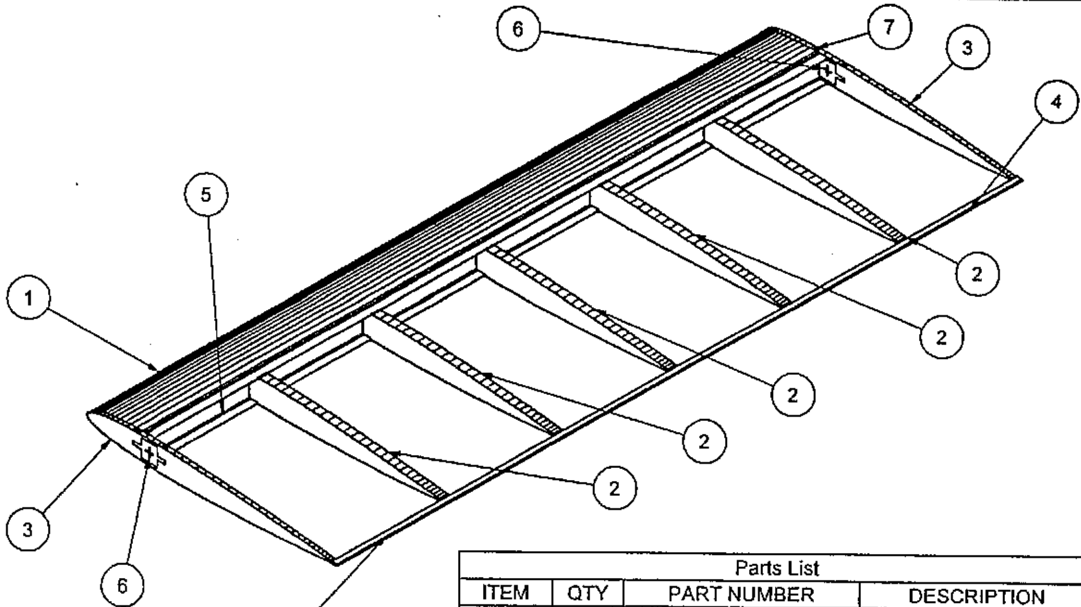


ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* ***WRIGHT FLYER*** ***1903-2003***			
DRAWN BY: J. Holfeltz				
MATERIAL: wood	***PART DESCRIPTION:*** wood insert		***PART NUMBER:*** WF-20-132	***REV***
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 ***of*** 1	



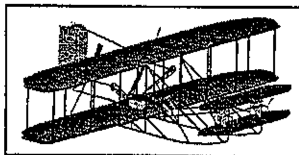
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	Utah State University — Mechanical & Aerospace Engineering **USU WRIGHT FLYER 1903-2003**
DRAWN BY: J. Holfeltz	
MATERIAL: Steel, High Strength Low Alloy	PART DESCRIPTION: steel pin / PART NUMBER: WF-20-133 / REV
DATE: 2/17/2002	SCALE: / SIZE: B / SHEET 1 of 1





ALL PARTS ARE BONDED WITH ADHESIVE

Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-20-111	Rudder D-tube
2	5	WF-20-114	Rudder Ribs
3	2	WF-20-113	Rudder Hard Plate
4	1	03-48900 pg.72	Rudder Trailing Edge
5	1	WF-20-112	Rudder C-beam
6	2	WF-20-116	Rudder Pivot Block Insert
7	4	WF-20-140	Rudder Pivot Block Insert Pins
8	1	covering	Dacron Covering



UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: J. Holfeltz

MATERIAL:

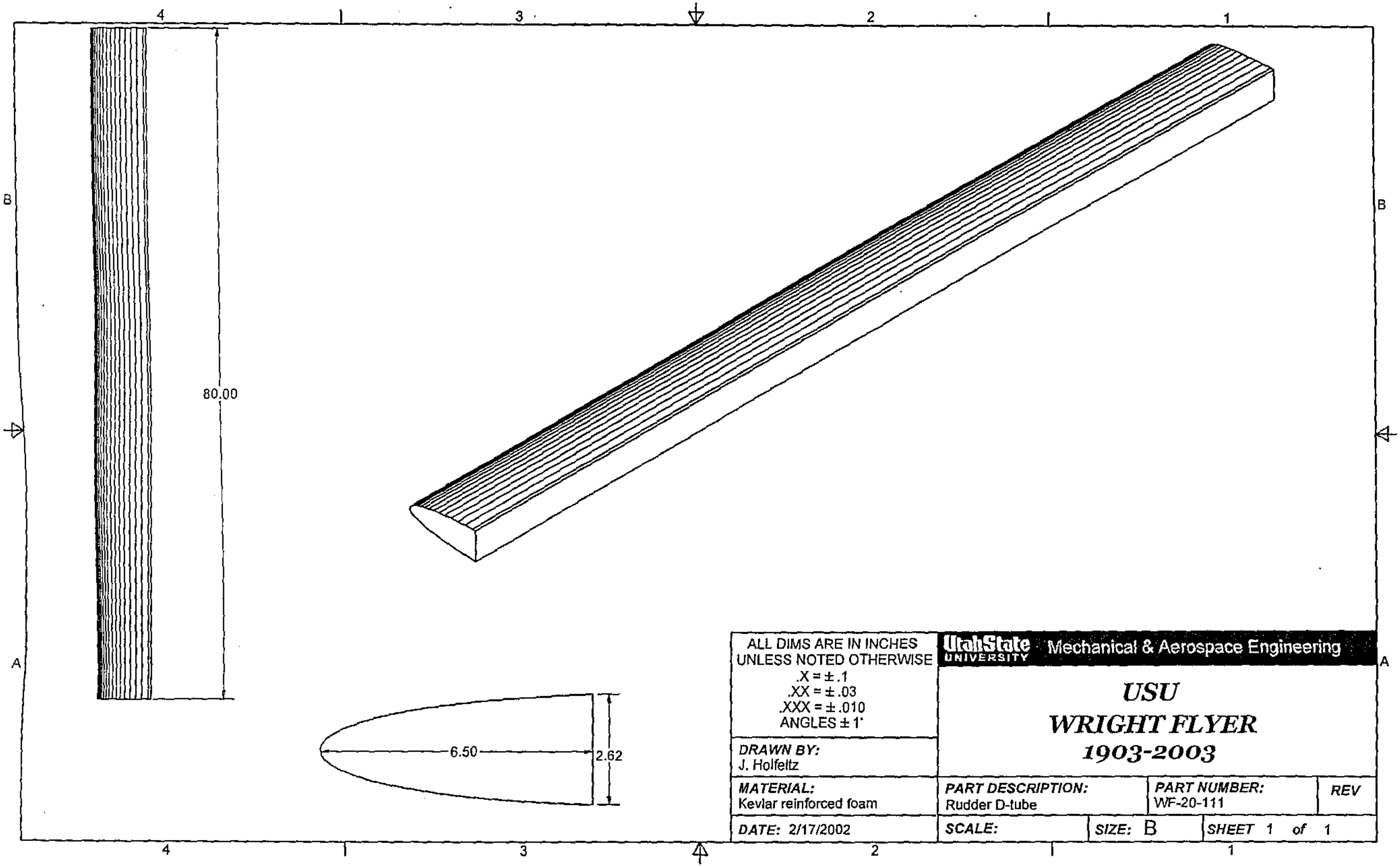
DATE: 2/17/2002

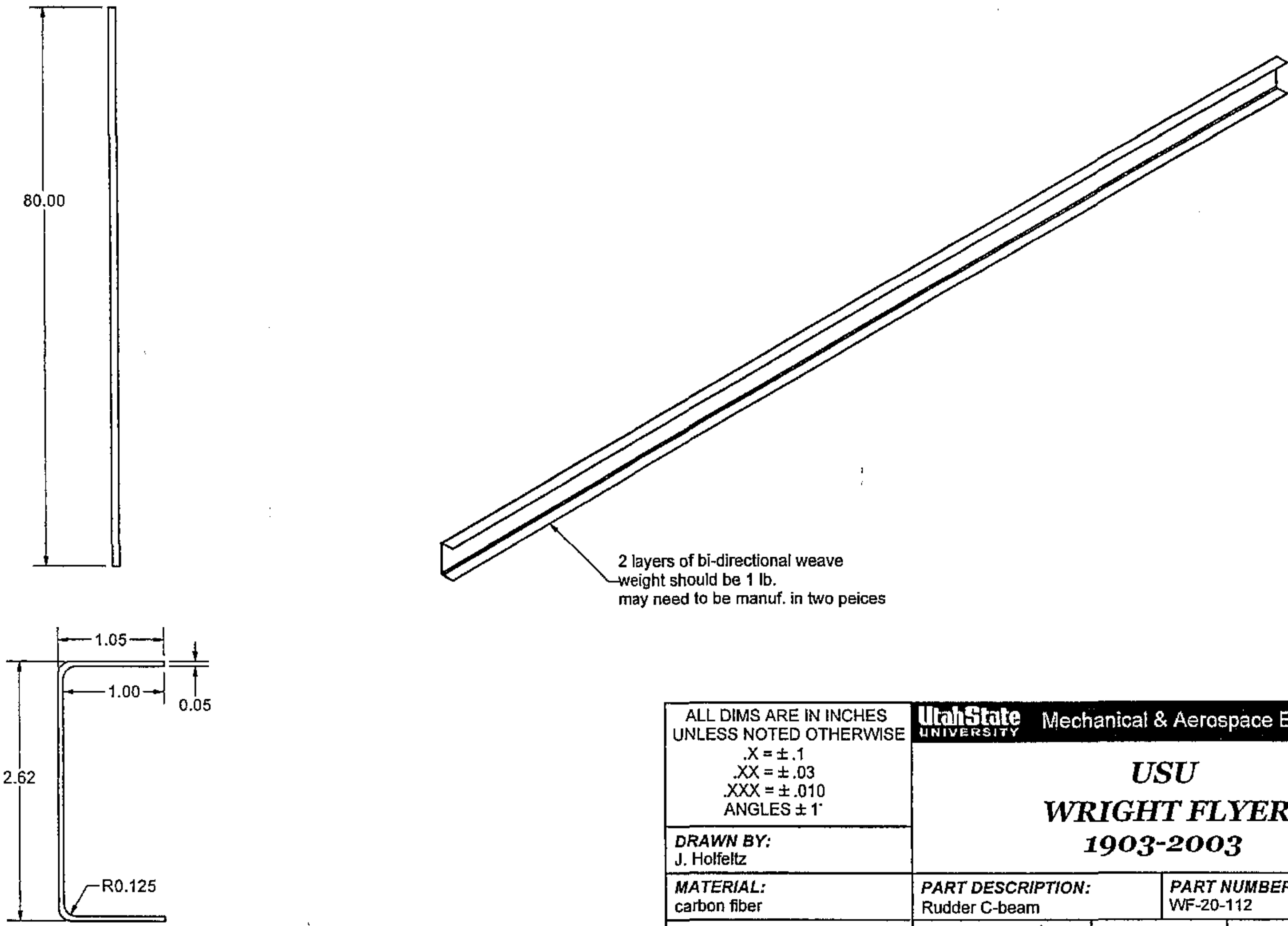
PART DESCRIPTION: Rudder Surface Assembly

PART NUMBER: WF-20-101

REV

SCALE: **SIZE:** B **SHEET** 1 of 1


4
3
2
1
B
A
80.00
6.50
2.62
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°
UtahState UNIVERSITY
Mechanical & Aerospace Engineering
USU
WRIGHT FLYER
1903-2003
DRAWN BY:
J. Holfeltz
MATERIAL:
Kevlar reinforced foam
PART DESCRIPTION:
Rudder D-tube
PART NUMBER:
WF-20-111
REV
DATE: 2/17/2002
SCALE:
SIZE: B
SHEET 1 of 1

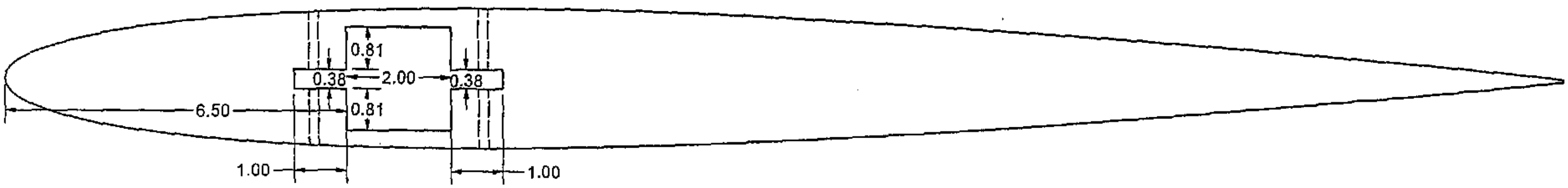


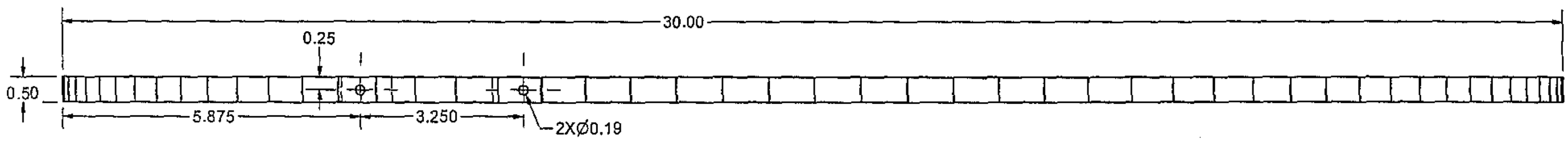
ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

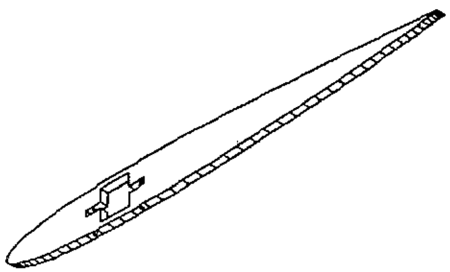
UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: J. Holfeltz			
MATERIAL: carbon fiber	***PART DESCRIPTION:*** Rudder C-beam	***PART NUMBER:*** WF-20-112	***REV***
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 ***of*** 1





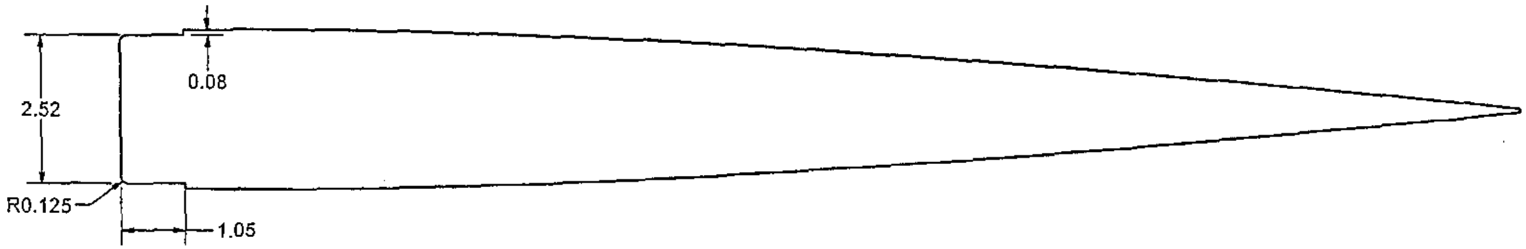


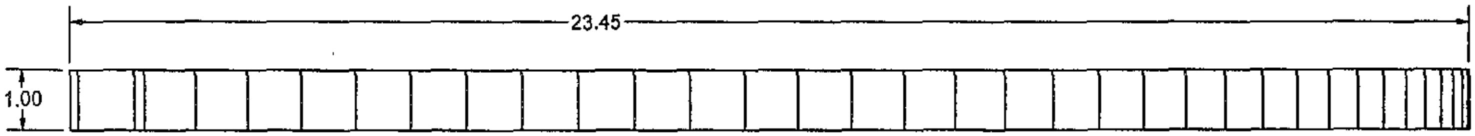
ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

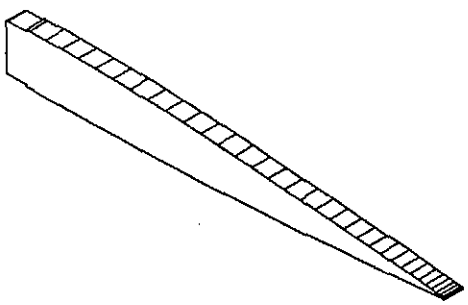
Utah State University — Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: J. Holfeltz			
MATERIAL: Al Honeycomb	*PART DESCRIPTION:* Rudder Hard Plate	*PART NUMBER:* WF-20-113	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 of 1





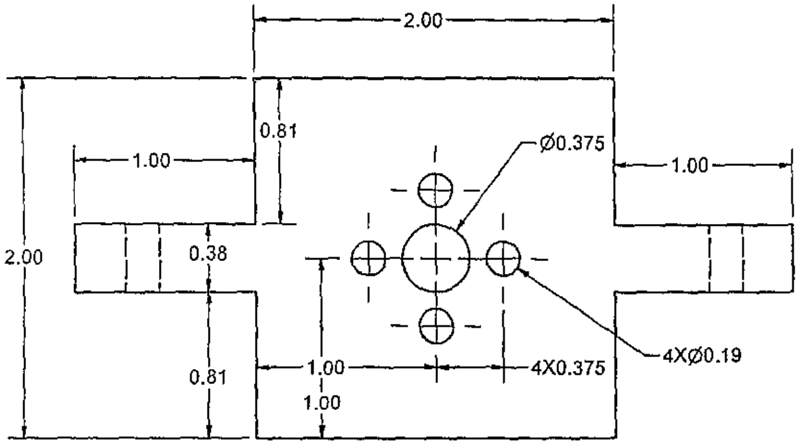


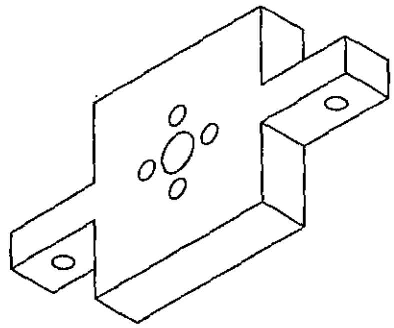
ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

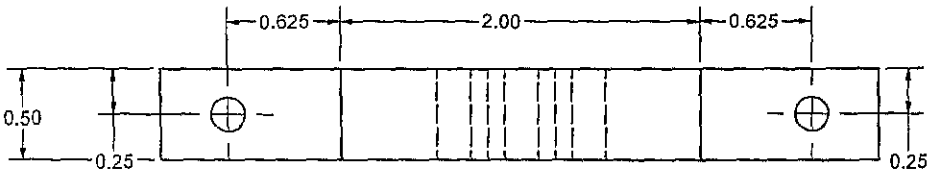
Utah State University — Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: J. Holfeltz			
MATERIAL: Kevlar reinforced foam	PART DESCRIPTION: Rudder Ribs	PART NUMBER: WF-20-114	REV
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1







ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: J. Holfeltz

MATERIAL: Delrin, Black

PART DESCRIPTION: Rudder Pivot Block Insert

PART NUMBER: WF-20-116

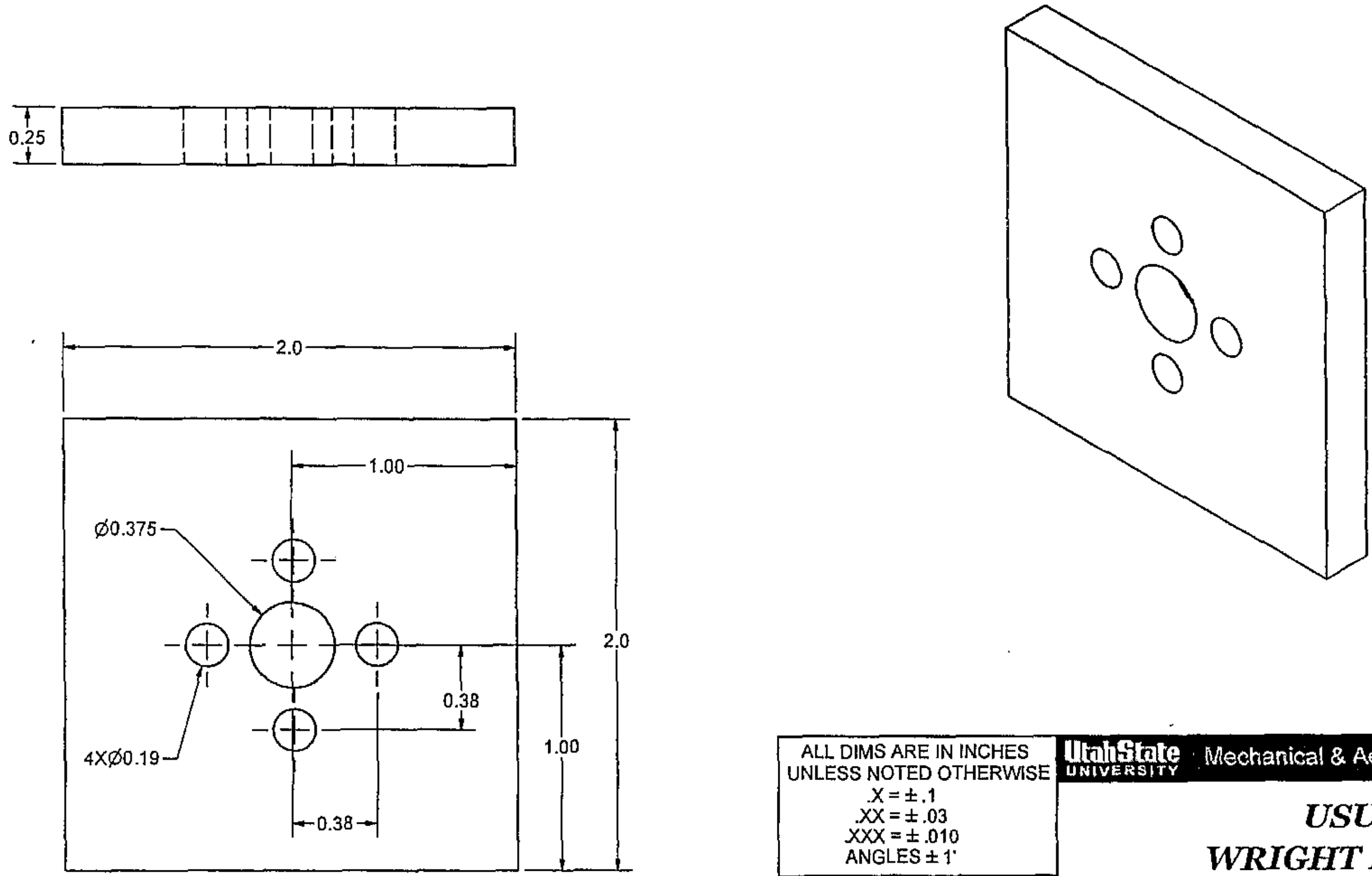
REV

DATE: 2/17/2002

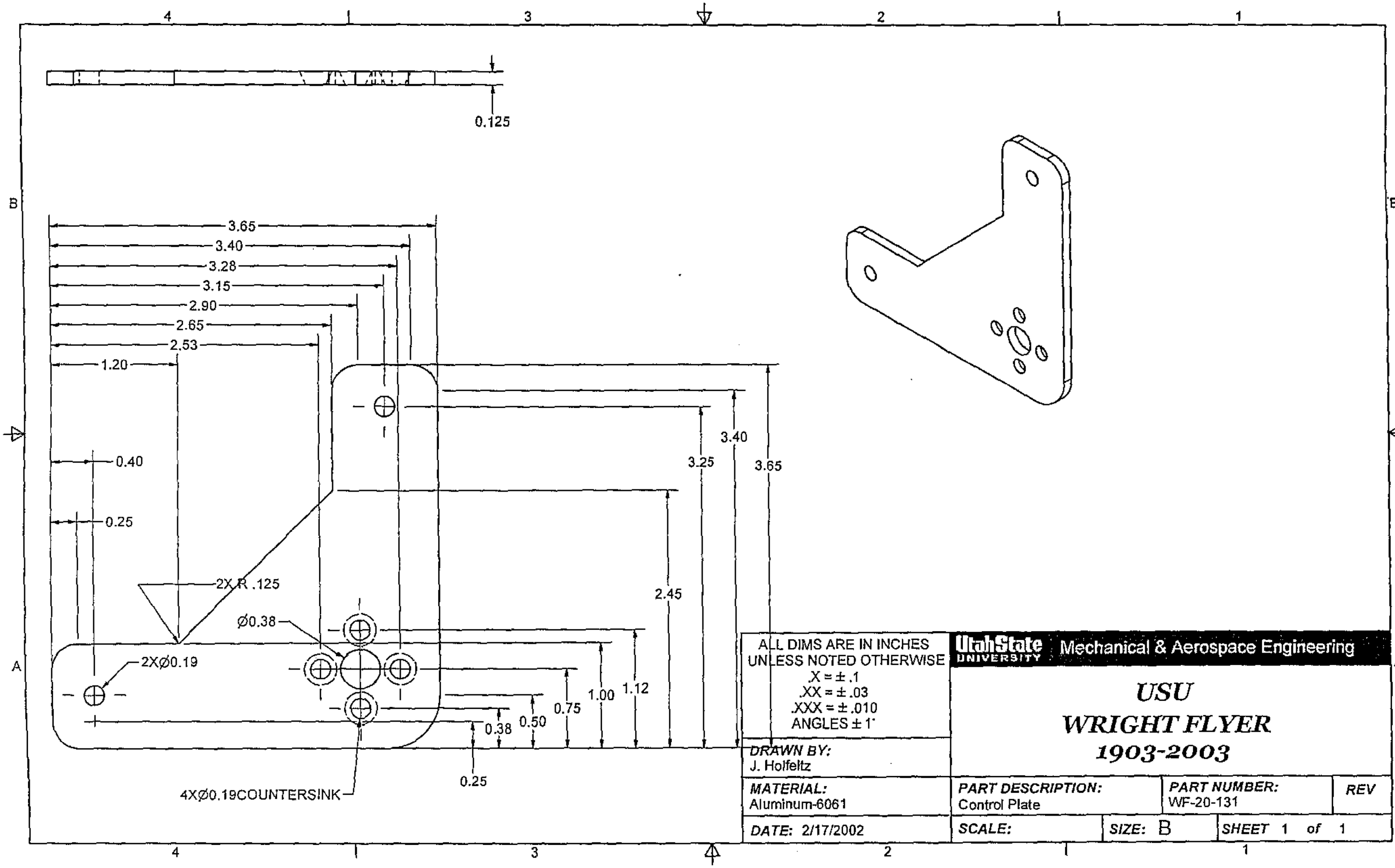
SCALE:

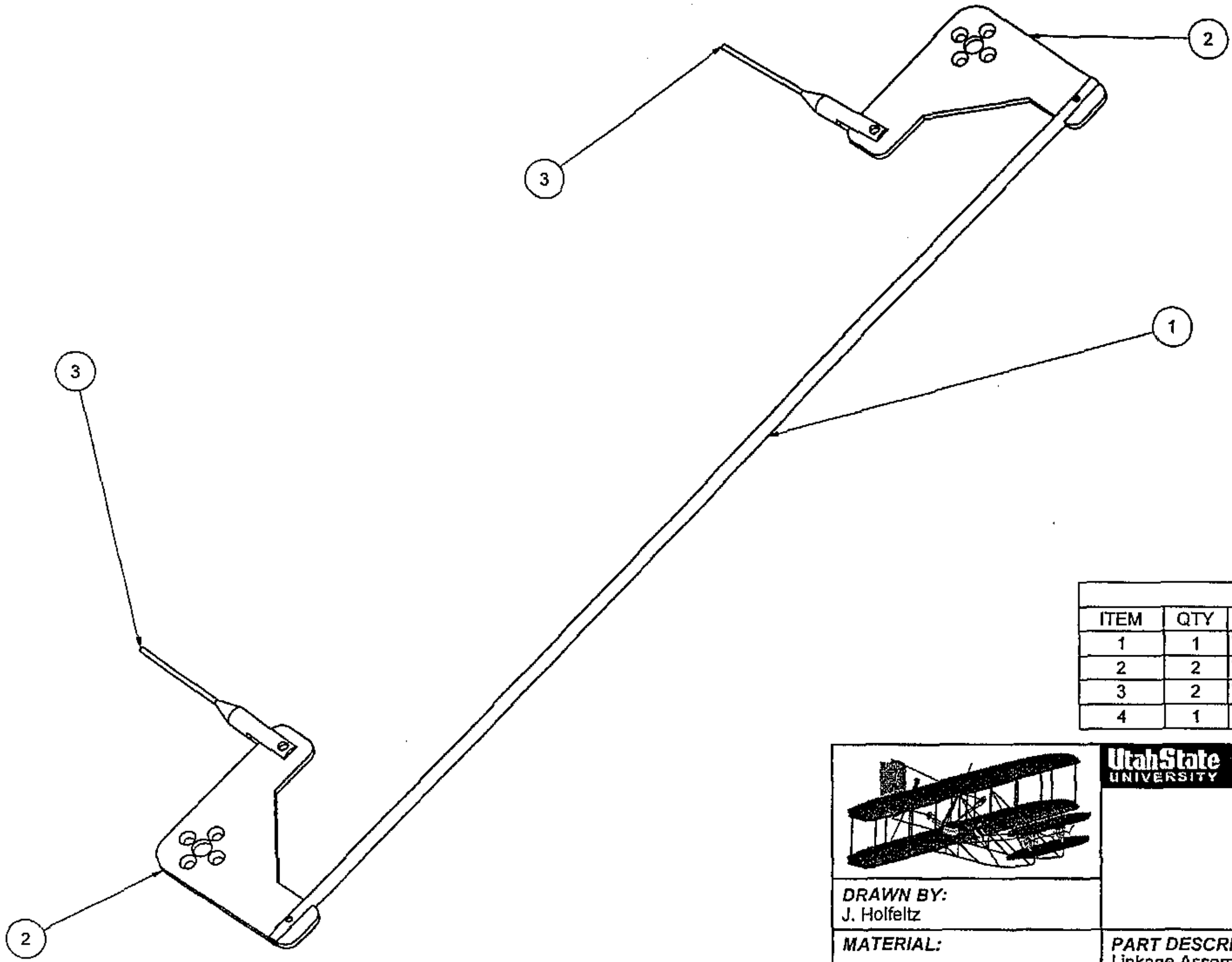
SIZE: B

SHEET 1 of 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering		
DRAWN BY: J. Holfeltz	**USU WRIGHT FLYER 1903-2003**		
MATERIAL: Nylon-6/6	**PART DESCRIPTION:** Rudder Spacer Plate (bottom)	**PART NUMBER:** WF-20-141	**REV**
DATE: 2/17/2002	**SCALE:**	**SIZE:** B	**SHEET** 1 **of** 1


0.125
3.65
3.40
3.28
3.15
2.90
2.65
2.53
1.20
0.40
0.25
2X R .125
Ø0.38
2XØ0.19
4XØ0.19COUNTERSINK
0.25
0.38
0.50
0.75
1.00
1.12
2.45
3.25
3.40
3.65
ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°
UtahState UNIVERSITY
Mechanical & Aerospace Engineering
USU
WRIGHT FLYER
1903-2003
DRAWN BY:
J. Holfeltz
MATERIAL:
Aluminum-6061
PART DESCRIPTION:
Control Plate
PART NUMBER:
WF-20-131
REV
DATE: 2/17/2002
SCALE:
SIZE: B
SHEET 1 of 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-20-130	Push/Pull Rod (round)
2	2	WF-20-131	Control Plate
3	2	WF-30-207	FORK END
4	1	Hardware	

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: J. Holfeltz

MATERIAL:

PART DESCRIPTION: Linkage Assembly

PART NUMBER: WF-20-105.

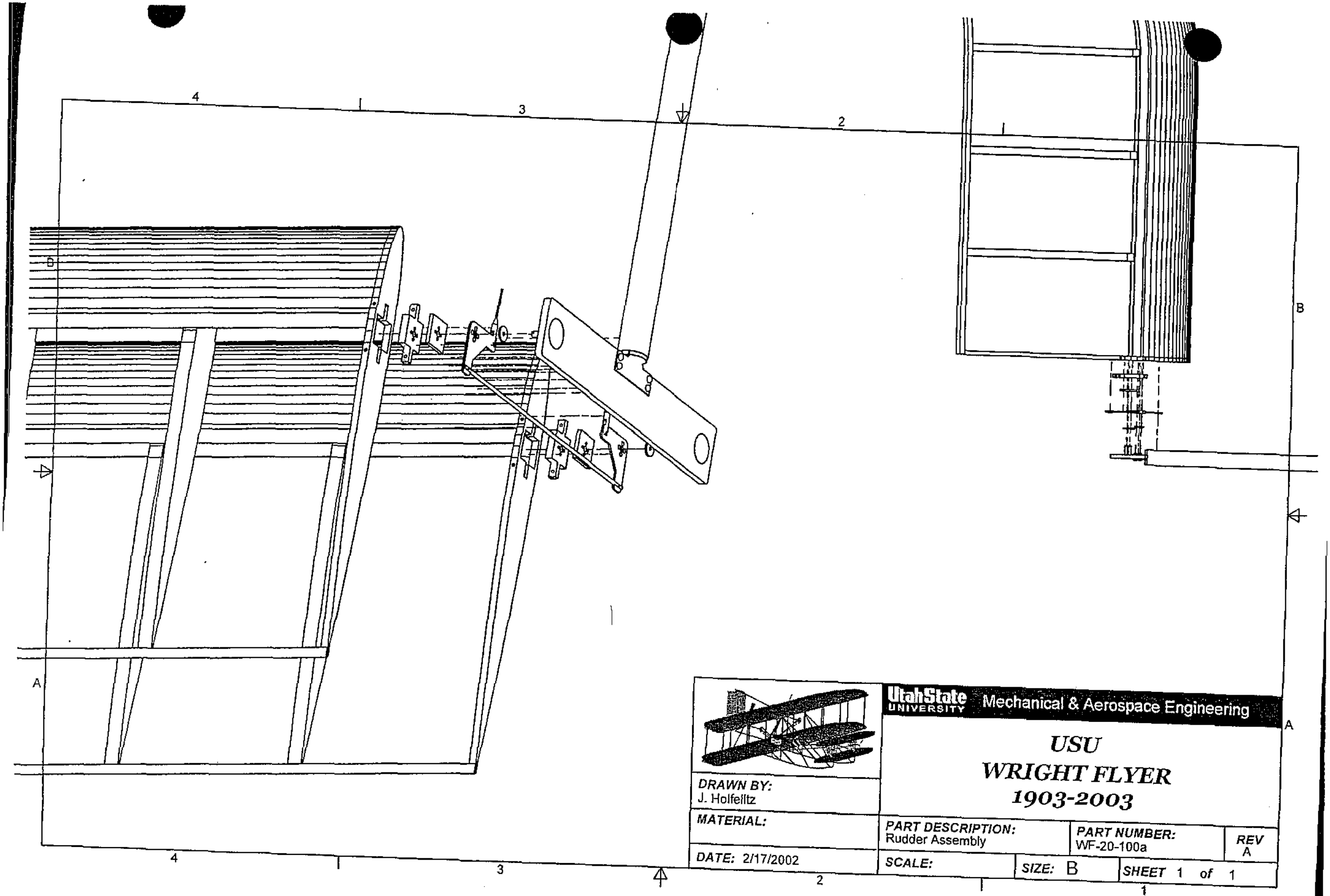
REV

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 of 1



Utah State University Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: J. Holfeltz

MATERIAL:

DATE: 2/17/2002

PART DESCRIPTION: Rudder Assembly

PART NUMBER: WF-20-100a

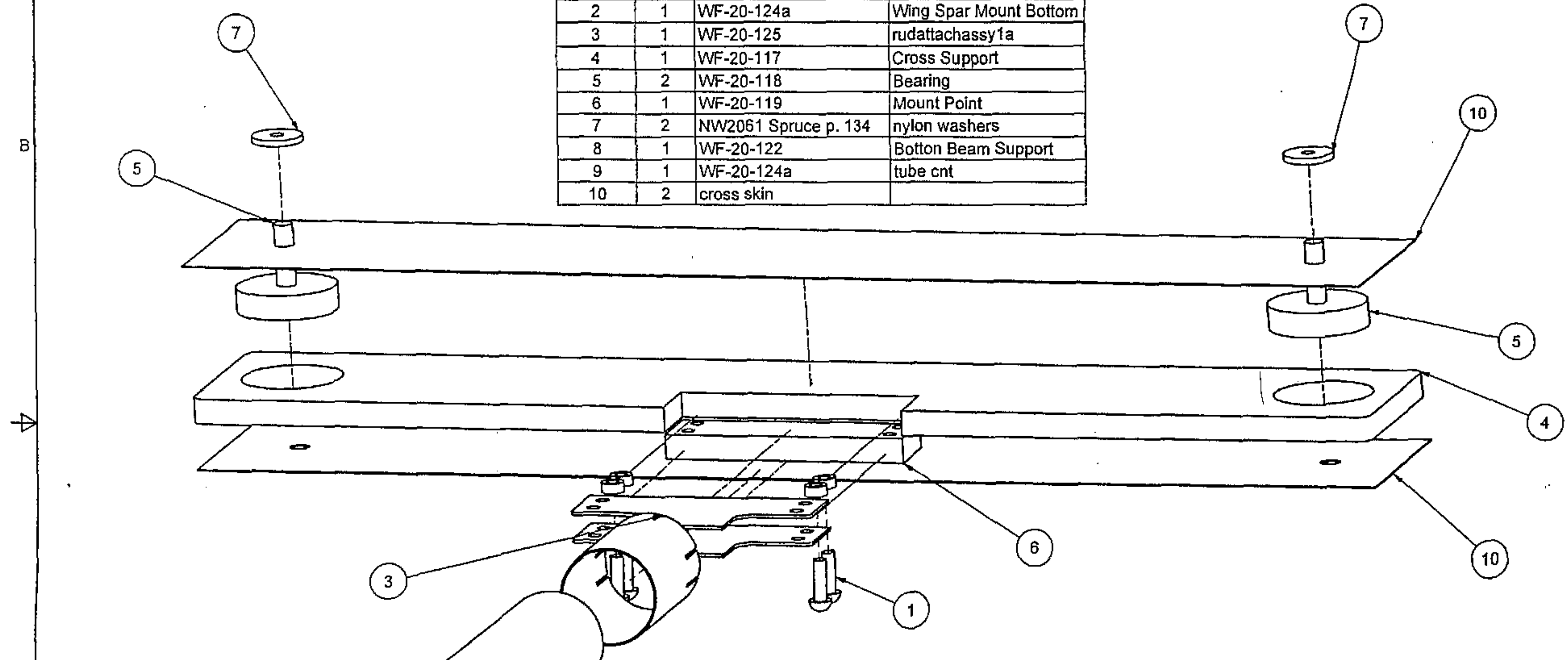
REV A

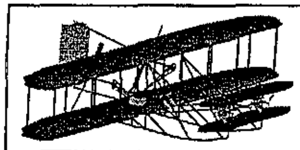
SCALE:

SIZE: B

SHEET 1 of 1

Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	4	.25in bolt&nut	
2	1	WF-20-124a	Wing Spar Mount Bottom
3	1	WF-20-125	rudattachassy1a
4	1	WF-20-117	Cross Support
5	2	WF-20-118	Bearing
6	1	WF-20-119	Mount Point
7	2	NW2061 Spruce p. 134	nylon washers
8	1	WF-20-122	Botton Beam Support
9	1	WF-20-124a	tube cnt
10	2	cross skin	





Utah State University Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: J. Holfeltz

MATERIAL:

PART DESCRIPTION: Bottom Plate Assembly

PART NUMBER: WF-20-103a

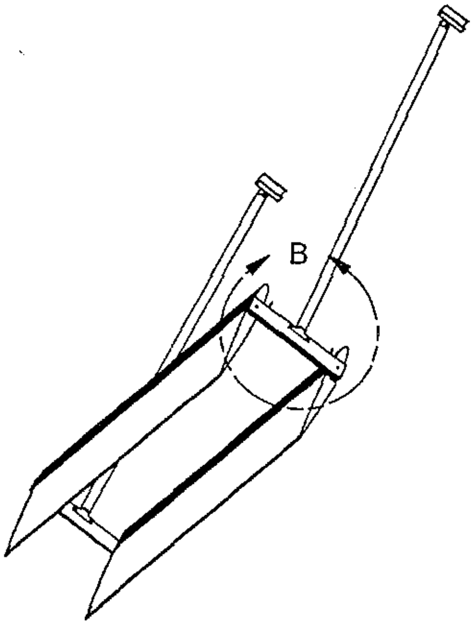
REV A

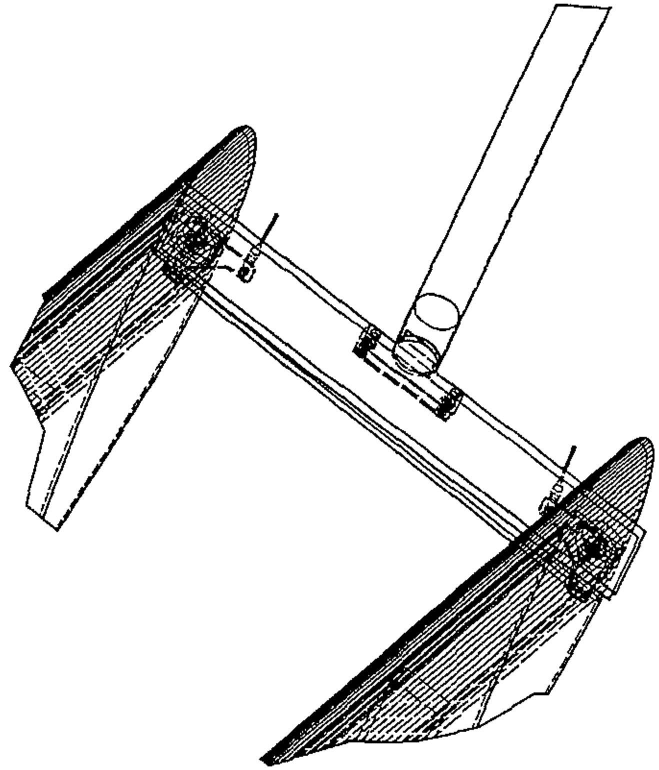
DATE: 2/17/2002

SCALE:

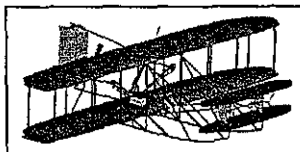
SIZE: B

SHEET 1 of 1





DETAIL B
SCALE 1 / 5

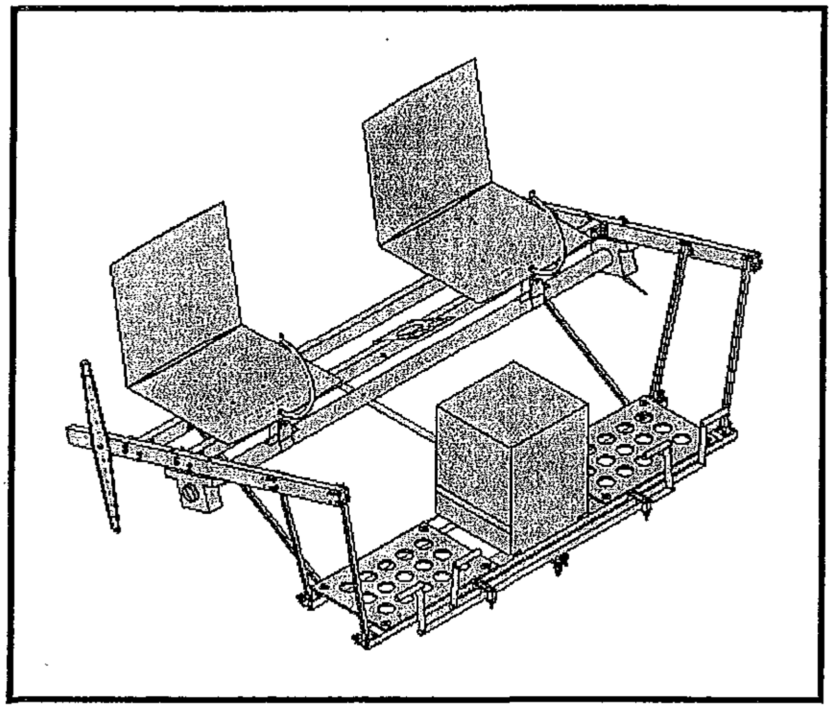


UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: J. Holfeltz			
MATERIAL:	*PART DESCRIPTION:* Rudder Assembly	*PART NUMBER:* WF-20-100a	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 of 1

Cockpit Assembly



Materials List for Cockpit

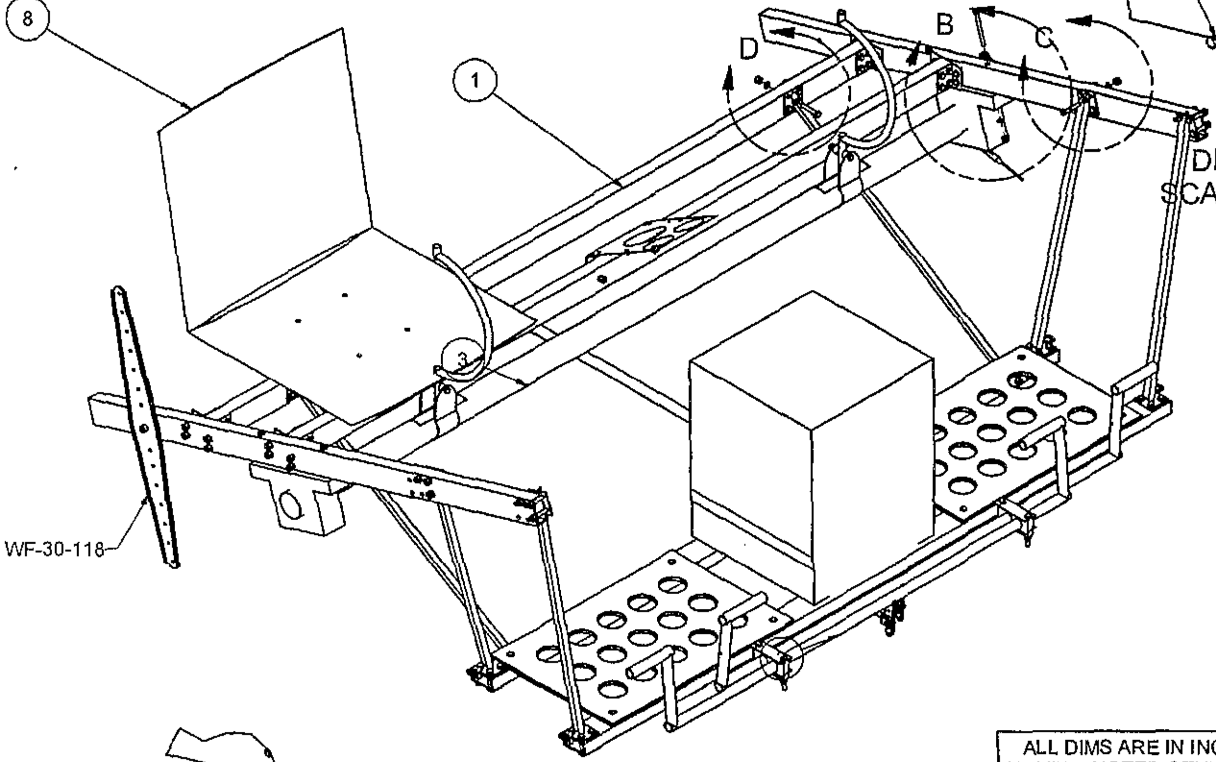
ck spc= check drawing specifications

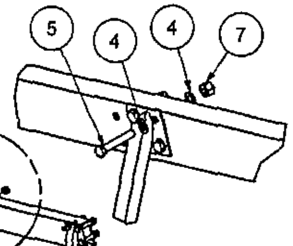
Item/Material	Description	Qty	Part #	Supplier
Washer	1/4" flat washer	186		0
Nut	1/4" locknut	96		0
Bolt	1 1/2" 1/4-20 grade 8 hex	78		0
Bolt	2 1/2" 1/4-20 grade 8 hex	12		0
Bolt	2" 1/4-20 grade 8 hex	2		0
Screw	1 1/2" 1/4-20 flat screw	4		0
Pillow Block	UHMW Duo 3/4" bore dia	2		IPACO
Pillow Block	UHMW 2" bore dia.	2		IPACO
Steel Tubing	4130 -- (3/4" OD X .063" wall)	122.5 in		0
Steel Tubing	4130 -- (2" OD X .049" wall)	69 in		0
Steel Tubing	4130 -- (1/2" OD X .03" wall)	28 in		0
Sheet Metal - Steel	4130 -- (.063" thick)	459.5 in^2		0
Sheet Metal - Aluminum	.016" thick	54 in^2		0
Honeycomb - Aluminum	(1/2" thick, 18"X12")	2		?
Rectangular Tube	aluminum (2" X 1" X 1/8" wall)	247 in		0
Angle Stock	aluminum 2"	20 in		0
Streamline Tube	4130 steel 1"	138 in	03-11300	0
Steel Rod	push rod	38 in		0
Linkages	fork end (cable terminal)	4	MS20667-4	0
Linkages	fork end (rod terminal)	4	AN161-32S	0
Linkages	eye end (cable terminal)	2	MS20668-5	0
Linkages	fork end (rod terminal)	2	AN665-34R	0
Tangs	1 prong ¼" (see wing parts)	4		0
Spacer	nylon 5/16" inside diameter	2.5 in		0
Bushing	1/4" inner diameter (1.5" long)	2		0
Bushing	1/4" inner diameter(1.75" long)	2		0
Clevis Pin	atleast 1" long	2		0
Cotter Pin	to fit clevis	2		0
Cable Wire	steel 1/8" diameter	?		0
Carbon Fiber	18" X 12" lamina	? (4)		ITE
Chair	pilot defined	2		ITE

Parts List for Cockpit

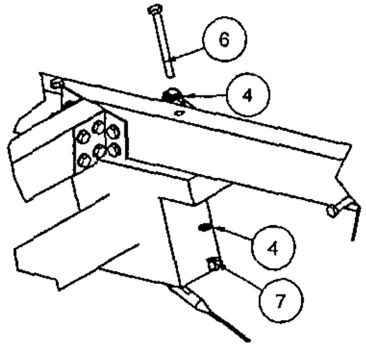
Part Number	Description	Qty	Type
WF-30-001	Span Bar Front	1	cut & drilled
WF-30-002	Span Bar Back	1	cut & drilled
WF-30-003	Foot Bar Front	1	cut & drilled
WF-30-004	Foot Bar Back	1	cut & drilled
WF-30-005	Span Bar Support	8	cut & drilled
WF-30-007	Streamline Rear Strut	2	cut & weldament
WF-30-008	Streamline Small Plate	2	cut & drilled
WF-30-013	Streamline Large Plate	10	cut & drilled
WF-30-014	Streamline Left Front	1	cut & weldament
WF-30-015	Streamline Right Front	1	cut & weldament
WF-30-016	Streamline Left Back	1	cut & weldament
WF-30-017	Streamline Right Back	1	cut & weldament
WF-30-019	1/16" Tab	4	cut & drilled
WF-30-021	Control Panel	1	cut & drilled
WF-30-022	Long Panel Legs	2	cut & drilled
WF-30-023	Short Panel Legs	2	cut & drilled
WF-30-031	Foot Plate Fiber Lamina	4	layed up
WF-30-032	Hardpoint	8	drilled & placed
WF-30-101	Control Case	1	cut & weldament
WF-30-102	Control Stick Mount	2	cut, bent & drilled
WF-30-104	Round Section of Stick	2	cut & bent
WF-30-105	Straight Section of Stick	2	cut & drilled
WF-30-106	Short Section	2	cut & threaded
WF-30-110	Canard Bell Crank	2	cut, bent & drilled
WF-30-112	Nylon Spacer	4	cut
WF-30-115	Push Pull Rod	1	cut & threaded
WF-30-119	Nylon Spacer	2	cut
WF-30-121	Wing Warp Bell	1	cut, bent & drilled
WF-30-201	Pedal Rod	2	cut & weldament
WF-30-203	Pedal -Foot Interface	4	cut & weldament
WF-30-204	Pedal Arm	4	cut, bored
WF-30-205	Rudder Tab	2	cut, bent & drilled
WF-30-209	Nylon Spacer	2	cut
WF-30-210	Rudder Bell Crank	1	cut, bent & drilled
WF-30-212	Push Pull Rod	2	cut & threaded

SEATS TO BE MOUNTED AT ITE'S DISCRETION

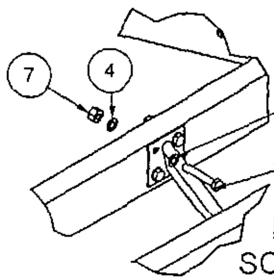




DETAIL C
SCALE 0.24 : 1



DETAIL B
SCALE 0.24 : 1



DETAIL D
SCALE 0.24 : 1

Parts List

ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-30-001	SITTING AREA
2	1	WF-30-002	FOOT REST AREA
3	1	WF-30-100	CONTOL ASSEMBLY
4	48	WF-30-094	1/4" FLAT WASHER
5	20	4P254	1.5 1/4-20 HEX GRADE 8
6	4	4P258	2.5 1/4-20 HEX GRADE 8
7	24	WF-30-093	1/4" LOCKNUT
8	2	CHAIR	CHAIR

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

Utah State UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: AMY HINTZE

MATERIAL:

PART DESCRIPTION: COCKPIT ASSEMBLY

PART NUMBER: WF-30-000

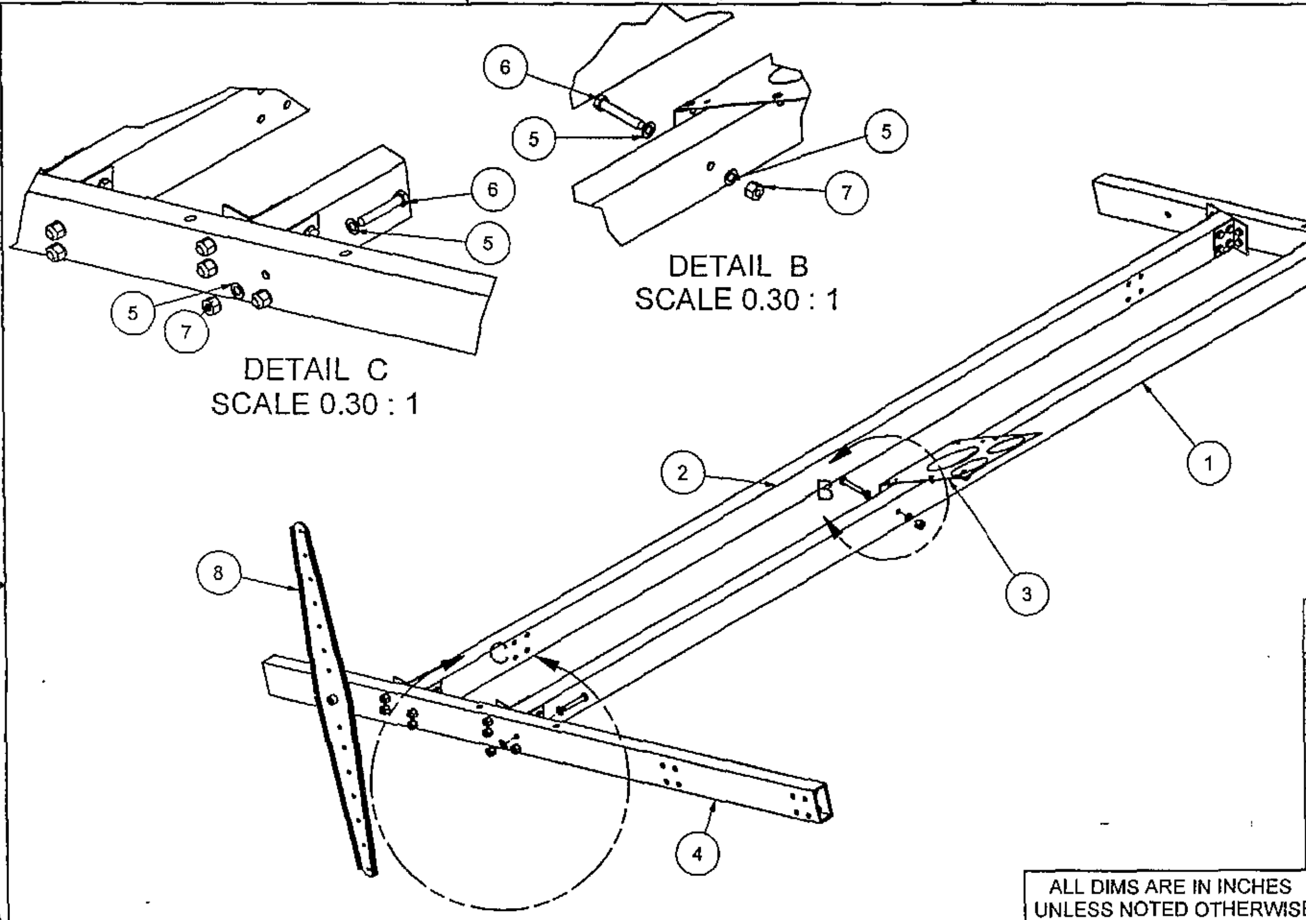
REV

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 of 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-30-001A	FRONT SIT BAR
2	1	WF-30-001B	BACK SIT BAR
3	1	WF-30-020	CONTROL PANEL ASSM
8	1	WF-30-118	WING WARP BELL ASSM
4	2	WF-30-301	PSEUDO CHASSIS
5	36	WF-30-094	1/4" FLAT WASHER
6	18	4P254	1.5 1/4-20 HEX GRADE 8
7	18	WF-30-093	1/4" LOCKNUT

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

Utah State University — Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: AMY HINTZE

MATERIAL:

PART DESCRIPTION: SITTING AREA

PART NUMBER: WF-30-001

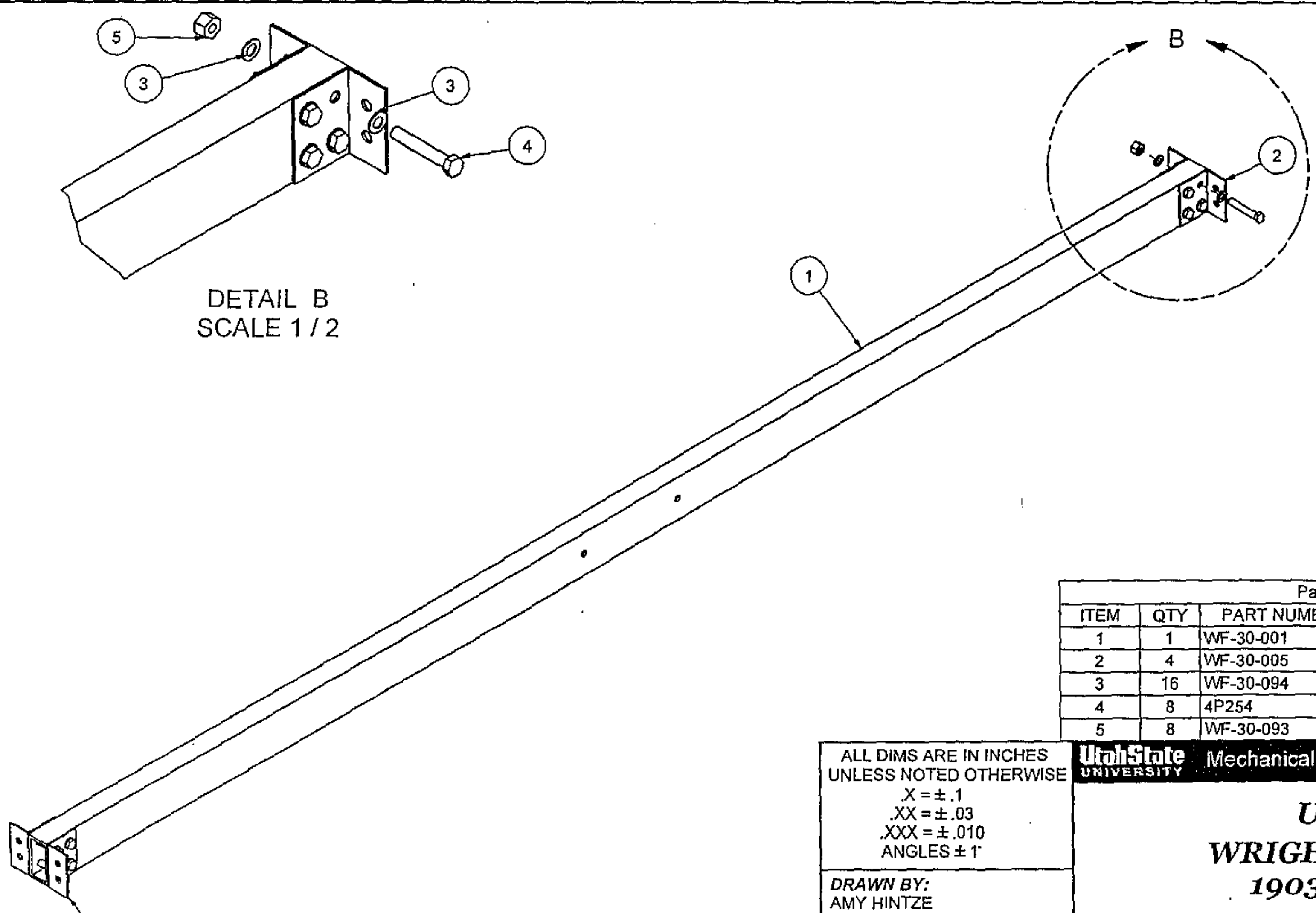
REV

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 *of* 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-30-001	SPAN BAR FRONT
2	4	WF-30-005	SPAN BAR SUPPORT
3	16	WF-30-094	1/4" FLAT WASHER
4	8	4P254	1.5 1/4-20 HEX GRADE 8
5	8	WF-30-093	1/4" LOCKNUT

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: AMY HINTZE

MATERIAL:

PART DESCRIPTION: FRONT SIT BAR

PART NUMBER: WF-30-001A

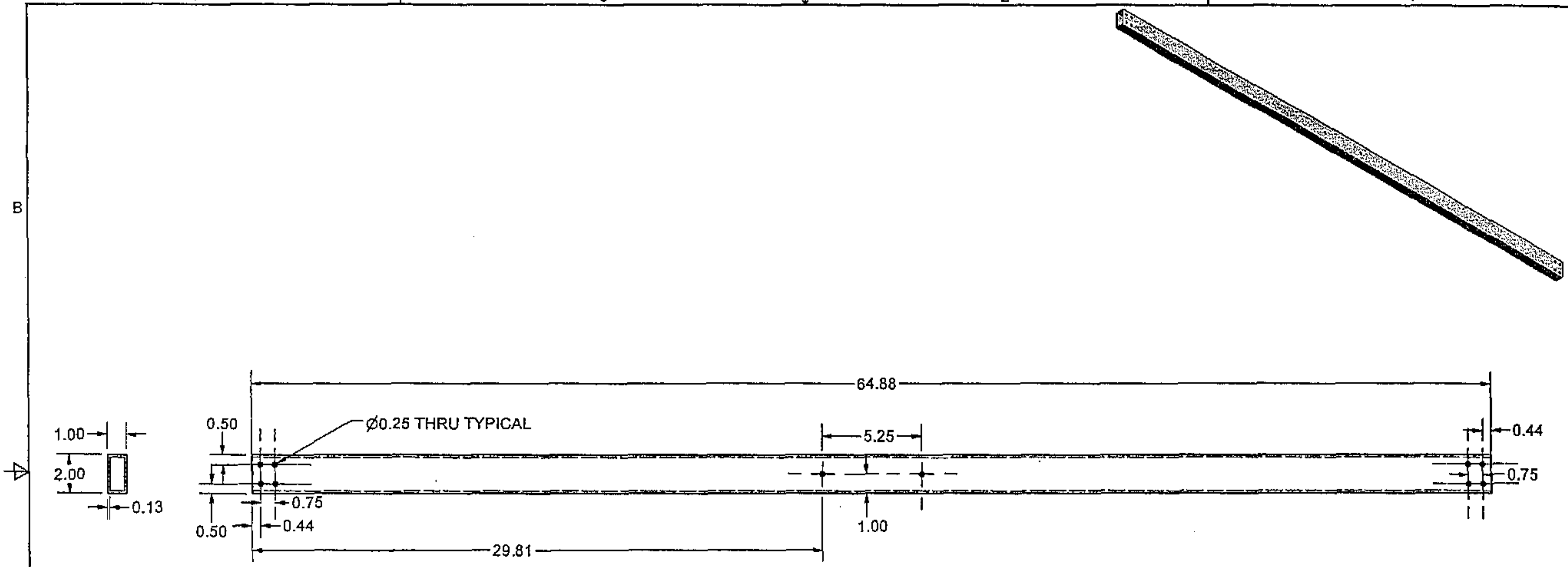
REV

DATE: 2/17/2002

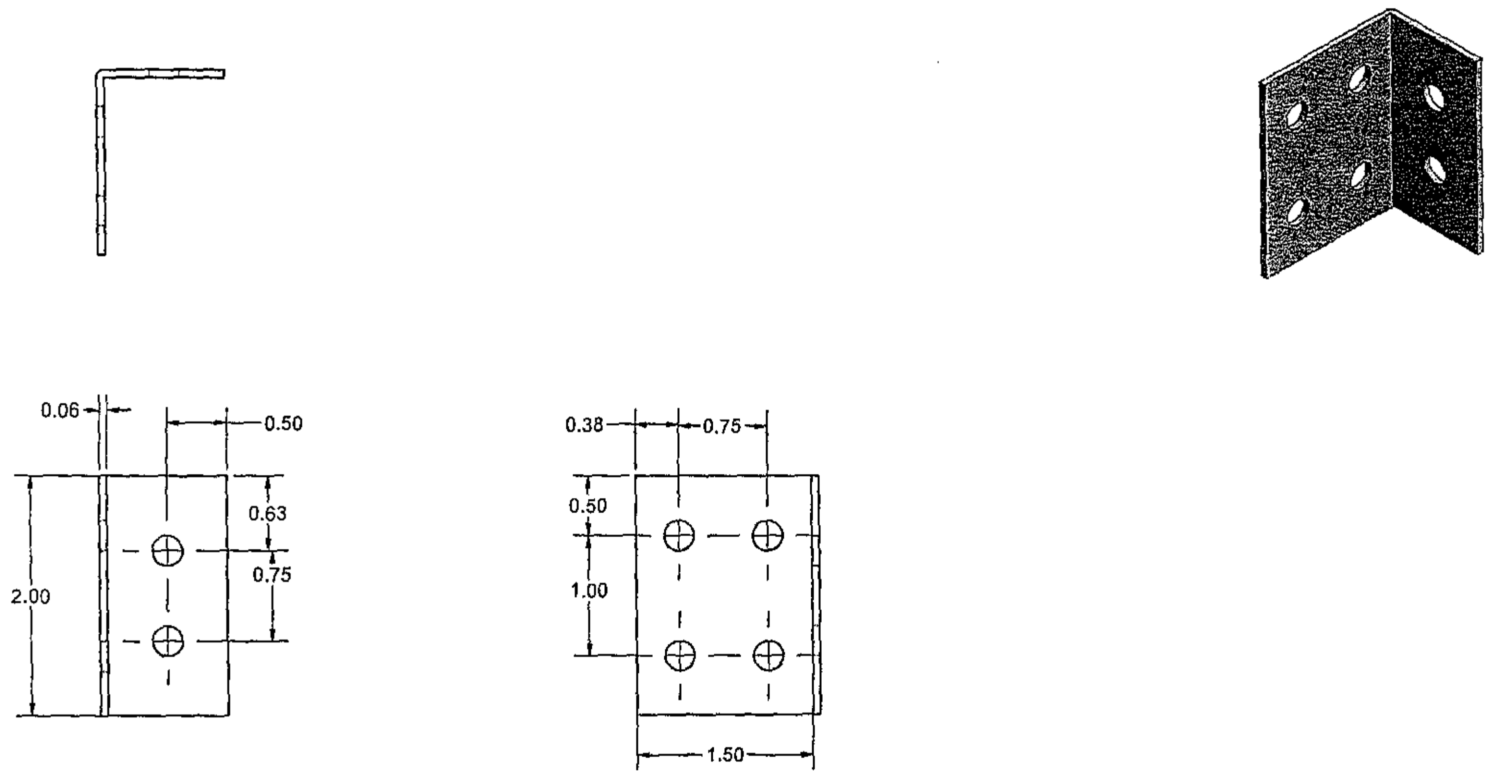
SCALE:

SIZE: B

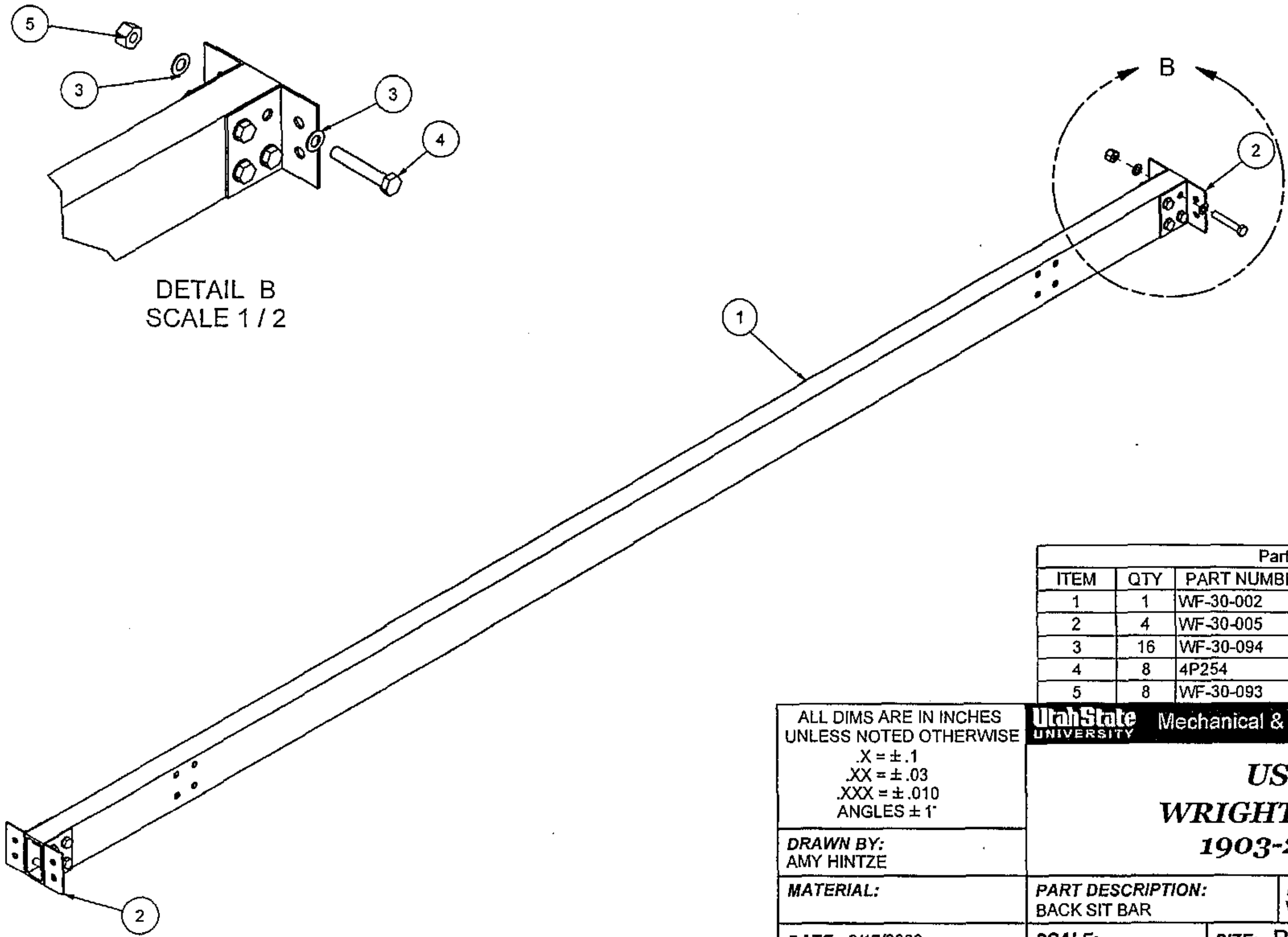
SHEET 1 *of* 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering			
	USU WRIGHT FLYER 1903-2003			
DRAWN BY: AMY HINTZE				
MATERIAL: Aluminum-6061	*PART DESCRIPTION:* SPAN BAR FRONT		*PART NUMBER:* WF-30-001	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering			
DRAWN BY: AMY HINTZE	USU WRIGHT FLYER 1903-2003			
MATERIAL: Aluminum-6061	PART DESCRIPTION: SPAN BAR SUPPORT		PART NUMBER: WF-30-005	REV
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	



DETAIL B
SCALE 1 / 2

Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-30-002	SPAN BAR BACK
2	4	WF-30-005	SPAN BAR SUPPORT
3	16	WF-30-094	1/4" FLAT WASHER
4	8	4P254	1.5 1/4-20 HEX GRADE 8
5	8	WF-30-093	1/4" LOCKNUT

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: AMY HINTZE

MATERIAL:

PART DESCRIPTION: BACK SIT BAR

PART NUMBER: WF-30-001B

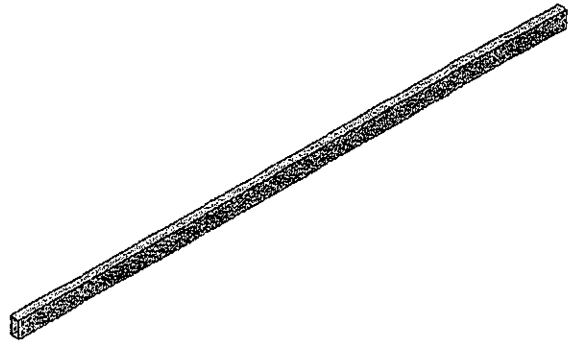
REV

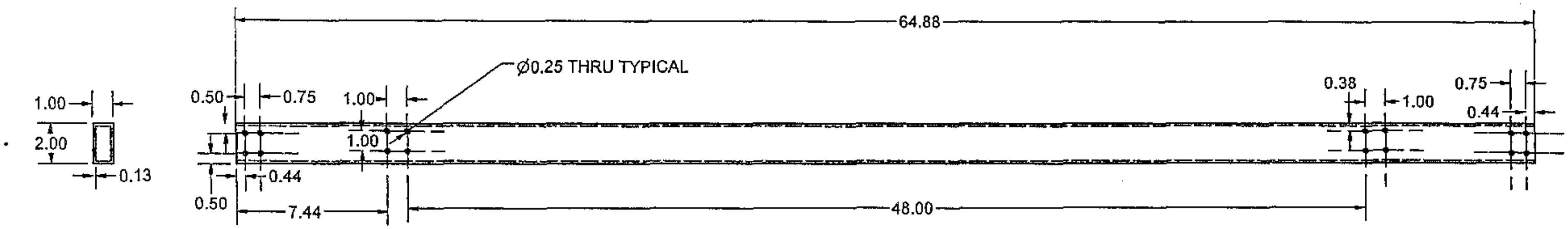
DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 *of* 1





ALL DIMS ARE IN INCHES
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.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: AMY HINTZE

MATERIAL: Aluminum-6061

PART DESCRIPTION: SPAN BAR BACK

PART NUMBER: WF-30-002

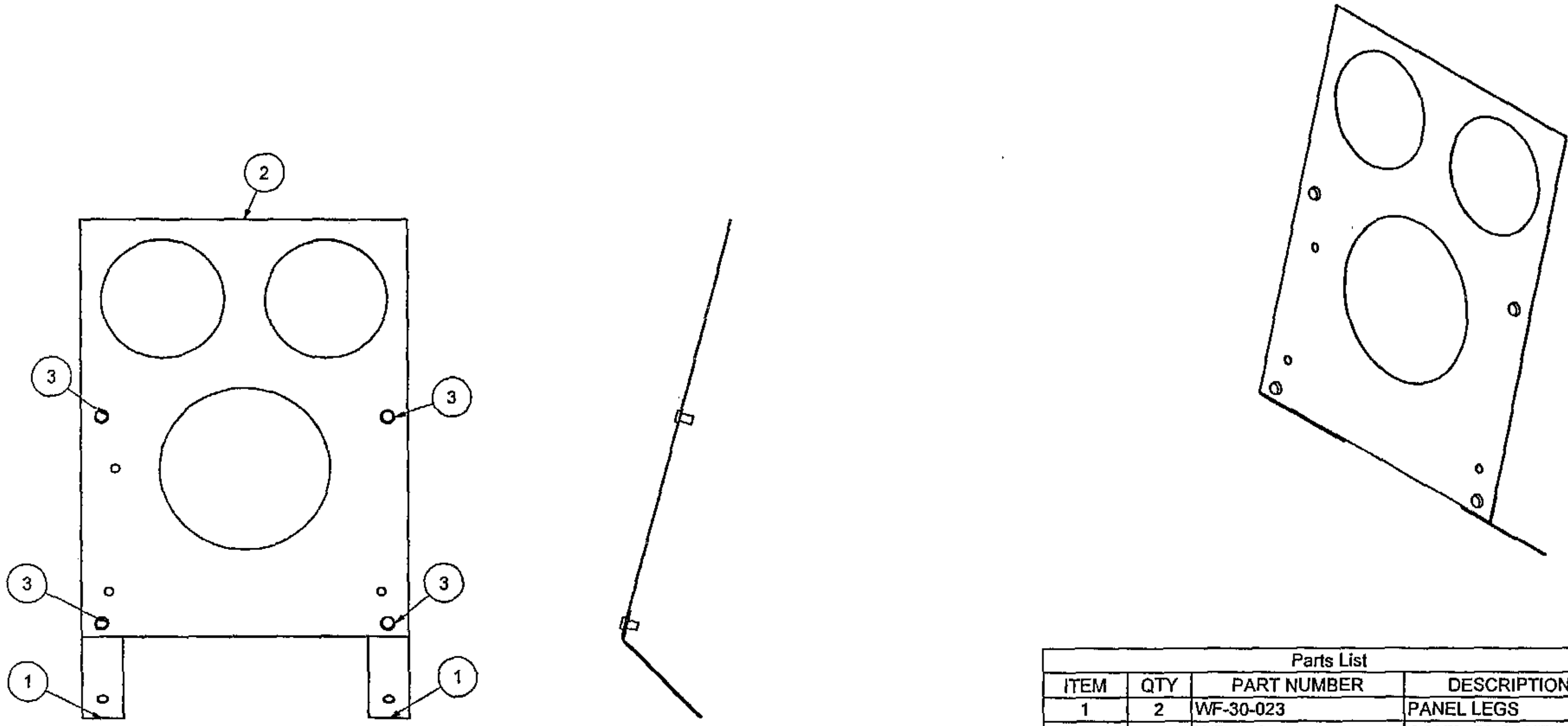
REV

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 of 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	WF-30-023	PANEL LEGS
2	1	WF-30-021	CONTROL PANEL
3	4	GRANGER 5K177	1/4" 10-24

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

Utah State University — Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: AMY HINTZE

MATERIAL:

PART DESCRIPTION: CONTROL PANEL ASSM

PART NUMBER: WF-30-020

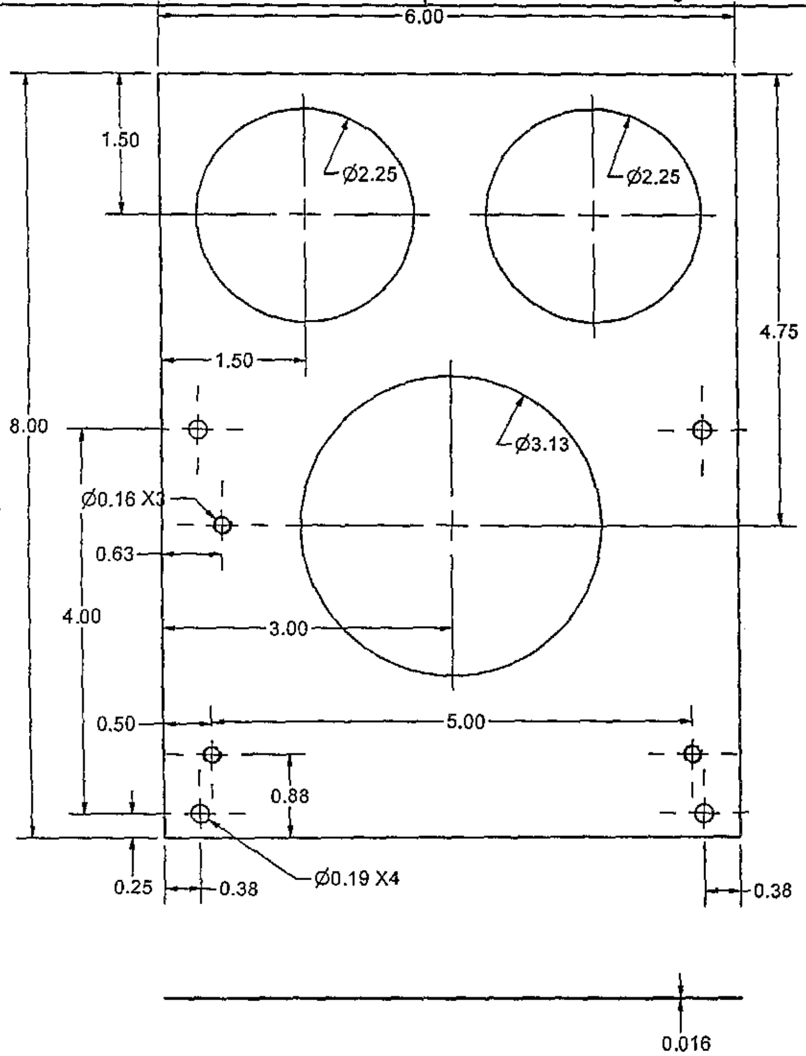
REV

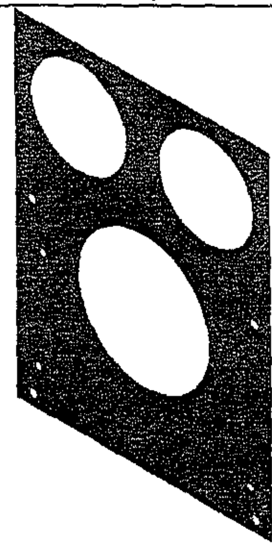
DATE: 2/17/2002

SCALE:

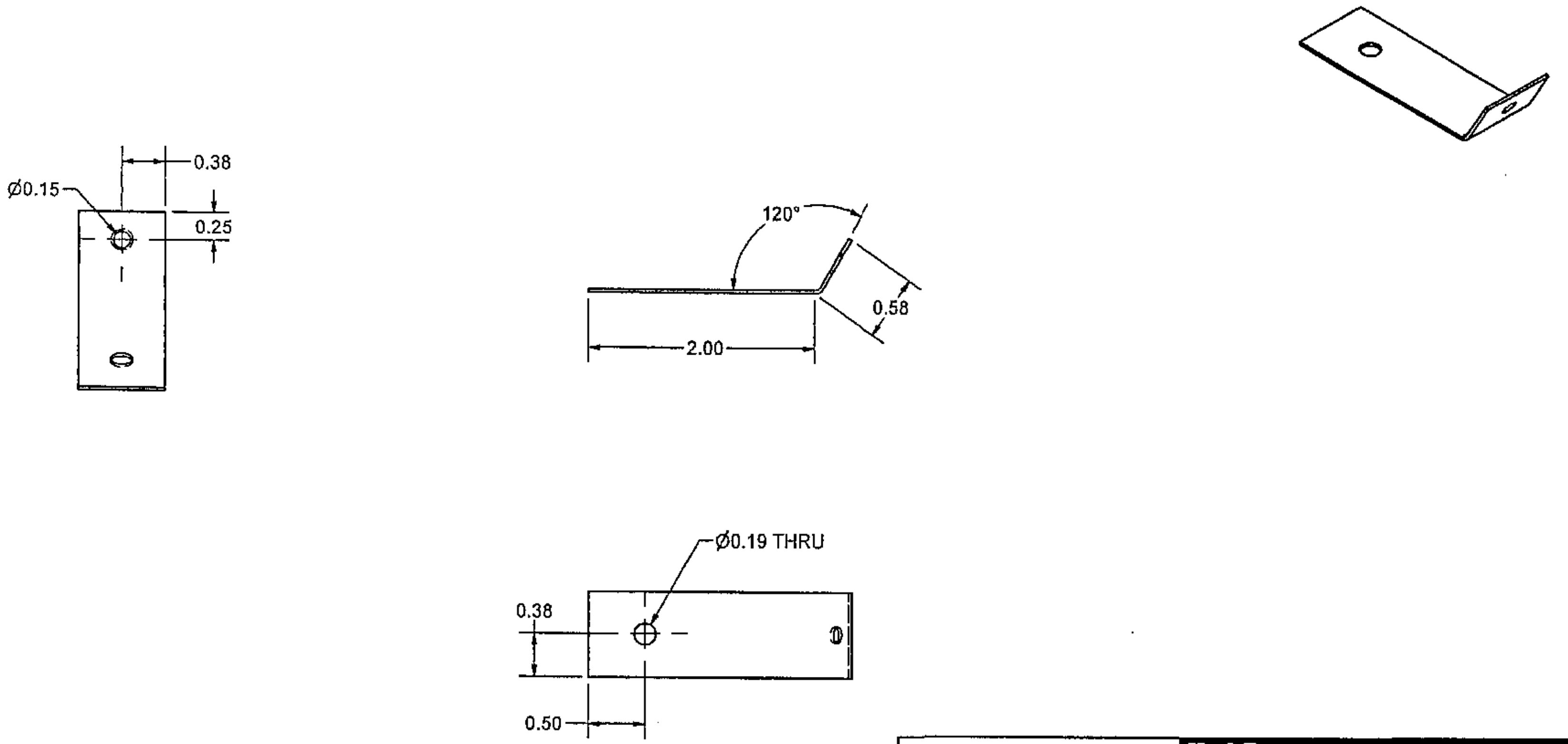
SIZE: B

SHEET 1 of 1

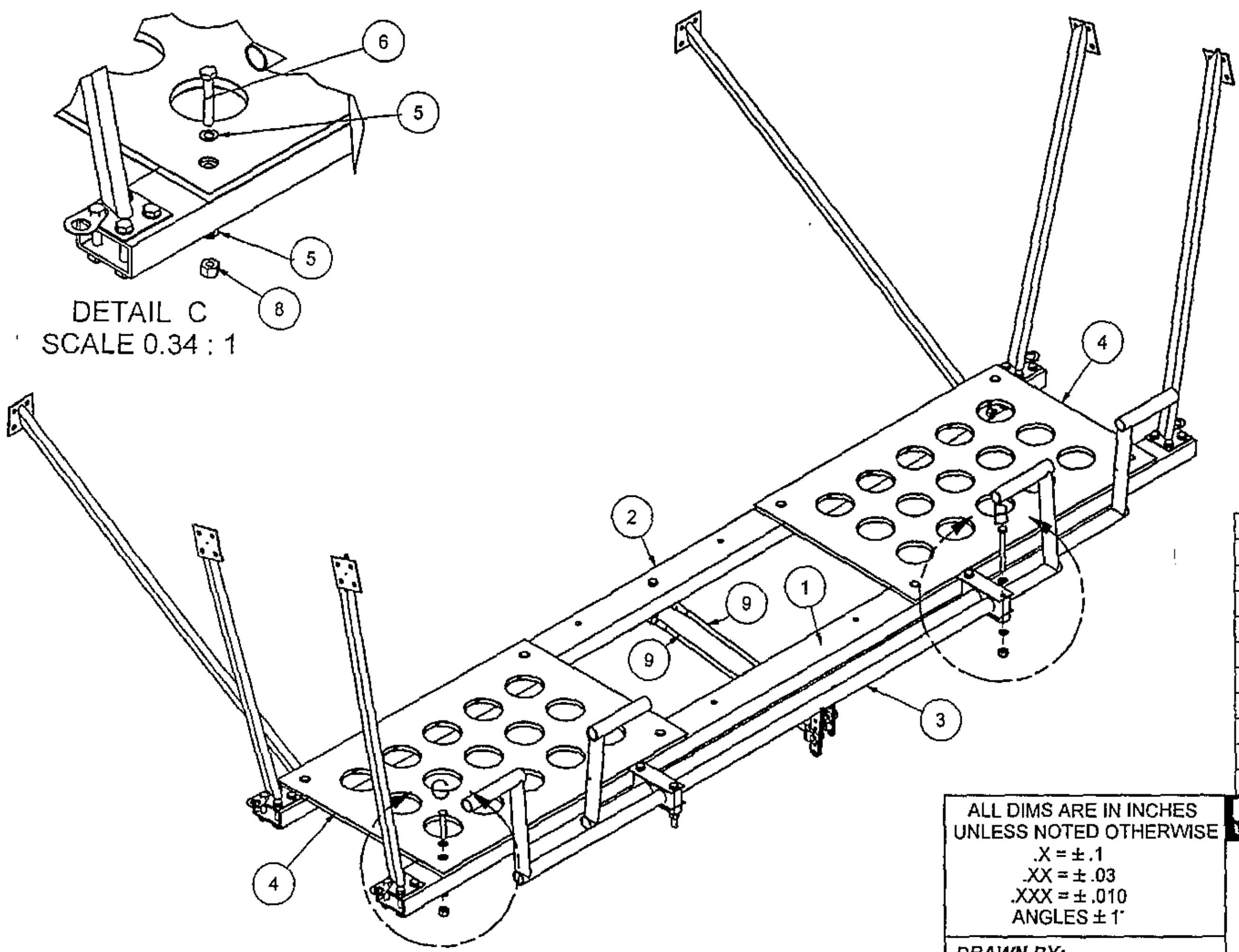


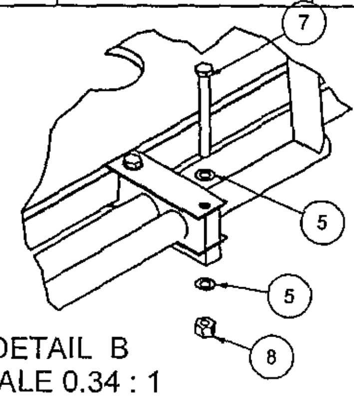


ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	Utah State University — Mechanical & Aerospace Engineering			
DRAWN BY: AMY HINTZE	*USU WRIGHT FLYER 1903-2003*			
MATERIAL: Aluminum-6061	*PART DESCRIPTION:* CONTROL PANEL		*PART NUMBER:* WF-30-021	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	Utah State University Mechanical & Aerospace Engineering				
	USU WRIGHT FLYER 1903-2003				
DRAWN BY: AMY HINTZE					
MATERIAL: Aluminum-6061	**PART DESCRIPTION:** PANEL LEGS		**PART NUMBER:** WF-30-023		**REV**
DATE: 2/17/2002	**SCALE:**	**SIZE:** B	**SHEET** 1 of 1		





Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-30-002A	FRONT FOOT REST
2	1	WF-30-002B	BACK FOOT REST
3	1	WF-30-200	TOP PEDAL ASSEMBLY
4	2	WF-30-030	FOOT PLATE
5	24	WF-30-094	1/4" FLAT WASHER
6	8	4P254	1.5 1/4-20 HEX GRADE 8
7	4	4P258	2.5 1/4-20 HEX GRADE 8
8	12	WF-30-093	1/4" LOCKNUT
9	2	WF-30-212	PUSH PULL ROD

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState University — Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: AMY HINTZE

MATERIAL:

PART DESCRIPTION: FOOT REST AREA

PART NUMBER: WF-30-002

REV

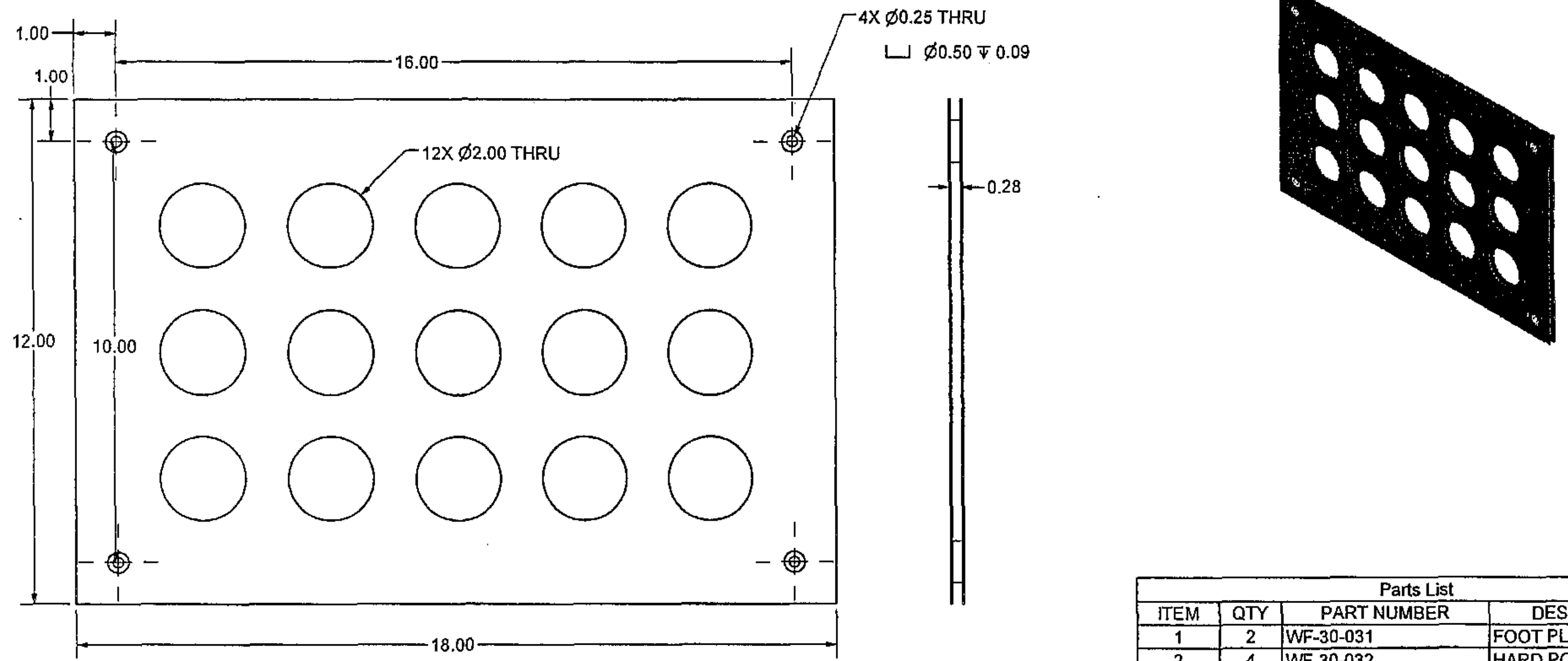
DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 *of* 1

HONEY COMB COMPOSITE PLATE
CARBON FIBER AND 1/4" ALUMINUM HONEYCOMB



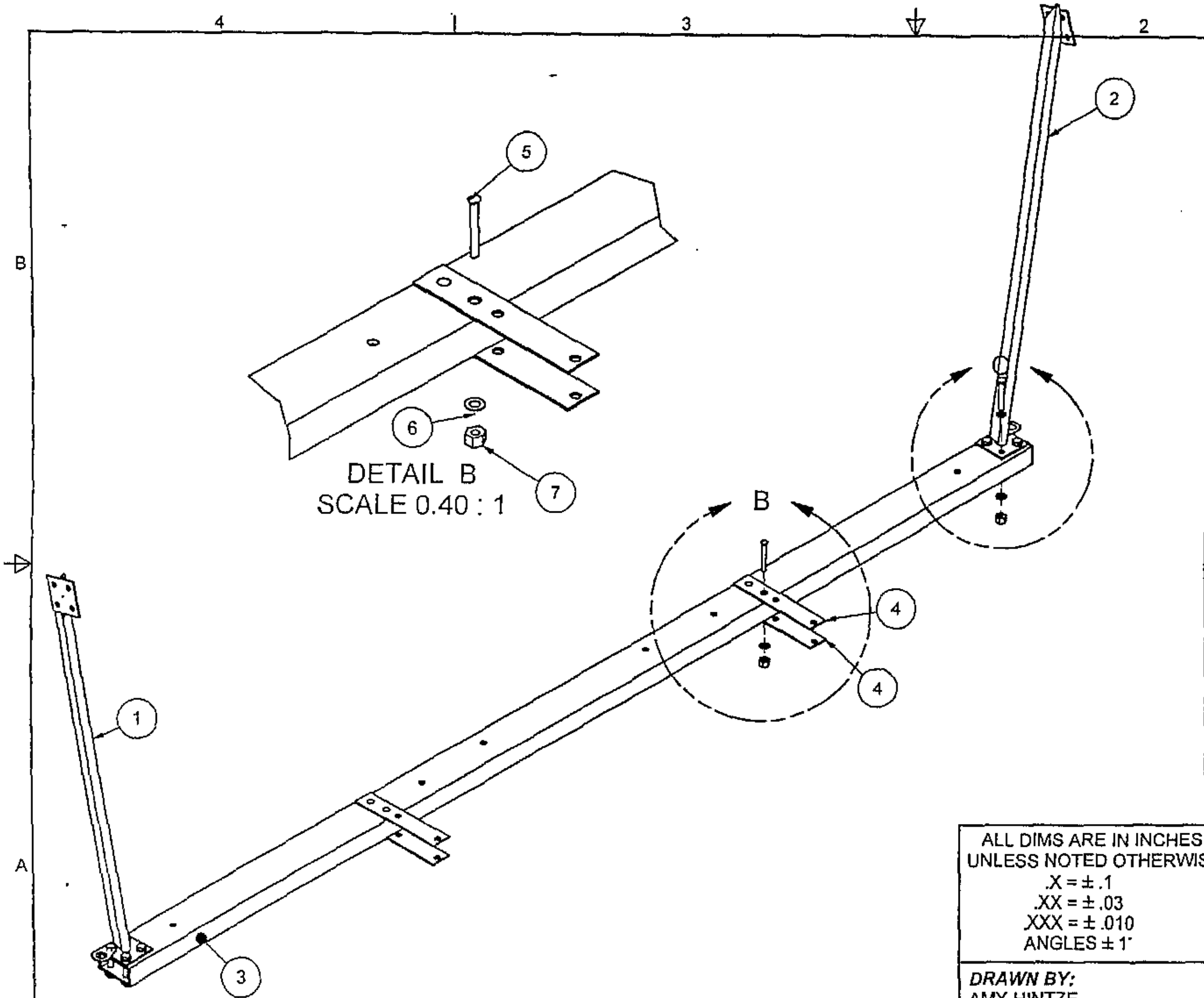
Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	WF-30-031	FOOT PLATE FIBER
2	4	WF-30-032	HARD POINTS

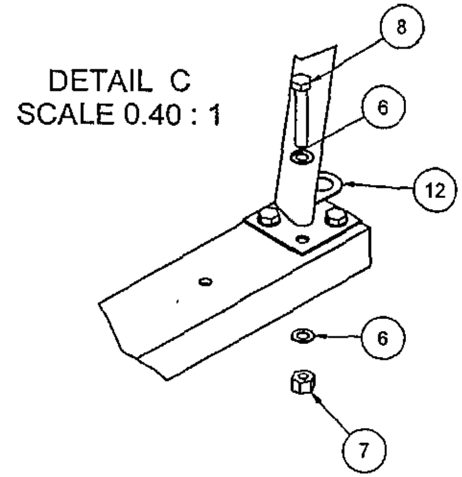
ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

Utah State University — Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: AMY HINTZE			
MATERIAL:	***PART DESCRIPTION:*** FOOT PLATE	***PART NUMBER:*** WF-30-030	***REV***
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 ***of*** 1





Parts List

ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-30-010	STREAMLINE F RIGHT
2	1	WF-30-009	STREAMLINE F LEFT
3	1	WF-30-003	FOOT BAR FRONT
4	4	WF-30-019	1/16" PLATE
5	4	4P599	1 1/2 10-24 FLAT SCREW
6	18	WF-30-094	1/4" FLAT WASHER
7	12	WF-30-093	1/4" LOCKNUT
8	8	4P254	1.5 1/4-20 HEX GRADE 8
12	2	CABLE PLATE - 1P RONG .25hole	CABLE PLATE, 1-PRONG

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: AMY HINTZE

MATERIAL:

PART DESCRIPTION: FRONT FOOT REST

PART NUMBER: WF-30-002A

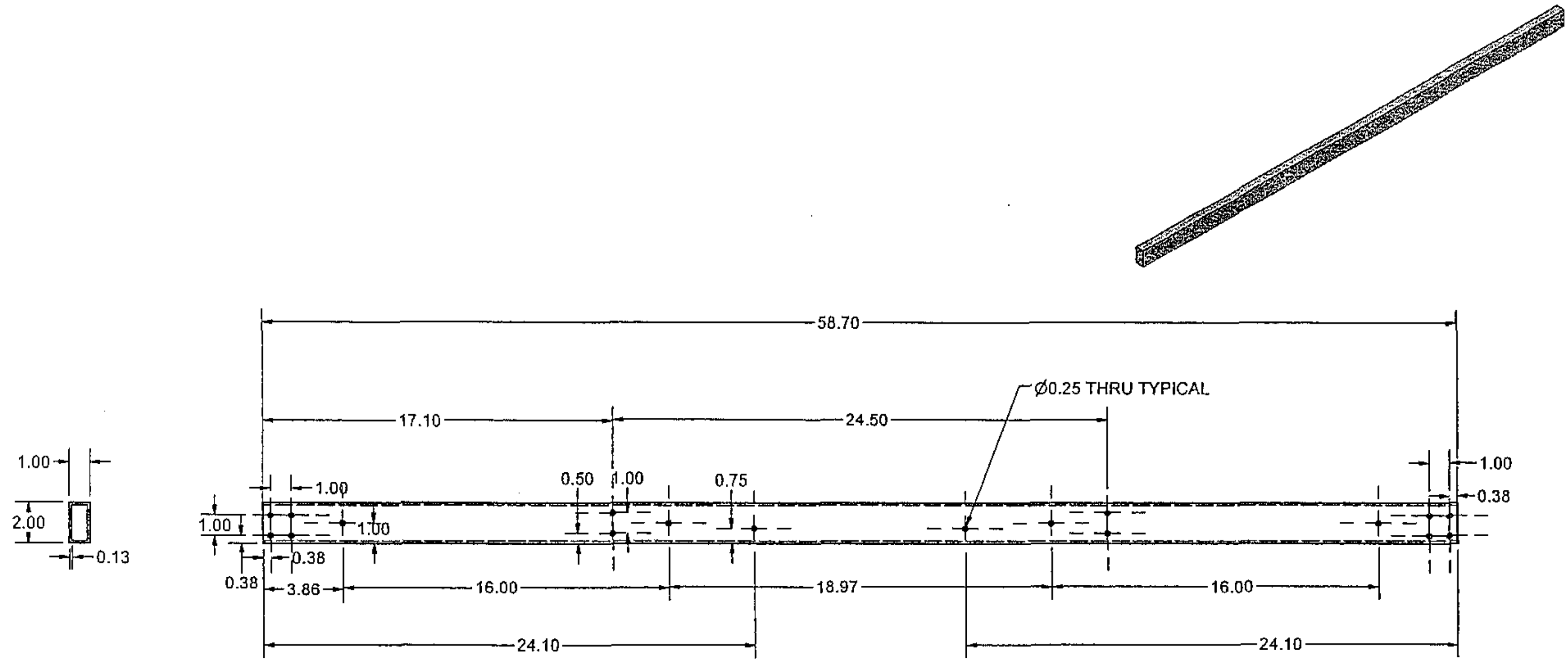
REV

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 *of* 1

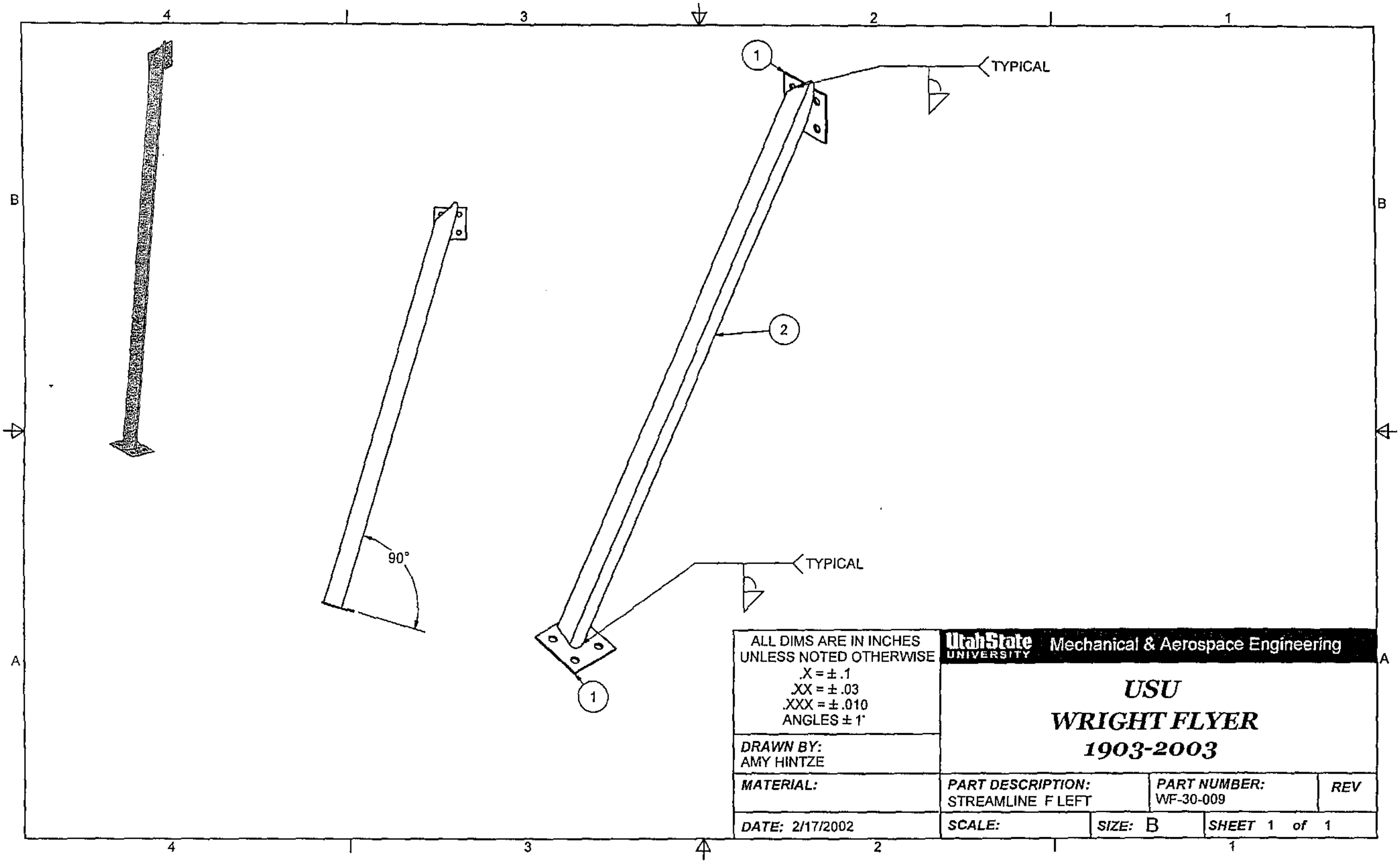


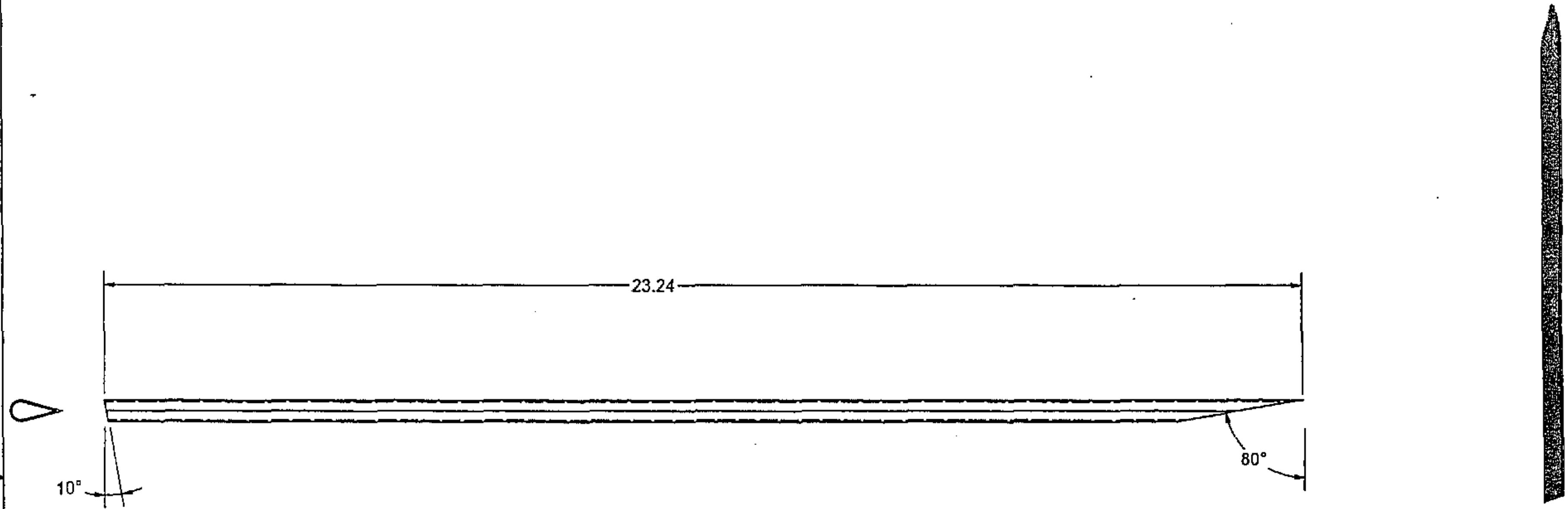
ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

Utah State University Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: AMY HINTZE			
MATERIAL: Aluminum-6061	***PART DESCRIPTION:*** FOOT BAR FRONT	***PART NUMBER:*** WF-30-003	***REV***
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 ***of*** 1

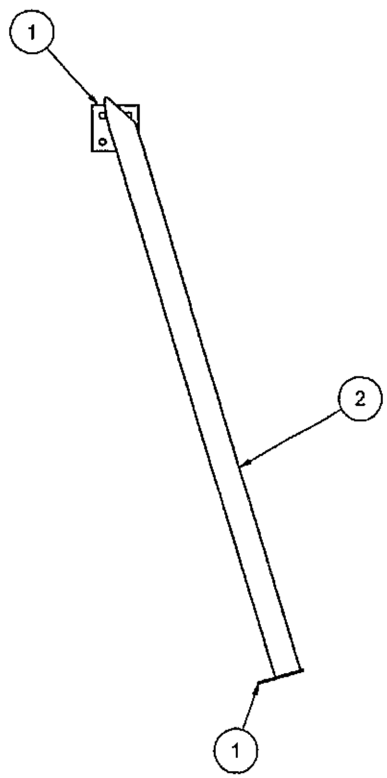

TYPICAL
TYPICAL
90°
1
2
1
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°
DRAWN BY: AMY HINTZE
MATERIAL:
DATE: 2/17/2002
UtahState UNIVERSITY
Mechanical & Aerospace Engineering
USU WRIGHT FLYER 1903-2003
PART DESCRIPTION: STREAMLINE F LEFT
PART NUMBER: WF-30-009
REV
SCALE:
SIZE: B
SHEET 1 of 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering			
DRAWN BY: AMY HINTZE	***USU WRIGHT FLYER 1903-2003***			
MATERIAL: Steel, High Strength Low Alloy	**PART DESCRIPTION:** STREAMLINE LEFT FR		**PART NUMBER:** 03-11300	**REV**
DATE: 2/17/2002	**SCALE:**	**SIZE:** B	**SHEET** 1 of 1	

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	Utah State University Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*		
DRAWN BY: AMY HINTZE			
MATERIAL: Steel, High Strength Low Alloy	*PART DESCRIPTION:* STREAMLINE PLATE	*PART NUMBER:* WF-30-013	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1

SAME AS DRAWING WF-30-009



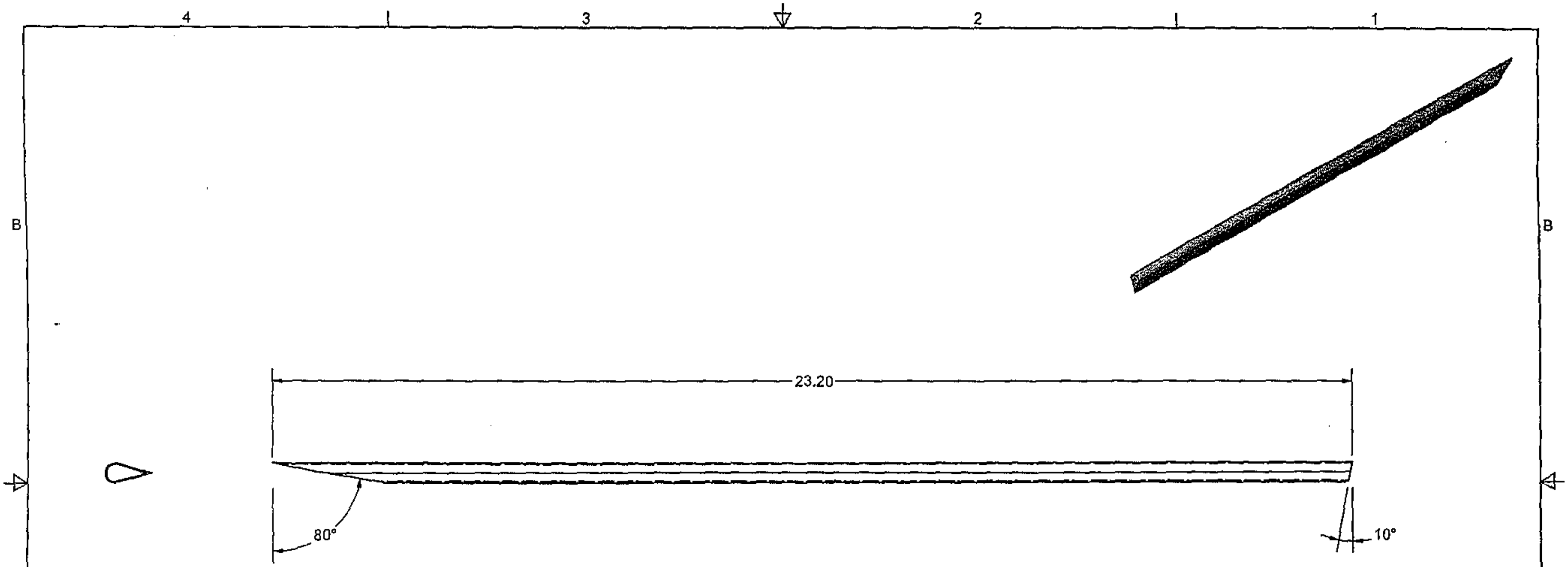
Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	WF-30-013	STREAMLINE PLATE
2	1	03-11300	STREAMLINE LEFT FR

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

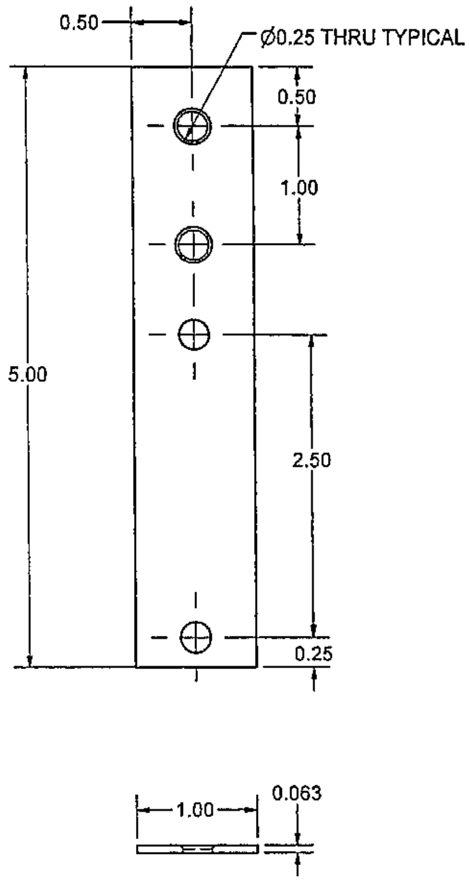
UtahState UNIVERSITY Mechanical & Aerospace Engineering

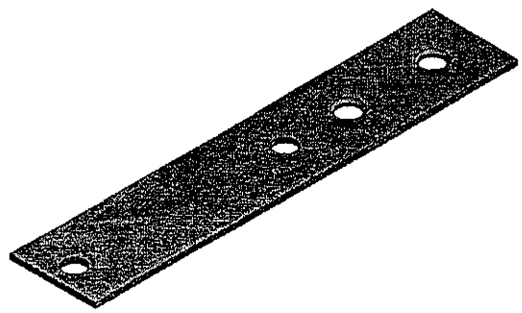
USU WRIGHT FLYER 1903-2003

DRAWN BY: AMY HINTZE			
MATERIAL:	*PART DESCRIPTION:* STREAMLINE F RIGHT	*PART NUMBER:* WF-30-010	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering			
DRAWN BY: AMY HINTZE	*USU WRIGHT FLYER 1903-2003*			
MATERIAL: Steel, High Strength Low Alloy	*PART DESCRIPTION:* STREAMLINE RIGHT FR		*PART NUMBER:* 03-11300	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	





ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: AMY HINTZE

MATERIAL: Steel, High Strength Low Alloy

PART DESCRIPTION: 1/16" PLATE

PART NUMBER: WF-30-019

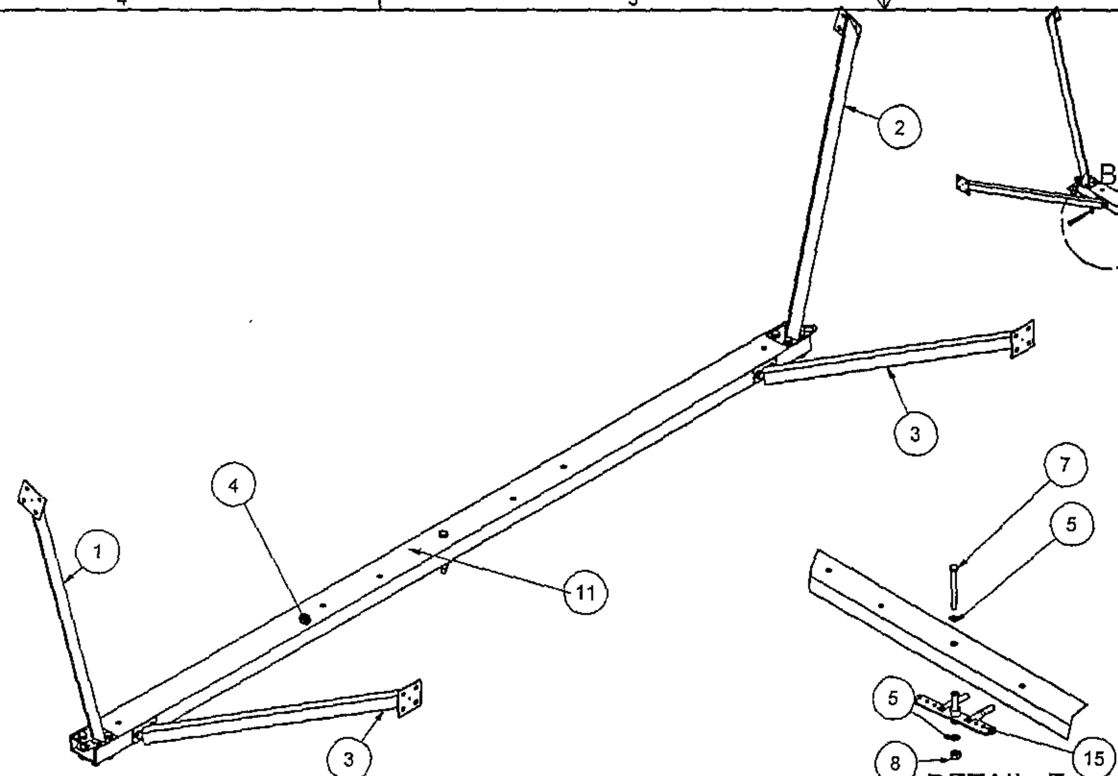
REV

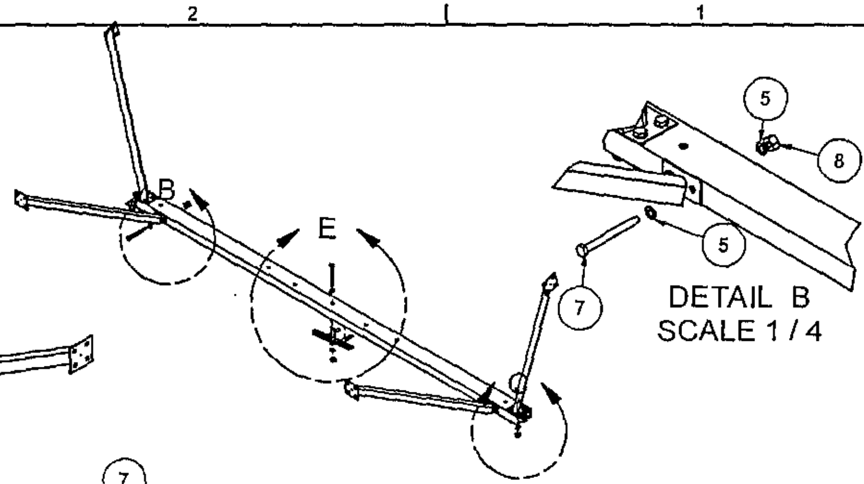
DATE: 2/17/2002

SCALE:

SIZE: B

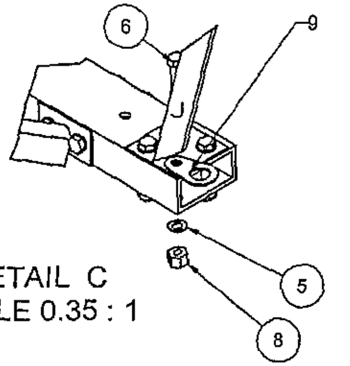
SHEET 1 *of* 1





DETAIL B
SCALE 1 / 4

DETAIL E
SCALE 0.16 : 1



DETAIL C
SCALE 0.35 : 1

Parts List

ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-30-011	STREAMLINE B LEFT
2	1	WF-30-012	STREAMLINE B RIGHT
3	2	WF-30-006	SUPPORT
10	1	WF-30-208	RUDDER BELL ASSM
4	1	WF-30-004	FOOT BAR BACK
5	24	WF-30-094	1/4" FLAT WASHER
6	8	4P254	1.5 1/4-20 HEX GRADE 8
7	5	4P258	2.5 1/4-20 HEX GRADE 8
8	13	WF-30-093	1/4" LOCKNUT
9	2	CABLE PLATE - 1PRONG .25hole	CABLE PLATE, 1-PRONG
11	2	AN665-34R	FORK END 2

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY — Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: AMY HINTZE

MATERIAL:

PART DESCRIPTION: BACK FOOT REST

PART NUMBER: WF-30-002B

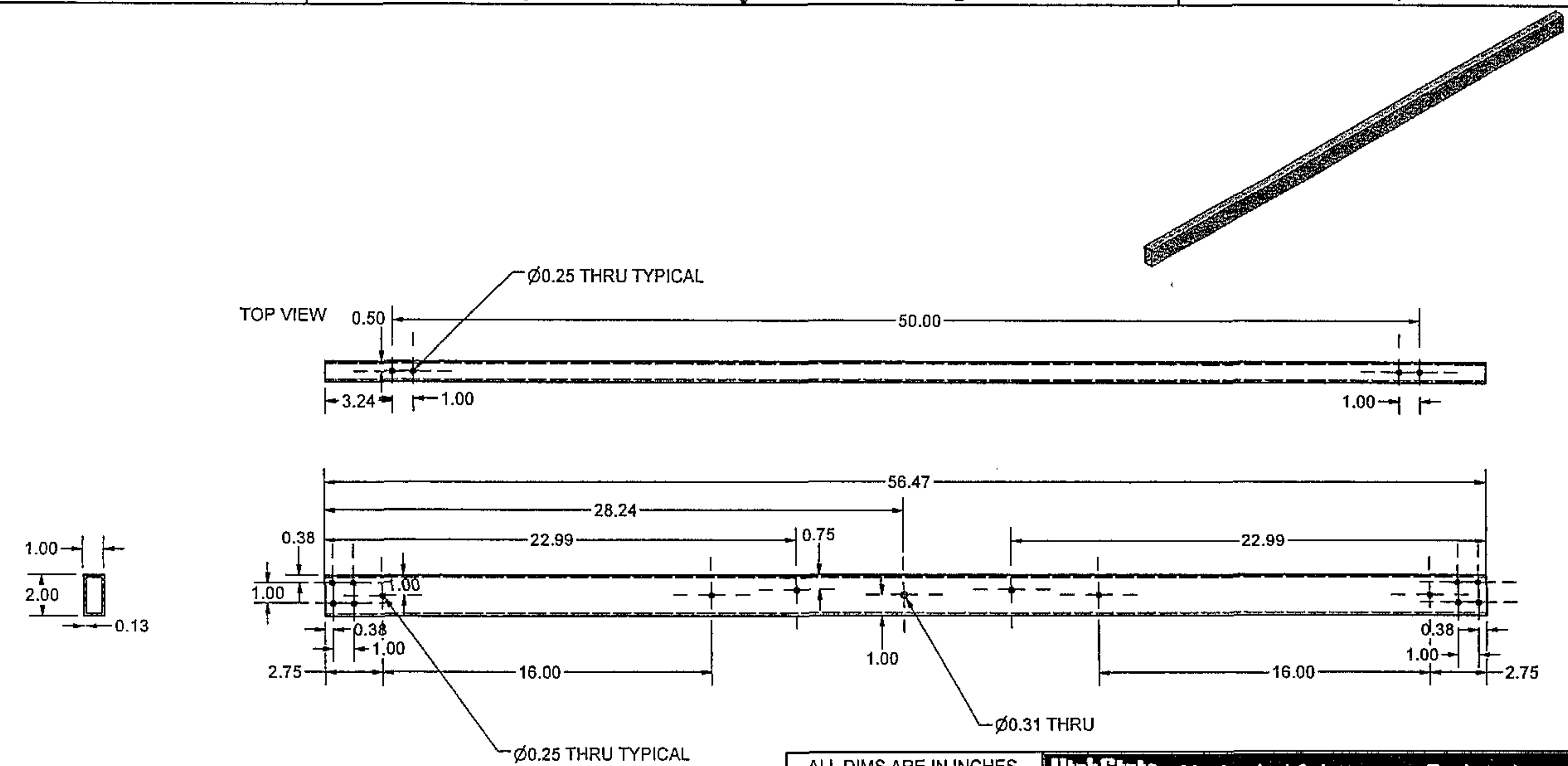
REV

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 ***of*** 1

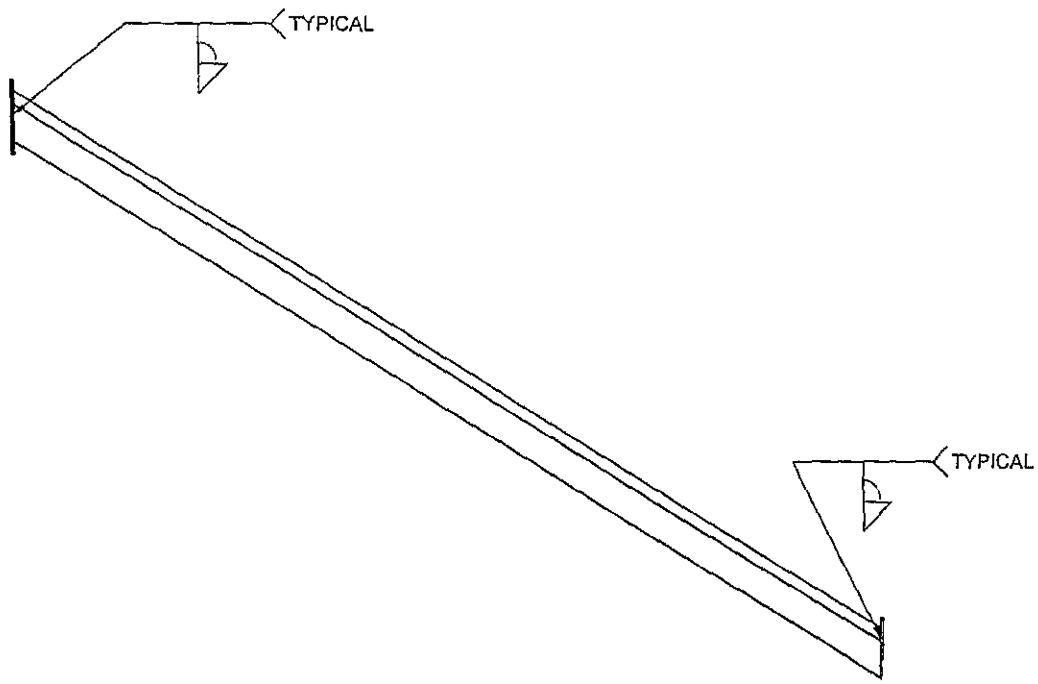


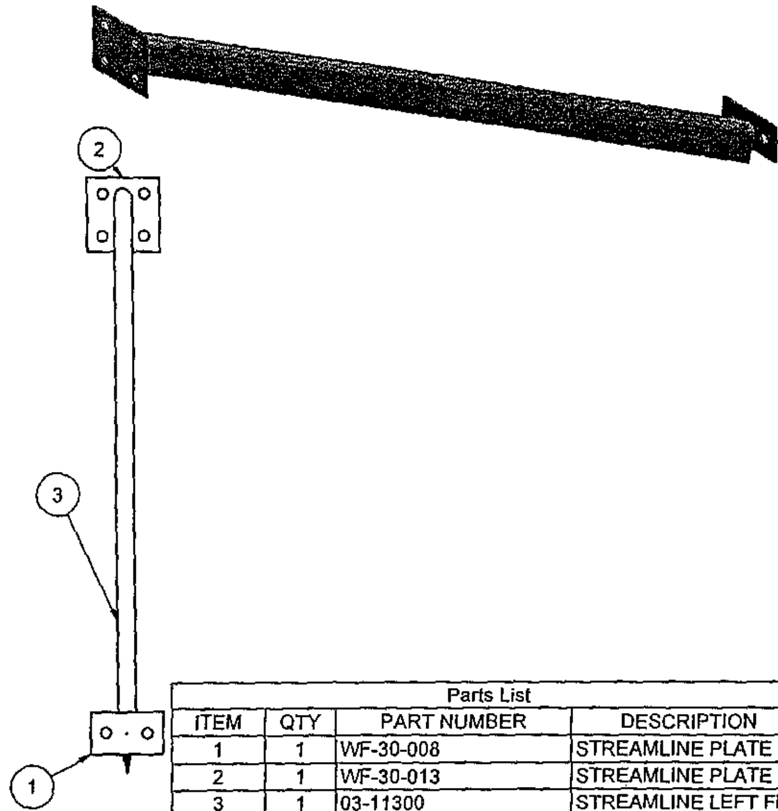
ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: AMY HINTZE			
MATERIAL: Aluminum-6061	**PART DESCRIPTION:** FOOT BAR BACK	**PART NUMBER:** WF-30-004	**REV**
DATE: 2/17/2002	**SCALE:**	**SIZE:** B	**SHEET** 1 **of** 1





Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-30-008	STREAMLINE PLATE
2	1	WF-30-013	STREAMLINE PLATE
3	1	03-11300	STREAMLINE LEFT FR

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: AMY HINTZE

MATERIAL:

PART DESCRIPTION: SUPPORT

PART NUMBER: WF-30-006

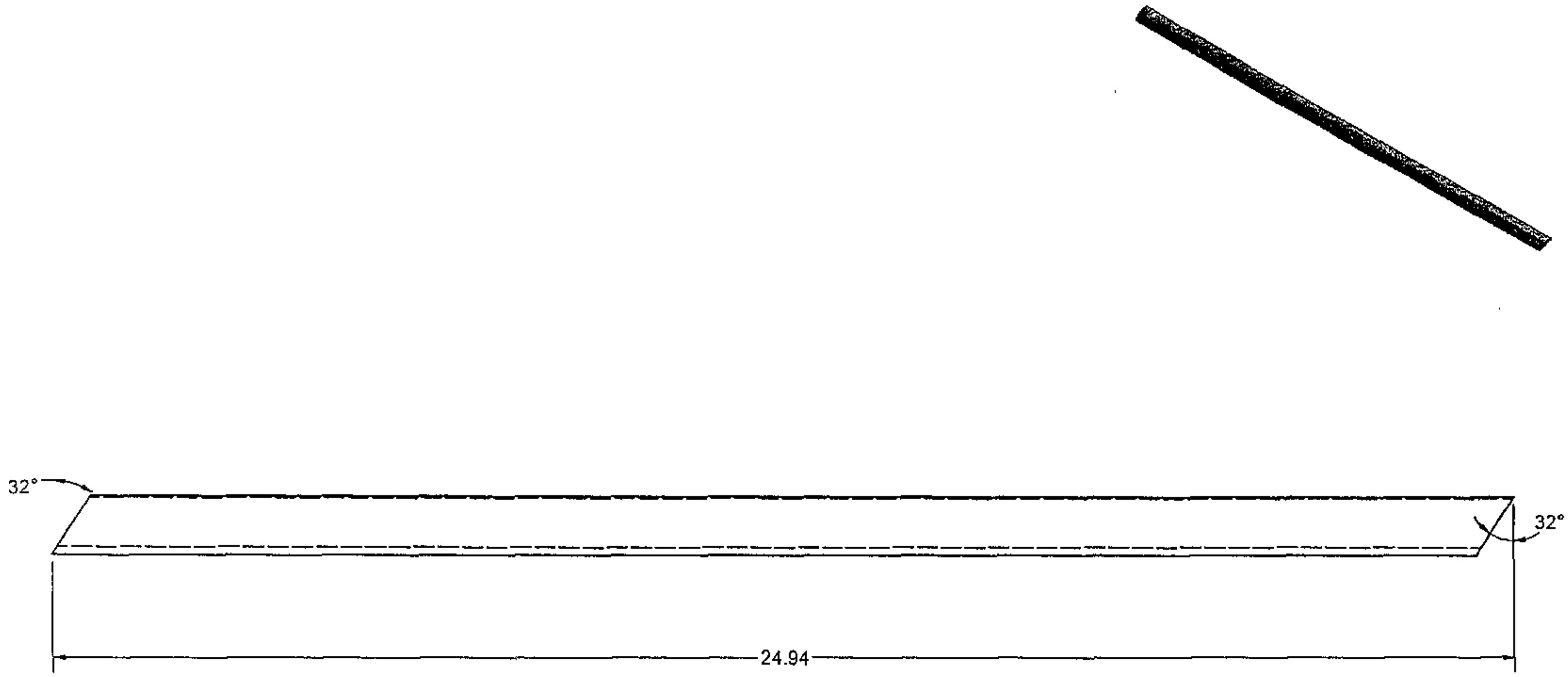
REV

DATE: 2/17/2002

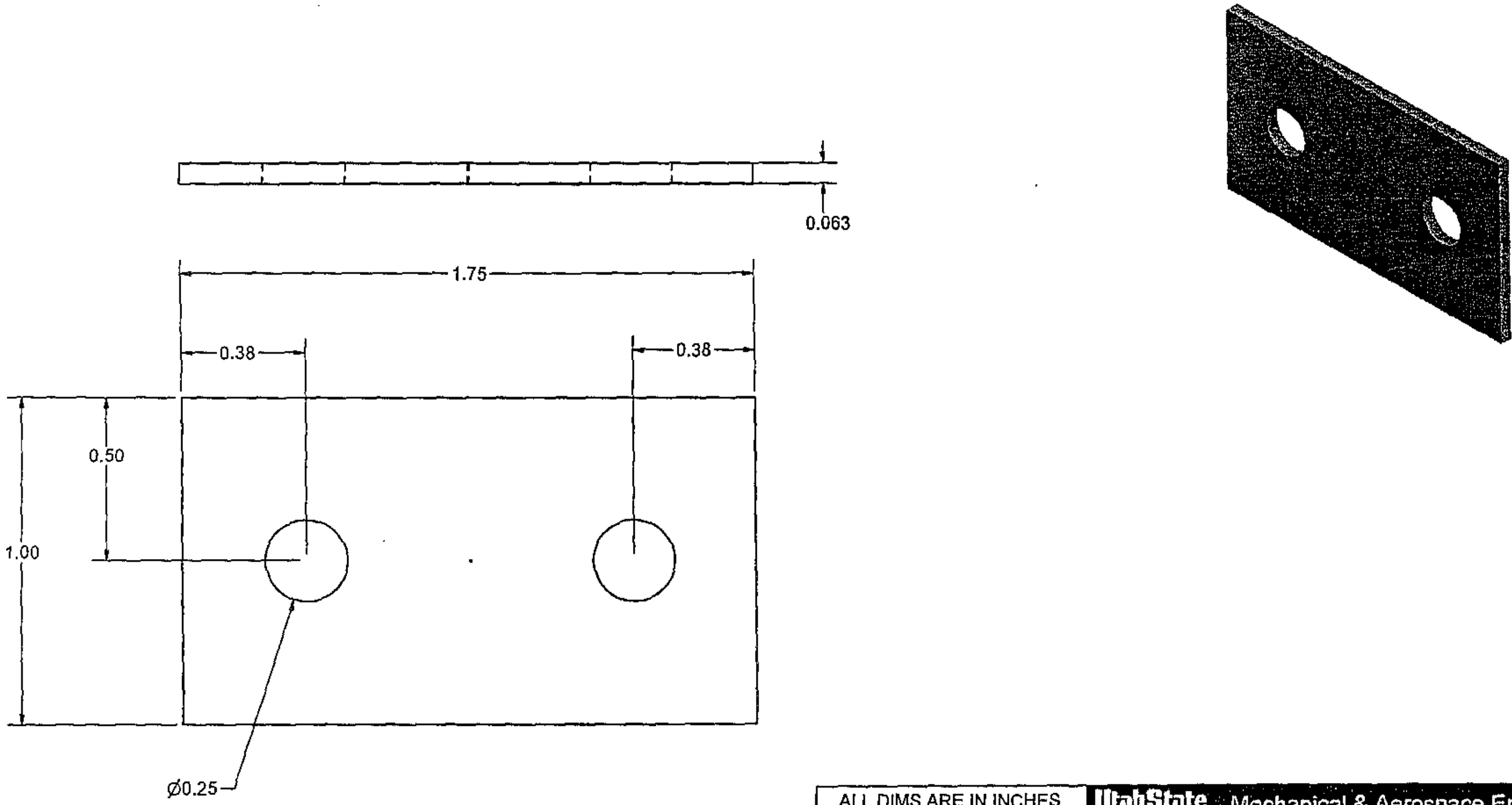
SCALE:

SIZE: B

SHEET 1 *of* 1

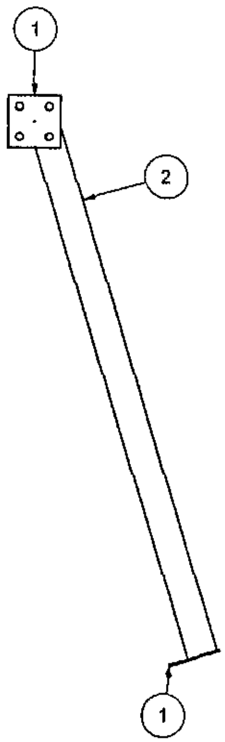


ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering			
	USU WRIGHT FLYER 1903-2003			
DRAWN BY: AMY HINTZE				
MATERIAL: Steel, High Strength Low Alloy	PART DESCRIPTION: STREAMLINE LEFT FR		PART NUMBER: 03-11300	REV
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	



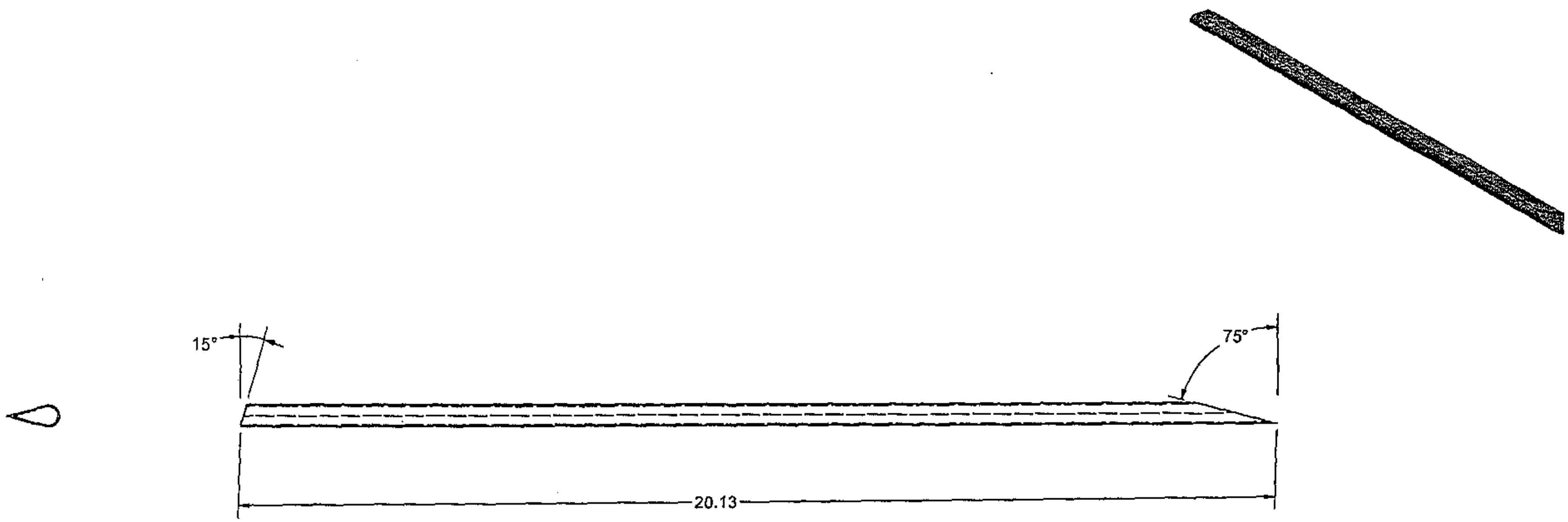
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003			
DRAWN BY: AMY HINTZE				
MATERIAL: Steel, High Strength Low Alloy	PART DESCRIPTION: STREAMLINE PLATE		PART NUMBER: WF-30-008	REV
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	

SAME AS DRAWING WF-30-009



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	WF-30-013	STREAMLINE PLATE
2	1	03-11300	STREAMLINE RIGHT BACK

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*			
DRAWN BY: AMY HINTZE				
MATERIAL:	***PART DESCRIPTION:*** STREAMLINE B LEFT		***PART NUMBER:*** WF-30-011	***REV***
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 ***of*** 1	



ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

Utah State University — Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: AMY HINTZE

MATERIAL: Steel, High Strength Low Alloy

PART DESCRIPTION: STREAMLINE LEFT BACK

PART NUMBER: 03-11300

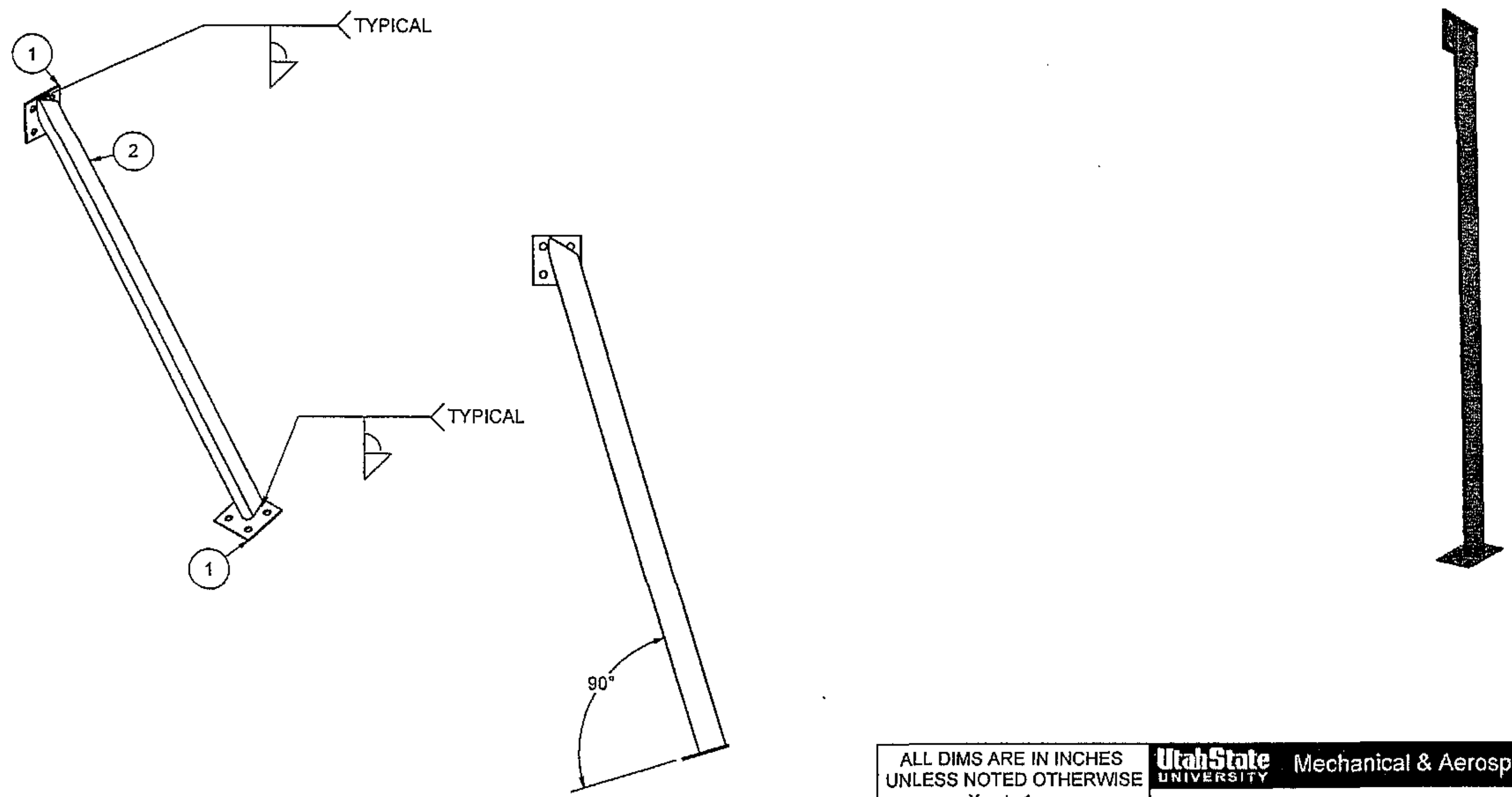
REV

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 *of* 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

DRAWN BY: AMY HINTZE

MATERIAL:

DATE: 2/17/2002

Utah State University — Mechanical & Aerospace Engineering

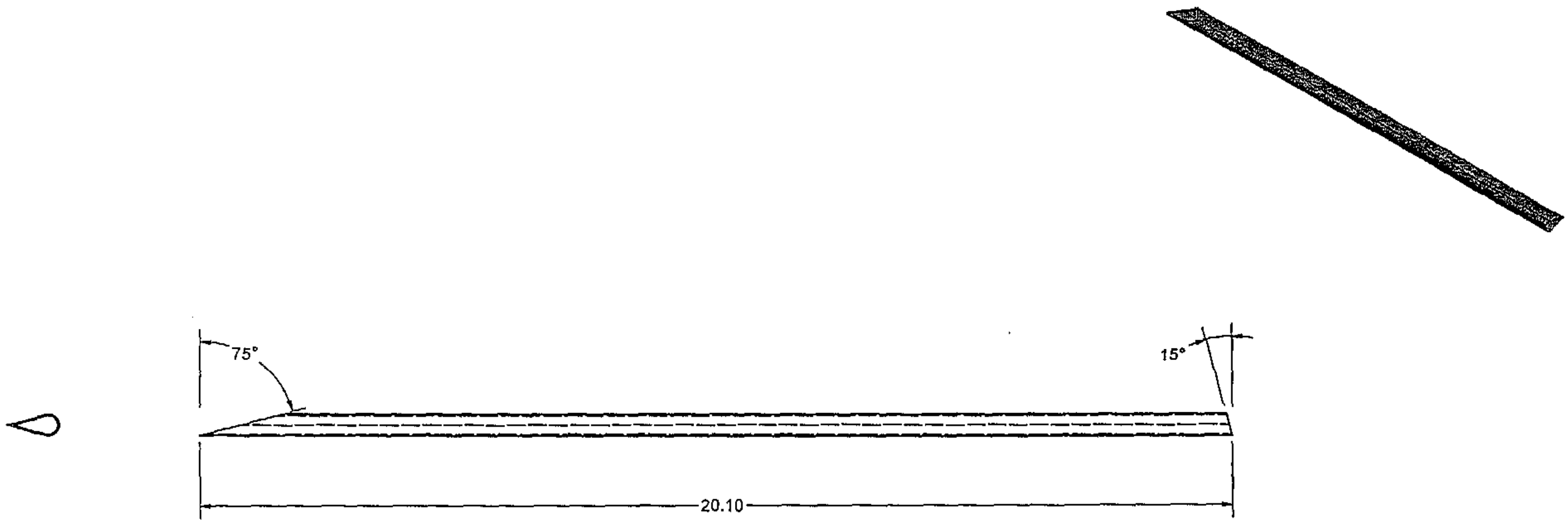
USU WRIGHT FLYER 1903-2003

PART DESCRIPTION:	PART NUMBER:	REV
STREAMLINE B RIGHT	WF-30-012	

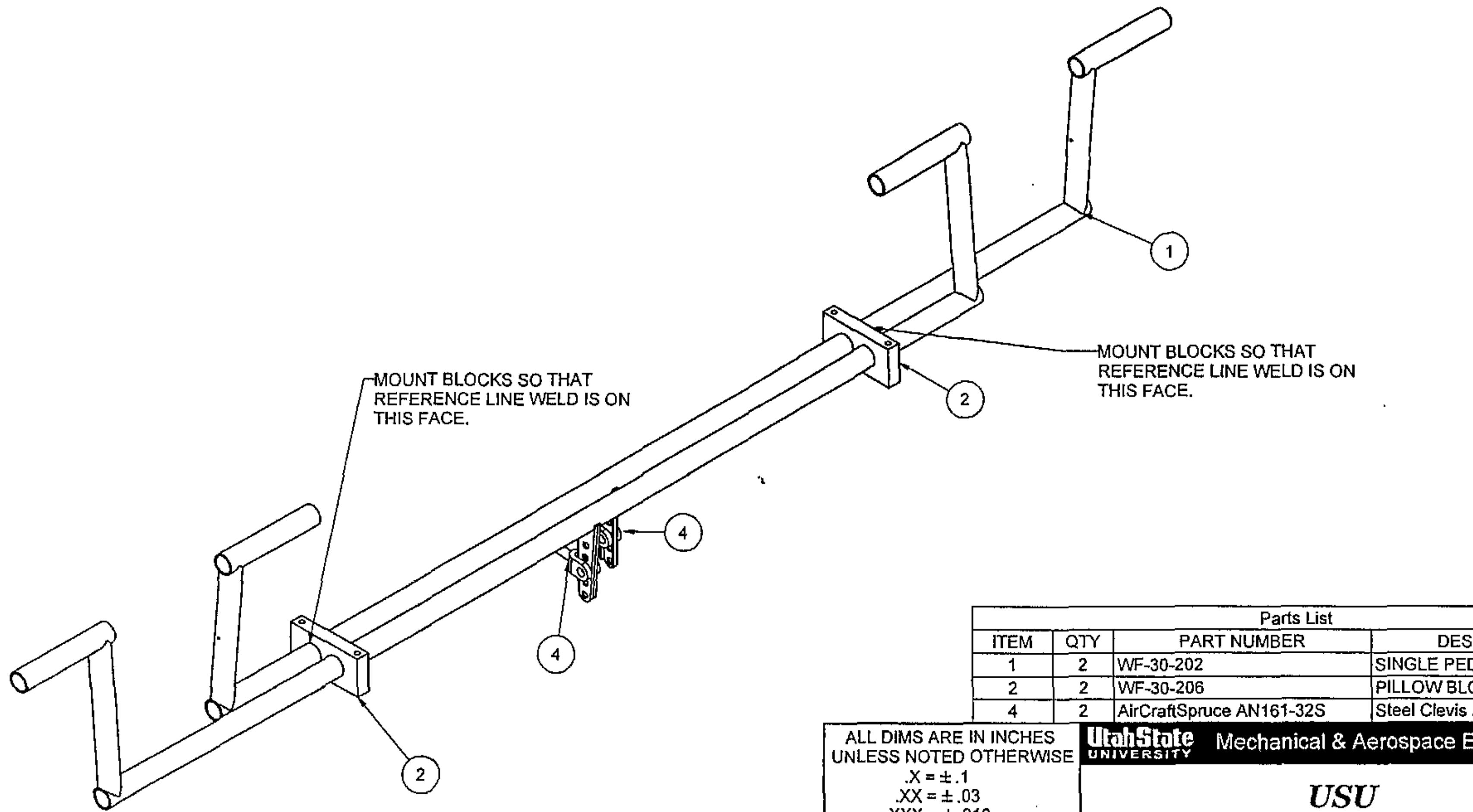
SCALE: | SIZE: B | SHEET 1 of 1

Parts List

ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	WF-30-013	STREAMLINE PLATE
2	1	03-11300	STREAMLINE LEFT BACK



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*			
DRAWN BY: AMY HINTZE				
MATERIAL: Steel, High Strength Low Alloy	*PART DESCRIPTION:* STREAMLINE RIGHT BACK	*PART NUMBER:* 03-11300		*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	WF-30-202	SINGLE PEDAL ASSEMBLY
2	2	WF-30-206	PILLOW BLOCK
4	2	AirCraftSpruce AN161-32S	Steel Clevis Fork

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: AMY HINTZE

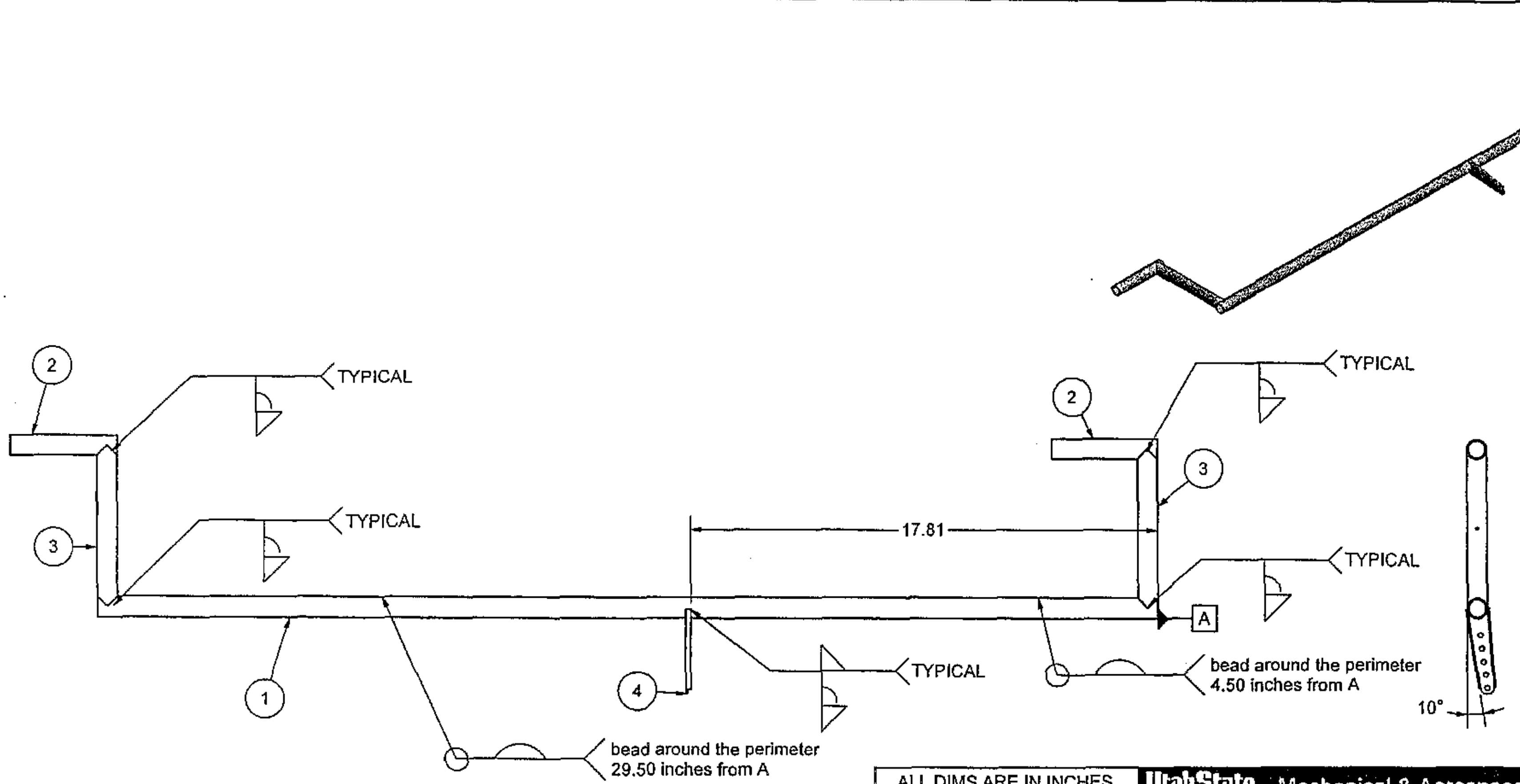
MATERIAL:

PART DESCRIPTION: TOP PEDAL ASSEMBLY

PART NUMBER: WF-30-200

REV

DATE: 2/17/2002 | ***SCALE:*** | ***SIZE:*** B | ***SHEET*** 1 ***of*** 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-30-201	PEDAL ROD
2	2	WF-30-203	PEDAL - FOOT INTERFACE
3	2	WF-30-204	PEDAL - ARM
4	1	WF-30-205	RUDDER TAB

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: AMY HINTZE

MATERIAL:

DATE: 2/17/2002

PART DESCRIPTION: SINGLE PEDAL ASSEMBLY

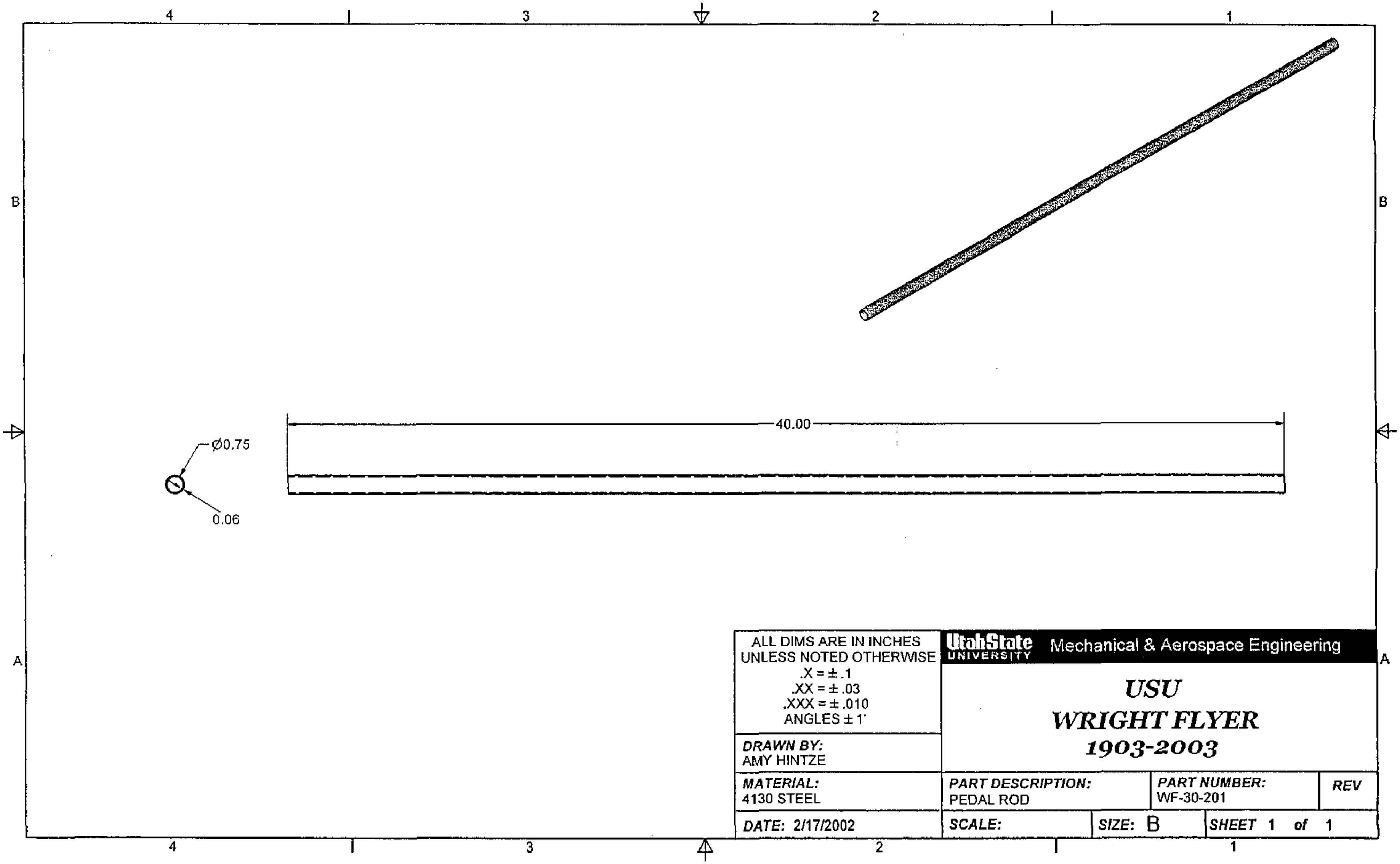
PART NUMBER: WF-30-202

REV

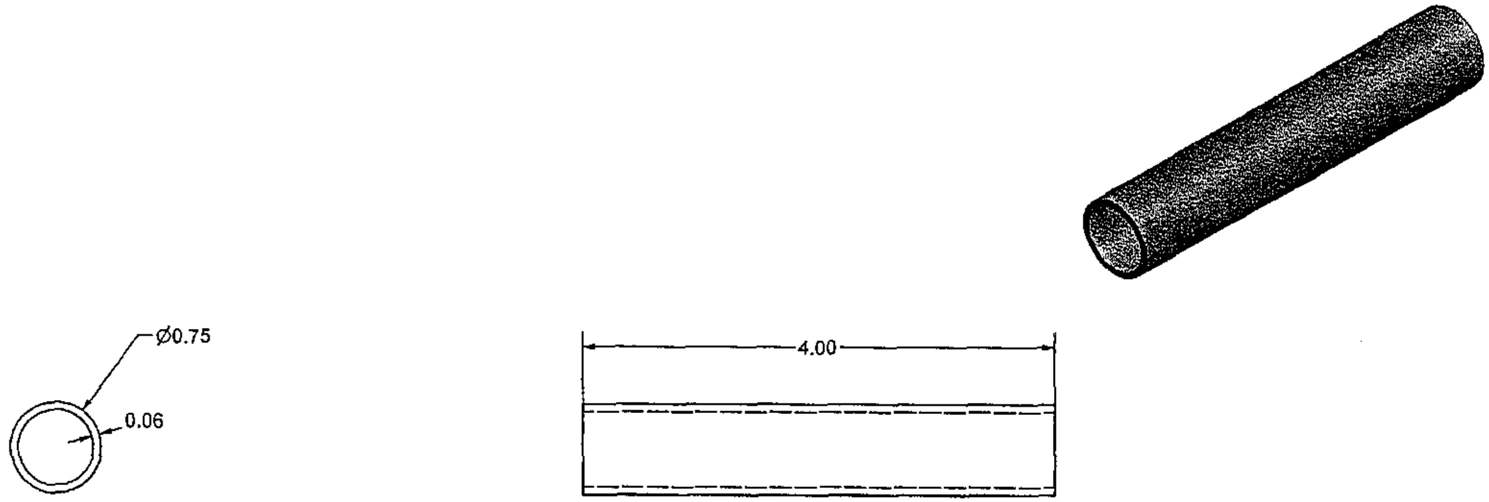
SCALE:

SIZE: B

SHEET 1 ***of*** 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1˚	UtahState UNIVERSITY Mechanical & Aerospace Engineering		
DRAWN BY: AMY HINTZE	***USU WRIGHT FLYER 1903-2003***		
MATERIAL: 4130 STEEL	*PART DESCRIPTION:* PEDAL ROD	*PART NUMBER:* WF-30-201	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1

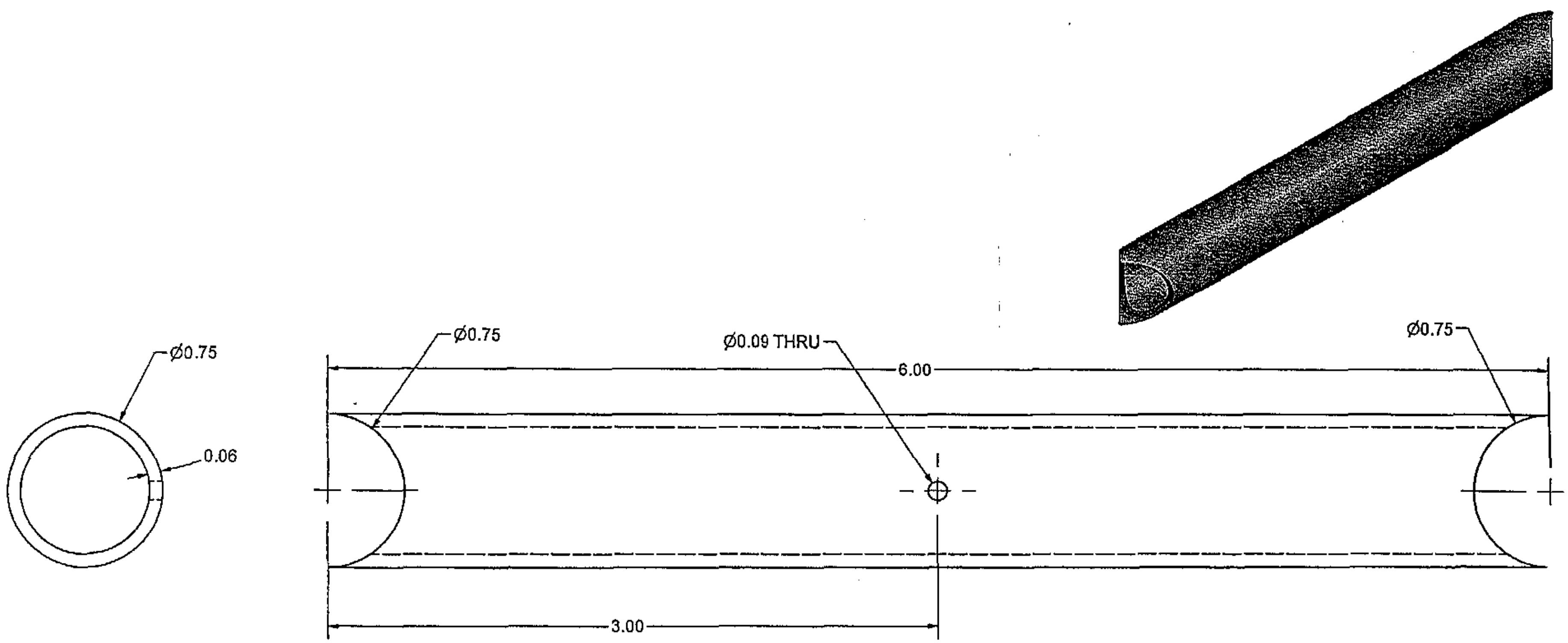


ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: AMY HINTZE			
MATERIAL: 4130 STEEL	*PART DESCRIPTION:* PEDAL - FOOT INTERFACE	*PART NUMBER:* WF-30-203	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1

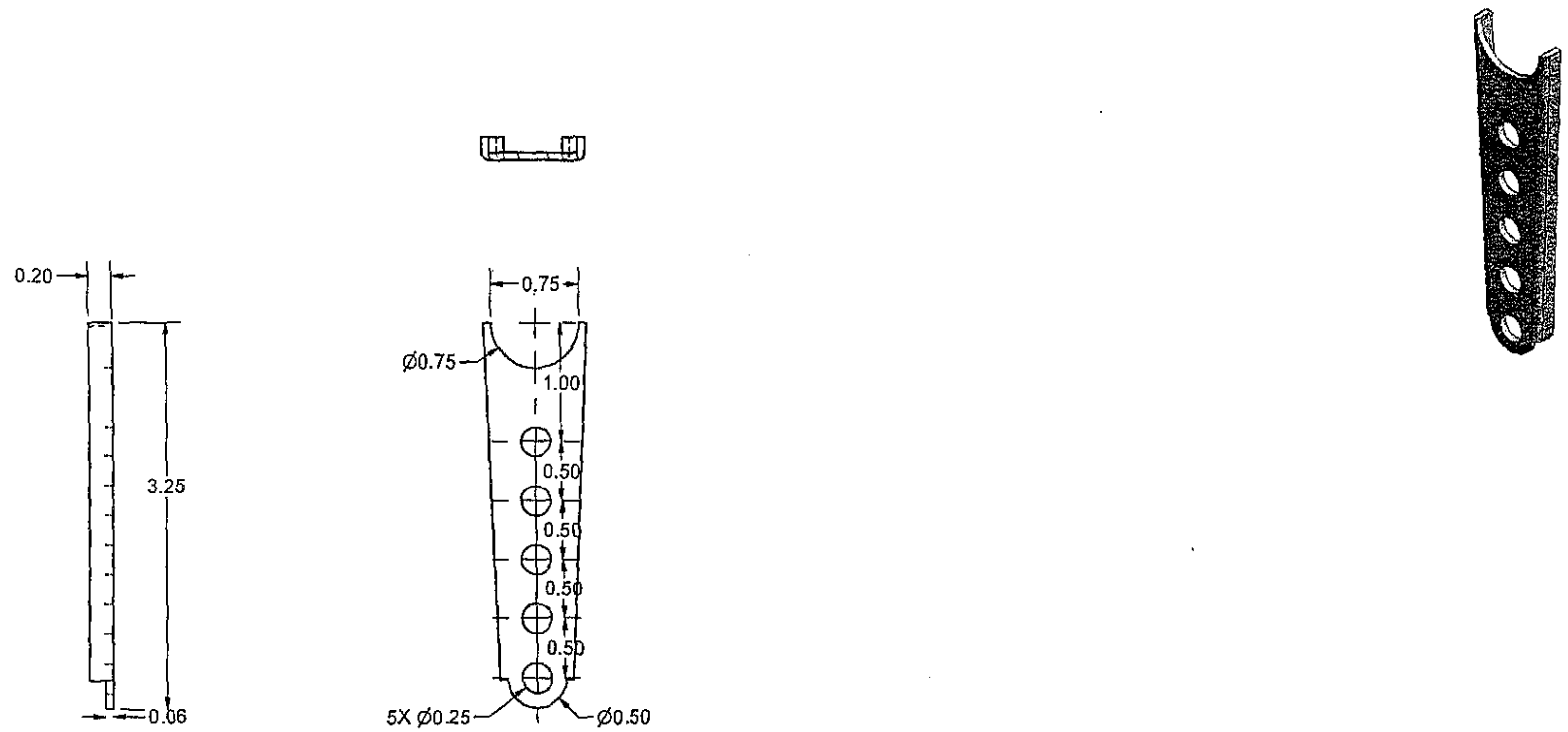


ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

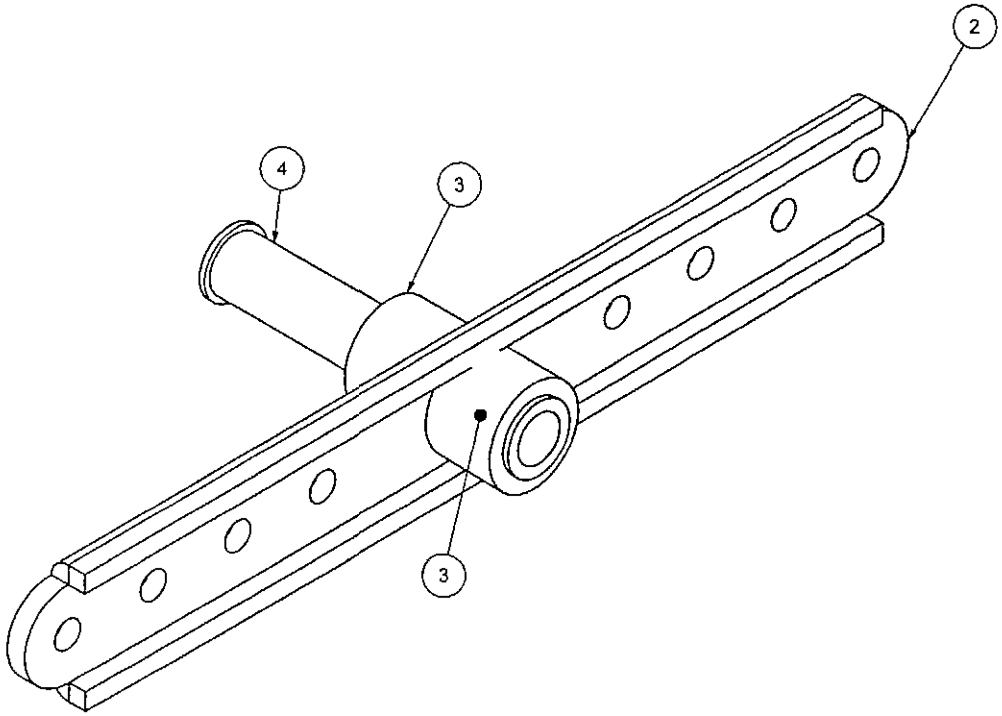
UtahState University — Mechanical & Aerospace Engineering

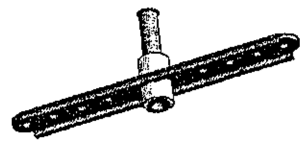
USU
WRIGHT FLYER
1903-2003

DRAWN BY: AMY HINTZE		
MATERIAL: 4130 STEEL	*PART DESCRIPTION:* PEDAL - ARM	*PART NUMBER:* WF-30-204 · *REV*
DATE: 2/17/2002	*SCALE:* · *SIZE:* B	*SHEET* 1 *of* 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*	
DRAWN BY: AMY HINTZE		
MATERIAL: 4130 STEEL	*PART DESCRIPTION:* RUDDER TAB	*PART NUMBER:* WF-30-205 · *REV*
DATE: 2/17/2002	*SCALE:* · *SIZE:* B	*SHEET* 1 *of* 1





Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
2	1	WF-30-208	RUDDER BELL CRANK
3	2	WF-30-209 CATALOG	NYLON SPACER
4	1	WF-30-211 (CATALOG)	BUSHING

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState University — Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: AMY HINTZE

MATERIAL:

PART DESCRIPTION: RUDDER BELL ASSM

PART NUMBER: WF-30-208

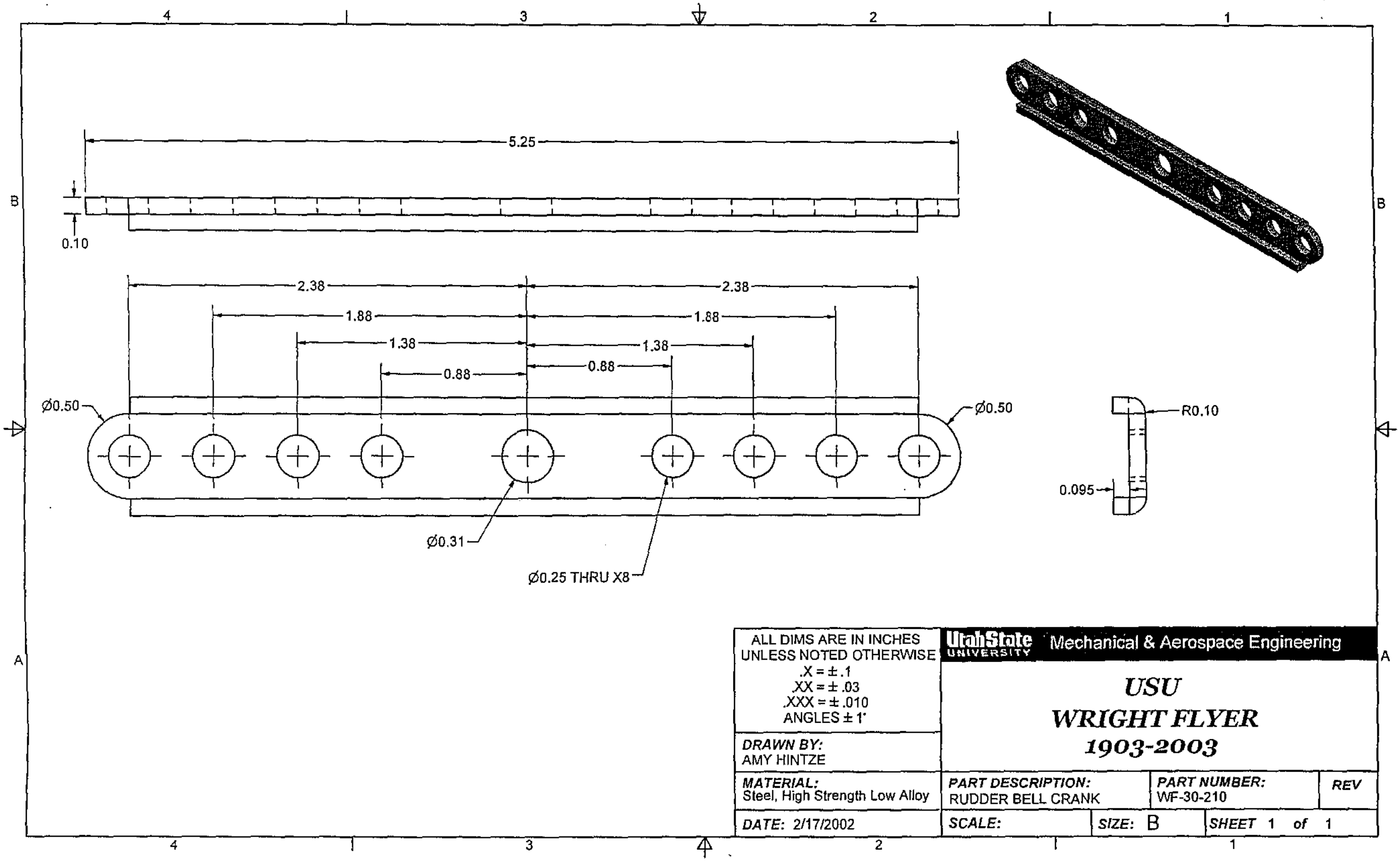
REV

DATE: 2/17/2002

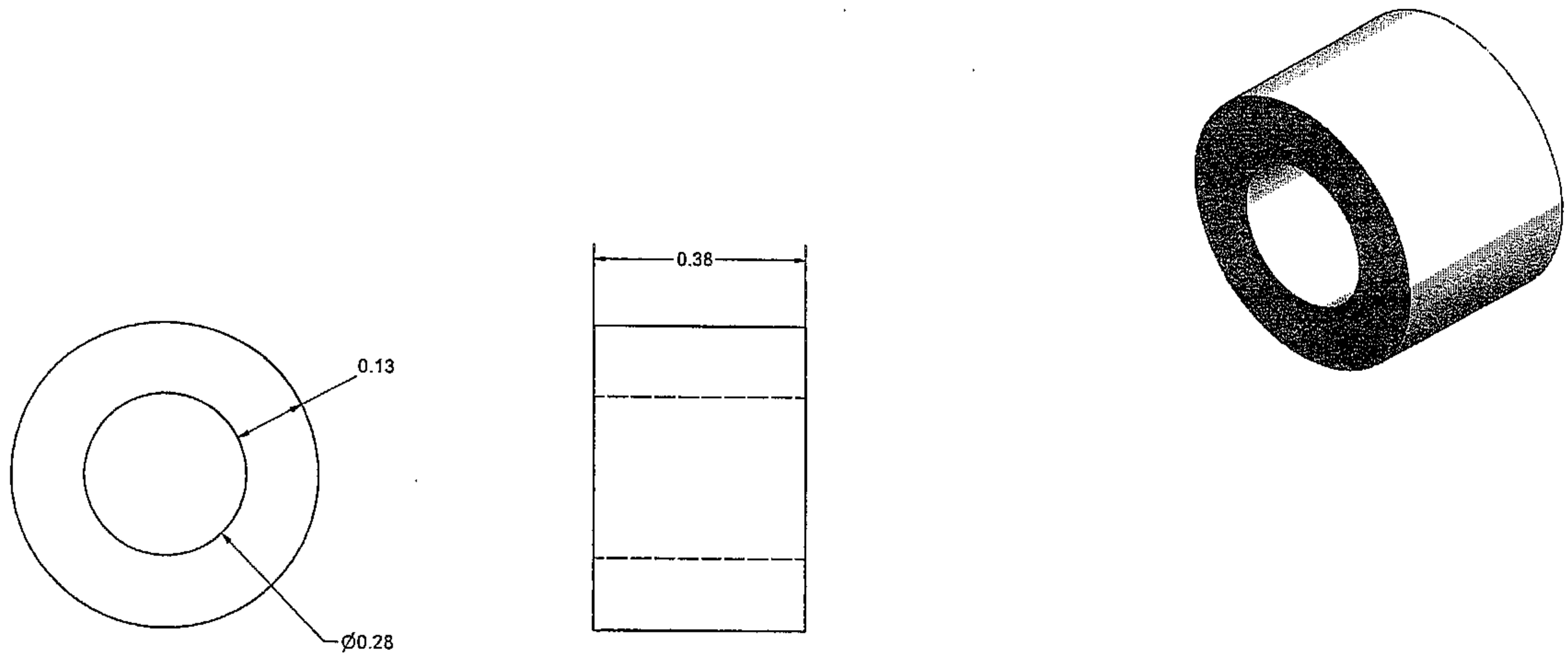
SCALE:

SIZE: B

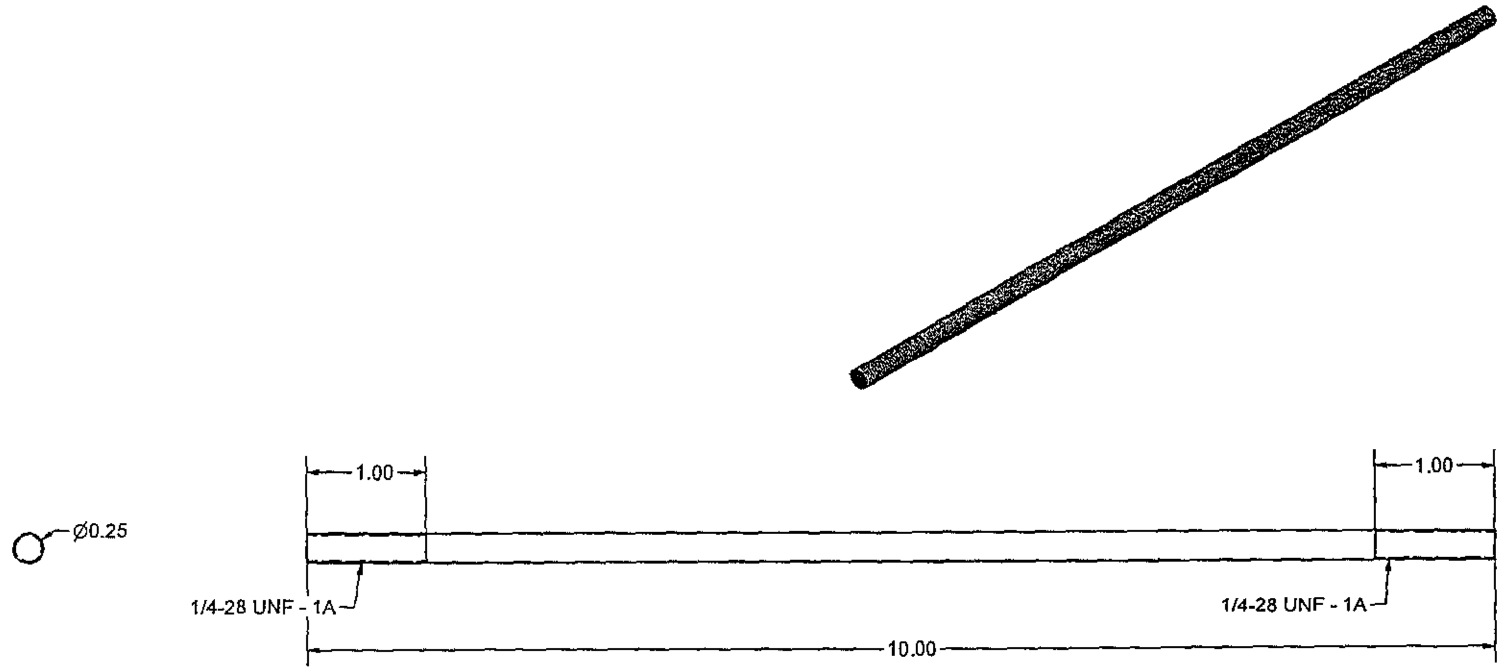
SHEET 1 *of* 1



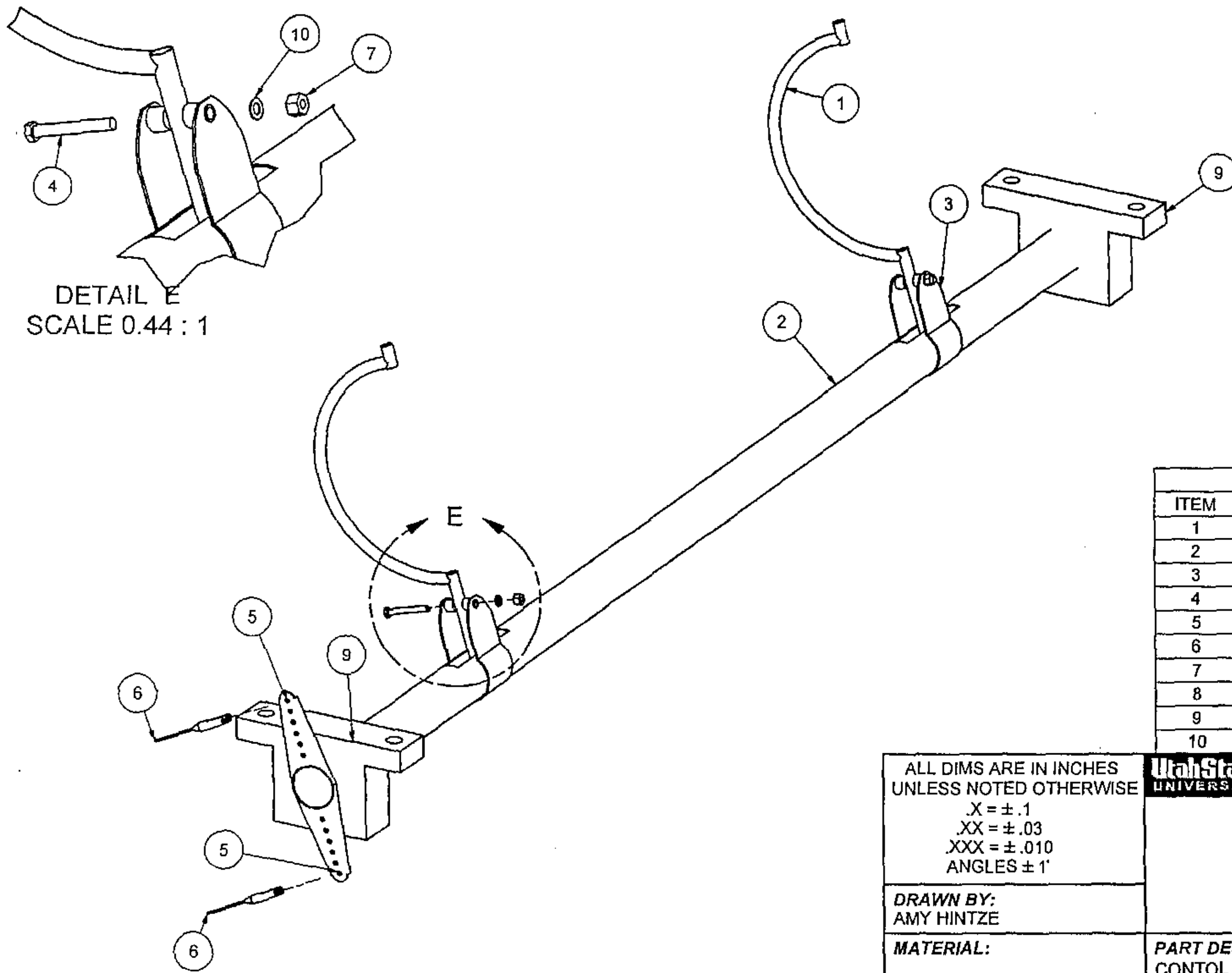
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState University Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003		
DRAWN BY: AMY HINTZE			
MATERIAL: Steel, High Strength Low Alloy	PART DESCRIPTION: RUDDER BELL CRANK	PART NUMBER: WF-30-210	REV
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*			
DRAWN BY: AMY HINTZE				
MATERIAL: Nylon-6/6	*PART DESCRIPTION:* NYLON SPACER		*PART NUMBER:* WF-30-209 CATALOG	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1˚	UtahState UNIVERSITY Mechanical & Aerospace Engineering			
DRAWN BY: AMY HINTZE	***USU WRIGHT FLYER 1903-2003***			
MATERIAL: Steel, High Strength Low Alloy	*PART DESCRIPTION:* PUSH PULL ROD		*PART NUMBER:* WF-30-212	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



Parts List

ITEM	QTY	PART NUMBE	DESCRIPTION
1	2	WF-30-107	CONTROL ASSM
2	1	WF-30-101	CASE
3	2	WF-30-102	CONTROL STICK MOUNT
4	2	4P258	2.0 1/4-20 HEX GRADE 8
5	2	WF-30-110	CANARD BELL CRANK
6	2	MS20667-4	FORK END
7	2	WF-30-093	1/4" LOCKNUT
8	1	WF-30-115	PUSH PULL ROD
9	2	6254K85	UHMW PILLOW BLOCK
10	2	WF-30-094	1/4" FLAT WASHER

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

Utah State University — Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: AMY HINTZE

MATERIAL:

PART DESCRIPTION: CONTOL ASSEMBLY

PART NUMBER: WF-30-100

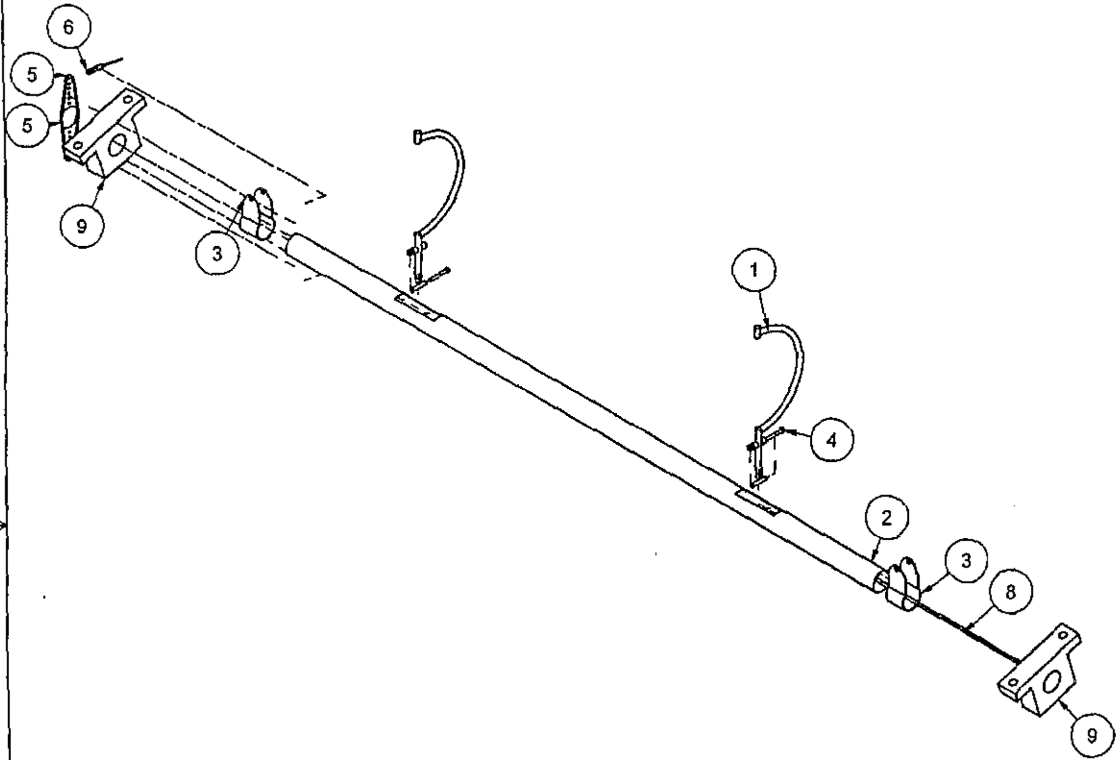
REV

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 ***of*** 1



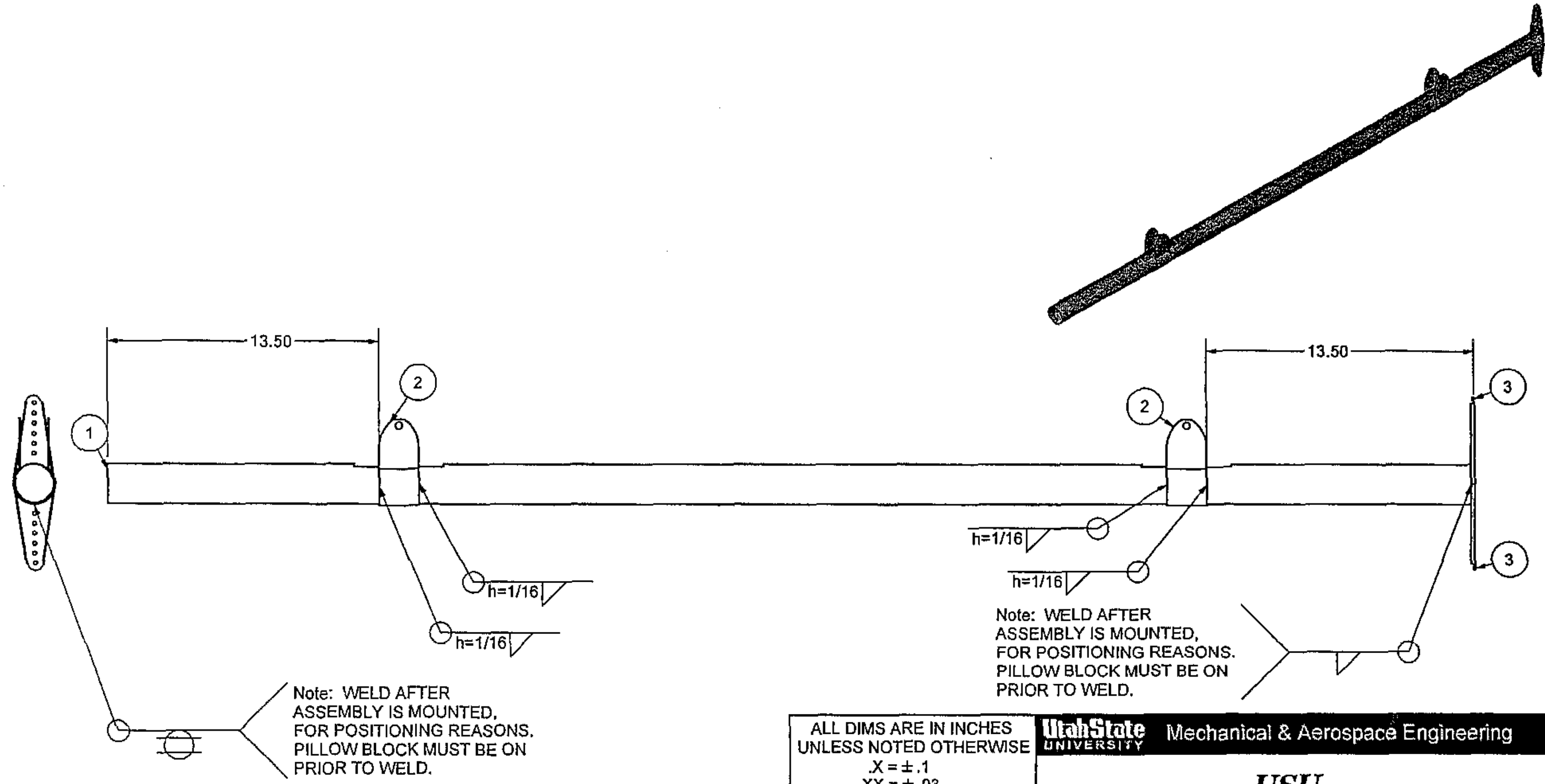
Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	WF-30-107	CONTROL ASSM
2	1	WF-30-101	CASE
3	2	WF-30-102	CONTROL STICK MOUNT
4	2	4P258	2.0 1/4-20 HEX GRADE 8
5	2	WF-30-110	CANARD BELL CRANK
6	2	MS20667-4	FORK END
7	2	WF-30-093	1/4" LOCKNUT
8	1	WF-30-115	PUSH PULL ROD
9	2	6254K85	UHMW PILLOW BLOCK
10	2	WF-30-094	1/4" FLAT WASHER

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

Utah State University — Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: AMY HINTZE			
MATERIAL:	*PART DESCRIPTION:* CONTOL ASSEMBLY	*PART NUMBER:* WF-30-100	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-30-101	CASE
2	2	WF-30-102	CONTROL STICK MOUNT
3	2	WF-30-110	CANARD BELL CRANK

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState University — Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: AMY HINTZE

MATERIAL:

DATE: 2/17/2002

PART DESCRIPTION: REF. FOR WELDING

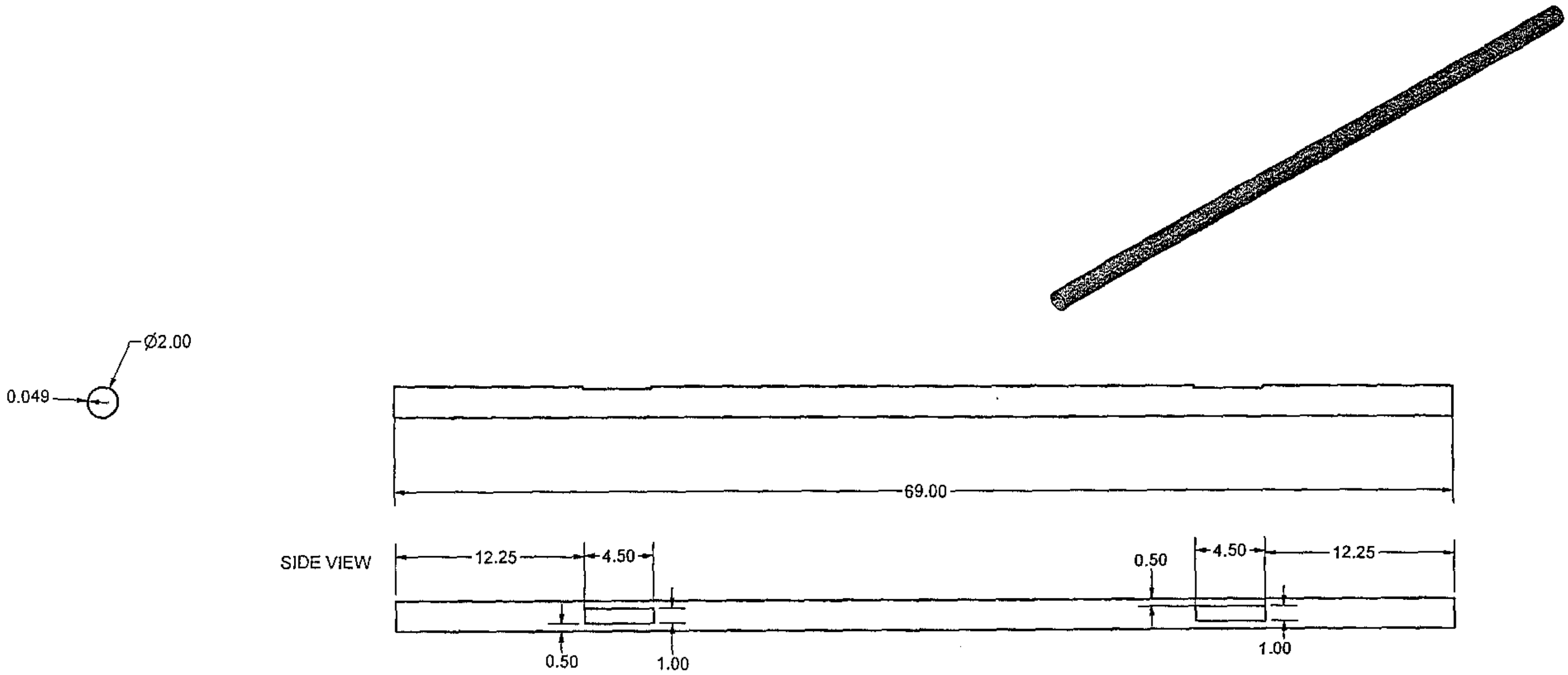
PART NUMBER: WF-30-100WELD

REV

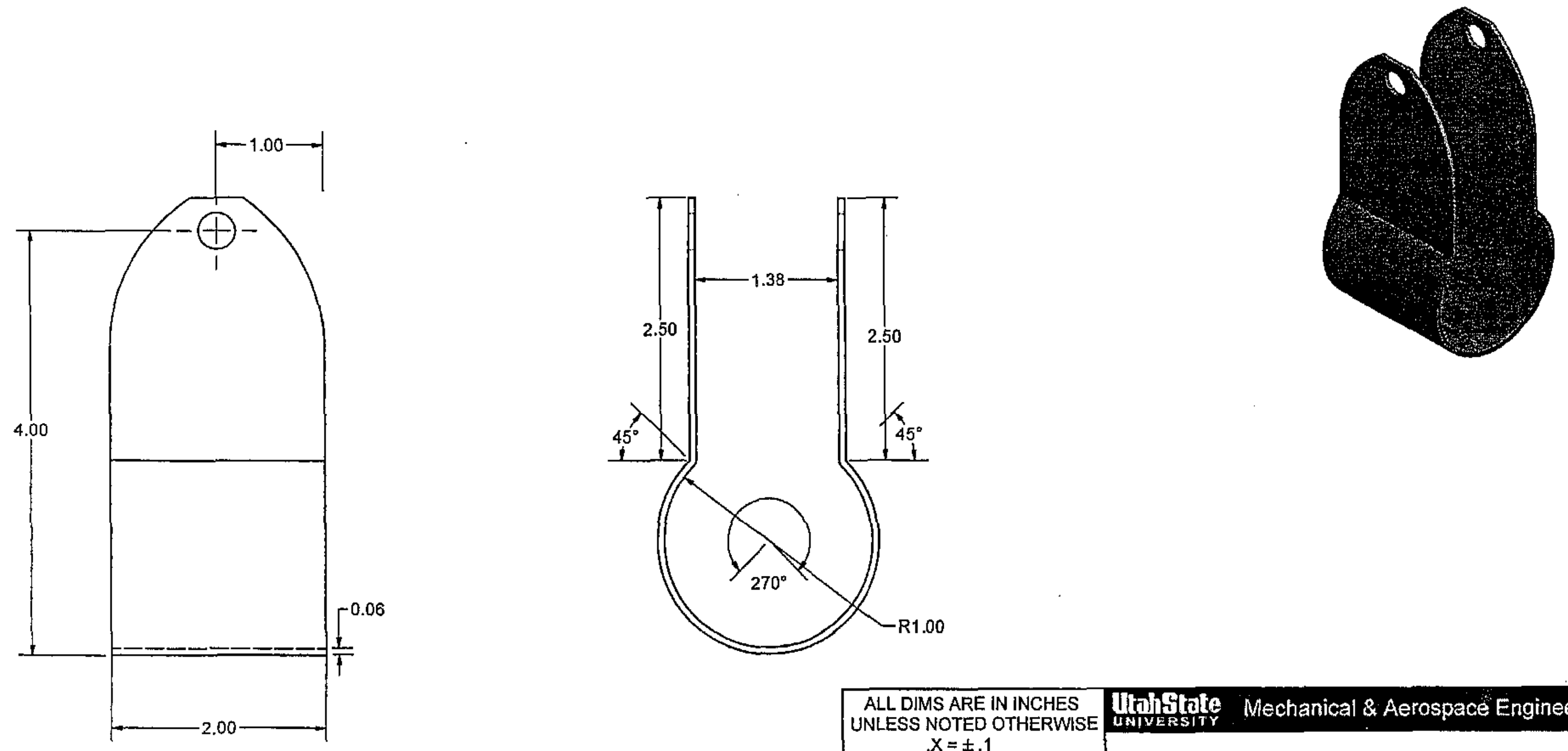
SCALE:

SIZE: B

SHEET 1 *of* 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*			
DRAWN BY: AMY HINTZE				
MATERIAL: Steel, High Strength Low Alloy	*PART DESCRIPTION:* CASE		*PART NUMBER:* WF-30-101	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

Utah State University Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: AMY HINTZE

MATERIAL: Steel, High Strength Low Alloy

PART DESCRIPTION: CONTROL STICK MOUNT

PART NUMBER: WF-30-102

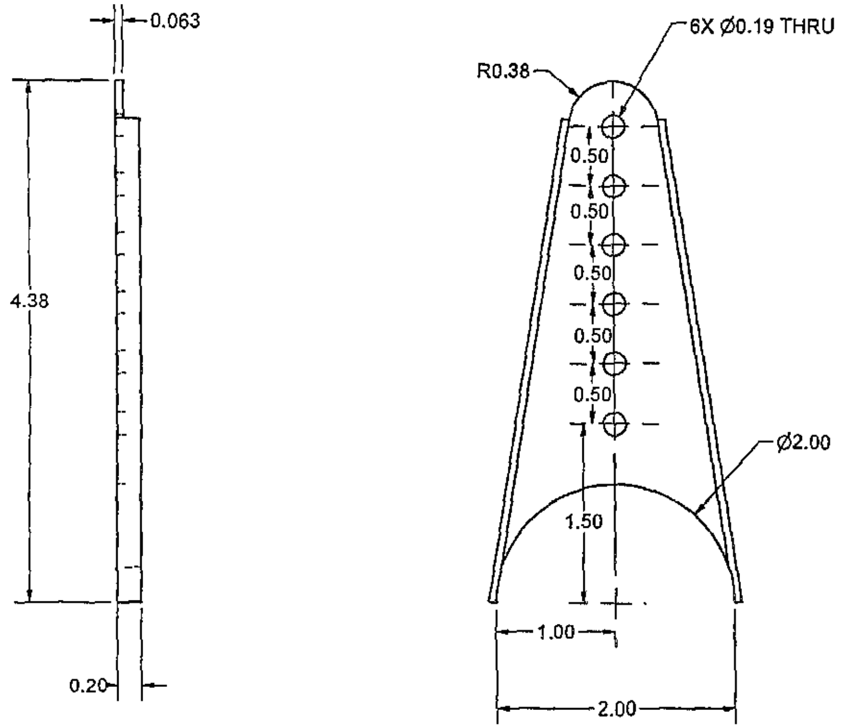
REV

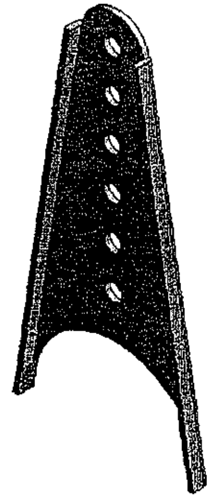
DATE: 2/17/2002

SCALE:

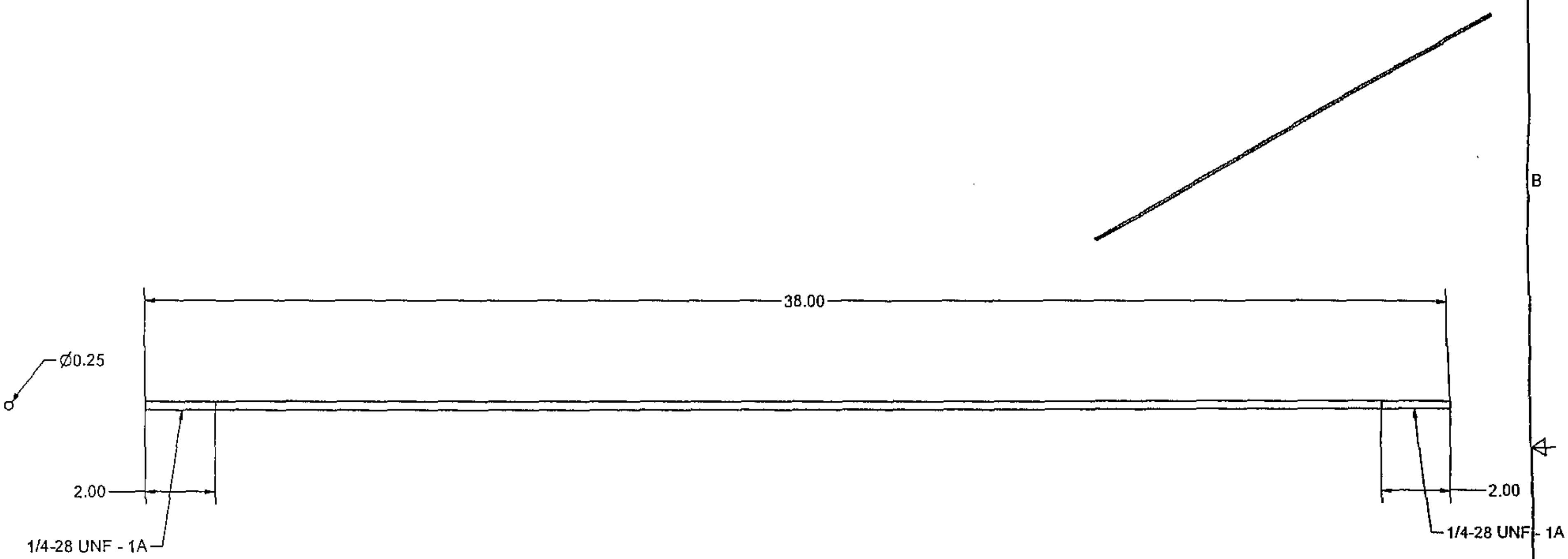
SIZE: B

SHEET 1 ***of*** 1





ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003			
DRAWN BY: AMY HINTZE				
MATERIAL: 4130 STEEL	*PART DESCRIPTION:* CANARD BELL CRANK		*PART NUMBER:* WF-30-110	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: AMY HINTZE

MATERIAL: Steel, High Strength Low Alloy

PART DESCRIPTION: PUSH PULL ROD

PART NUMBER: WF-30-115

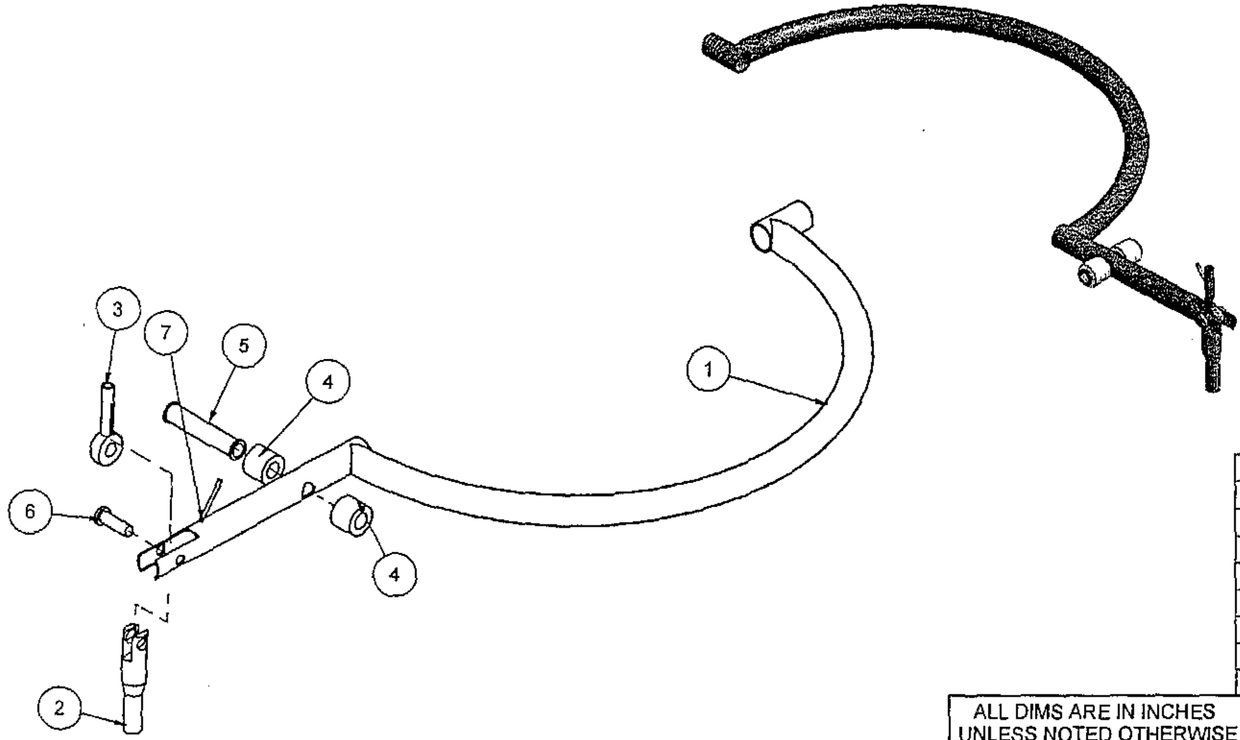
REV

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 ***of*** 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-30-103	CONTROL STICK ASSM
2	1	AN665-34R	FORK END 2
3	1	MS20668-5	EYE END
4	2	WF-30-112 CATALOG	NYLON SPACER
5	1	WF-30-111 (CATALOG)	BUSHING
6	1	AN-395-33	5/16" CLEVIS PIN
7	1	AN-380-2-3	3/4" COTTER PIN

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1˚

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: AMY HINTZE

MATERIAL:

PART DESCRIPTION: CONTROL ASSM

PART NUMBER: WF-30-107

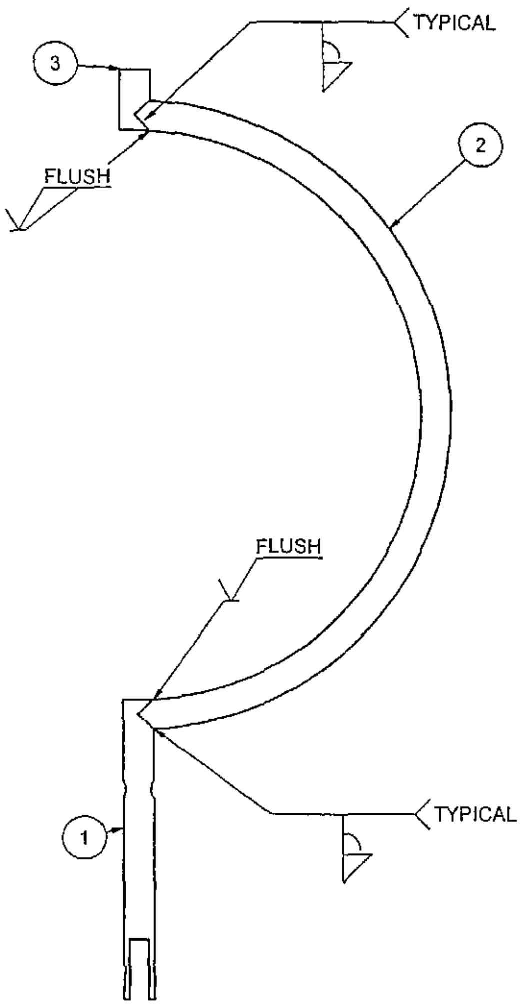
REV

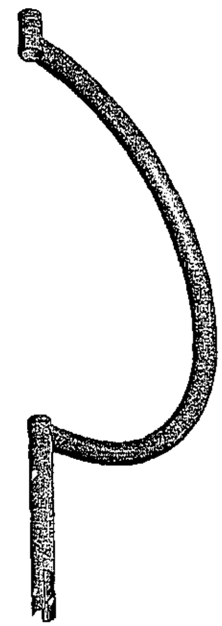
DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 *of* 1





Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-30-105	STRAIGHT SECT.
2	1	WF-30-104	RND SEC. OF STICK
3	1	WF-30-106	SHORT SECTION

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: AMY HINTZE

MATERIAL:

PART DESCRIPTION: CONTROL STICK ASSM

PART NUMBER: WF-30-103

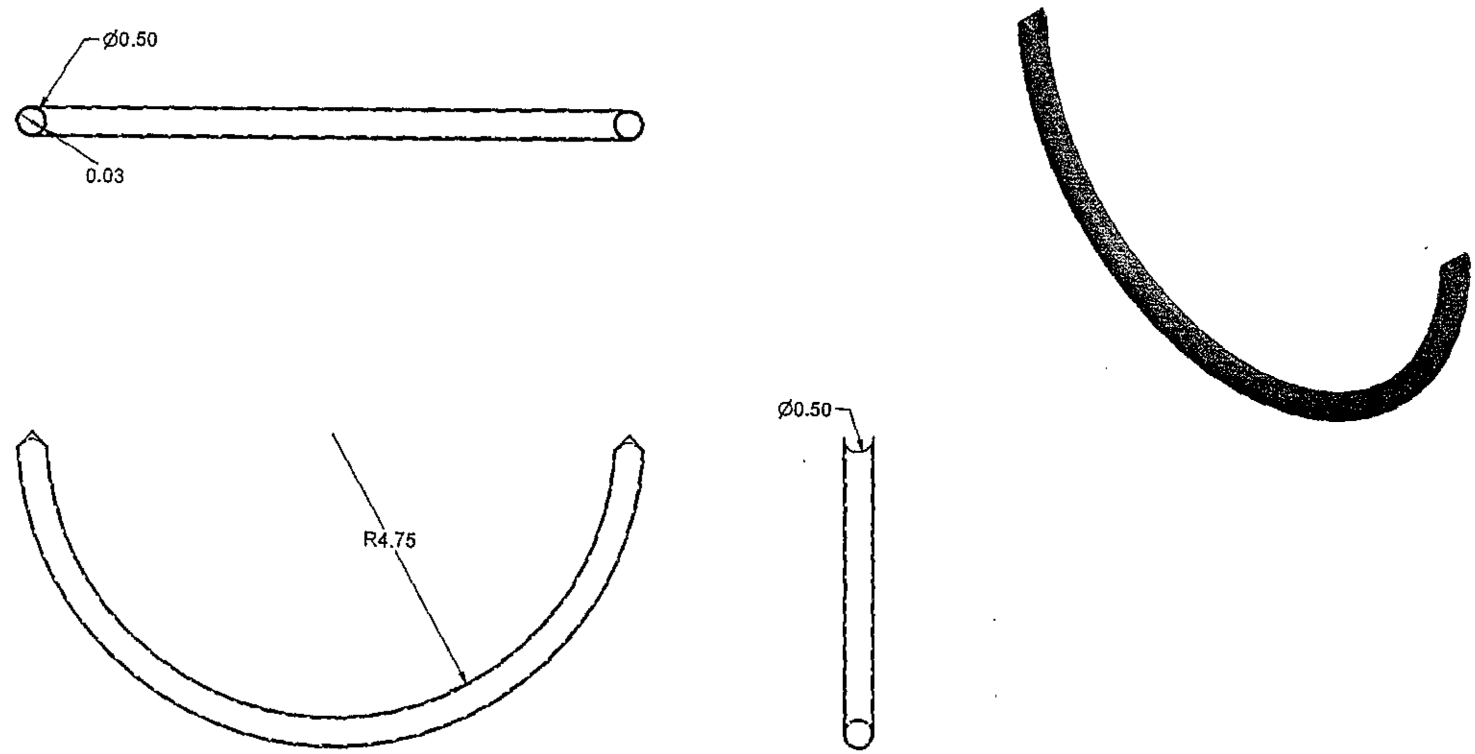
REV

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 ***of*** 1

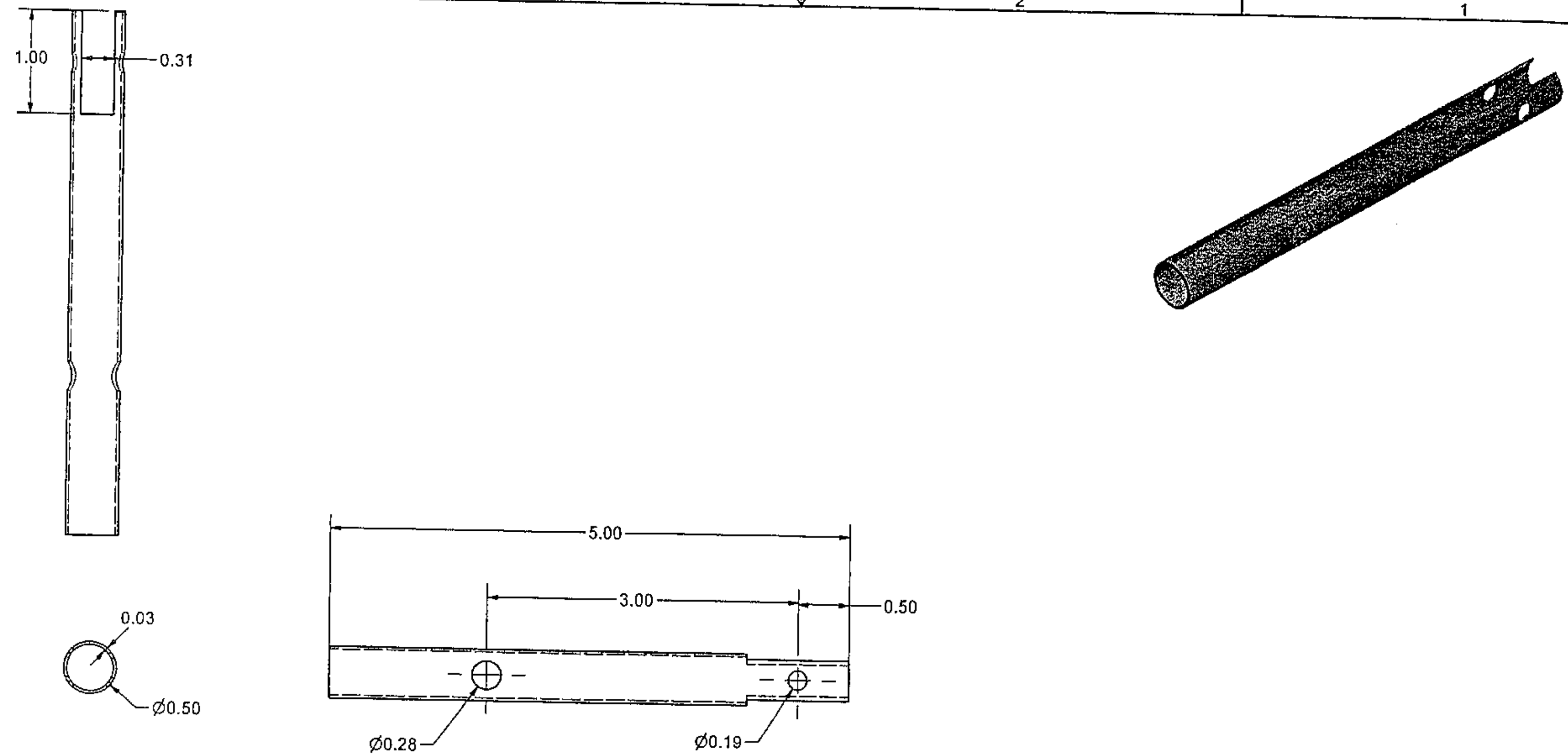


ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

Utah State UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: AMY HINTZE			
MATERIAL: Steel, High Strength Low Alloy	*PART DESCRIPTION:* RND SEC. OF STICK	*PART NUMBER:* WF-30-104	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1



ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: AMY HINTZE

MATERIAL: Steel, High Strength Low Alloy

PART DESCRIPTION: STRAIGHT SECT.

PART NUMBER: WF-30-105

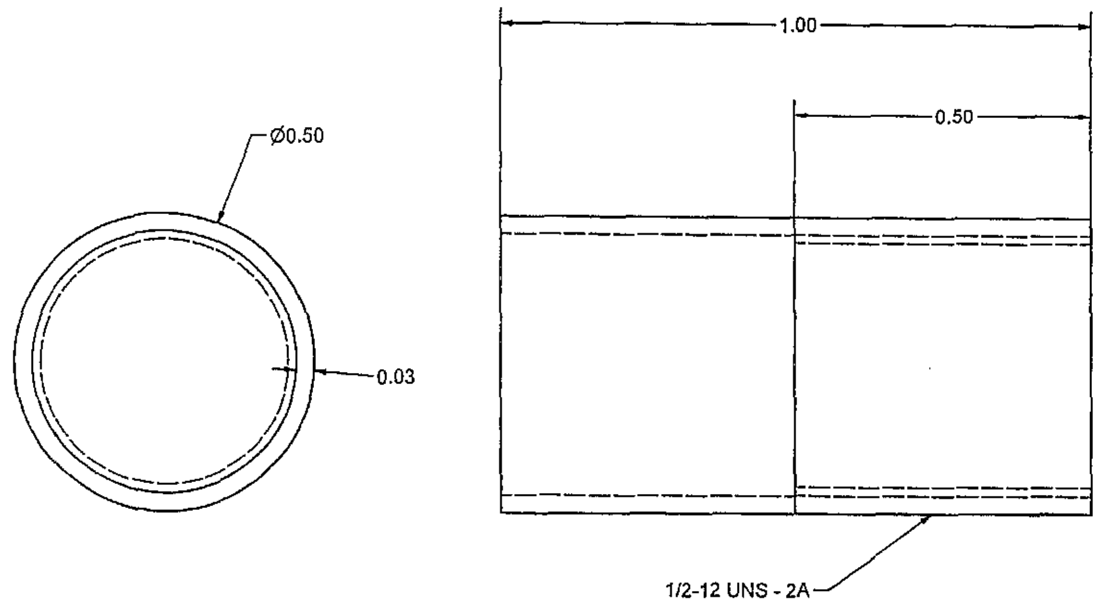
REV

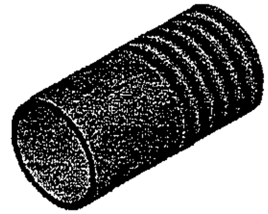
DATE: 2/17/2002

SCALE:

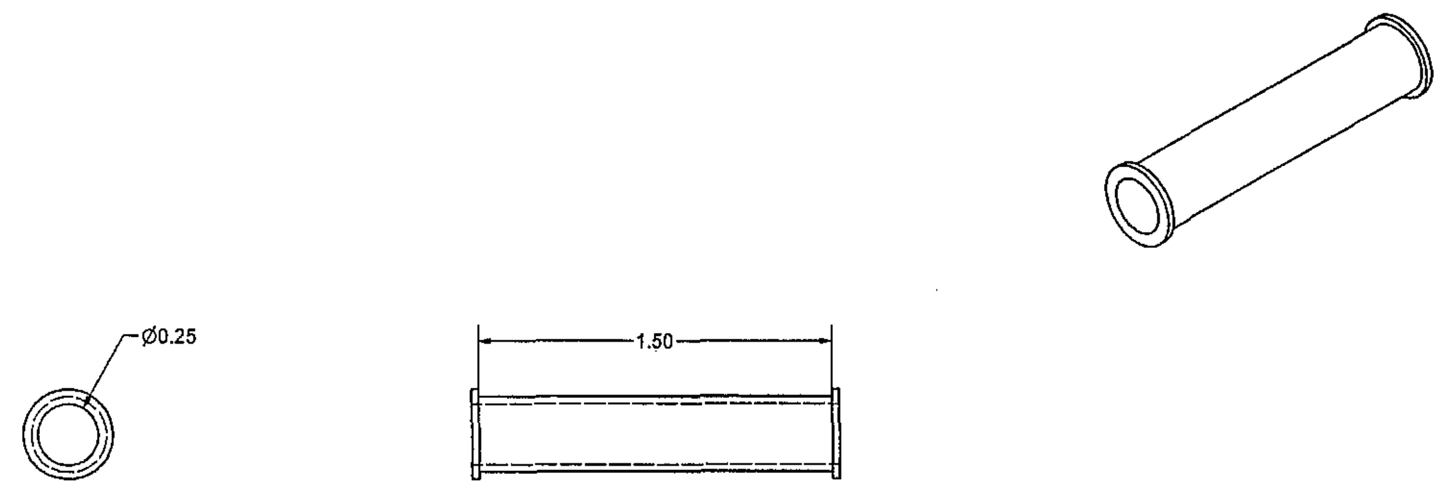
SIZE: B

SHEET 1 **of** 1

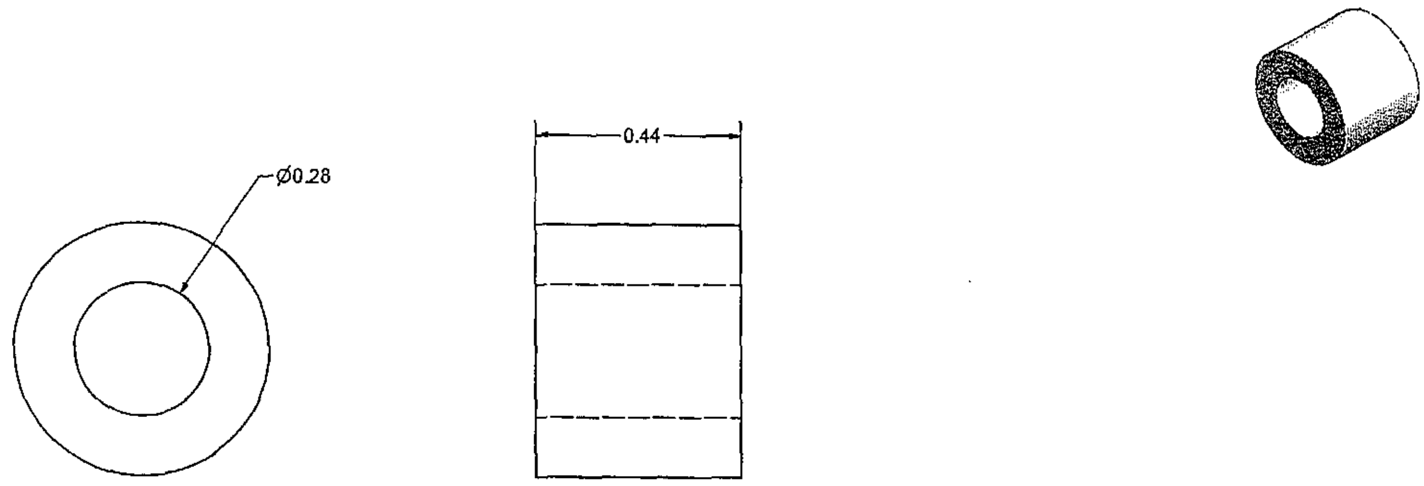




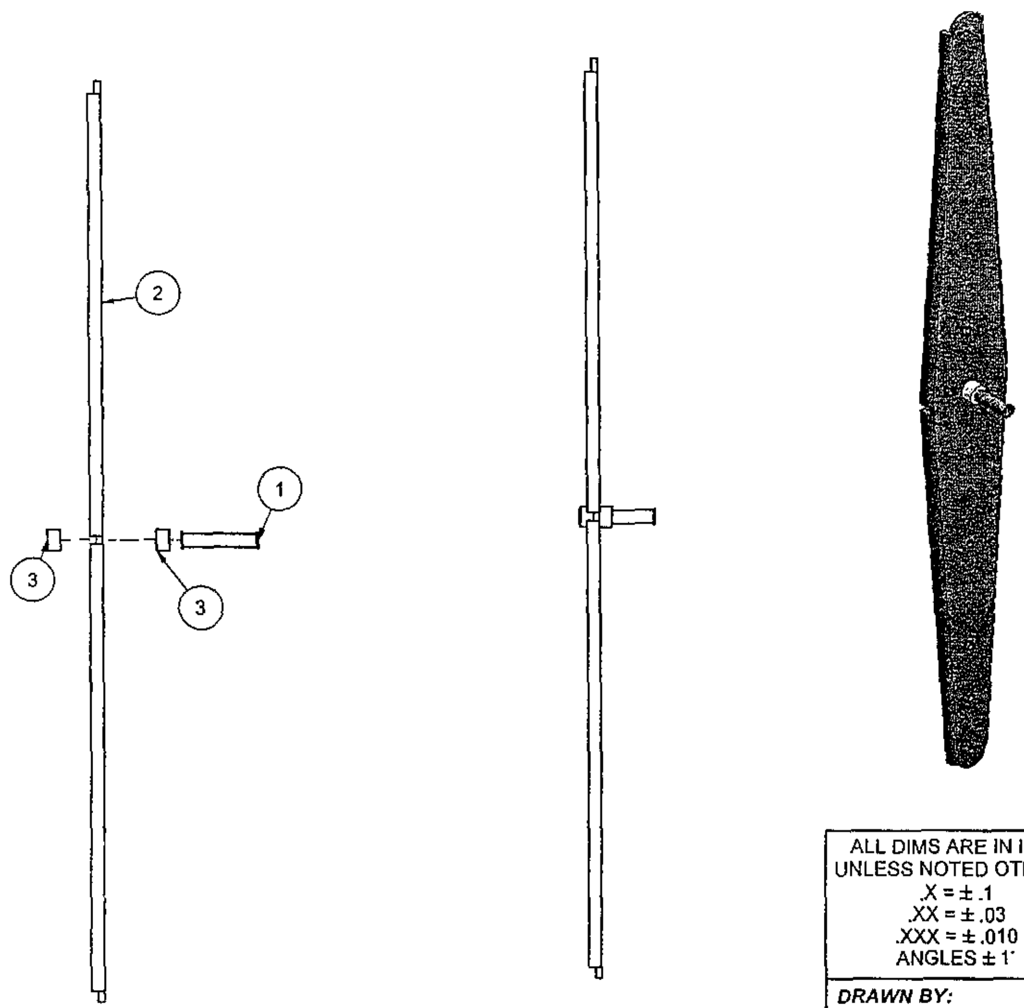
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	Utah State University Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003			
DRAWN BY: AMY HINTZE				
MATERIAL: Steel, High Strength Low Alloy	**PART DESCRIPTION:** SHORT SECTION		**PART NUMBER:** WF-30-106	**REV**
DATE: 2/17/2002	**SCALE:**	**SIZE:** B	**SHEET** 1 **of** 1	



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*			
DRAWN BY: AMY HINTZE				
MATERIAL: Stainless Steel, 440C	*PART DESCRIPTION:* BUSHING		*PART NUMBER:* WF-30-111 (CATALOG)	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering **USU WRIGHT FLYER 1903-2003**			
DRAWN BY: AMY HINTZE				
MATERIAL: Nylon-6/6	*PART DESCRIPTION:* NYLON SPACER		*PART NUMBER:* WF-30-112 CATALOG	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-30-120	BUSHING .25 ID X 1.75 BARREL
2	1	WF-30-121	WING WARP BELL
3	2	WF-30-119	SPACER .25 ID X 0.3 L

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: AMY HINTZE

MATERIAL:

PART DESCRIPTION: WING WARP BELL ASSM

PART NUMBER: WF-30-118

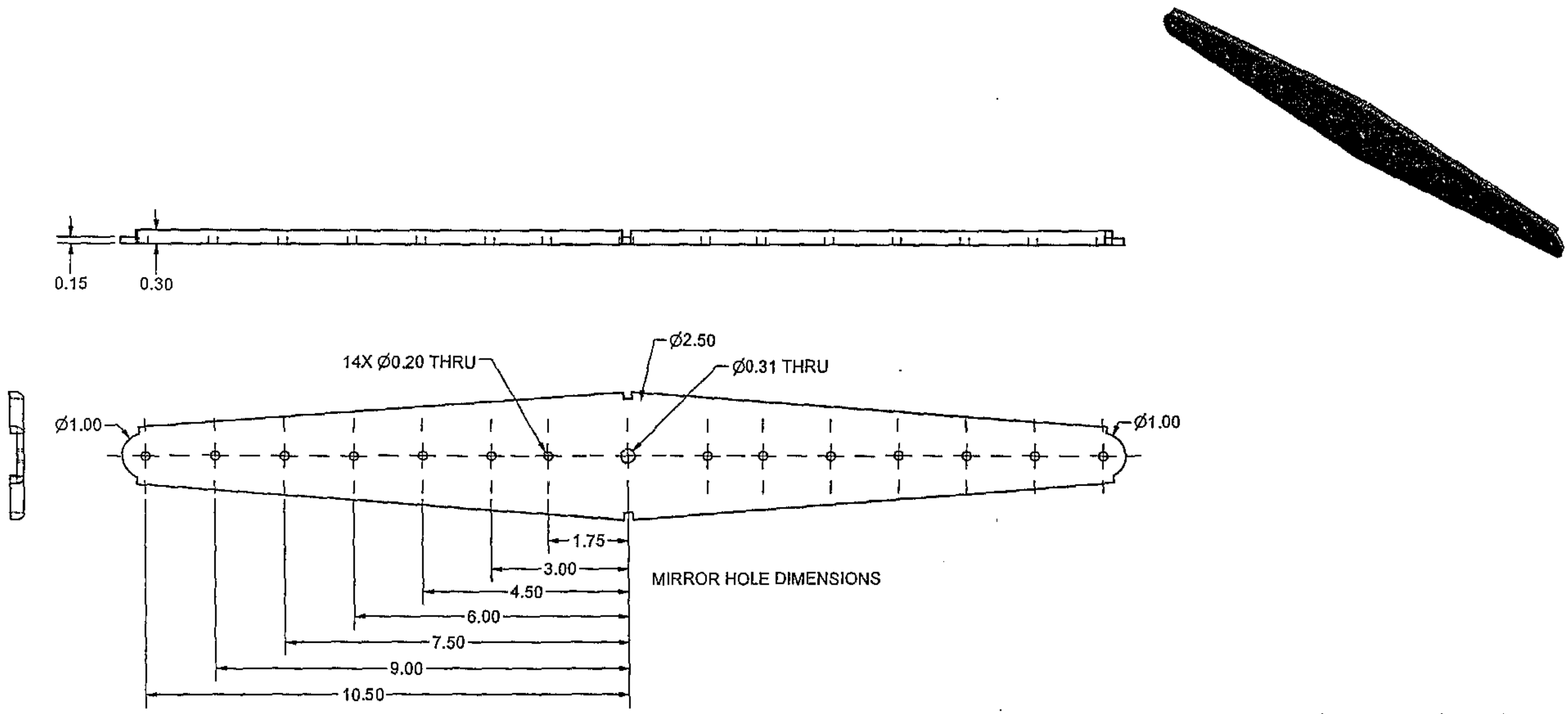
REV

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 *of* 1



ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

Utah State University — Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: AMY HINTZE

MATERIAL: Steel, High Strength Low Alloy

PART DESCRIPTION: WING WARP BELL

PART NUMBER: WF-30-121

REV

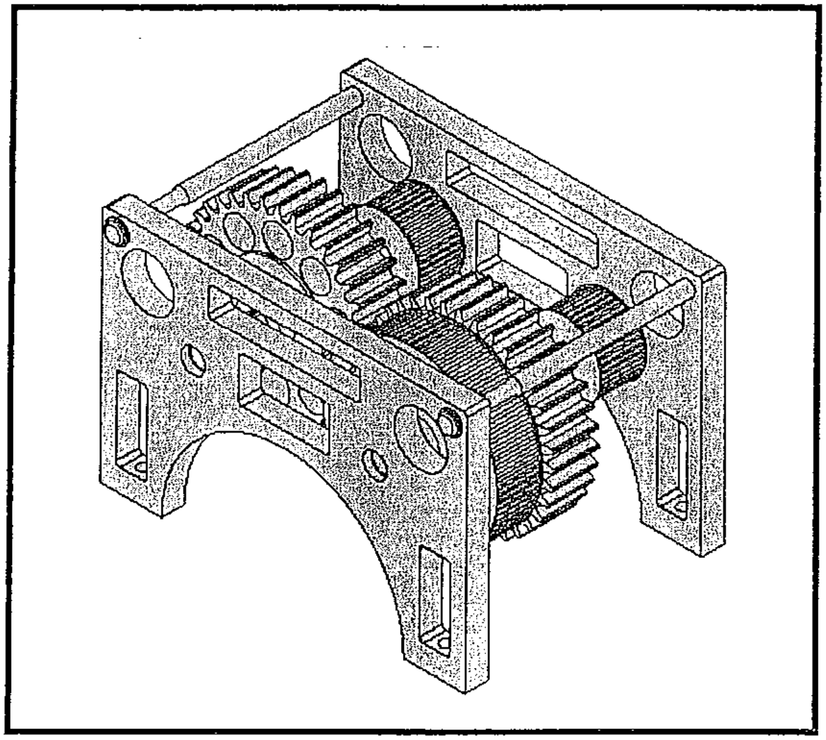
DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 *of* 1

Transmission Assembly



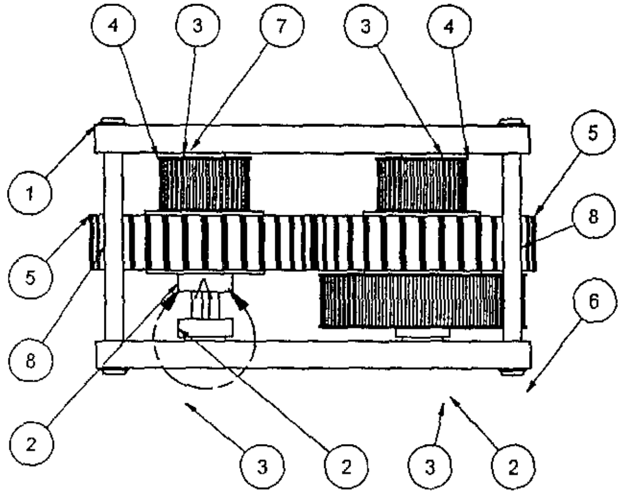
Materials List for Transmission

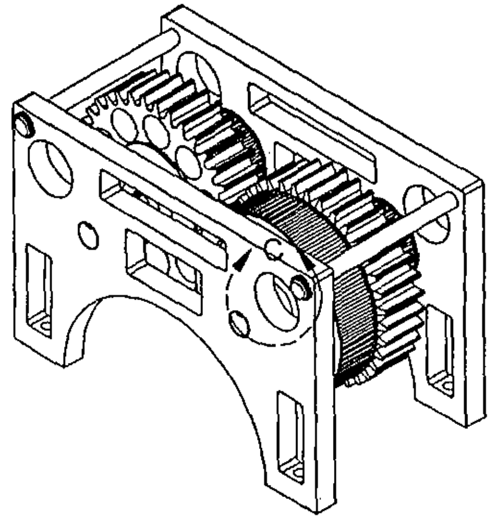
ck spc= check drawing specifications

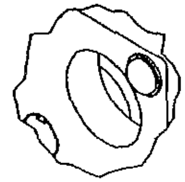
Item/Material	Description	Qty	Part #	Supplier
Square Tubing	4x4x72"	2	88875k44	McMaster
Keyed Shaft	0.5x12"	2	1497k61	McMaster
Hollow Rod	0.5x12", 1/8 wall	2	89965k65	McMaster
Ball Bearing	0.5x1.5x0.5"	4	2329k37	McMaster
Sheave	24 tooth	2	P24-8MGT-30	Gates
Sheave	56 tooth	2	P56-8MGT-30	Gates
Spacer	0.5x1.0x0.25"	6	3088A514	McMaster
Shaft Collar	0.5x2.0x1.0"	2	6157k16	McMaster
Gear	36 tooth, 1.5" face, steel	2	A636H	Rush Gears
Drive Belt	144 tooth, 30mm wide	2	B144-8MGT-30	Gates
Bolt	grade 8, 0.375 x 3.5	4		?
Nut	grade 8, 0.375	4		?
Washer	grade 8, 0.375	8		?
Bolt	grade 8. 0.375 x 2.5	4		?

Parts List for Transmission

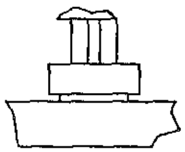
Part Number	Description	Qty	Type
WF-40-002-602	Mounting Bracket	2	cut & drilled
WF-40-002-603	Bearing Block	2	milled & drilled
WF-40-002-604	Keyed Shaft	2	cut
WF-40-002-605	Support Shaft	2	cut
WF-40-002-606	Ball Bearing	4	N/A
WF-40-002-607	24 Tooth Sheave	2	N/A
WF-40-002-608	56 Tooth Sheave	2	N/A
WF-40-002-609	Shaft Spacer	6	N/A
WF-40-002-610	Shaft Collar	5	N/A
WF-40-002-611	Gear	2	Bored
WF-40-002-612	Drive Belt	2	N/A



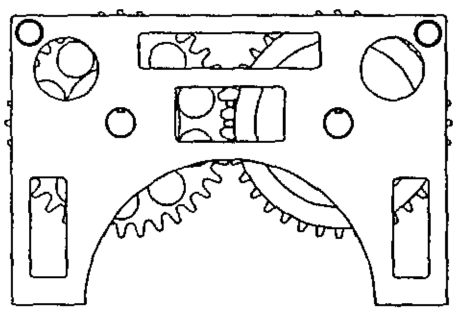




DETAIL C
SCALE 1 / 2



DETAIL A
SCALE 1 / 2



Parts List

ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	WF-40-002	Transmission Block and Bearings
2	5	WF-40-002-610 / McMaster# 6157K16	Transmission Shaft Collar
3	6	WF-40-002-609 / McMaster# 3088A514	Transmission Shaft Inner Race Spacer
4	2	WF-40-002-607 / Gates# P24-8MGT-30	Transmission Sheave 24 Tooth
5	2	WF-40-002-611 / Rush Gear# A636H	Transmission Gear
6	1	WF-40-002-608 / Gates# P56-8MGT-30	Transmission Sheave 56 Tooth
7	2	WF-40-002-604 / McMaster# 1497K61	Transmission Shaft Keyed
8	2	WF-40-002-605 / Mcmaster# 89965K54	Transmission Support Rods
11	4	Bolt - 0.375 - 2.25	AN HardWare
12	4	Washer 0.375 Reg	AN Hardware

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UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

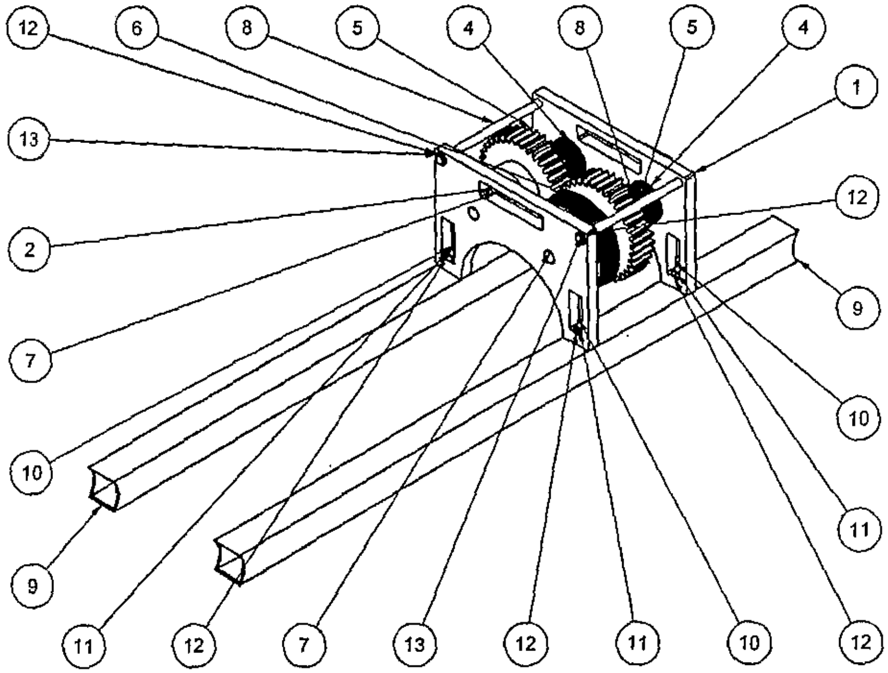
USU
WRIGHT FLYER
1903-2003

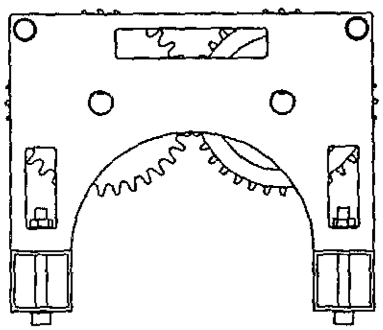
DRAWN BY:

MATERIAL: | *PART DESCRIPTION:* | *PART NUMBER:* | *REV*

DATE: 4/21/2002 | *SCALE:* | *SIZE:* B | *SHEET* 1 *of* 1

Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	WF-40-002-600	Block and Bearing
2	5	WF-40-002-610 / McMaster# 6157k16	Shaft Collar
3	6	WF-40-002-609 / Mcmaster# 3088a514	Inner Race Spacer
4	2	WF-40-002-607 / Gates# P24-8MGT-30	24 Tooth Sheave
5	2	WF-40-002-611 / Rush Gear# A636H	Gear
6	1	WF-40-002-608 / Gates# P56-8MGT-30	56 Tooth Sheave
7	2	WF-40-002-604 / Mcmaster# 1497K61	Keyed Shaft
8	2	WF-40-002-605 / McMaster# 89965k54	Support Rods
9	2	WF-40-002-601	Mounting Brackets
10	4		Bolt 0.375 - 3.5
11	4		Nut 0.375
12	12		Washer 0.375 Reg
13	4		Bolt - 0.375 - 2.25



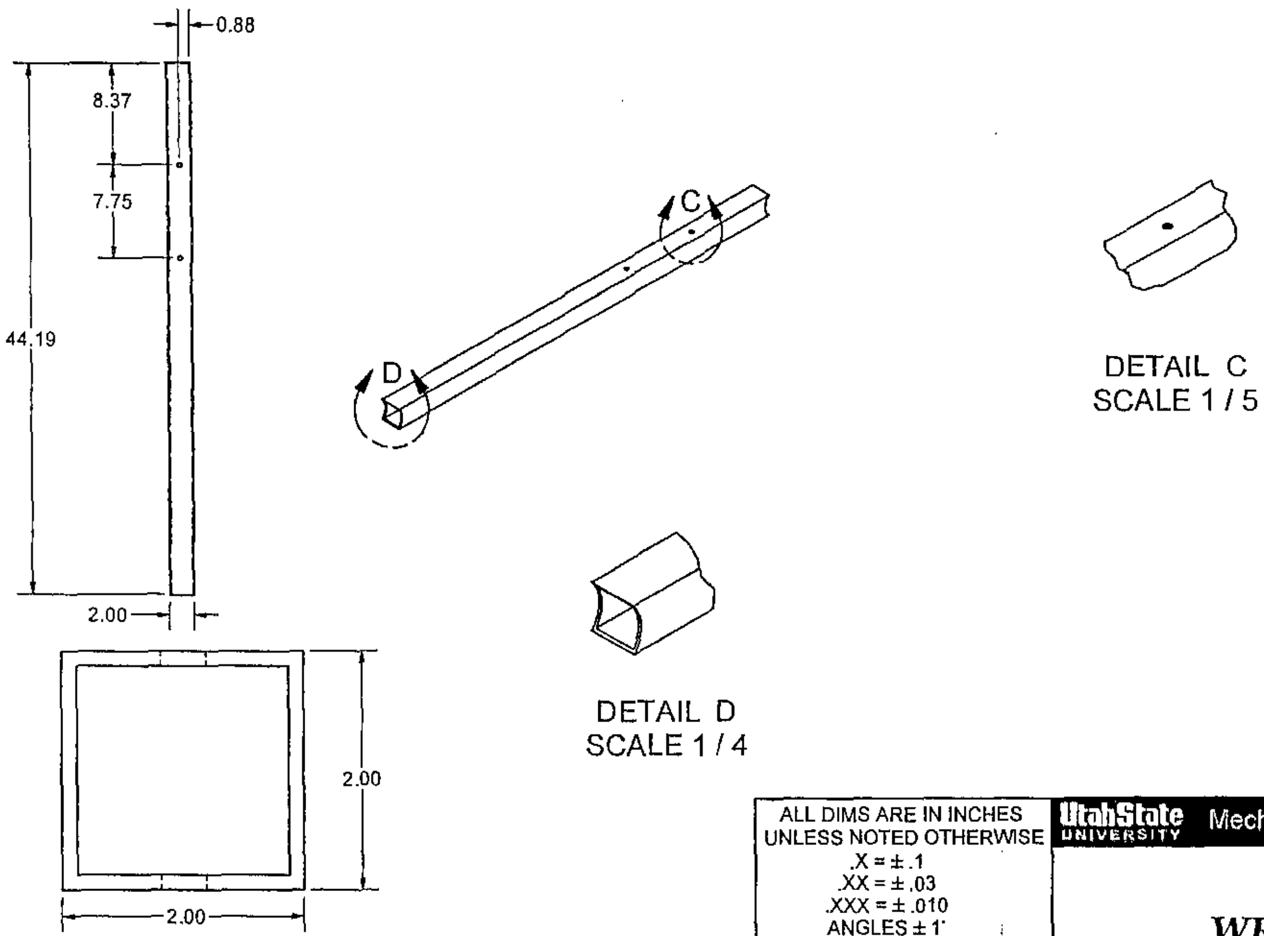


ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

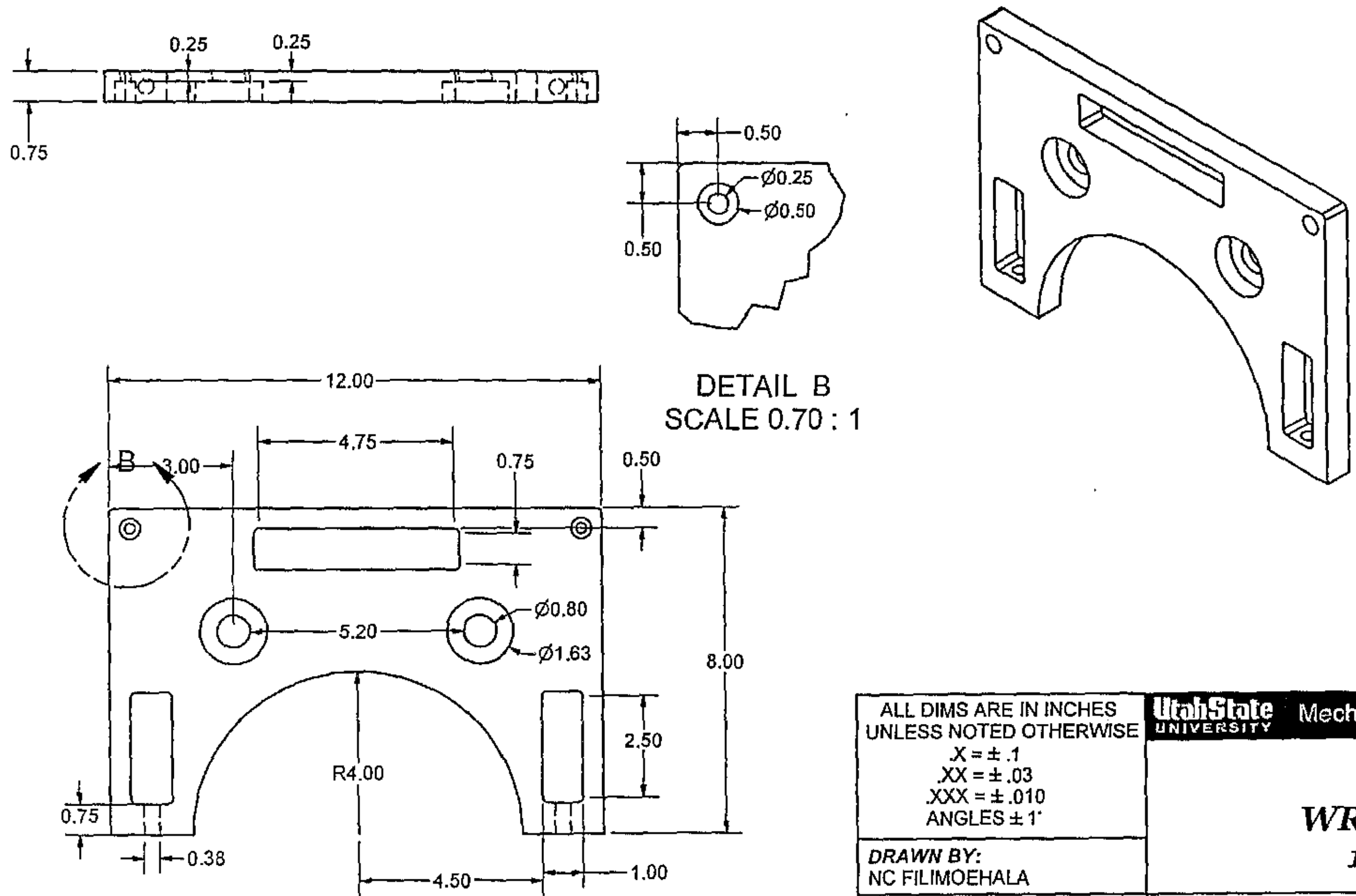
UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY:	PART DESCRIPTION:	PART NUMBER:	REV
MATERIAL:			
DATE: 4/21/2002	SCALE:	SIZE: B	SHEET 1 of 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* ***WRIGHT FLYER*** ***1903-2003***			
DRAWN BY: NC FILIMOEHALA				
MATERIAL:	***PART DESCRIPTION:*** SUPPORT TUBING		***PART NUMBER:*** WF-40-002-602	***REV***
DATE: 4/21/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 ***of*** 1	



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.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: NC FILIMOEHALA

MATERIAL:

PART DESCRIPTION: TRANS BEARING BLOCK

PART NUMBER: WF-40-002-603

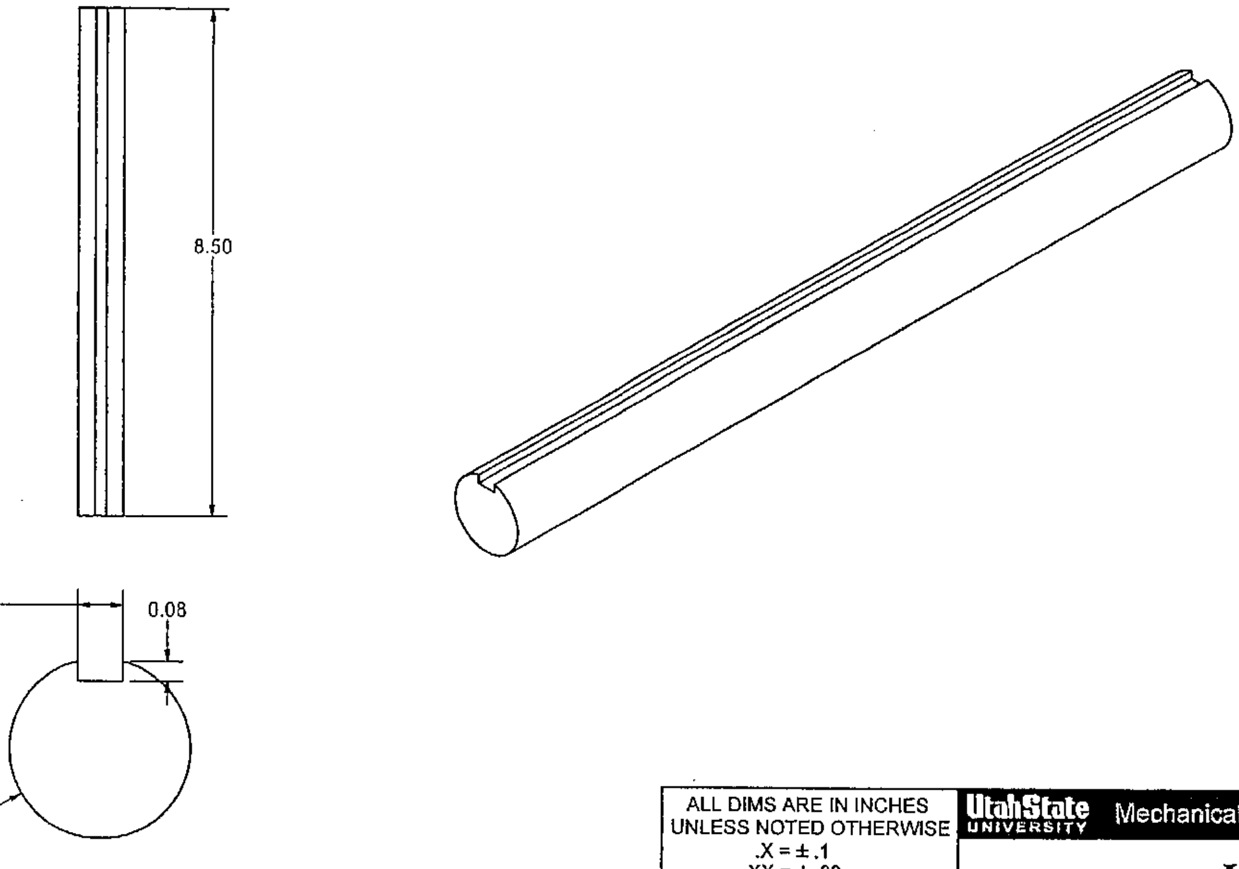
REV

DATE: 4/21/2002

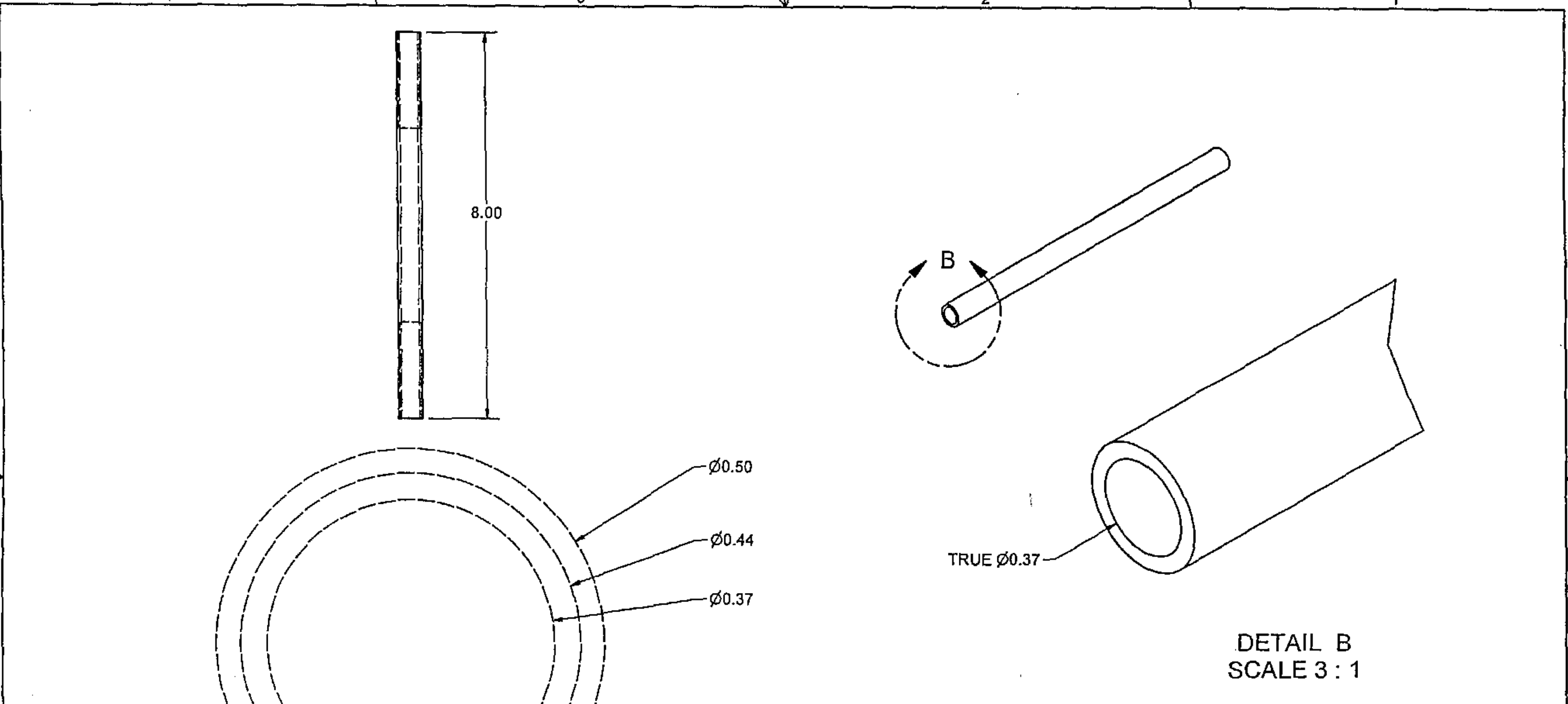
SCALE:

SIZE: B

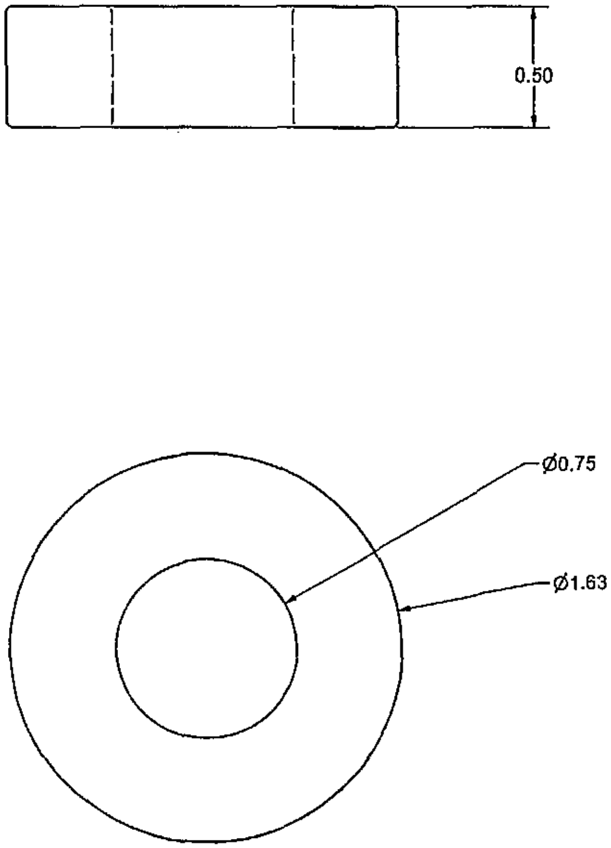
SHEET 1 *of* 1

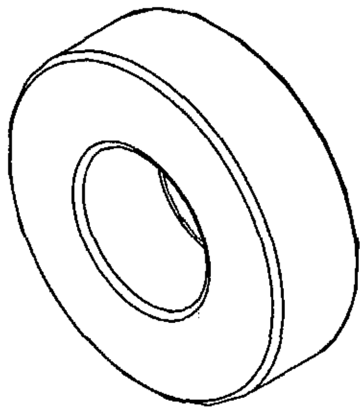


ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1˚	Utah State University Mechanical & Aerospace Engineering			
DRAWN BY: NC FILIMOEHALA	***USU WRIGHT FLYER 1903-2003***			
MATERIAL:	*PART DESCRIPTION:* KEYED SHAFT		*PART NUMBER:* WF-40-002-604	*REV*
DATE: 4/21/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1˚	UtahState UNIVERSITY Mechanical & Aerospace Engineering ***USU*** ***WRIGHT FLYER*** ***1903-2003***
DRAWN BY: NC FILIMOEHALA	
MATERIAL:	***PART DESCRIPTION:*** SUPPORT ROD — ***PART NUMBER:*** WF-40-002-605 — ***REV***
DATE: 4/21/2002	***SCALE:*** — ***SIZE:*** B — ***SHEET*** 1 ***of*** 1





ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

DRAWN BY:
NC FILIMOEHALA

MATERIAL:

DATE: 4/21/2002

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

PART DESCRIPTION:
SHAFT BEARING

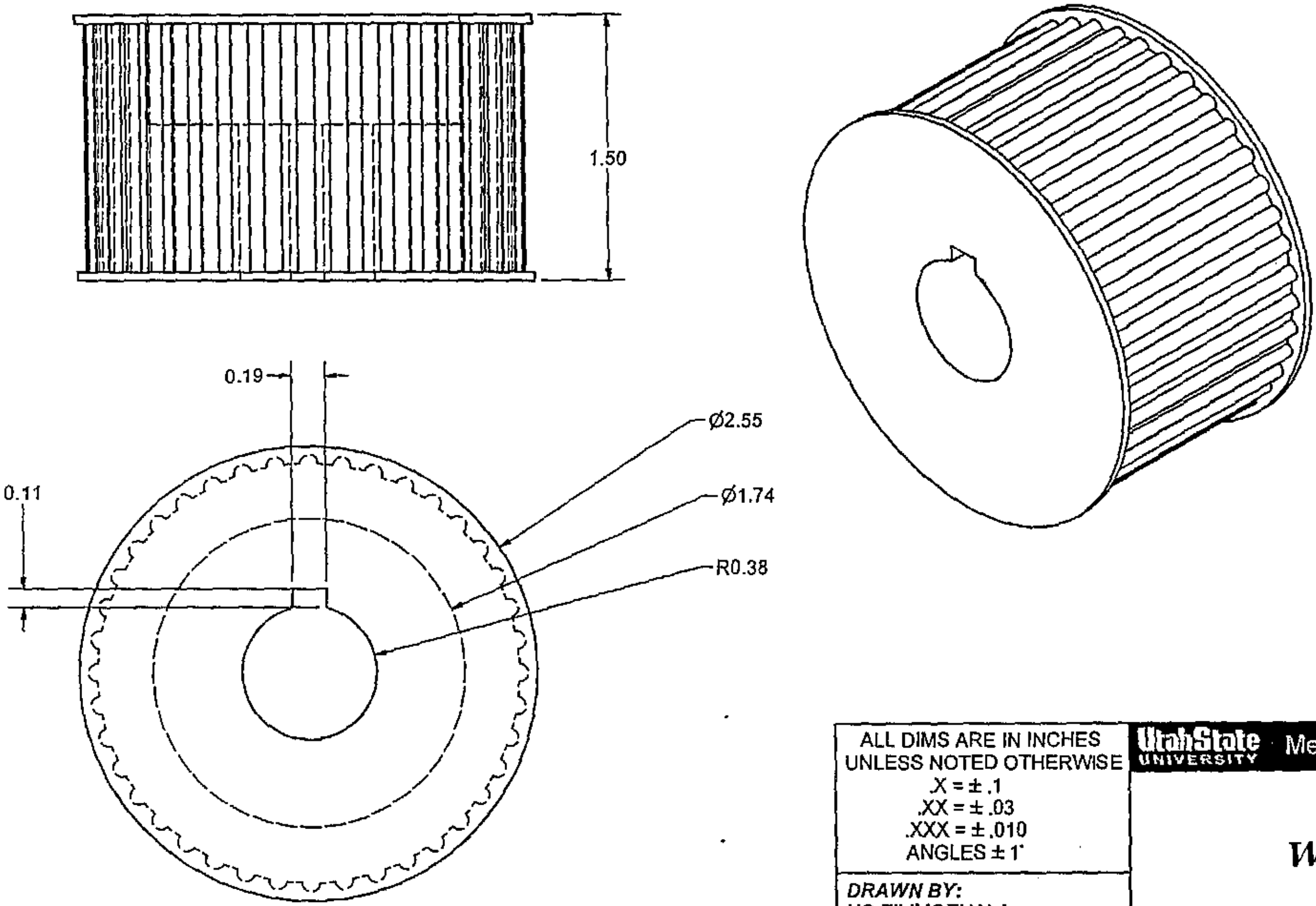
PART NUMBER:
WF-40-002-606

REV

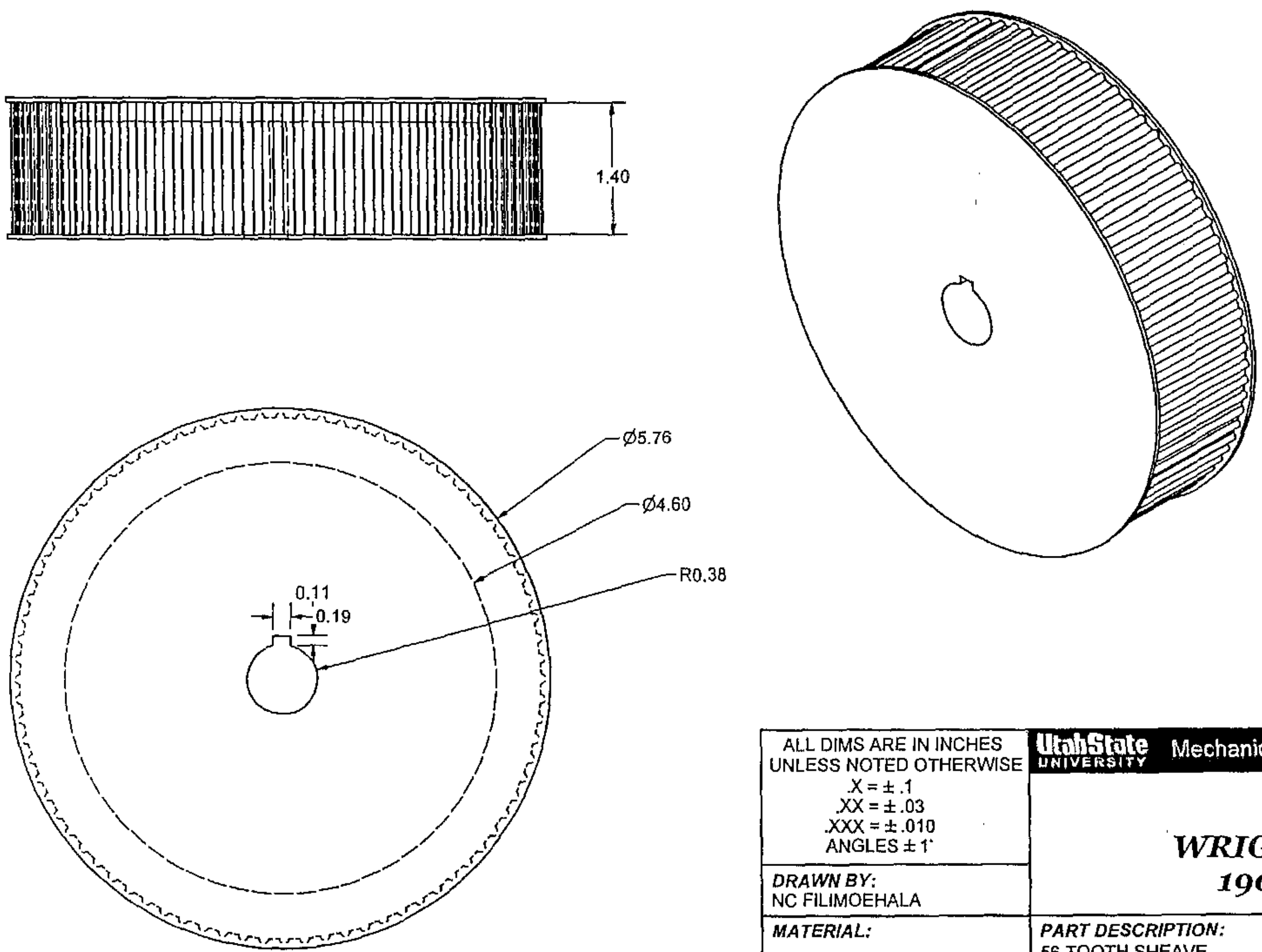
SCALE:

SIZE: B

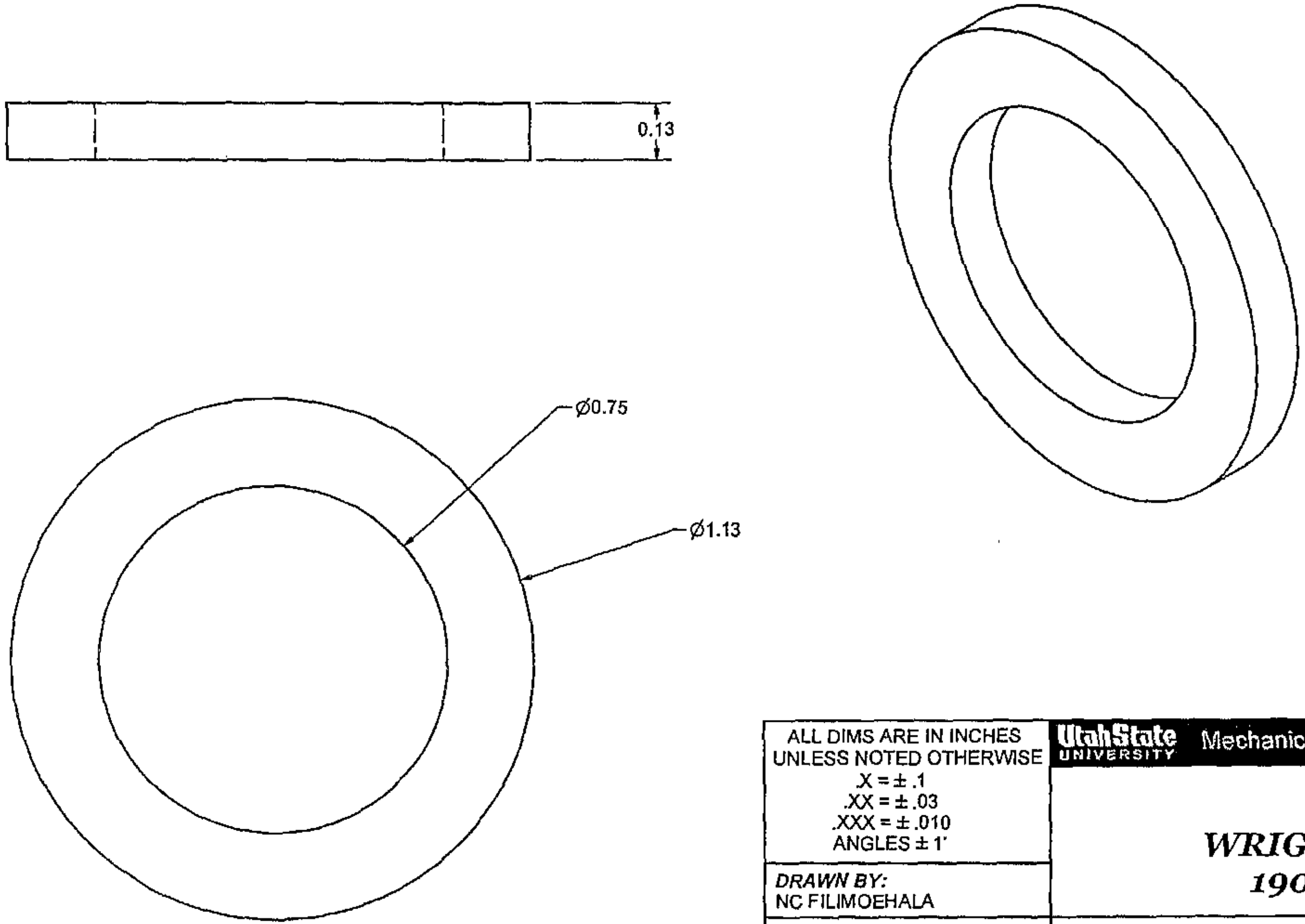
SHEET 1 **of** 1



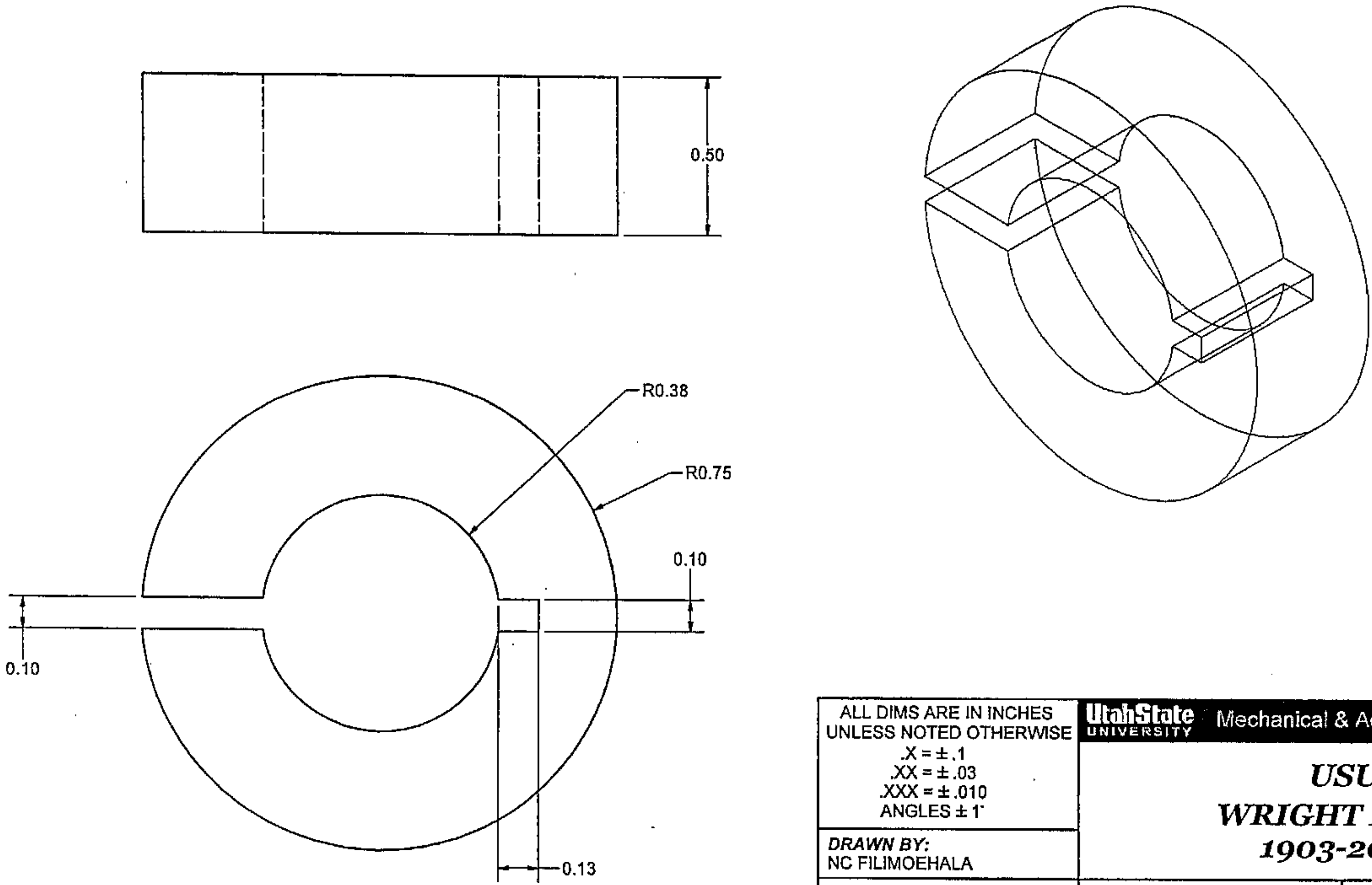
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering ***USU WRIGHT FLYER 1903-2003***		
DRAWN BY: NC FILIMOEHALA			
MATERIAL:	*PART DESCRIPTION:* 24 TOOTH SHEAVE	*PART NUMBER:* WF-40-002-607	*REV*
DATE: 4/21/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003			
DRAWN BY: NC FILIMOEHALA				
MATERIAL:	PART DESCRIPTION: 56 TOOTH SHEAVE		PART NUMBER: WF-40-002-608	REV
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	Utah State University — Mechanical & Aerospace Engineering			
DRAWN BY: NC FILIMOEHALA	***USU WRIGHT FLYER 1903-2003***			
MATERIAL:	*PART DESCRIPTION:* SHAFT SPACER		*PART NUMBER:* WF-40-002-609	*REV*
DATE: 4/21/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



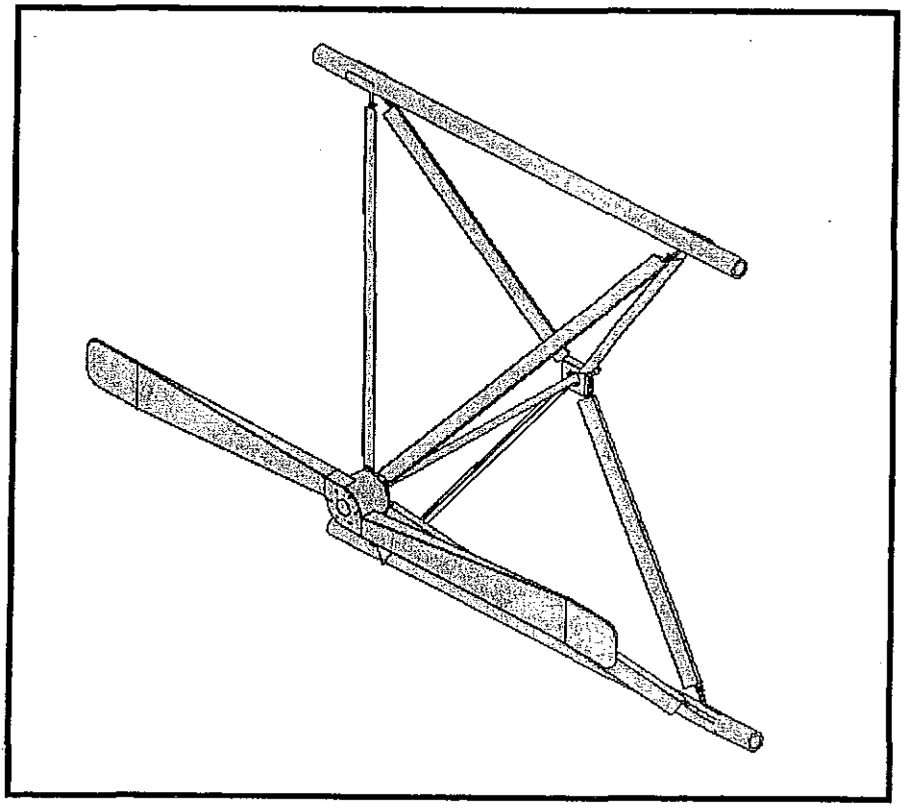
ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1˚

UtahState University — Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: NC FILIMOEHALA			
MATERIAL:	*PART DESCRIPTION:* SHAFT COLLAR	*PART NUMBER:* WF-40-002-610	*REV*
DATE: 4/21/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 of 1

Propeller Assembly



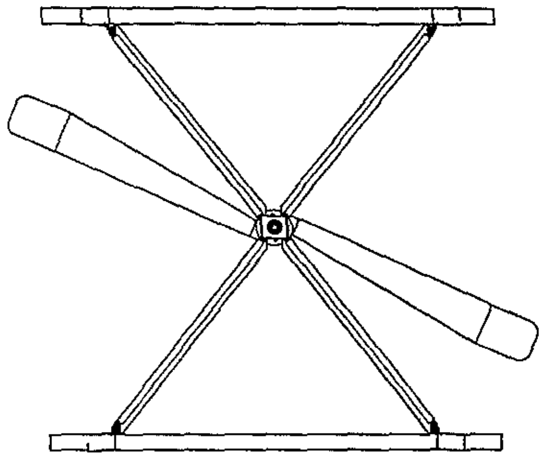
Materials List for Propeller Support Assembly

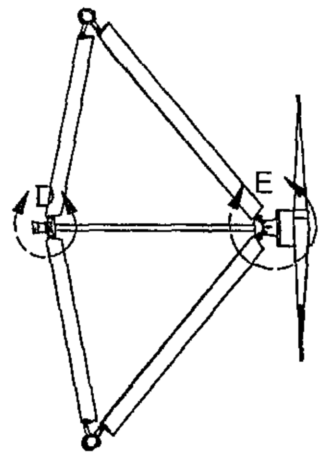
ck spc= check drawing specifications

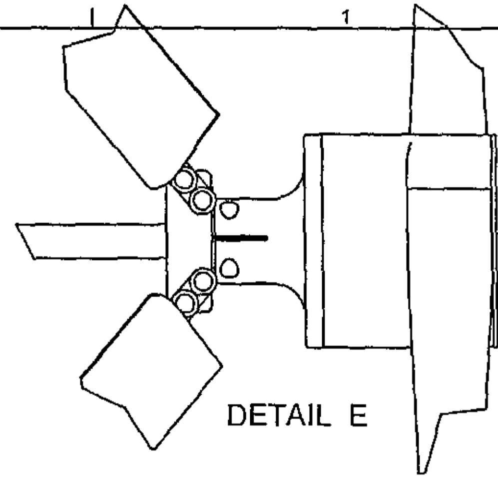
Item/Material	Description	Qty	Part #	Supplier
4130 Normalized Tubing	1" X 0.065" wall	8 ft		Aircraft Spruce
Ball Bearings	# 6305	4		Motion Industries
6061-T6 Aluminum	1.25" X 4" X 4"	4		ITE
4130 Steel Round Stock	1 1/2" dia. - normalized	1 ft	MIL-S-6758A	Aircraft Spruce
4131 Steel Round Tubing	1 7/8" OD - 0.25" wall - nrmlized	1 ft		Aircraft Spruce
6061-T6 Aluminum	round stock - 6" diameter	1.5 ft		?
4131 Steel Plate	0.125" thick X 6" wide	1.5 ft		ITE
4132 Steel Strap	0.125" X 3/4"	12 ft		ITE
4133 Steel Strap	0.125" X 5/8"	12 ft		ITE
Steamlined Carbon Tubes		16		ITE

Parts List for Propeller Support Assembly

Part Number	Description	Qty	Type
WF-40-009-03	Drive Shaft	2	cut and ground
Bearing - 6305	Drive Shaft Bearings	4	purchased
WF-40-009-06	Front Bearing Block	2	milled & drilled
WF-40-009-04	Rear Bearing Block	2	milled & drilled
WF-40-009-09A	Shive Hub	2	cut, drilled, keyed
WF-40-009-09B	Shive Hub Outer Collar	2	cut & drilled
WF-40-009-09C	Shive Hub Inner Collar	2	cut & drilled
WF-40-009-10A	Propeller Hub	2	turned & drilled
WF-40-009-10B	Hub Backing Plate	2	water jet cut
WF-40-009-05A	Rear Support	8	layed up & cut
WF-40-009-07A	Front Support	8	layed up & cut
WF-40-009-05B	Rear Support Mounting Tab	8	cut, formed & drilled
WF-40-009-07B	Front Support Mounting Tab	8	cut, formed & drilled
WF-40-009-08A	Spar Mount Bar - Rear	4	cut, formed & drilled
WF-40-009-08B	Spar Mount Bar - Front	4	cut, formed & drilled
Flat sheet to wrap around spar to glue and lash	Sheet Steel 0.065" (any type)	4	cut & formed

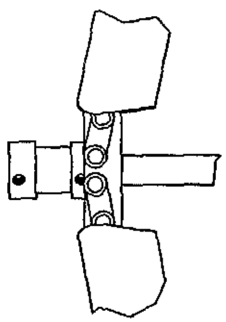






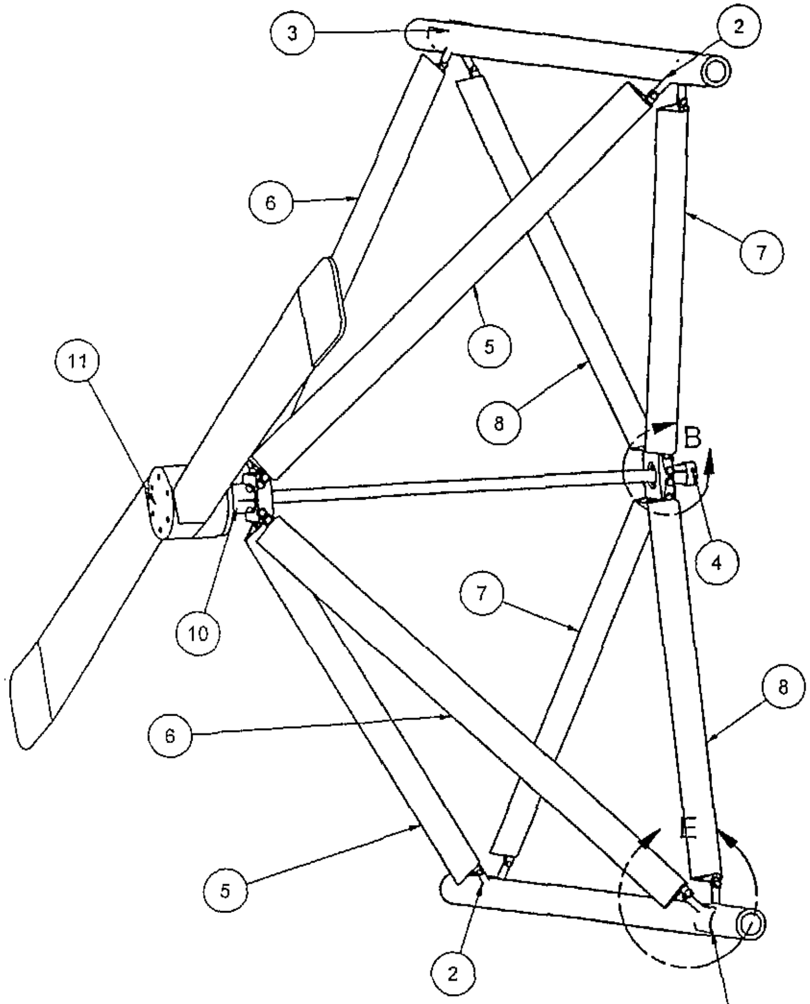
DETAIL E

Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	Spar Assm	
2	2	WF-40-002-507A	Mounting Assembly
3	2	WF-40-002-507B	Mounting Assembly
4	1	WF-40-002-503	Shaft Support Assm
5	2	WF-40-002-505A	Rear Support Assm - A
6	2	WF-40-002-505B	Rear Support Assm - B
7	2	WF-40-002-506A	Front Support Assm - A
8	2	WF-40-002-506B	Front Support Assm - B
9	1	WF-40-003 Propeller	Designed by CATT O PROPS
10	1	WF-40-099-10A	In-House propeller hub d esign
11	1	WF-40-099-10B	hub back plate

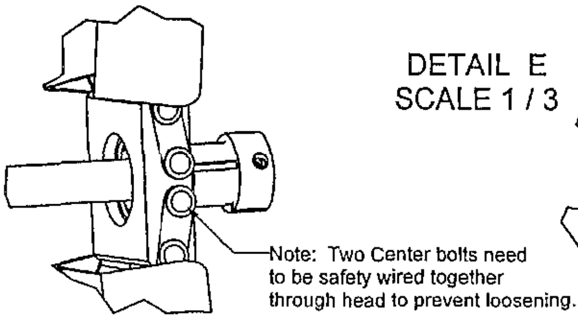


DETAIL D
SCALE 1 / 4

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering			
DRAWN BY: Adam Richards	***USU WRIGHT FLYER 1903-2003***			
MATERIAL:	*PART DESCRIPTION:* Prop Support Assembly		*PART NUMBER:* WF-40-002-555	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	

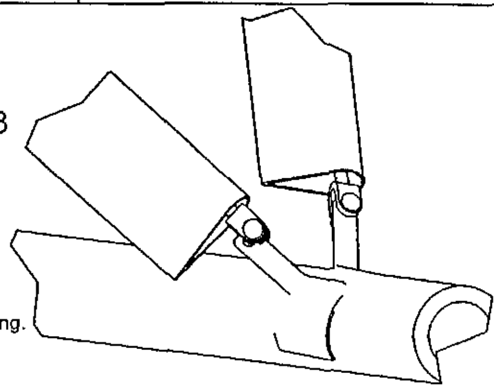


The design of the hub is depending on the propeller design, and will be added later.



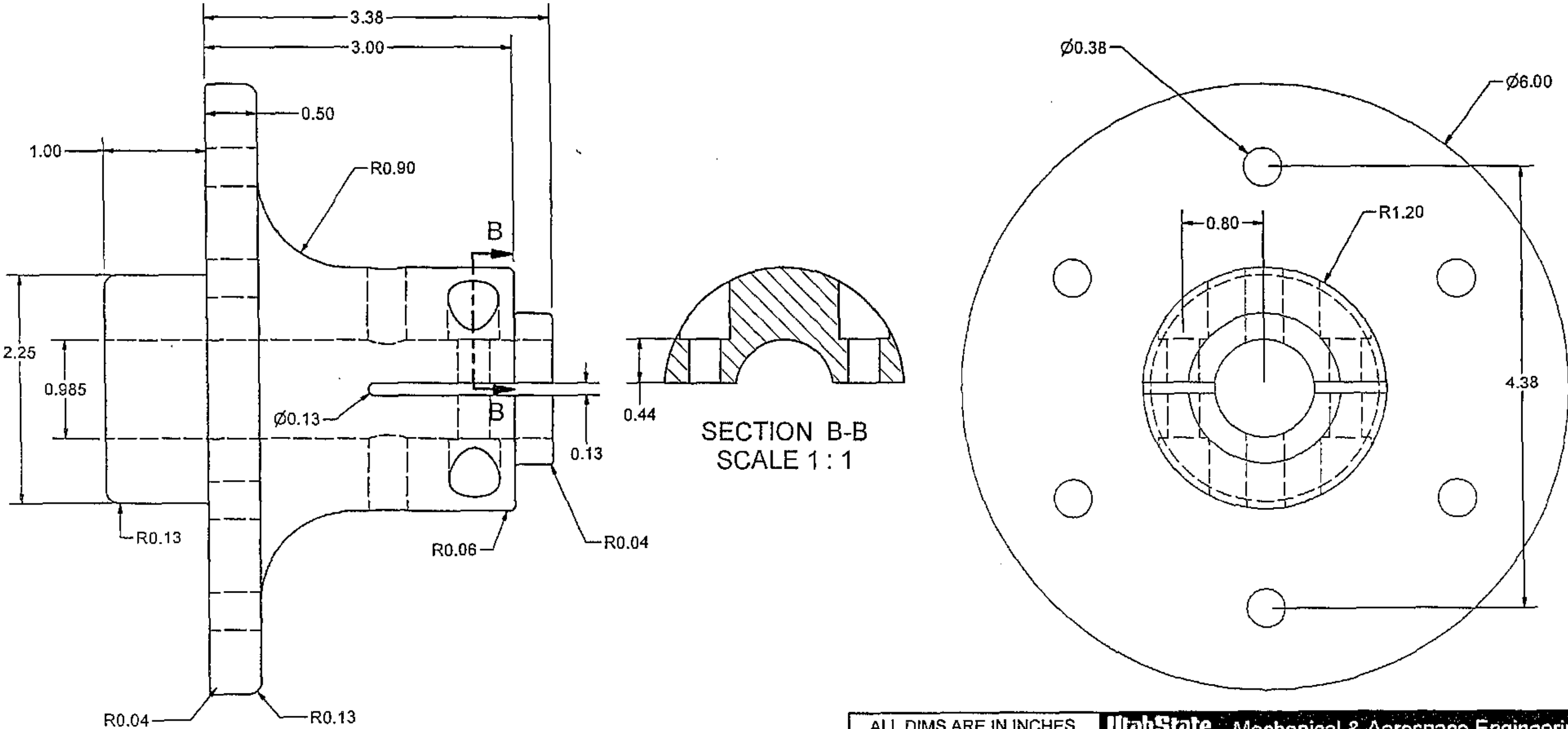
DETAIL B
SCALE 0.35 : 1

DETAIL E
SCALE 1 / 3



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	Spar Assm	
2	2	WF-40-002-507A	Mounting Assembly
3	2	WF-40-002-507B	Mounting Assembly
4	1	WF-40-002-503	Shaft Support Assm
5	2	WF-40-002-505A	Rear Support Assm - A
6	2	WF-40-002-505B	Rear Support Assm - B
7	2	WF-40-002-506A	Front Support Assm - A
8	2	WF-40-002-506B	Front Support Assm - B
9	1	WF-40-003 Propeller	Designed by CATT O PROPS
10	1	WF-40-099-10A	In-House propeller hub d esign
11	1	WF-40-099-10B	hub back plate

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering			
	USU WRIGHT FLYER 1903-2003			
DRAWN BY: Adam Richards				
MATERIAL:	*PART DESCRIPTION:* Prop Support Assembly		*PART NUMBER:* WF-40-002-555	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



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.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: A Richards

MATERIAL: Aluminum-6061

PART DESCRIPTION: In-House propeller hub design

PART NUMBER: WF-40-099-10A

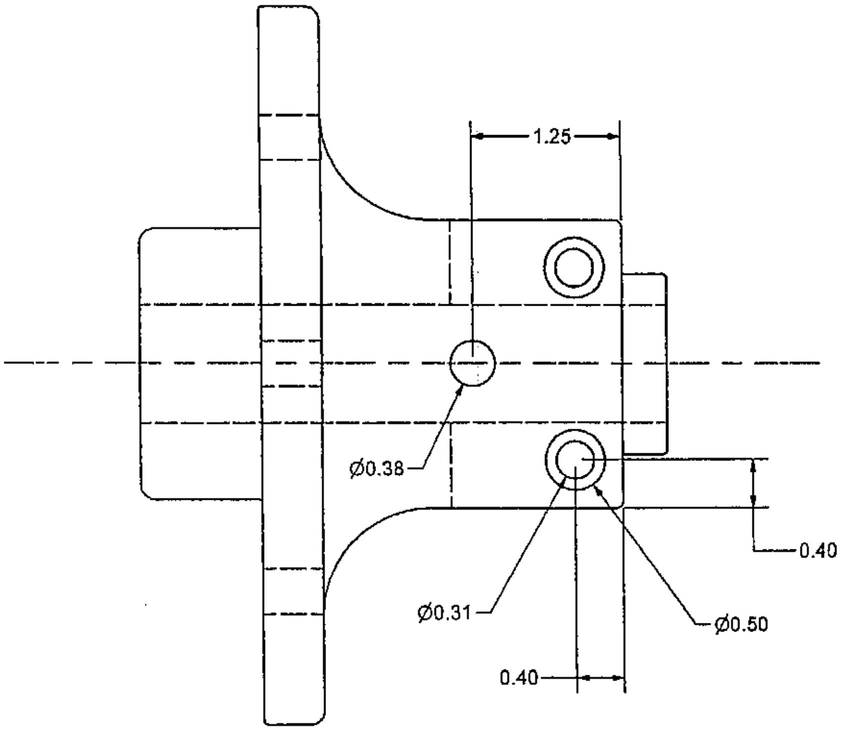
REV

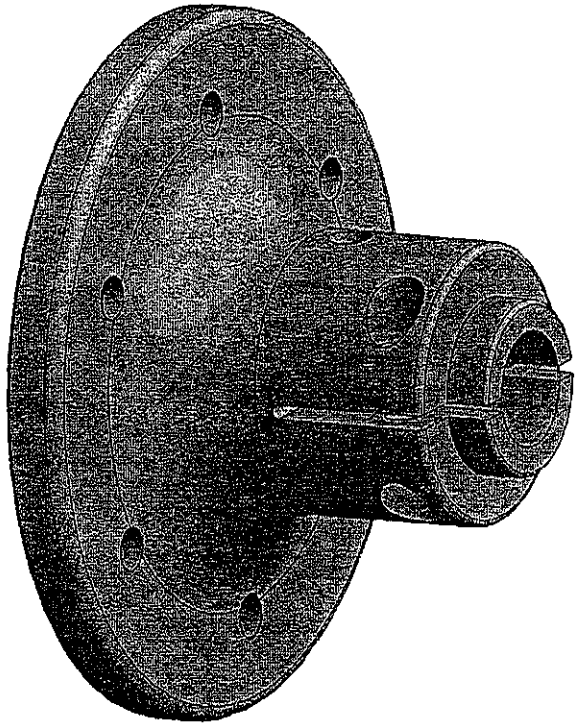
DATE: 2/17/2002

SCALE:

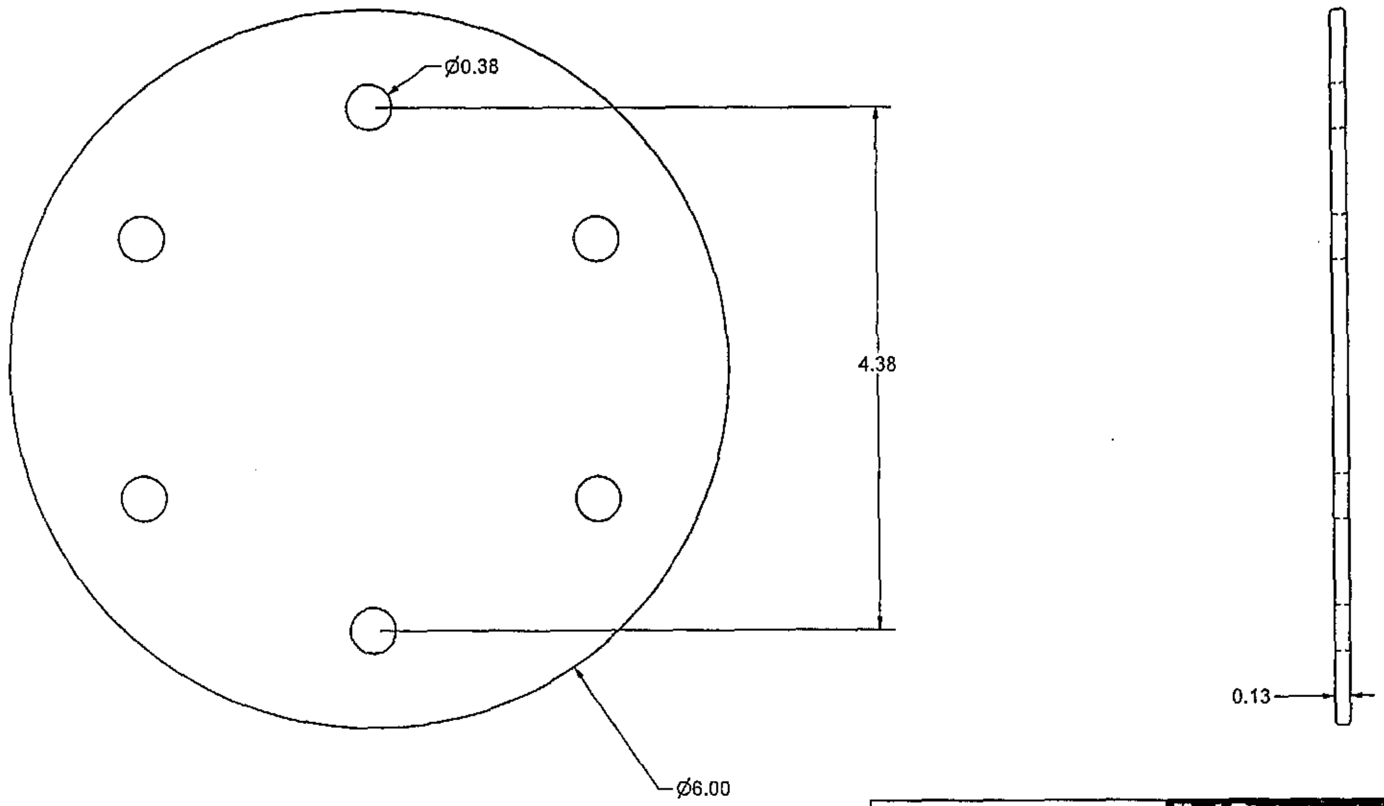
SIZE: B

SHEET 2 **of** 2





ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	USU WRIGHT FLYER 1903-2003		
DRAWN BY: A Richards			
MATERIAL: Aluminum-6061	**PART DESCRIPTION:** In-House propeller hub design	**PART NUMBER:** WF-40-099-10A	**REV**
DATE: 2/17/2002	**SCALE:**	**SIZE:** B	**SHEET** 2 of 2



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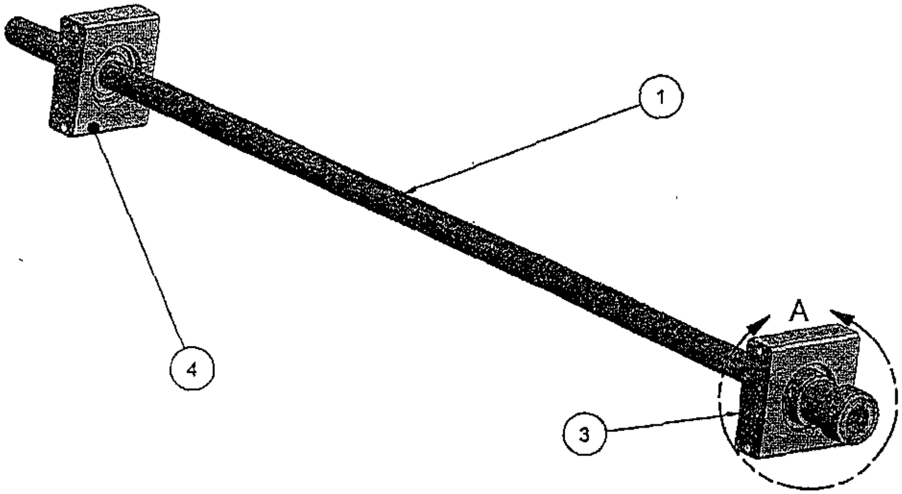
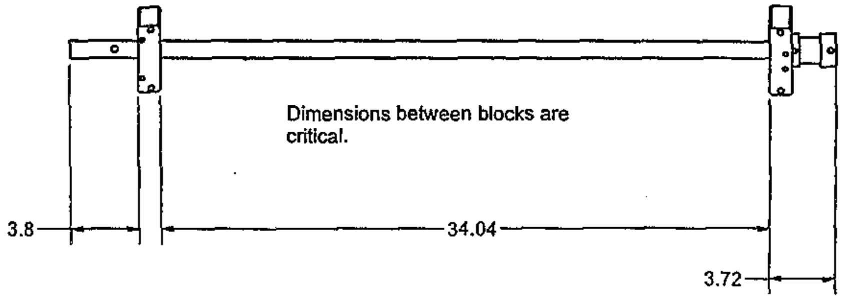
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

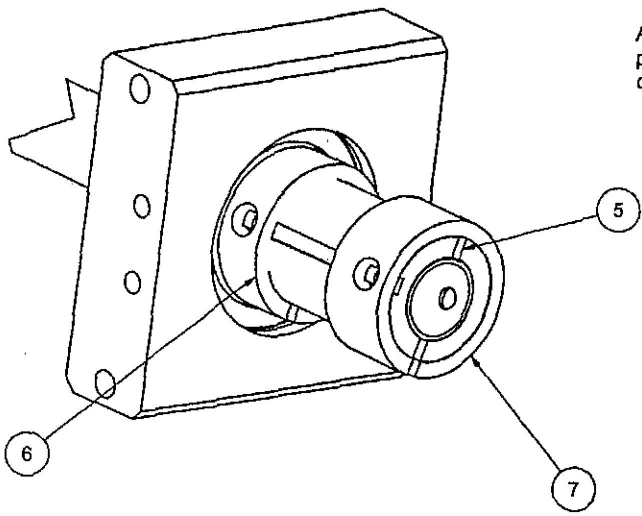
DRAWN BY: A Richards			
MATERIAL: Steel, High Strength Low Alloy	*PART DESCRIPTION:* hub back plate	*PART NUMBER:* WF-40-099-10B	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1





Dimensions between blocks are critical.

After grinding shaft,
press fit bearings to either the blocks
or the shaft first, which ever is best.



DETAIL A
SCALE 3 / 4

Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-40-099-03	Prop Drive Shaft
2	2	Ball Bearing - 6305	Deep groove double seal ed
3	1	WF-40-099-06	Front Bearing Block
4	1	WF-40-099-04	Rear Bearing Block
5	1	WF-40-099-09A	Drive Shive Hub
6	1	WF-40-099-09C	Hub Collar - Inner
7	1	WF-40-099-09B	Drive Shive Hub Collar

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: A Richards

MATERIAL:

PART DESCRIPTION: Shaft Support Assm

PART NUMBER: WF-40-002-503

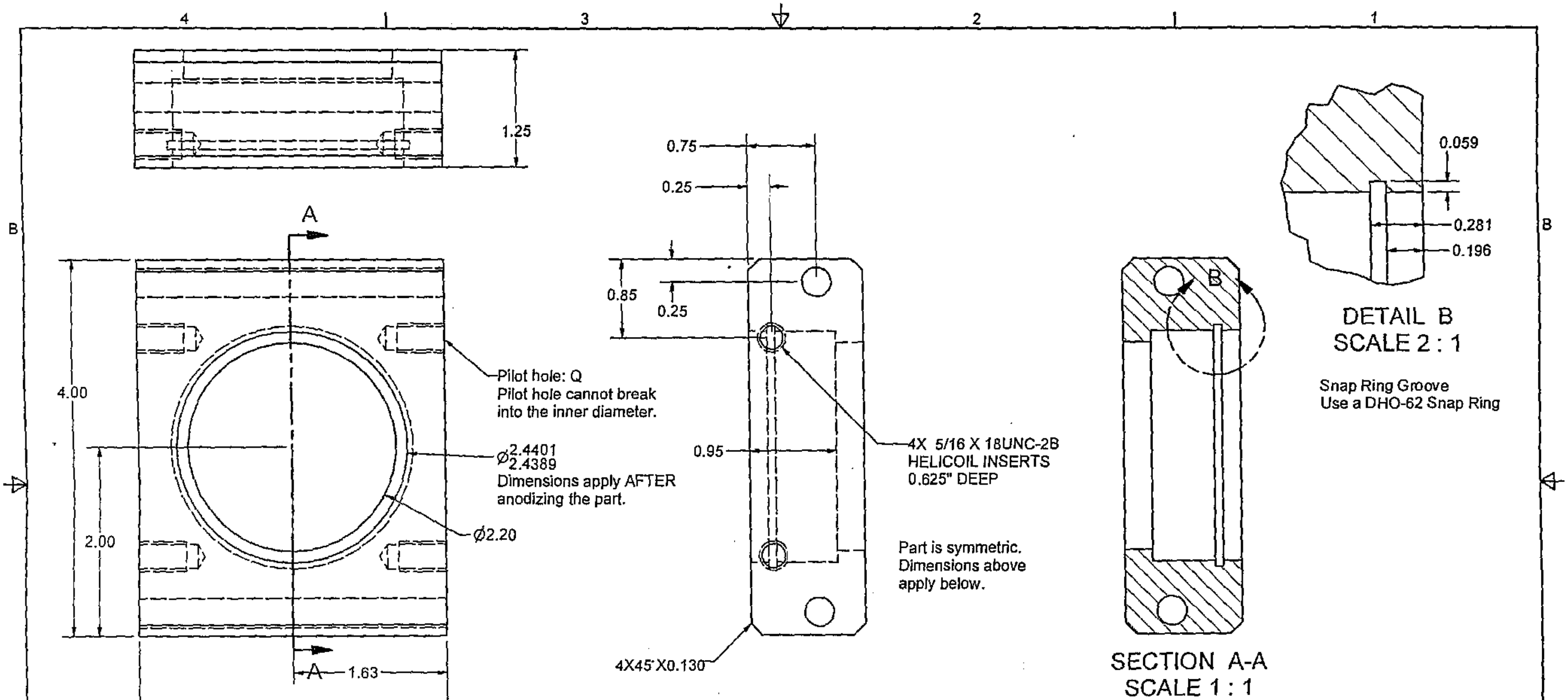
REV

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 ***of*** 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
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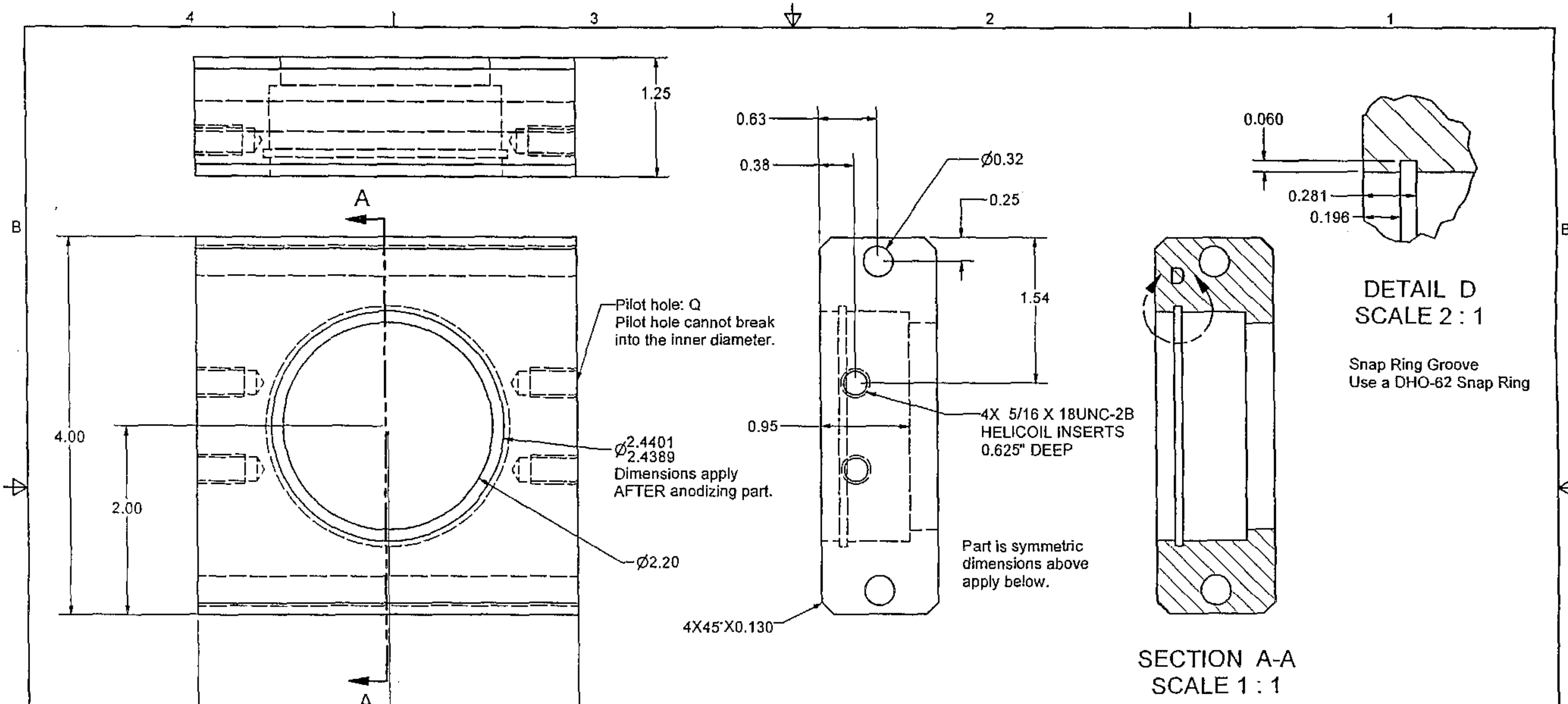
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

Utah State University — Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

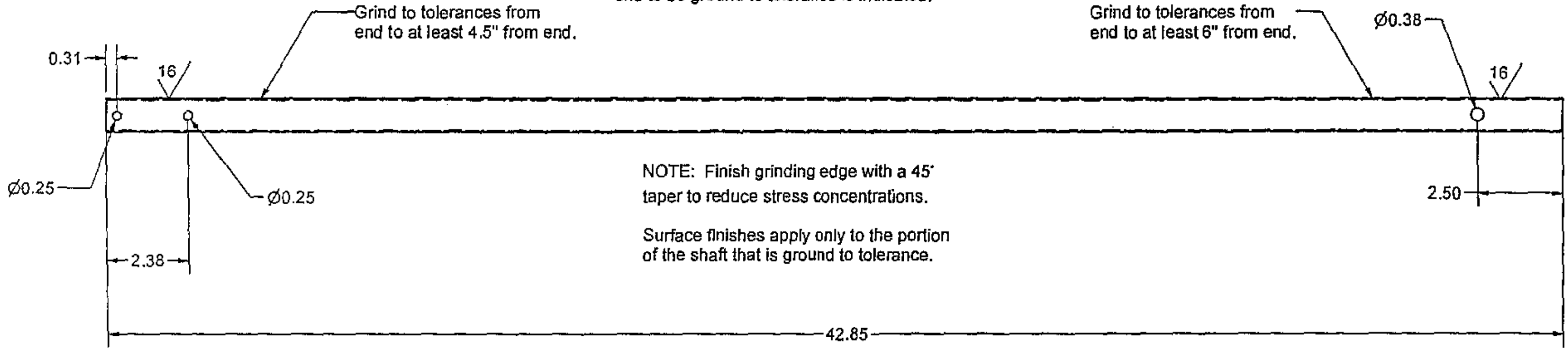
DRAWN BY: Adam Richards

MATERIAL: Aluminum-6061	*PART DESCRIPTION:* Rear Bearing Block	*PART NUMBER:* WF-40-099-04	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 of 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*
DRAWN BY: A Richards	
MATERIAL: Aluminum-6061	*PART DESCRIPTION:* Front Bearing Block — *PART NUMBER:* WF-40-099-06 — *REV*
DATE: 2/17/2002	*SCALE:* — *SIZE:* B — *SHEET* 1 *of* 1

Shaft needs to be ground down to given tolerance for bearing press fit, but only on the ends. Distance from end to be ground to tolerance is indicated.

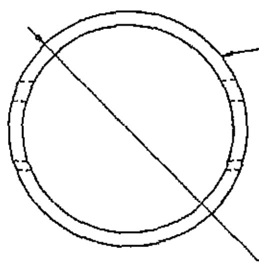


NOTE: Finish grinding edge with a 45° taper to reduce stress concentrations.

Surface finishes apply only to the portion of the shaft that is ground to tolerance.

Revisions:

- REV A April 12, 2002
  - Added surface finish to bearing surfaces
  - Moved Propeller Hub bolt hole from 3" from end to 2.25" from end
- REV B May 1, 2002
  - Shortened the length of the shaft
  - Moved Propeller Hub bolt hole from 2.25" from end to 2.50" from end

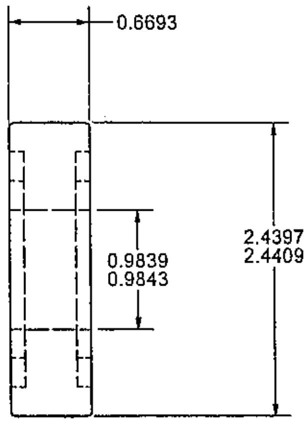


Buy 1" 4130 MIL-T-6736 Normalized tubing. Grind down to tolerances. Original wall thickness is 0.065"

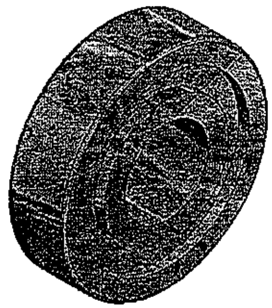
Ø 0.9843 / 0.9839

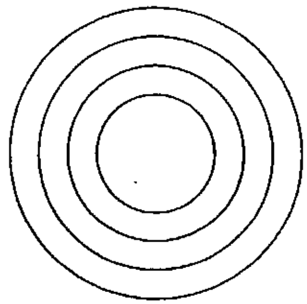
These tolerances apply only to the ends where the shaft is ground to allow press fit of bearings.
Original Wall Thickness: 0.065 in.

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*			
DRAWN BY: A. Richards				
MATERIAL: 4130 MIL-T-6736 Normalized	*PART DESCRIPTION:* Prop Drive Shaft		*PART NUMBER:* WF-40-099-03	*REV* B
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	

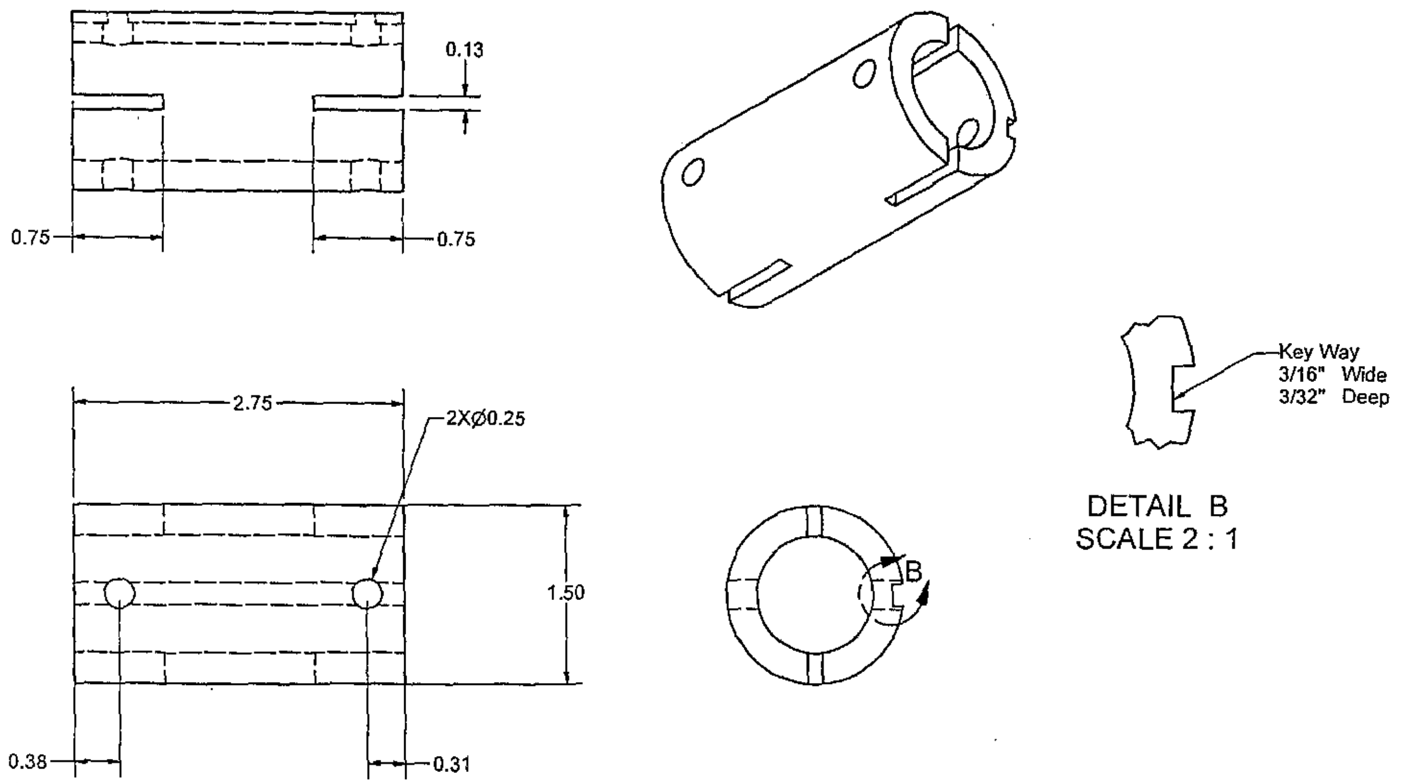


NOTE: For illustration only. This is a deep groove, double sealed ball bearing. It is a metric size, 25mm shaft and 62mm housing. Inch tolerances are given here.

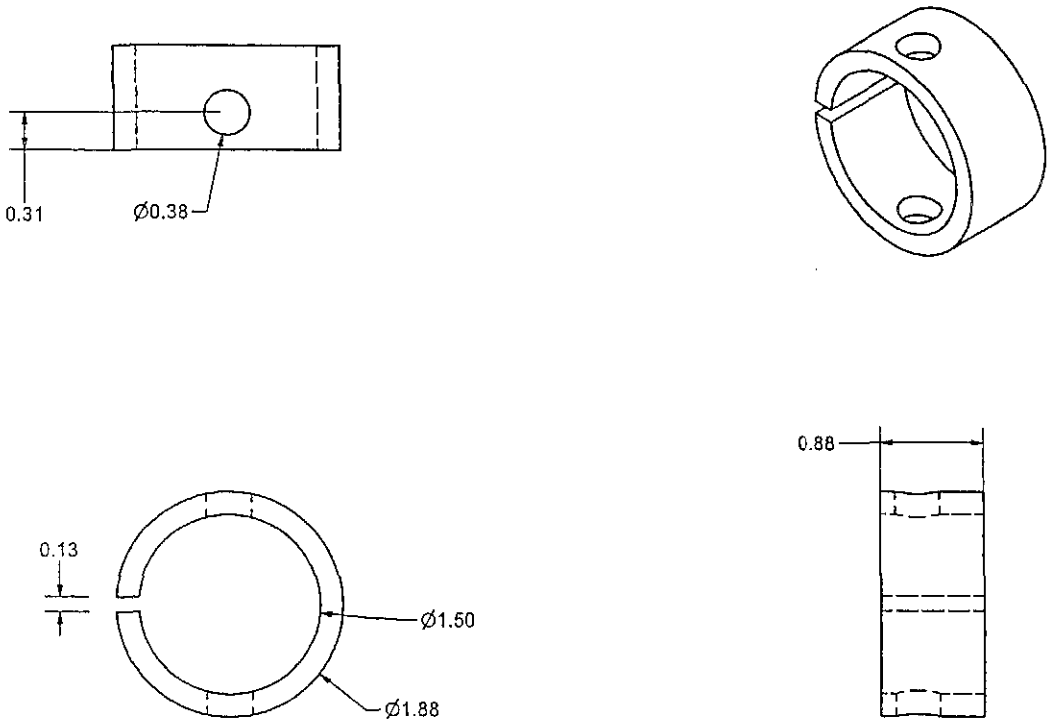




ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*			
DRAWN BY: A Richards				
MATERIAL:	*PART DESCRIPTION:* Deep groove double sealed		*PART NUMBER:* Ball Bearing - 6305	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	

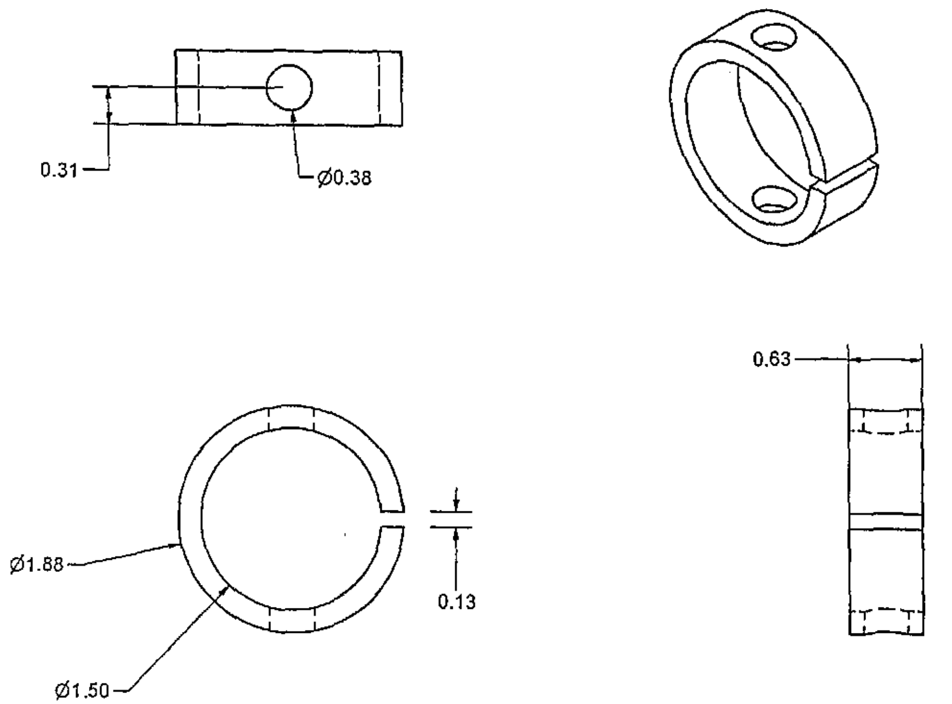


ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState University — Mechanical & Aerospace Engineering			
DRAWN BY: Adam Richards	**USU WRIGHT FLYER 1903-2003**			
MATERIAL: Steel, High Strength Low Alloy	*PART DESCRIPTION:* Drive Shive Hub		*PART NUMBER:* WF-40-099-09A	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



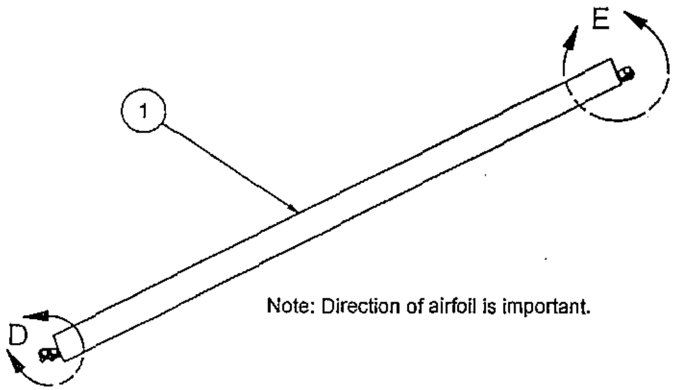
Revisions:
- REV A April 12, 2002
  - Changed the OD dimension from 2" to 1.875"

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1˚	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*		
DRAWN BY: Adam Richards			
MATERIAL: Steel, High Strength Low Alloy	*PART DESCRIPTION:* Hub Collar - Outer	*PART NUMBER:* WF-40-099-09B	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 of 1



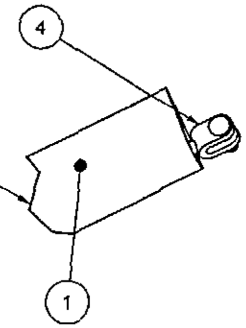
Revisions:
- REV A April 12, 2002
  - Changed the OD dimension from 2" to 1.875"

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	Utah State University Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*			
DRAWN BY: A Richards				
MATERIAL: Steel, High Strength Low Alloy	*PART DESCRIPTION:* Hub Collar - Inner		*PART NUMBER:* WF-40-099-09C	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



Note: Direction of airfoil is important.

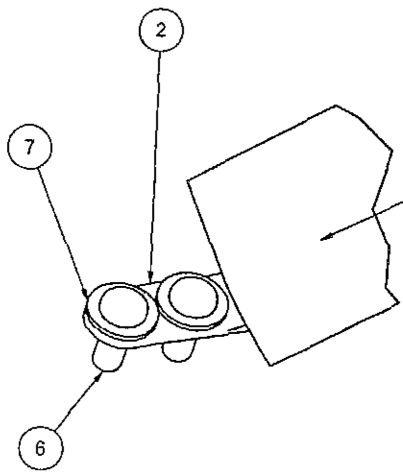
Composite tube has a hard point here. A threaded insert is also included in the hard point for the clevis fork to screw into.



ATTENTION:
Assembly WF-40-002-505B is assembled just like this assembly, except the airfoil must be turned the opposite direction.

DETAIL E
SCALE 0.35 : 1

Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-40-099-05A	Rear Support
2	1	WF-40-099-05B	Rear support mount Tab
4	1	AirCraftSpruce AN161-4 6S	Steel Clevis Fork
5	1	AN5-6	Nut & washers to fit
6	2	Bolt - 0.3125 - 0.875	AN HardWare
7	2	Washer 0.3125Reg	AN Hardware



Composite tube has a hard point at this end. The tab stem is attached by being inserted into the hard point resin before it hardens.

Inner bolt is drilled through the head for safety wire.

Outer bolt will go all the way through the bearing block for a nut on the other side.

DETAIL D
SCALE 0.80 : 1

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: A Richards

MATERIAL:

PART DESCRIPTION: Rear Support Assm - A

PART NUMBER: WF-40-002-505A

REV

DATE: 2/17/2002

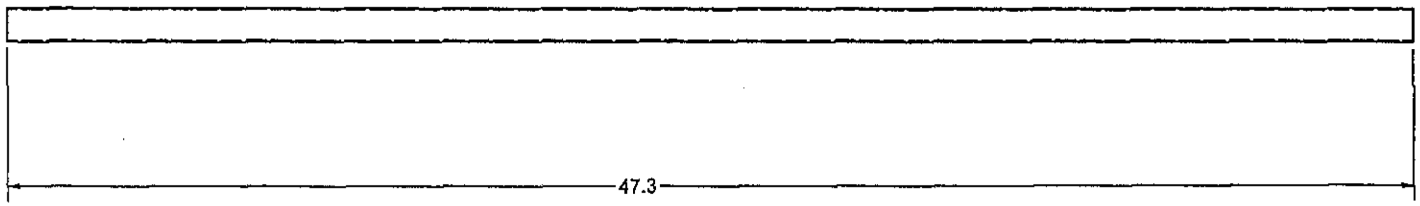
SCALE:

SIZE: B

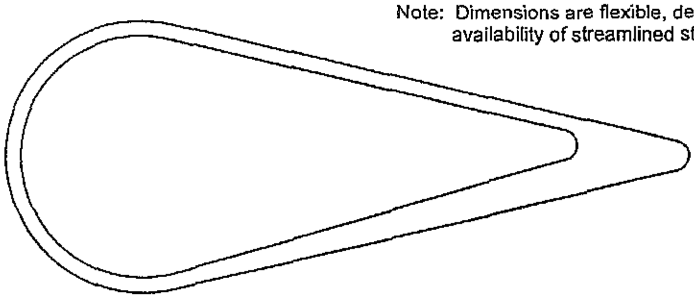
SHEET 1 of 1

NOTE: This part can be constructed two ways. Build a round tube of composite material, and then cover it with a thin airfoil. Or use the steel tubing as the mandrel to lay up the part as drawn.

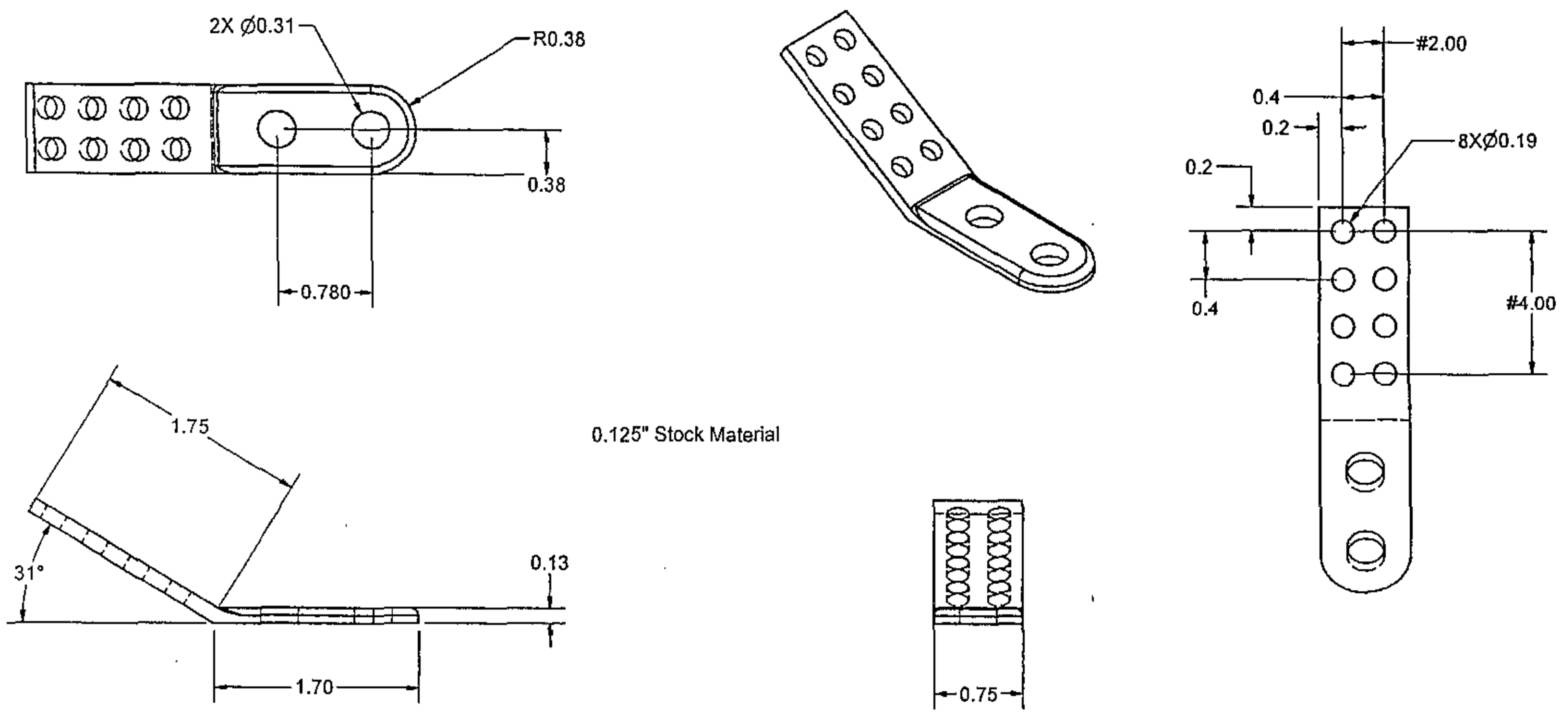
ATTENTION: Wall thicknesses and layup methods will be determined after testing of parts.



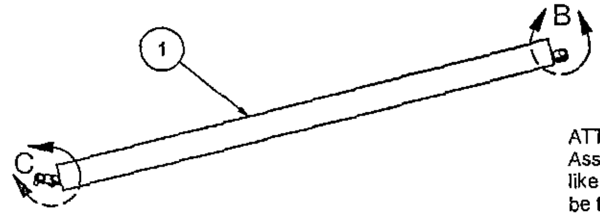
Note: Dimensions are flexible, depending on the availability of streamlined steel tubing for mandrels.



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	Utah State University — Mechanical & Aerospace Engineering **USU WRIGHT FLYER 1903-2003**			
DRAWN BY: Adam Richards				
MATERIAL: Carbon Fiber	***PART DESCRIPTION:*** Rear Support		***PART NUMBER:*** WF-40-099-05A	***REV*** A
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 of 1	

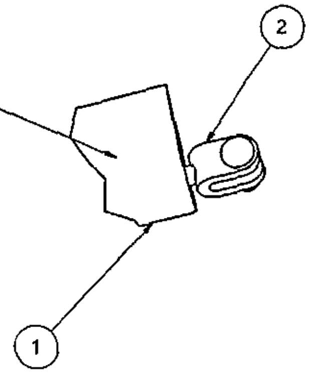


ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	Utah State University Mechanical & Aerospace Engineering			
DRAWN BY: Adam Richards	*USU WRIGHT FLYER 1903-2003*			
MATERIAL: Steel, High Strength Low Alloy	PART DESCRIPTION: Rear support mount Tab		PART NUMBER: WF-40-099-05B	REV
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	

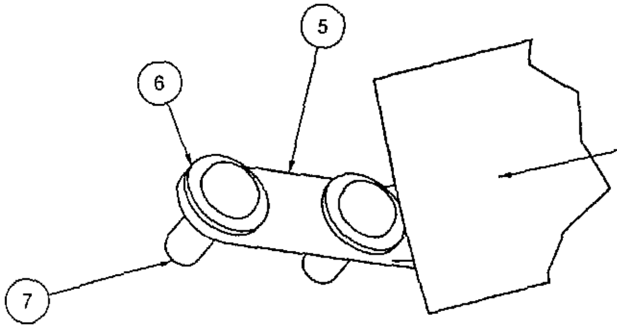


ATTENTION:
Assembly WF-40-002-506B is assembled just like this assembly, except the airfoil must be turned the opposite direction.

Composite tube has a hard point here. A threaded insert is also included in the hard point for the clevis fork to screw into.



DETAIL B
SCALE 0.55 : 1



Composite tube has a hard point at this end. The tab stem is attached by being inserted into the hard point resin before it hardens.

Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-40-099-07A	Front Support
2	1	AirCraftSpruce AN161-4 6S	Steel Clevis Fork
3	1	AN5-6	Nut & washers to fit
5	1	WF-40-099-07B	Fnt support mount Tab
6	2	Washer 0.3125Reg	AN Hardware
7	2	Bolt - 0.3125 - 0.875	AN HardWare

Inner bolt is drilled through the head for safety wire.

Outer bolt will go all the way through the bearing block for a nut on the other side.

DETAIL C
SCALE 1 : 1

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

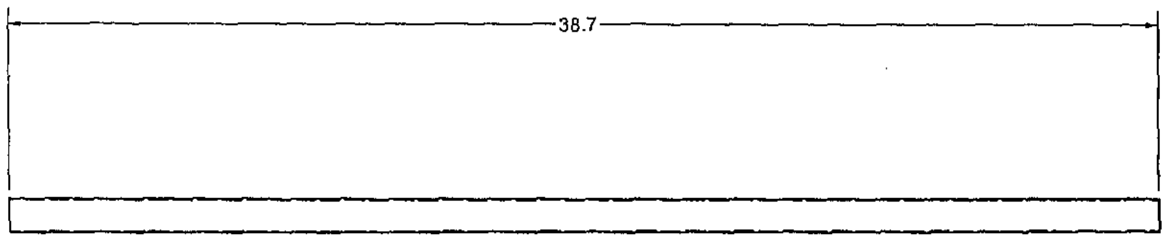
UtahState UNIVERSITY — Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

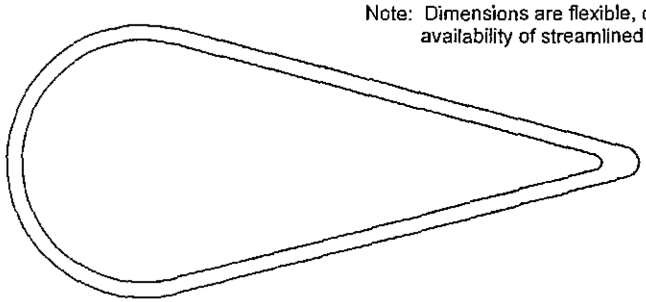
DRAWN BY: A Richards			
MATERIAL:	*PART DESCRIPTION:* Front Support Assm - A	*PART NUMBER:* WF-40-002-506A	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1

NOTE: This part can be constructed two ways. Build a round tube of composite material, and then cover it with a thin airfoil. Or use the steel tubing as the mandrel to lay up the part as drawn.

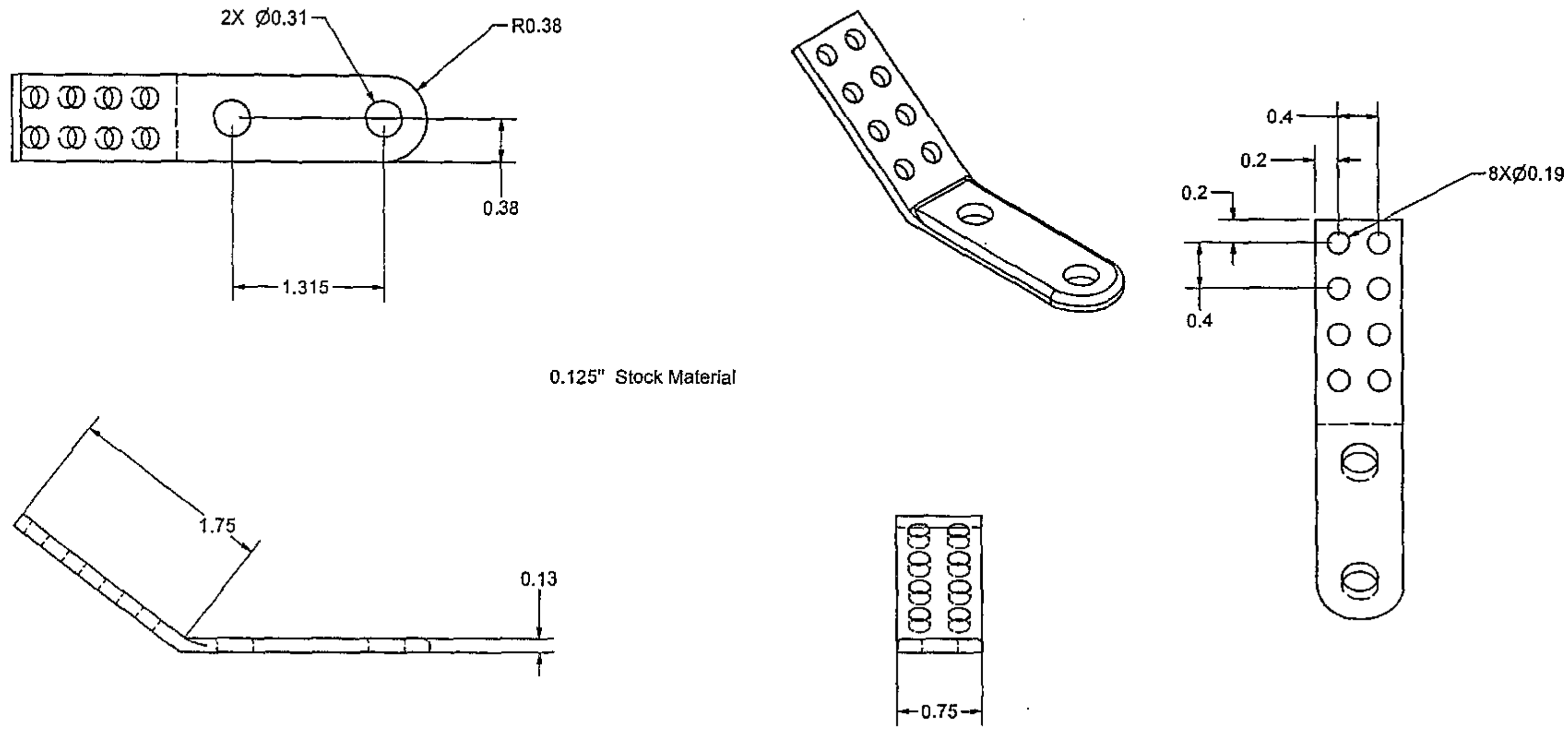
ATTENTION: Wall thicknesses and layup methods will be determined after testing of parts.



Note: Dimensions are flexible, depending on the availability of streamlined steel tubing for mandrels.



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*		
DRAWN BY: Adam Richards			
MATERIAL:	*PART DESCRIPTION:* Front Support	*PART NUMBER:* WF-40-099-07A	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

DRAWN BY: Adam Richards

MATERIAL: Steel, High Strength Low Alloy

DATE: 2/17/2002

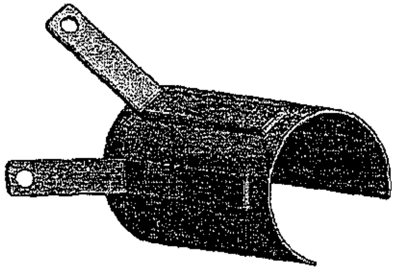
Utah State University — Mechanical & Aerospace Engineering

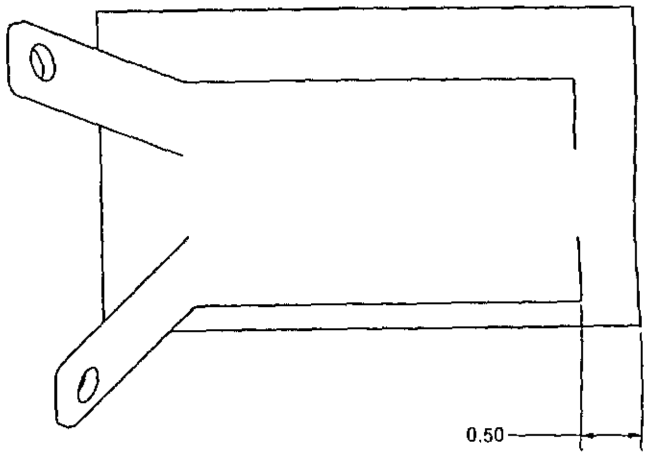
USU WRIGHT FLYER 1903-2003

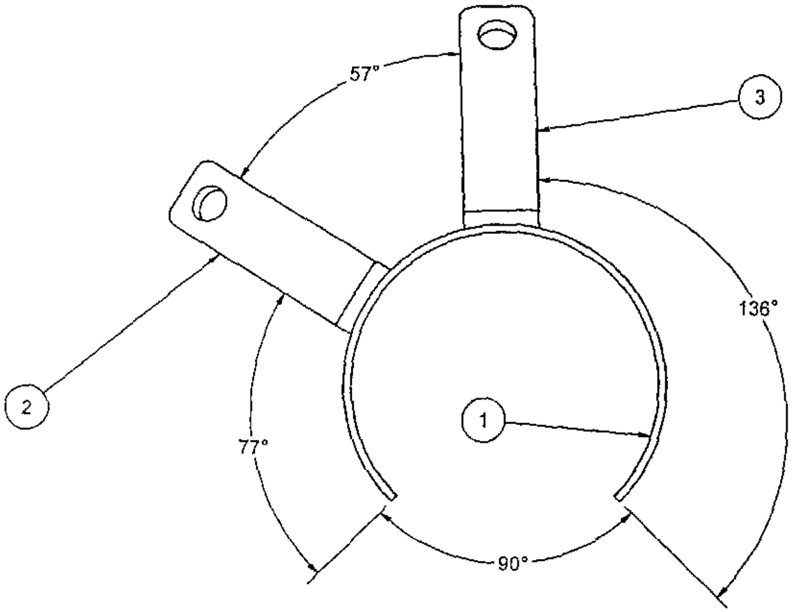
PART DESCRIPTION:	PART NUMBER:	REV
Fnt support mount Tab	WF-40-099-07B	

SCALE:	SIZE: B	SHEET 1 of 1

Spar Mounting Cup is made of 4130 steel, Normalized.
It is cutout flat 0.063" X 4.5" X 6". It is then rolled as shown. The mounting plates are welded at the angles shown all the way around.
For mounting, the cup is glued and lashed in place on the rear spar.
A vertical line runs through the center of the top and bottom rear spars. The center line of the mounting cup must be parellel to that line in order for the tabs to line up properly.







Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-40-099-08C	Spar Mounting Cup
2	1	WF-40-099-08B	Spar Mount PLate - Front
3	1	WF-40-099-08A	Spar Mount Plate - Rear

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: A RIchards

MATERIAL:

PART DESCRIPTION: Mounting Assembly

PART NUMBER: WF-40-002-507B

REV

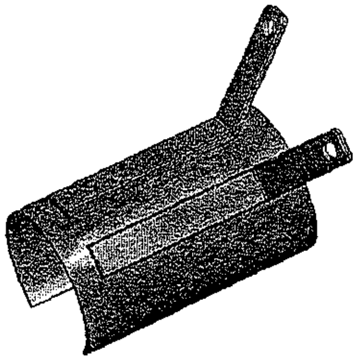
DATE: 2/17/2002

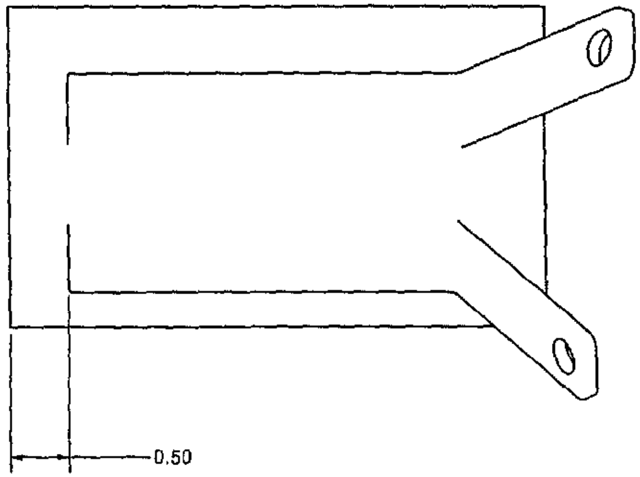
SCALE:

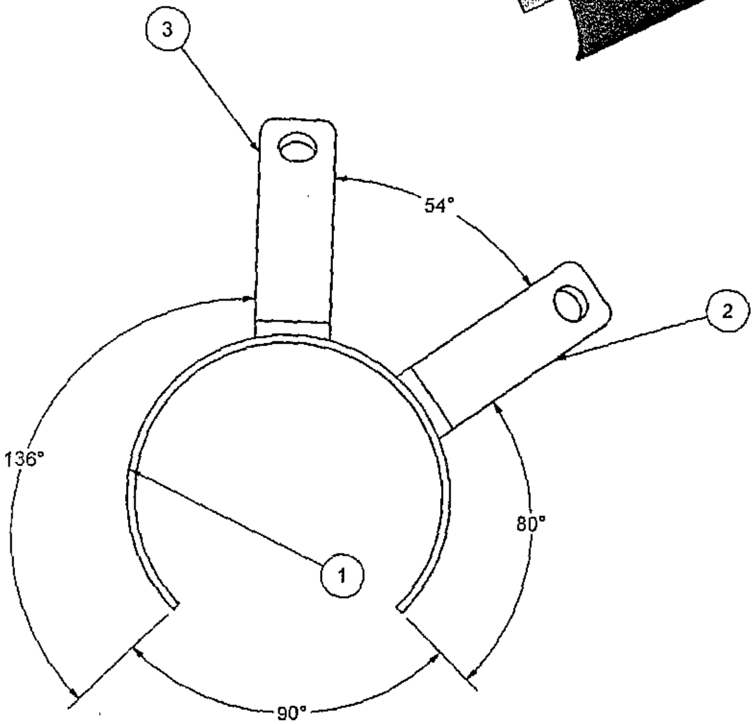
SIZE: B

SHEET 1 *of* 1

Spar Mounting Cup is made of 4130 steel, Normalized.
It is cutout flat 0.063" X 4.5" X 6". It is then rolled as shown. The mounting plates are welded at the angles shown all the way around.
For mounting, the cup is glued and lashed in place on the rear spar.
A vertical line runs through the center of the top and bottom rear spars. The center line of the mounting cup must be parelleI to that line in order for the tabs to line up properly.







Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-40-099-08C	Spar Mounting Cup
2	1	WF-40-099-08B	Spar Mount PLate - Front
3	1	WF-40-099-08A	Spar Mount Plate - Rear

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: A RIchards

MATERIAL:

PART DESCRIPTION: Mounting Assembly

PART NUMBER: WF-40-002-507A

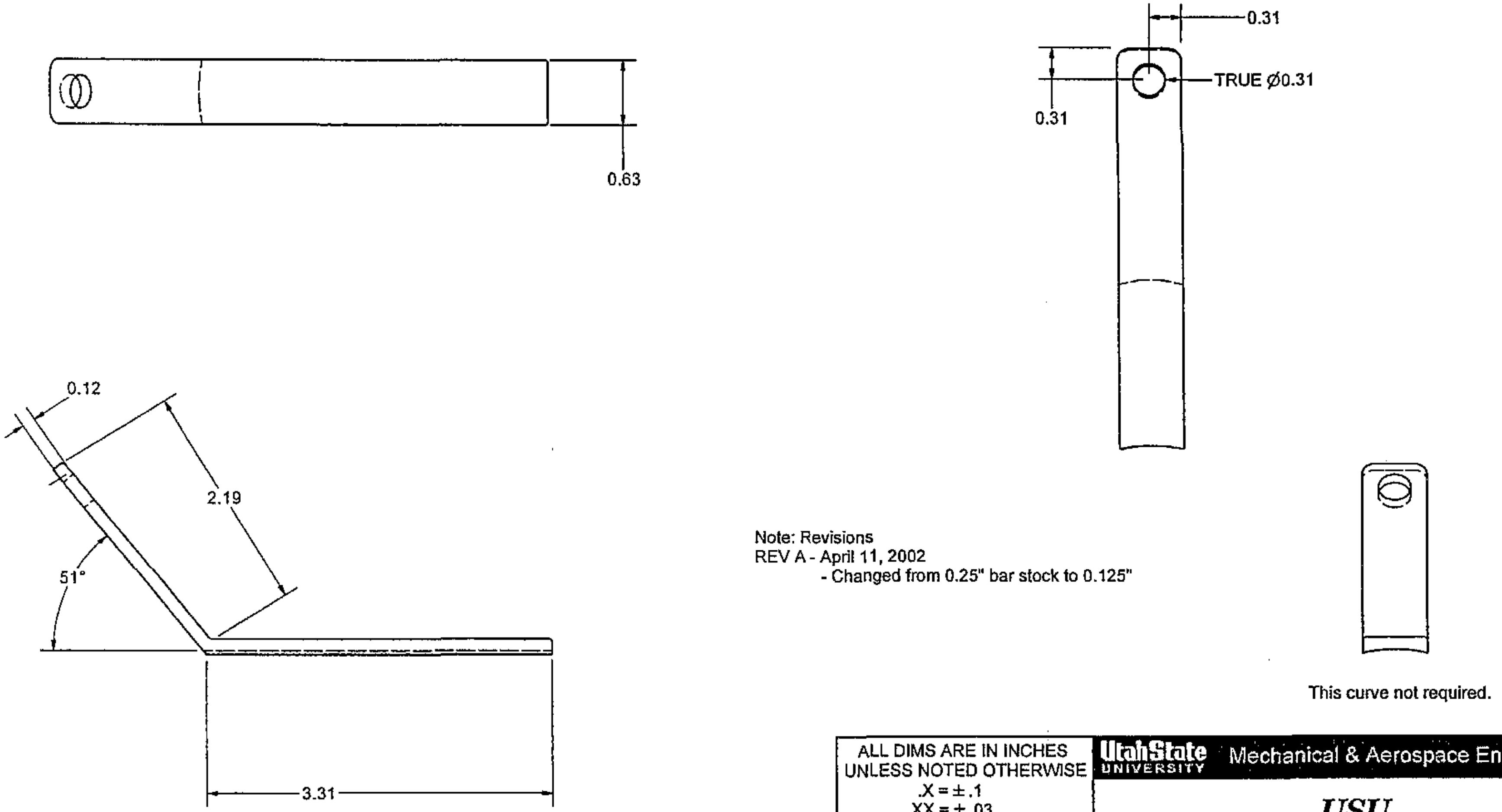
REV

DATE: 2/17/2002

SCALE:

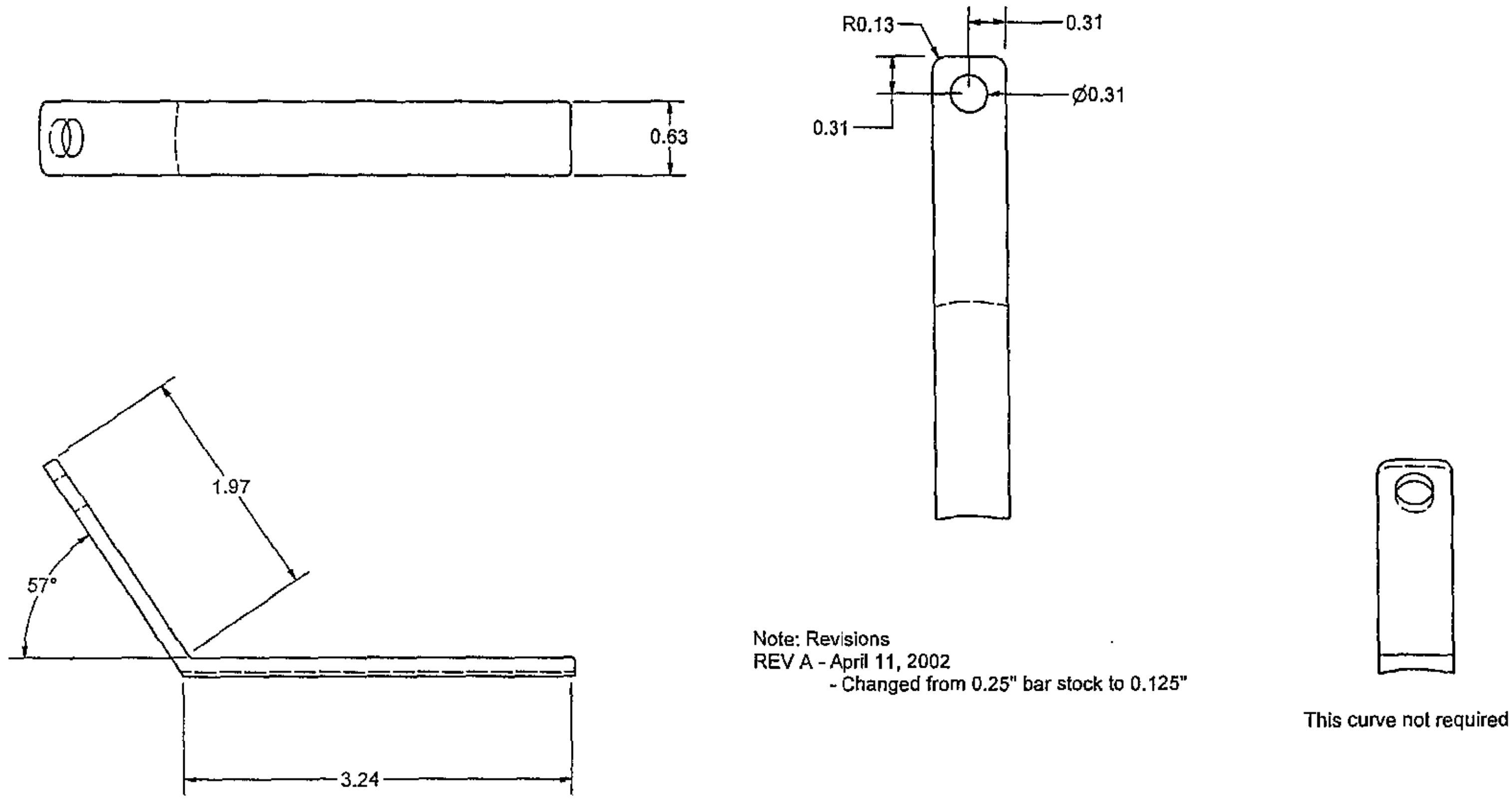
SIZE: B

SHEET 1 of 1



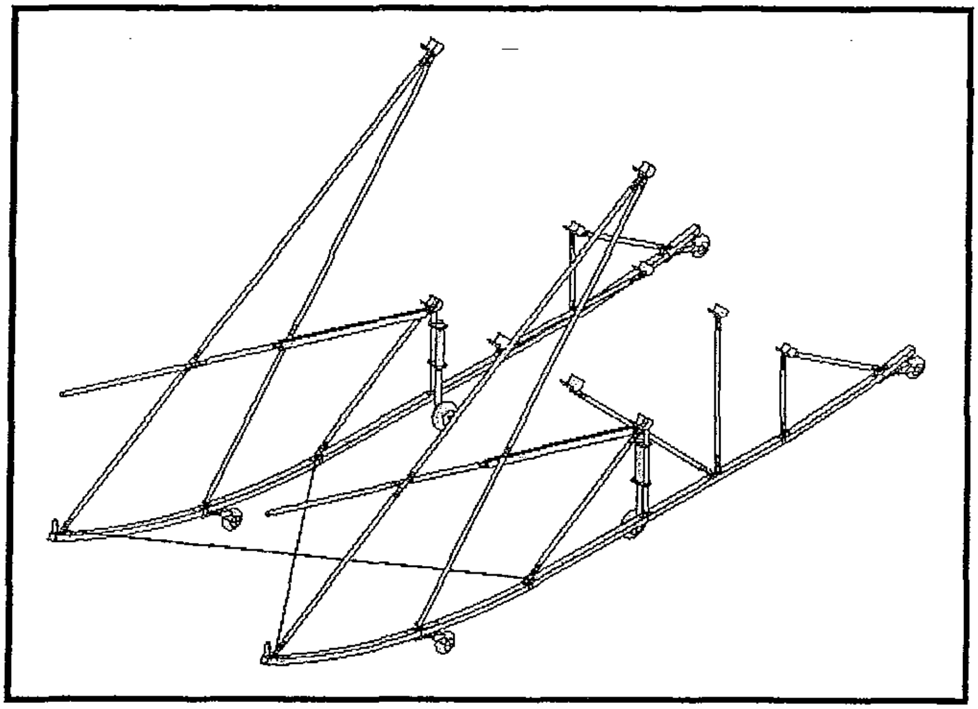
Note: Revisions
REV A - April 11, 2002
- Changed from 0.25" bar stock to 0.125"

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ±.1 .XX = ±.03 .XXX = ±.010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering **USU WRIGHT FLYER 1903-2003**			
DRAWN BY: Adam Richards				
MATERIAL: Steel, High Strength Low Alloy	PART DESCRIPTION: Spar Mount Plate - Rear	PART NUMBER: WF-40-099-08A		REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState University Mechanical & Aerospace Engineering				
DRAWN BY: Adam Richards	***USU WRIGHT FLYER 1903-2003***				
MATERIAL: Steel, High Strength Low Alloy	**PART DESCRIPTION:** Spar Mount PLate - Front		**PART NUMBER:** WF-40-099-08B		**REV** A
DATE: 2/17/2002	**SCALE:**	**SIZE:** B	**SHEET** 1 **of** 1		

Chassis Assembly



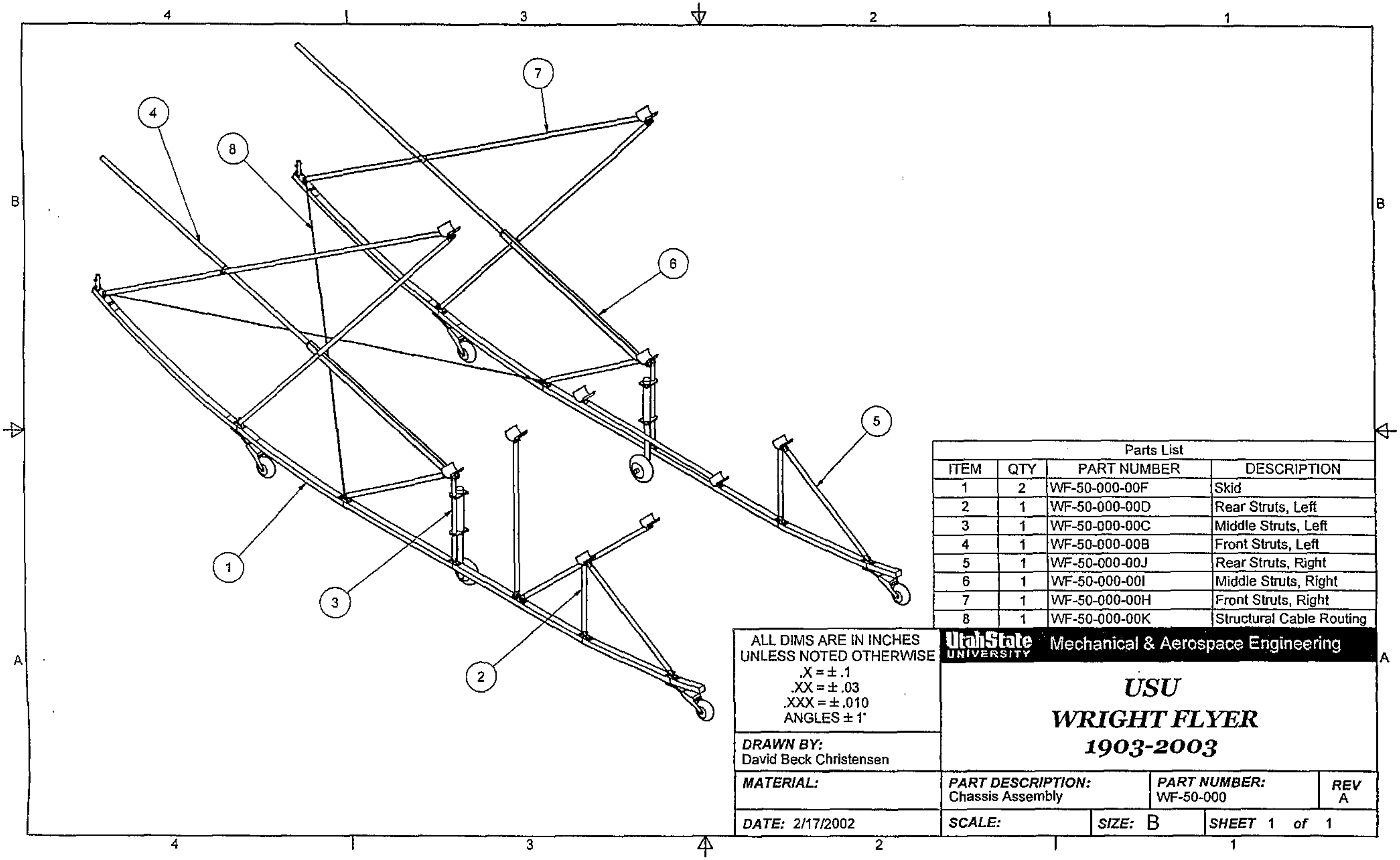
Materials List for Chassis

ck spc= check drawing specifications

Item/Material	Description	Qty	Part #	Supplier
Spruce Strips	1.75" wide	ck spc		Aircraft Spruce
Kevlar (lay up with spruce)	1.75" wide	ck spc		?
Carbon Tubes	1 40/1000" I.D. x 1/16" wall	ck spc		ITE Dept.
Steel Tubing	1" O.D. x 1/16" wall	18 ft		ITE/IPACO
Steel Tubing	7/8" O.D. x 1/8" wall	10 in		ITE/IPACO
Plate Steel (strapping)	1.75" x 1/16"	9 ft		ITE/IPACO
Plate Steel (strapping)	1" x 1/8"	3 ft		ITE/IPACO
Plate Steel (strapping)	4" x 1/16"	8 ft		ITE/IPACO
Plate Steel (strapping)	3 3/8" x 1/8"	2 ft		ITE/IPACO
Plate Steel (strapping)	2 3/4" x 1/8"	5 in		ITE/IPACO
Plate Steel	2 1/2" x 3/8"	18 in		ITE/IPACO
Bolt		2	AN4-24	ITE/Aircraft Spruce
Bolt		4	AN5-13	ITE/Aircraft Spruce
Bolt		28	AN4-14	ITE/Aircraft Spruce
Bolt		2	AN4-23	ITE/Aircraft Spruce
Bolt		2	AN4-25	ITE/Aircraft Spruce
Bolt (machine screw)		60	MS24694	ITE/Aircraft Spruce
Nut		60	AN365-(match MS)	ITE/Aircraft Spruce
Nut		4	AN365-524A	ITE/Aircraft Spruce
Nut		34	AN365-428A	ITE/Aircraft Spruce
Washer	5/16" hole	8		ITE/Aircraft Spruce
Washer	1/4" hole	72		ITE/Aircraft Spruce
Nylon Bushing	1/4" hole x 1/2" (shaped to size)	70		?
Aluminum Tubing (rect)	1" x 2" outside x 1/8" wall	97 in		ITE/IPACO
Aluminum Plate	1" x 1/8"	18 in		ITE/IPACO
Aluminum Disks	1.25" O.D. x 1/8" wall	2		ITE/IPACO
Aluminum Tubing (circ)	1' O.D. x 1/8" wall	6 in		ITE/IPACO
Matco Wheel	castered, solid rubber	4	P/N 06-01615	Aircraft Spruce
Azusalite Nylon Wheel	4" wheel	2	P/N 06-02600	Aircraft Spruce
Tire & Tube Assembly		2	P/N 06-02800	Aircraft Spruce
Cannondale Shock	Lefty model	2		Cannondale Corp.

Parts List for Chassis

Part Number	Description	Qty	Type
WF-50-099-01	Skid Hardpoint	2	weldament
WF-50-099-01A	Plate	2	cut & drilled
WF-50-099-01B	Tab	20	cut,shaped & drilled
WF-50-099-01C	Plate	2	cut & drilled
WF-50-099-02	Fitting	26	cut, milled & drilled
WF-50-099-02B	Disk	2	cut or stamped
WF-50-099-02C	Fitting	2	cut & drilled
WF-50-099-03	Canard/Skid Hardpoint	2	weldament
WF-50-099-03A	Plate	2	cut & drilled
WF-50-099-03B	Fitting	2	cut & drilled
WF-50-099-03C	Plate	2	cut & drilled
WF-50-099-04-01	Spar Hardpoint	1	weldament
WF-50-099-04-02	Spar Hardpoint	1	weldament
WF-50-099-04A	Fitting	6	cut & rolled
WF-50-099-05-01	Spar Hardpoint	1	weldament
WF-50-099-05-02	Spar Hardpoint	1	weldament
WF-50-099-05A	Fitting	4	cut & rolled
WF-50-099-06	Spar Hardpoint	2	weldament
WF-50-099-06A	Tab	8	cut, milled & drilled
WF-50-099-07	Spar Hardpoint	2	weldament
WF-50-099-08	Spar Hardpoint	2	weldament
WF-50-099-08A	Tab	2	cut, milled & drilled
WF-50-099-10	Skid Hardpoint	10	weldament
WF-50-099-10A	Plate	10	cut & drilled
WF-50-099-10B	Plate	14	cut & drilled
WF-50-099-11	Cockpit Mounting Strut	2	weldament
WF-50-099-11A	Strut	2	cut
WF-50-099-11B	Plate	4	cut
WF-50-099-11C	Tab	4	cut,shaped & drilled
WF-50-099-13	Fitting	2	cut, milled & drilled
WF-50-099-14A1	Strut	2	layed up & cut
WF-50-099-14A2	Strut	2	layed up & cut
WF-50-099-14B	Strut	2	layed up & cut
WF-50-099-14C1	Strut	2	layed up & cut
WF-50-099-14C2	Strut	2	layed up & cut
WF-50-099-14D	Strut	2	layed up & cut
WF-50-099-14E	Strut	2	cut, milled & drilled
WF-50-099-14F	Strut	2	layed up & cut
WF-50-099-14G	Strut	2	layed up & cut
WF-50-099-14H	Strut	2	layed up & cut
WF-50-099-14I	Strut	2	layed up & cut
WF-50-099-14J	Strut	2	cut, milled & drilled
WF-50-099-18	Fitting	4	cut, milled & drilled
WF-50-099-19	Strut/Shock Mount	2	weldament
WF-50-099-19A	Mount	4	cut, milled & drilled



Parts List

ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	WF-50-000-00F	Skid
2	1	WF-50-000-00D	Rear Struts, Left
3	1	WF-50-000-00C	Middle Struts, Left
4	1	WF-50-000-00B	Front Struts, Left
5	1	WF-50-000-00J	Rear Struts, Right
6	1	WF-50-000-00I	Middle Struts, Right
7	1	WF-50-000-00H	Front Struts, Right
8	1	WF-50-000-00K	Structural Cable Routing

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Chassis Assembly

PART NUMBER: WF-50-000

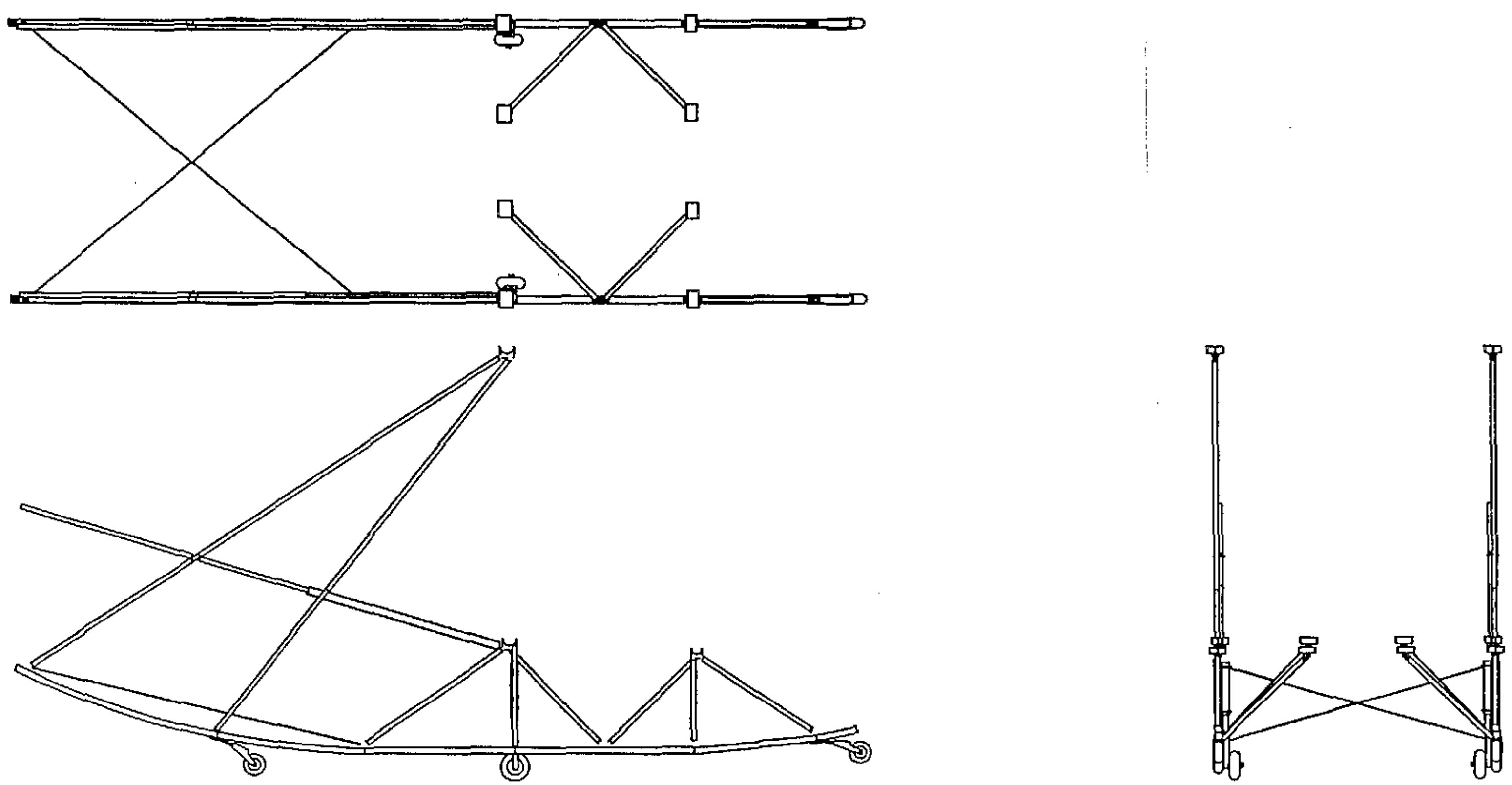
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 **of** 1



ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

DRAWN BY:
David Beck Christensen

MATERIAL:

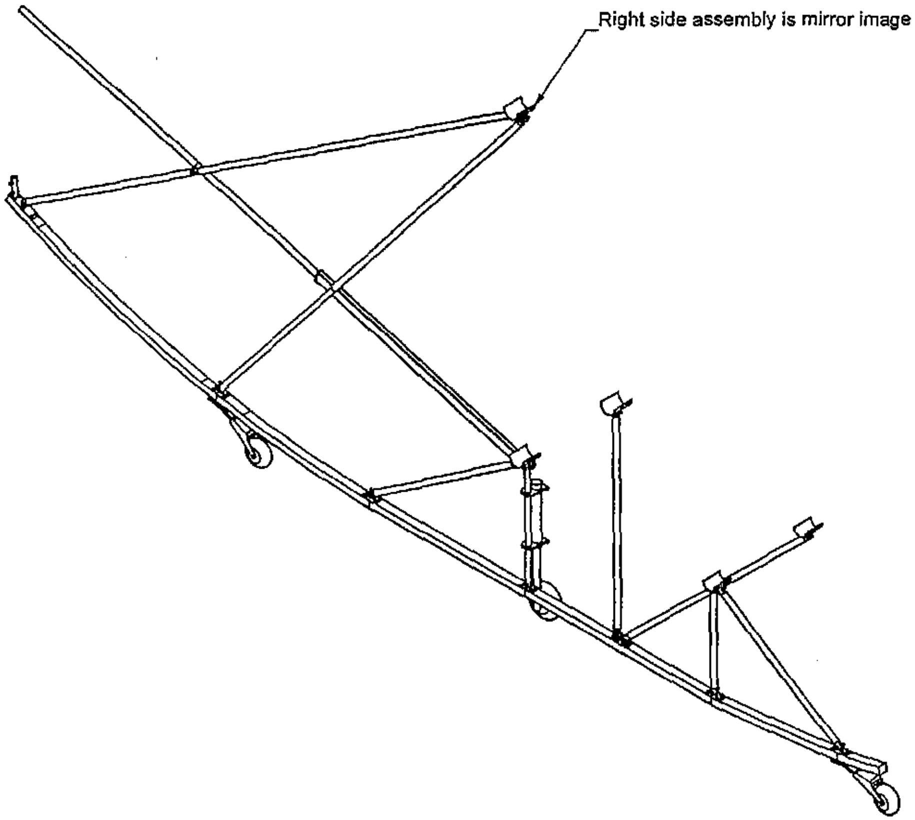
DATE: 2/17/2002

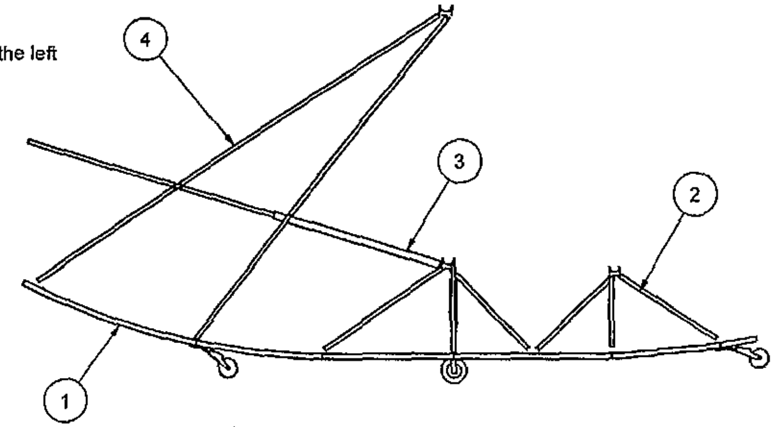
UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

PART DESCRIPTION:	PART NUMBER:	REV
Chassis Assembly	WF-50-000	A

SCALE: SIZE: B SHEET 1 of 1





Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-000-00F	Skid
2	1	WF-50-000-00D	Rear Struts, Left
3	1	WF-50-000-00C	Middle Struts, Left
4	1	WF-50-000-00B	Front Struts, Left

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

Utah State University — Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Chassis Assembly

PART NUMBER: WF-50-000-00A

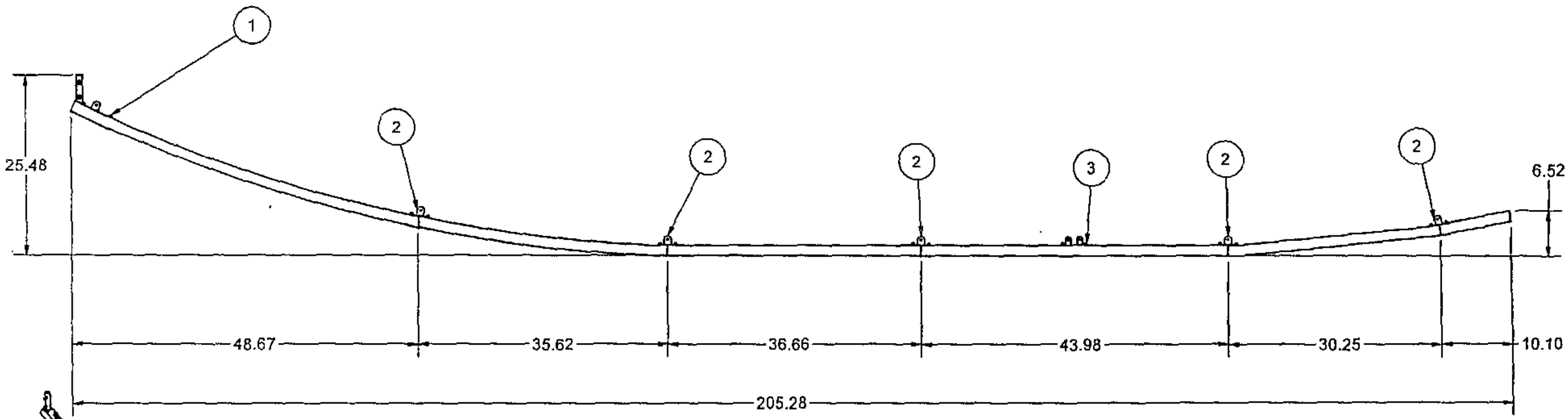
REV A

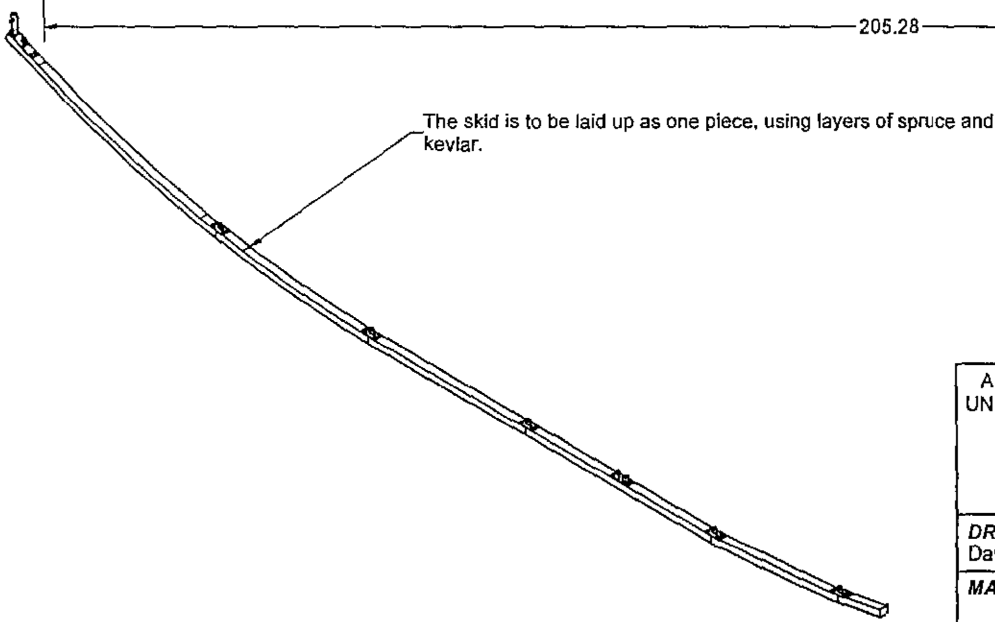
DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 *of* 1





Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-000-03A	Canard Mount Assembly
2	5	WF-50-000-05	Skid Hardpoint Assembly
3	1	WF-50-000-01	Angled Hard Point Asse mbly

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

Utah State University — Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Skid Hardpoint Placement

PART NUMBER: WF-50-000-00E

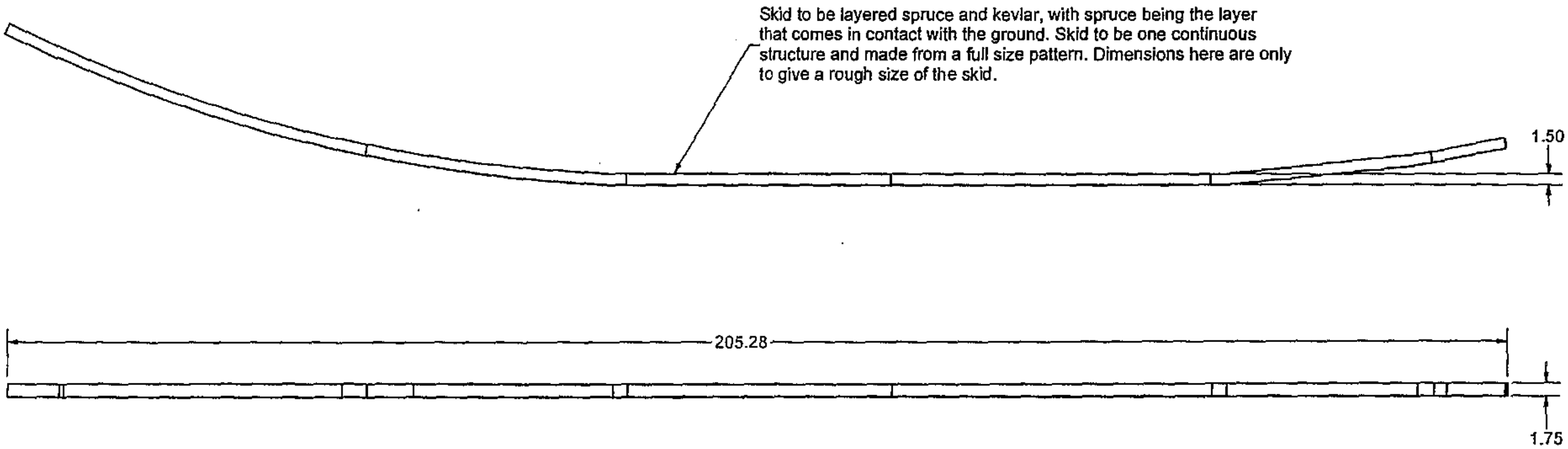
REV A

DATE: 2/17/2002

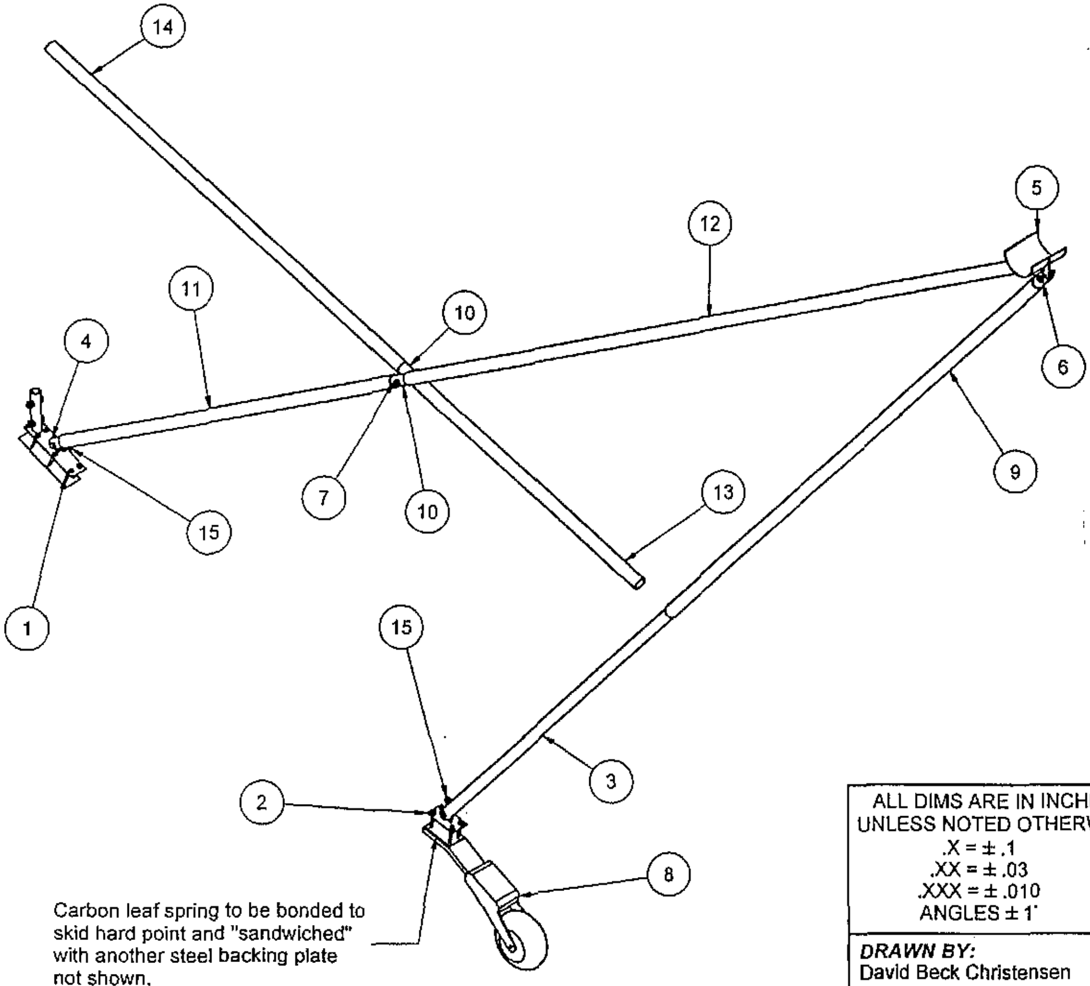
SCALE:

SIZE: B

SHEET 1 ***of*** 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState University Mechanical & Aerospace Engineering			
DRAWN BY: David Beck Christensen	**USU WRIGHT FLYER 1903-2003**			
MATERIAL:	PART DESCRIPTION: Skid		PART NUMBER: WF-50-000-00F	REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-000-03A	Canard Mount Assembly
2	1	WF-50-000-05	Skid Hardpoint Assembly
3	1	WF-50-000-09	Tube Assembly
4	2	WF-50-000-06	Tube Fitting Assembly
5	1	WF-50-099-07	Hardpoint, Spar, Lead, Top
6	1	WF-50-000-04	Tube Fitting Assembly
7	1	WF-50-000-08	Bolt & Nut Assembly
8	1	P_N 06-01615	Matco Wheel & Carbon Spring
9	1	WF-50-099-14B	Strut
10	2	WF-50-099-18	Fitting, Splice
11	1	WF-50-099-14A1	Strut
12	1	WF-50-099-14A2	Strut
13	1	WF-50-099-14C2	Strut
14	1	WF-50-099-14C1	Strut
15	2	CABLE PLATE - 1PRONG .25holemount	CABLE PLATE, 1-PRONG

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Front Struts, Left

PART NUMBER: WF-50-000-00B

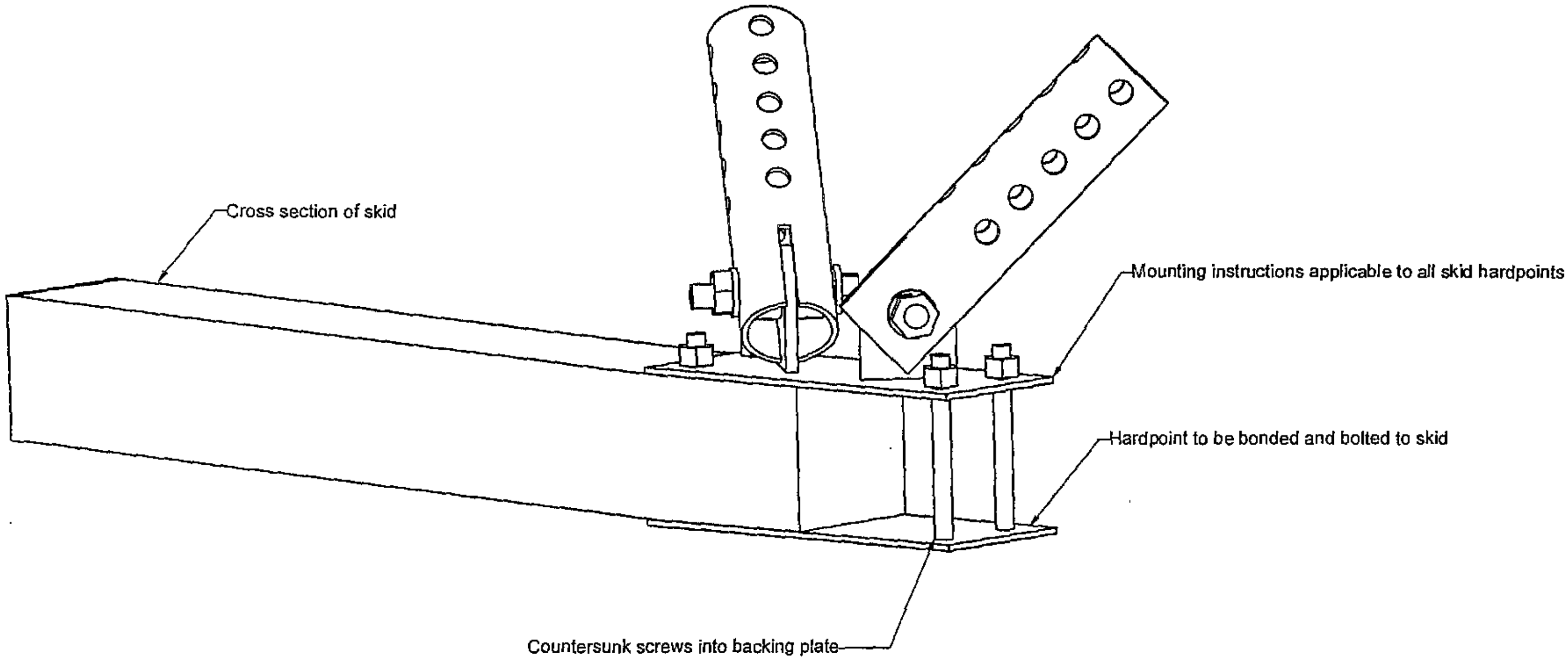
REV A

DATE: 2/17/2002

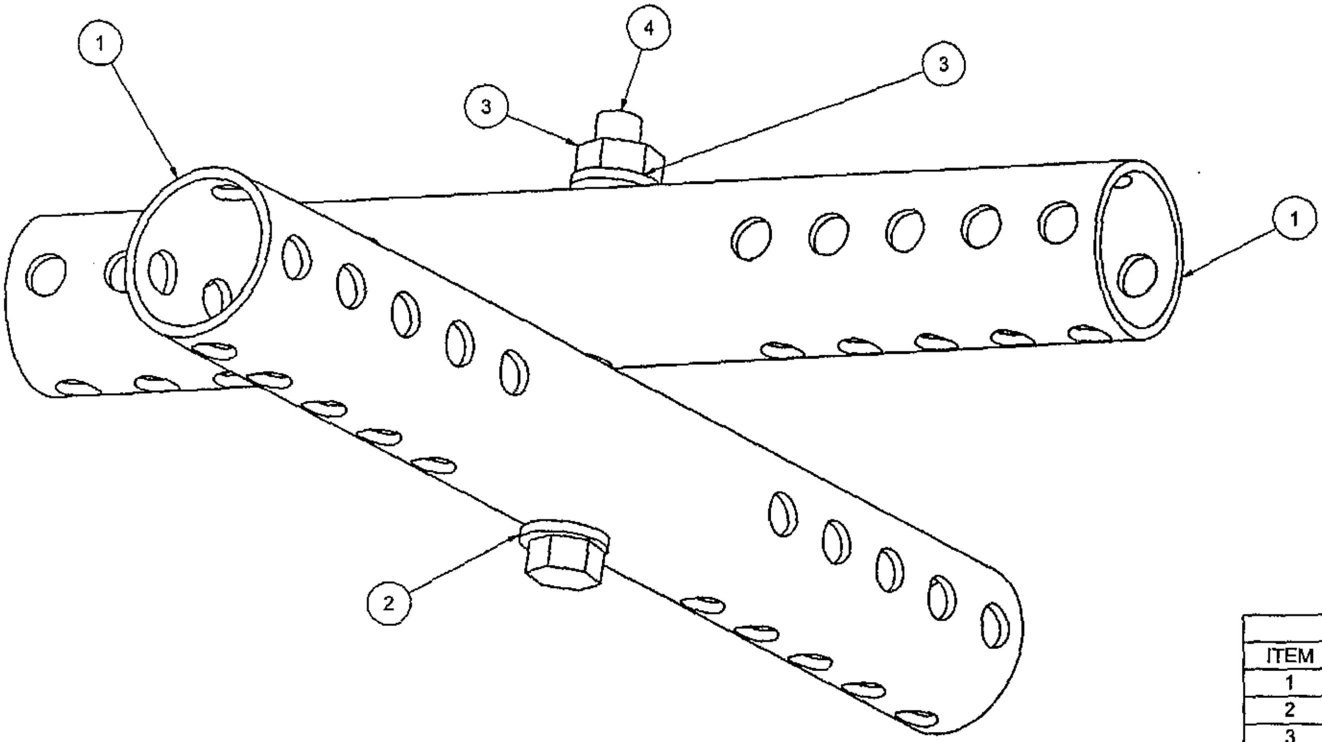
SCALE:

SIZE: B

SHEET 1 *of* 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	Utah State University Mechanical & Aerospace Engineering **USU WRIGHT FLYER 1903-2003**			
DRAWN BY: David Beck Christensen				
MATERIAL:	PART DESCRIPTION: Mounting Info		PART NUMBER: WF-50-000-01A	REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	WF-50-099-18	Fitting, Splice
2	2	.25washer	Washer, misc
3	1	AN365-428A	Nut
4	1	AN4-24	Bolt

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Assembly Info

PART NUMBER: WF-50-000-01B

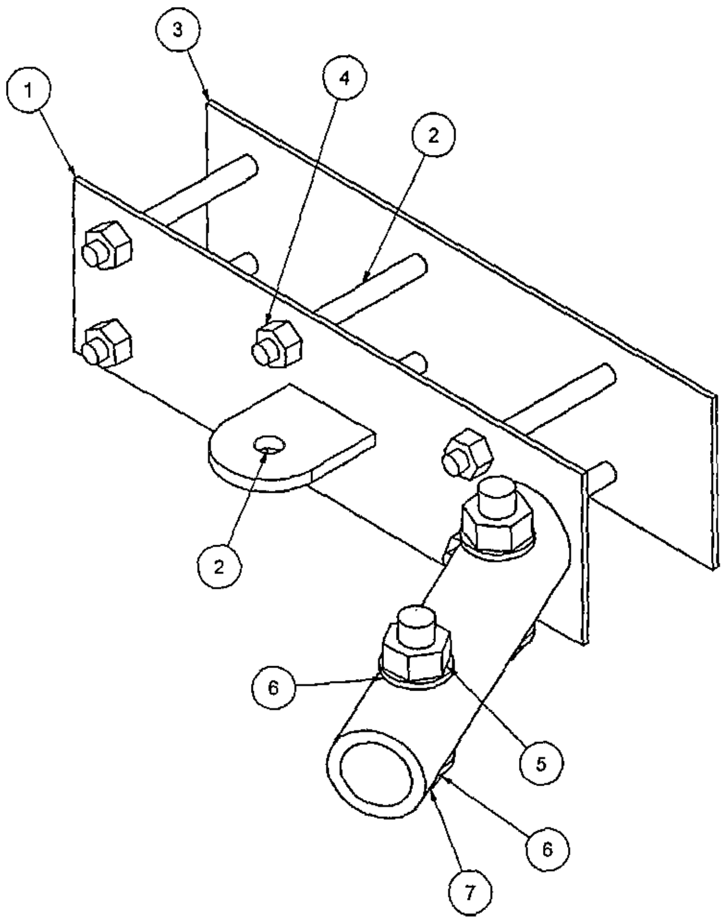
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 of 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-099-03	Mount, Canard to Skid
2	6	MS24694	Screw, Machine
3	1	WF-50-099-03C	Plate, Mounting
4	6	AN365	Nut
5	2	AN365-524A	Nut
6	4	.313washer	Washer, misc
7	2	AN5-13	Bolt

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ±.1
.XX = ±.03
.XXX = ±.010
ANGLES ± 1'

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Canard Mount Assembly

PART NUMBER: WF-50-000-03A

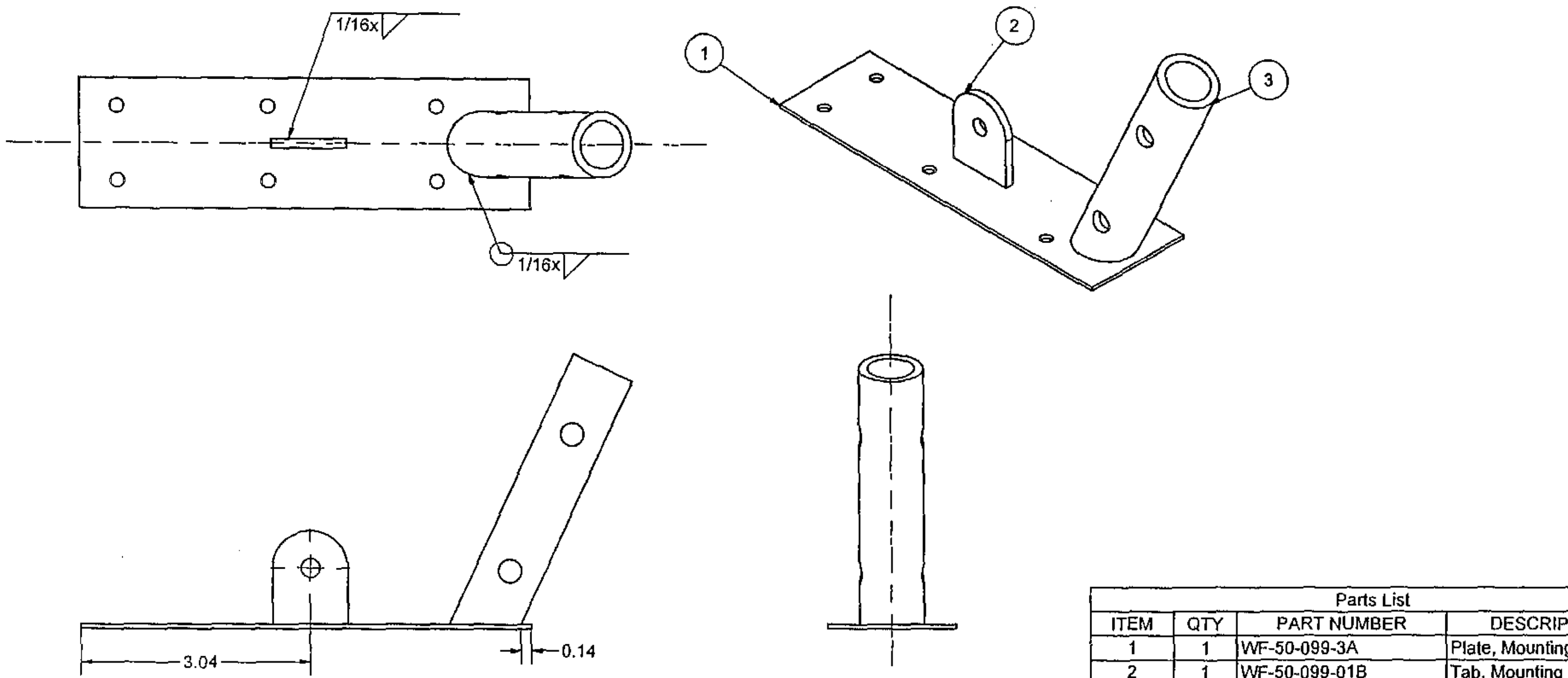
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 *of* 1



Parts List

ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-099-3A	Plate, Mounting
2	1	WF-50-099-01B	Tab, Mounting
3	1	WF-50-099-03B	Tube, Fitting

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Mount, Canard to Skid

PART NUMBER: WF-50-099-03

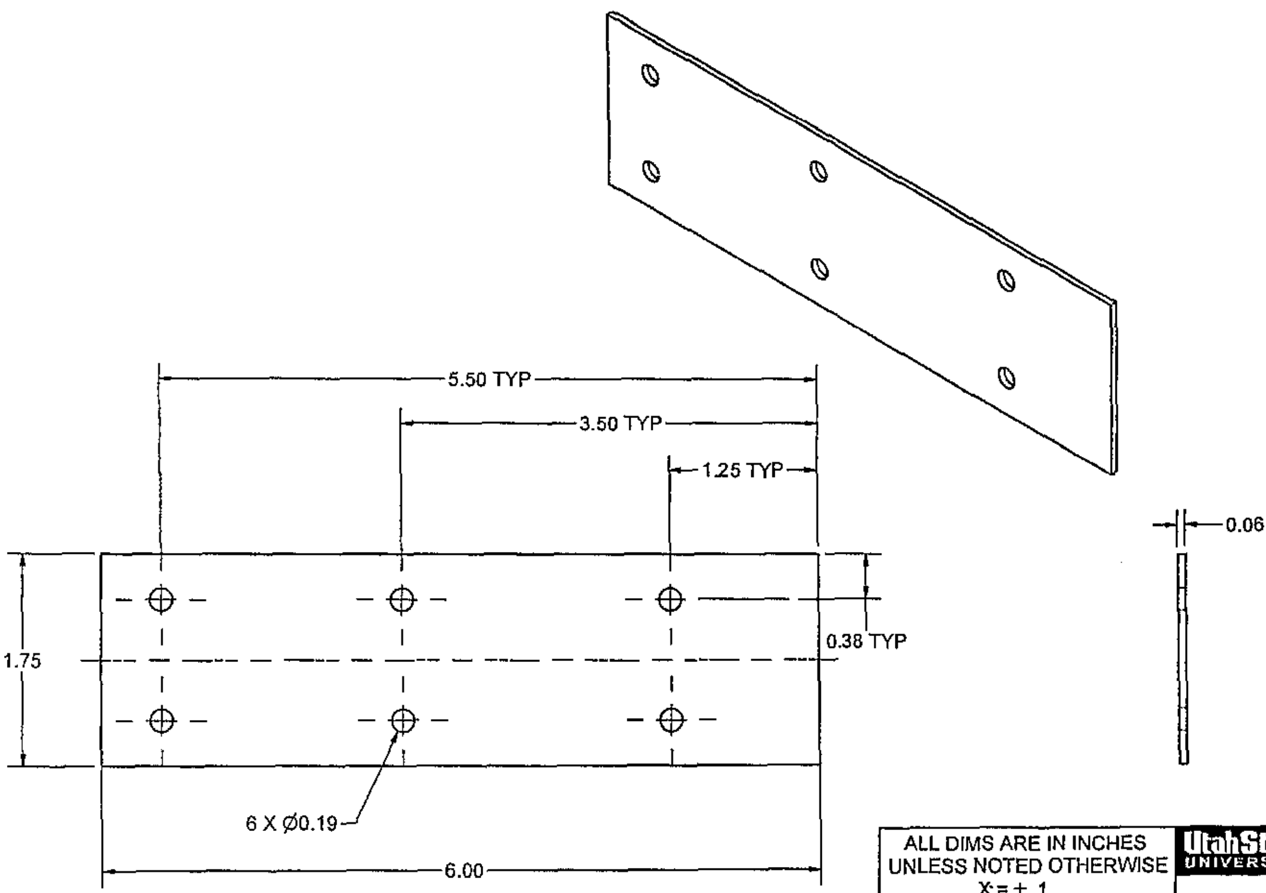
REV A

DATE: 2/17/2002

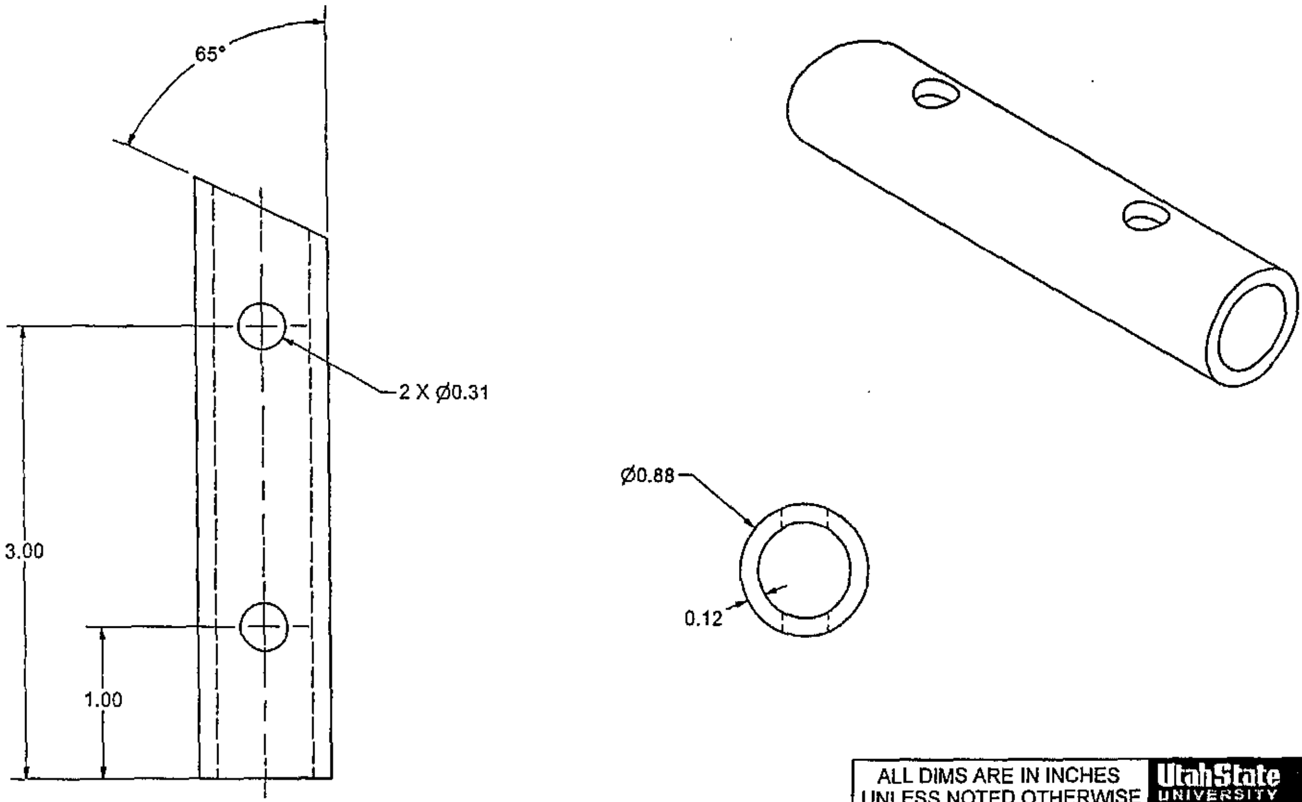
SCALE:

SIZE: B

SHEET 1 of 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003			
DRAWN BY: David Beck Christensen				
MATERIAL: Steel, Mild	PART DESCRIPTION: Plate, Mounting		PART NUMBER: WF-50-099-3A	REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	



ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

Utah State University — Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL: Steel, Mild

PART DESCRIPTION: Tube, Fitting

PART NUMBER: WF-50-099-03B

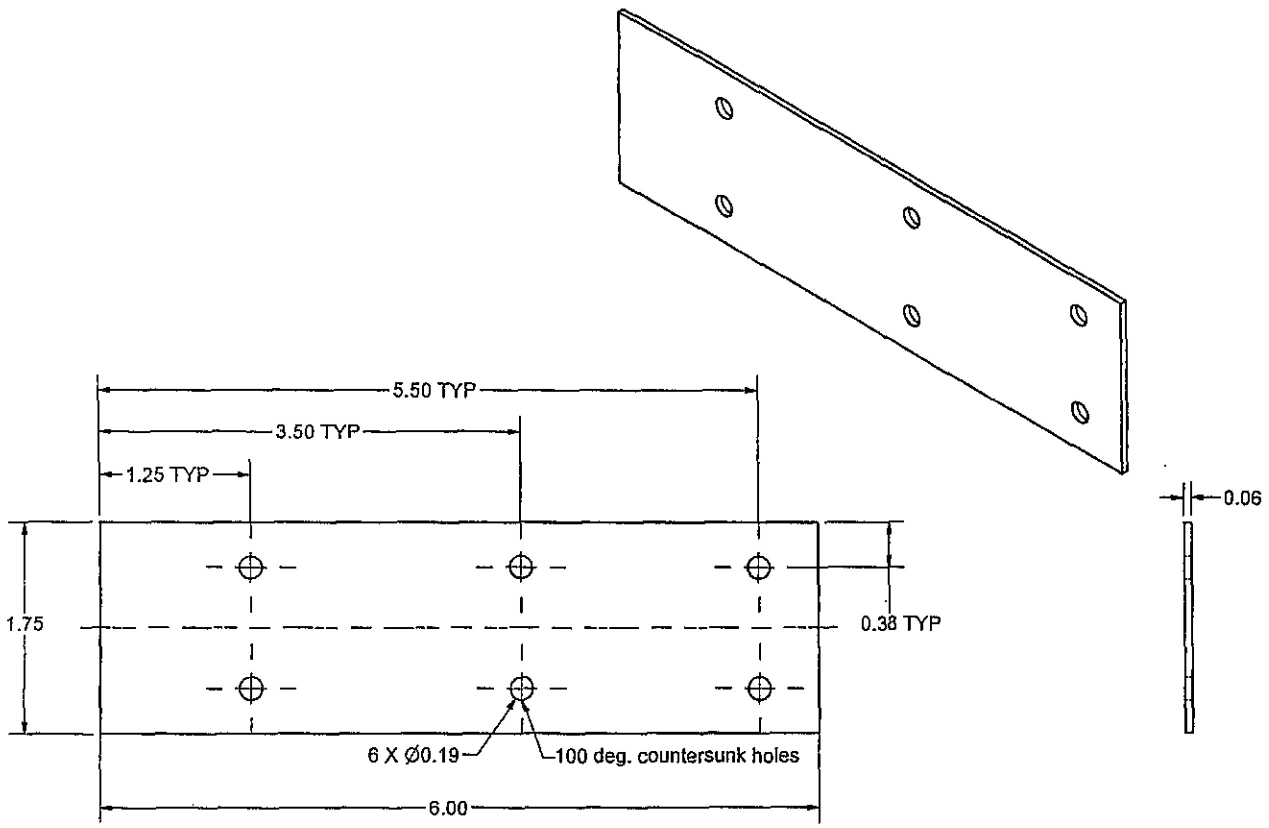
REV A

DATE: 2/17/2002

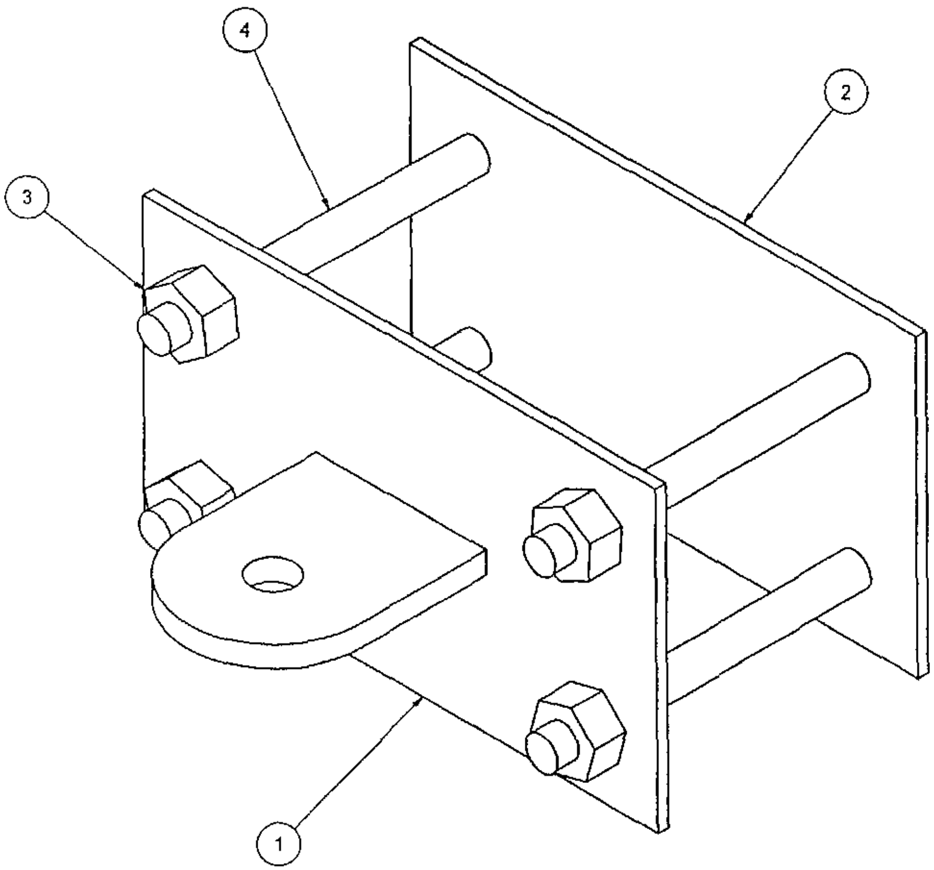
SCALE:

SIZE: B

SHEET 1 ***of*** 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*			
DRAWN BY: David Beck Christensen				
MATERIAL: Steel, Mild	*PART DESCRIPTION:* Plate, Mounting		*PART NUMBER:* WF-50-099-03C	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-099-10	
2	1	WF-50-099-10B	Plate, Mounting
3	4	AN365	Nut
4	4	MS24694	Screw, Machine

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

Utah State University — Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Skid Hardpoint Assembly

PART NUMBER: WF-50-000-05

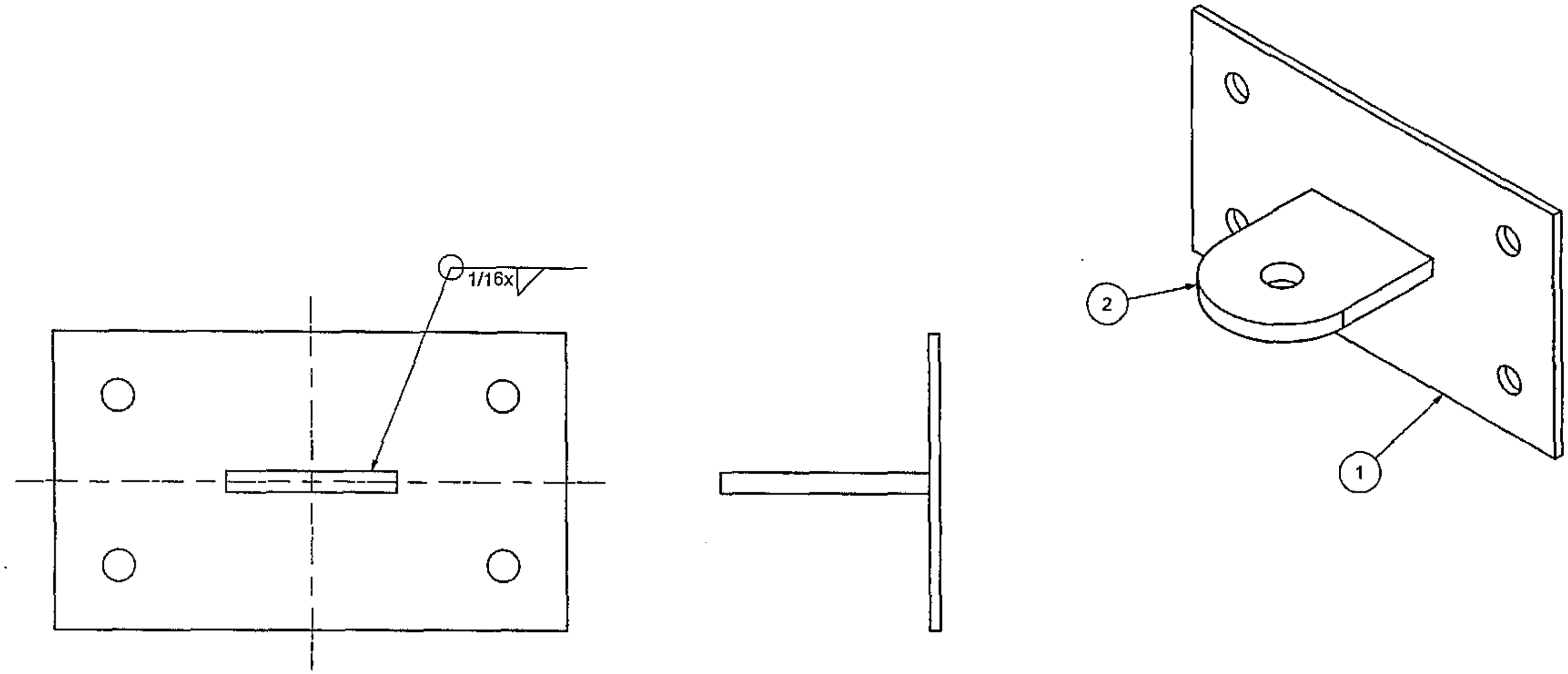
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 *of* 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-099-10A	Plate, Mounting
2	1	WF-50-099-01B	Tab, Mounting

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1˚

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Hardpoint, Skid

PART NUMBER: WF-50-099-10

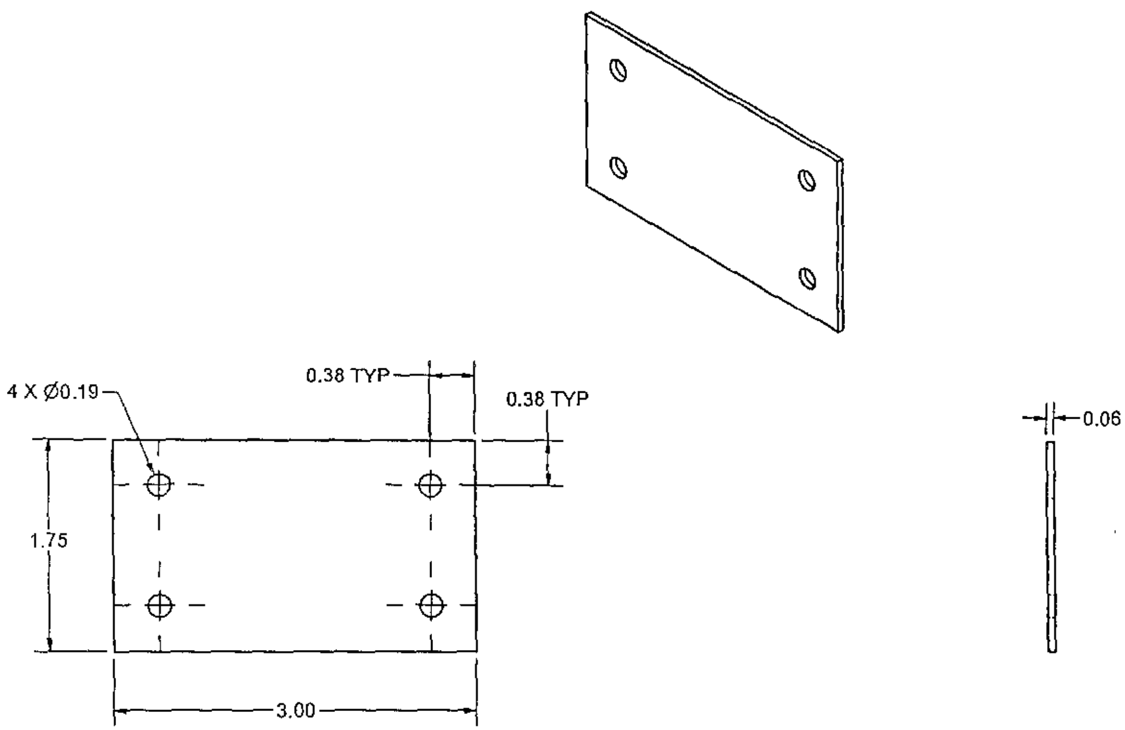
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 of 1



ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1˚

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL: Steel, Mild

PART DESCRIPTION: Plate, Mounting

PART NUMBER: WF-50-099-10A

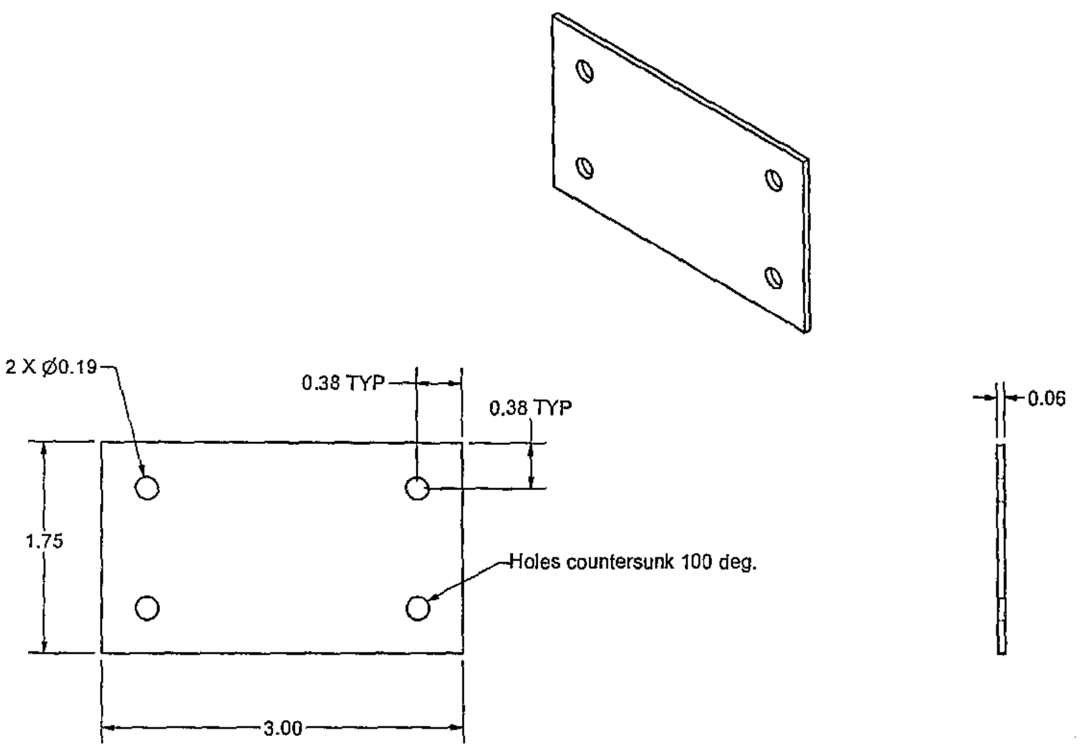
REV A

DATE: 2/17/2002

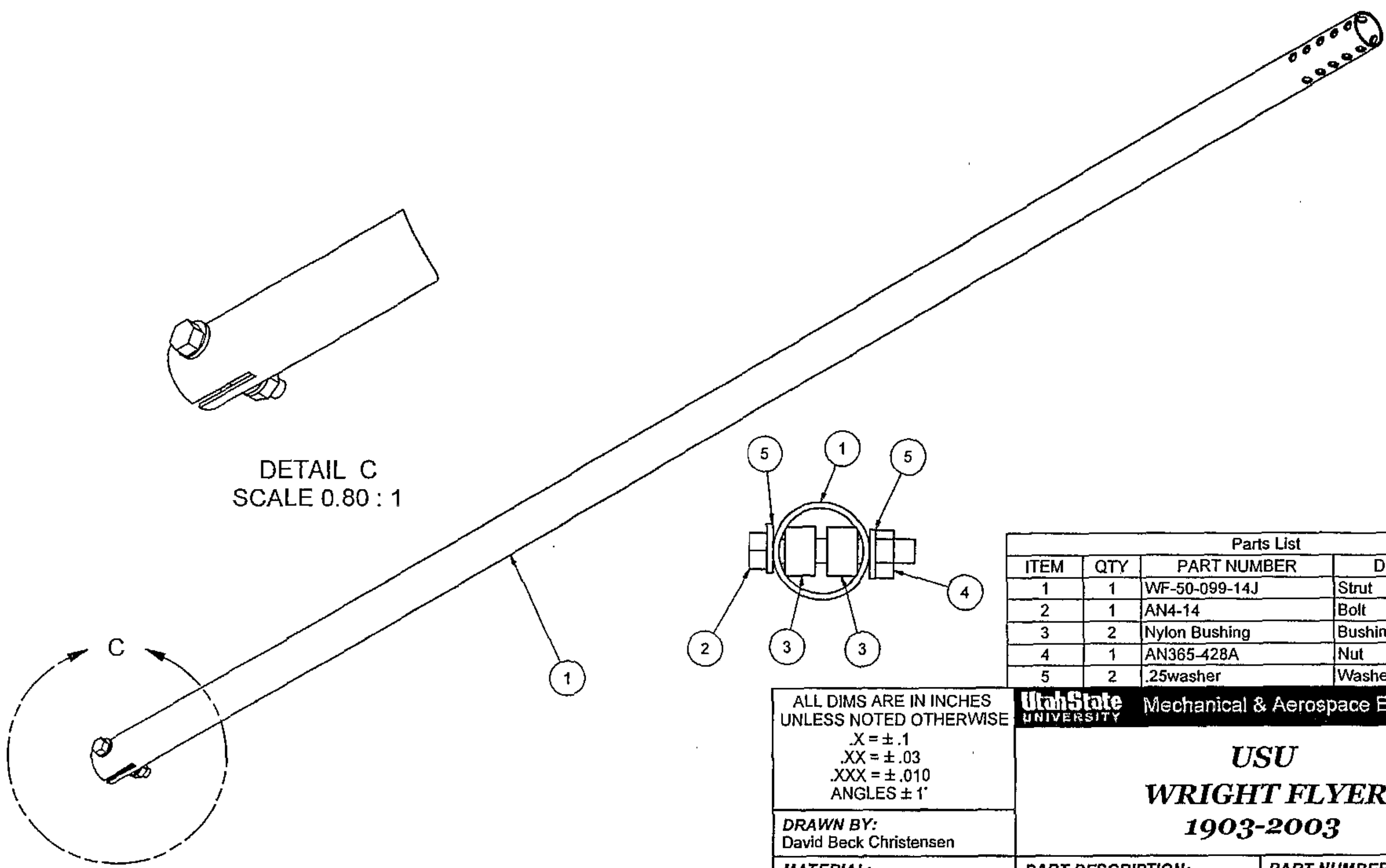
SCALE:

SIZE: B

SHEET 1 **of** 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*			
DRAWN BY: David Beck Christensen				
MATERIAL: Steel, Mild	*PART DESCRIPTION:* Plate, Mounting		*PART NUMBER:* WF-50-099-10B	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-099-14J	Strut
2	1	AN4-14	Bolt
3	2	Nylon Bushing	Bushing, Nylon
4	1	AN365-428A	Nut
5	2	.25washer	Washer, misc

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

Utah State University — Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Tube Assembly

PART NUMBER: WF-50-000-09

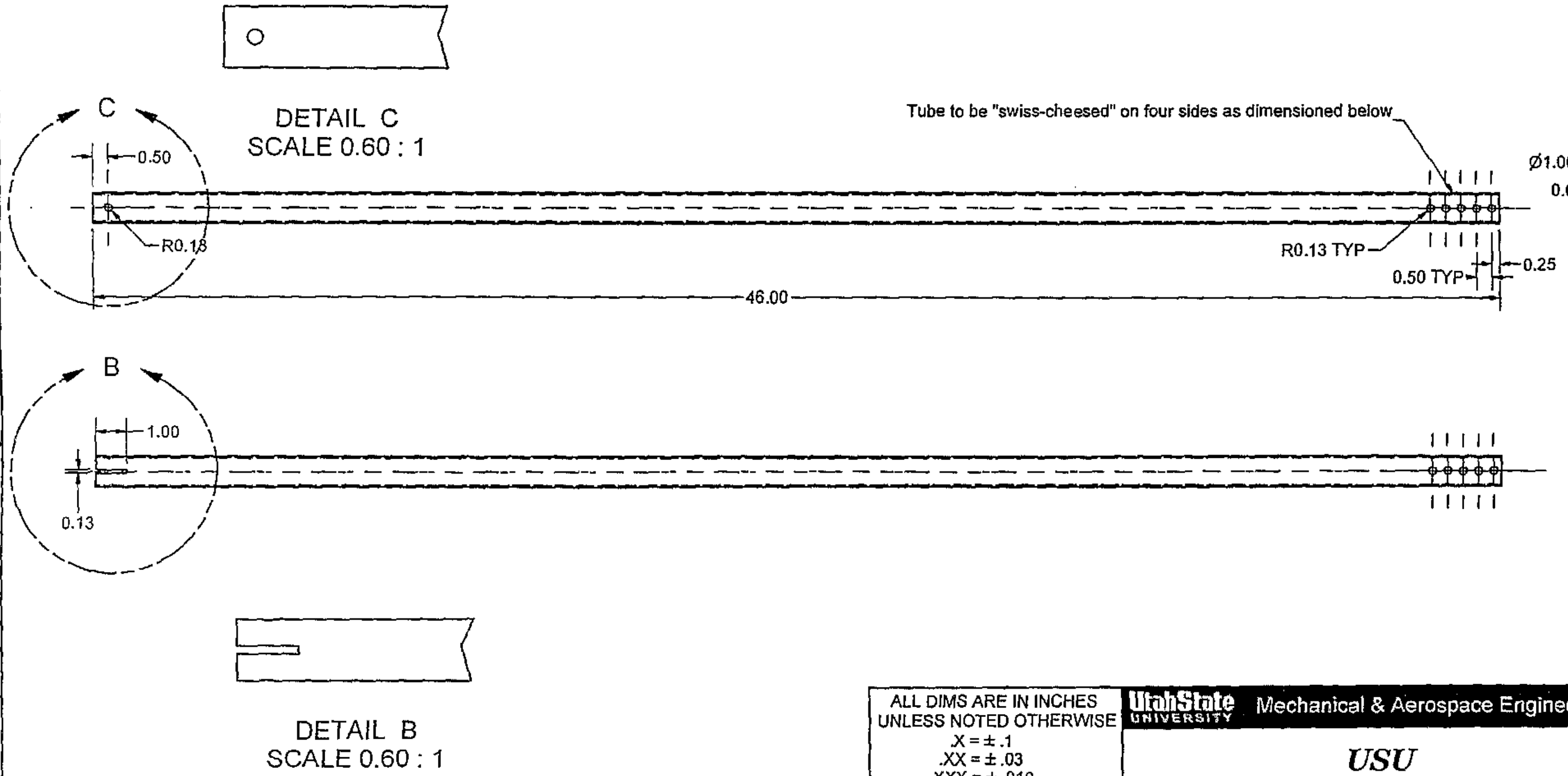
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 ***of*** 1



ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: David Beck Christensen

MATERIAL: Steel, Mild

PART DESCRIPTION: Strut

PART NUMBER: WF-50-099-14J

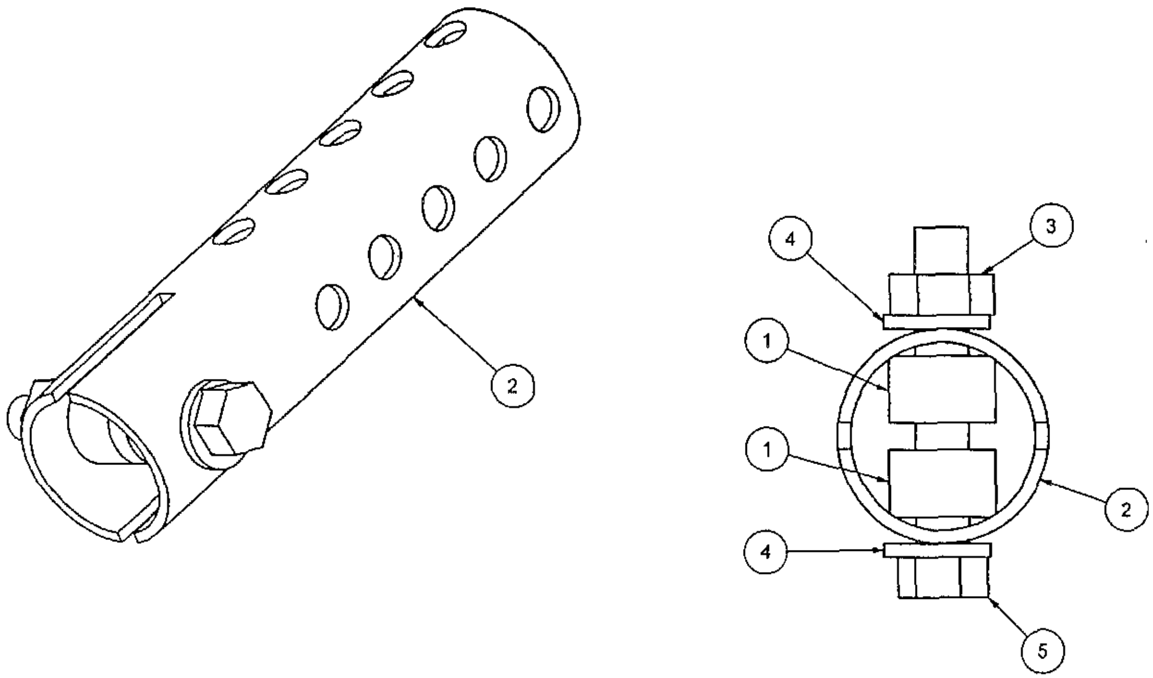
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 of 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	Nylon Bushing	Bushing, Nylon
2	1	WF-50-099-02	Tube, Fitting
3	1	AN365-428A	Nut
4	2	.25washer	Washer, misc
5	1	AN4-14	Bolt

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Tube Fitting Assembly

PART NUMBER: WF-50-000-06

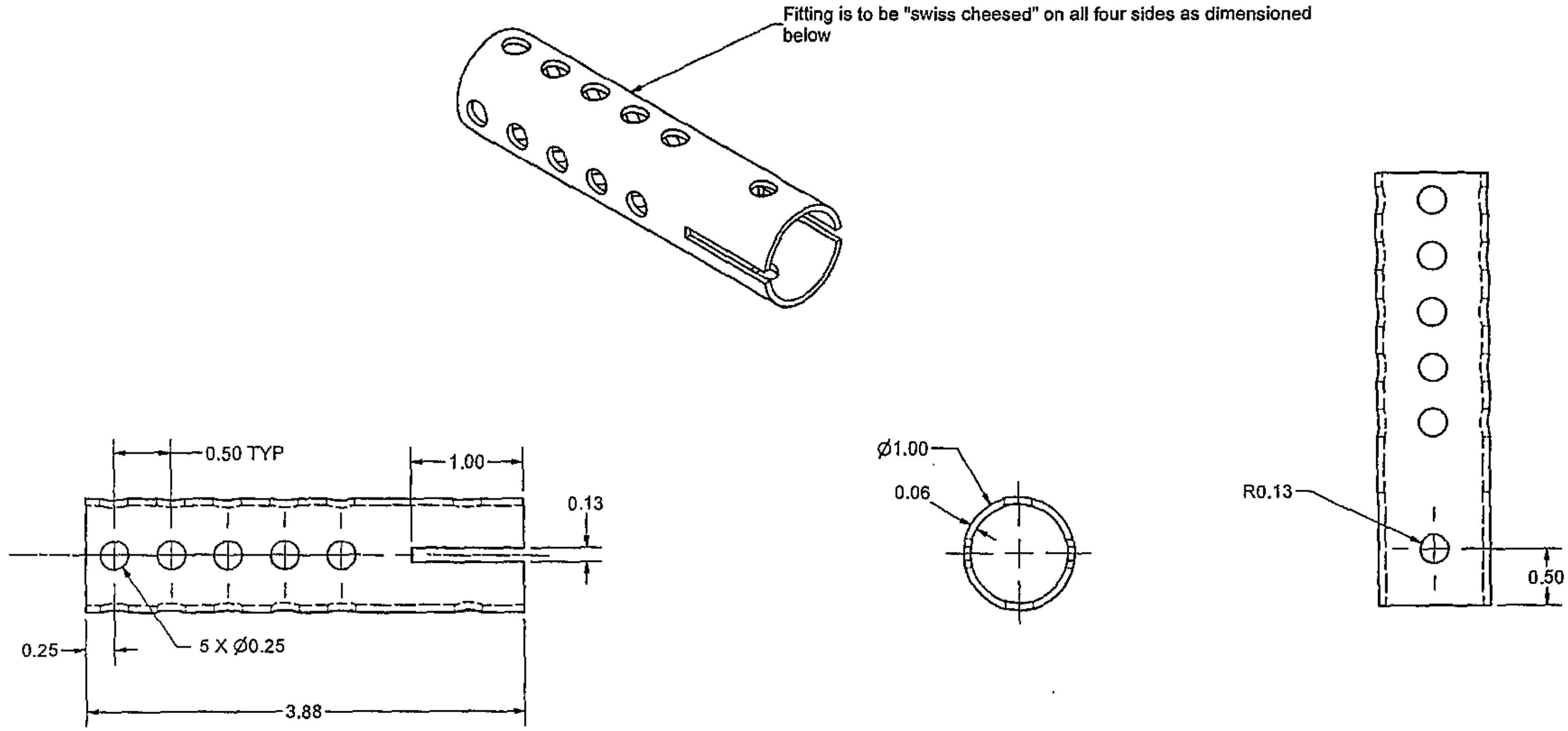
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 *of* 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL: Steel, Mild

PART DESCRIPTION: Tube, Fitting

PART NUMBER: WF-50-099-02

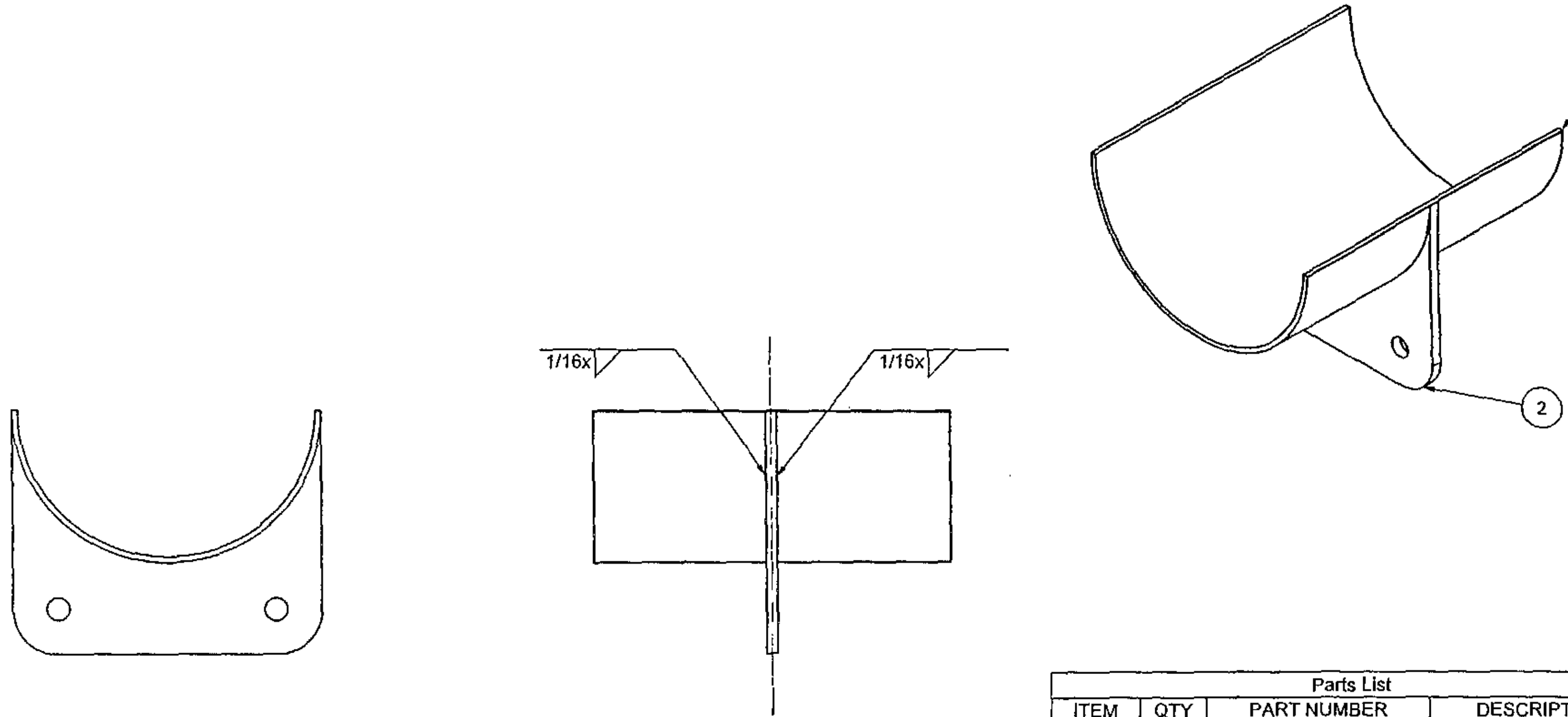
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 *of* 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-099-04A	Tube, Mount, Spar, Lead
2	1	WF-50-099-06A	Tab, Mount, Spar, Lead

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Hardpoint, Spar, Lead, Top

PART NUMBER: WF-50-099-07

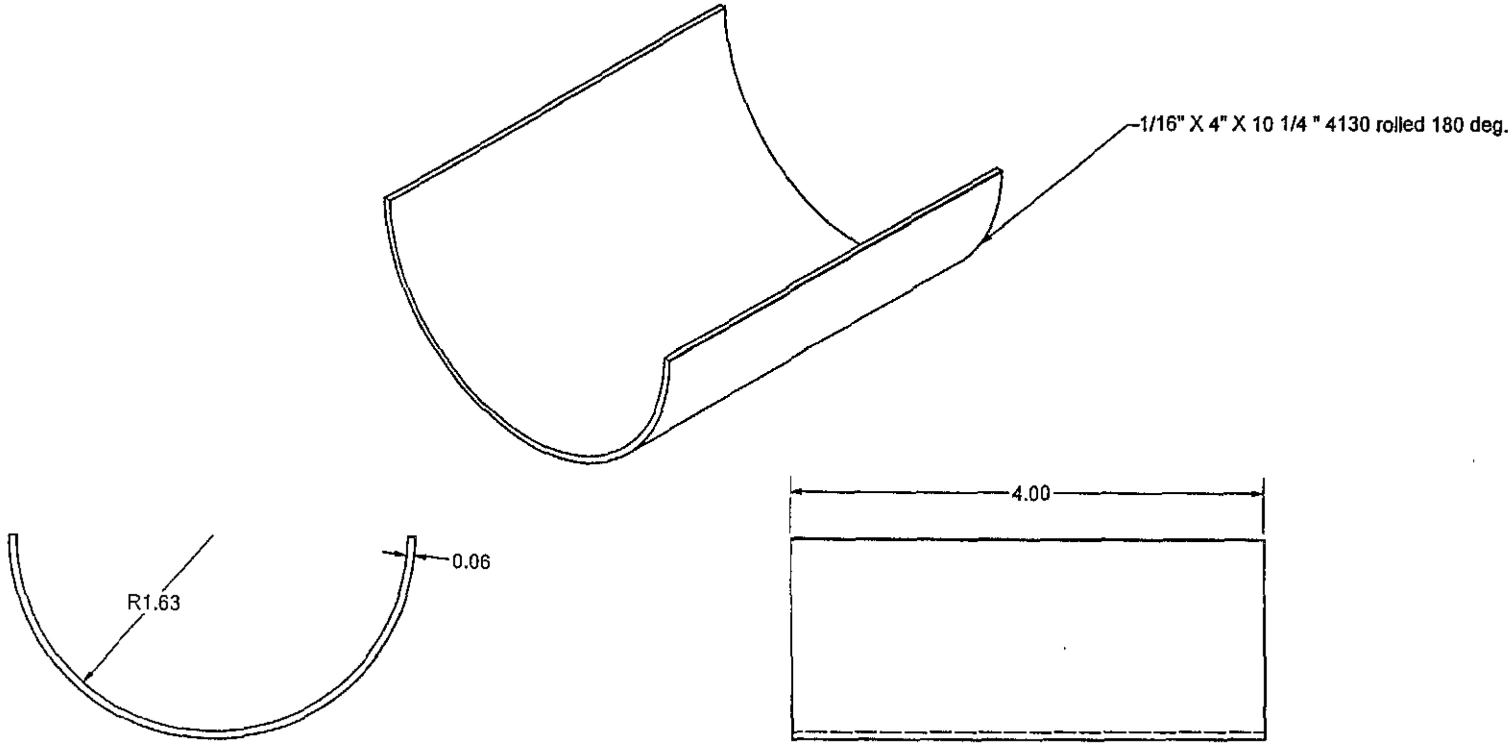
REV A

DATE: 2/17/2002

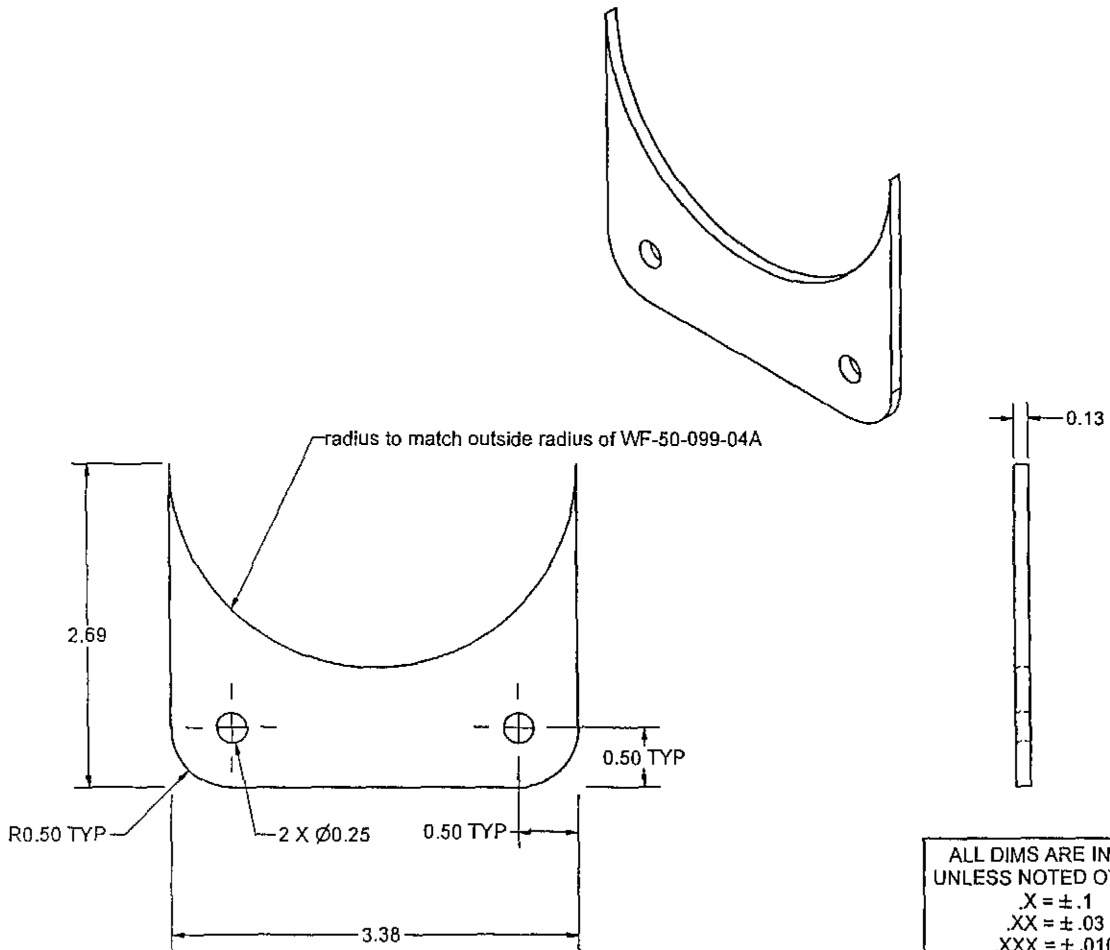
SCALE:

SIZE: B

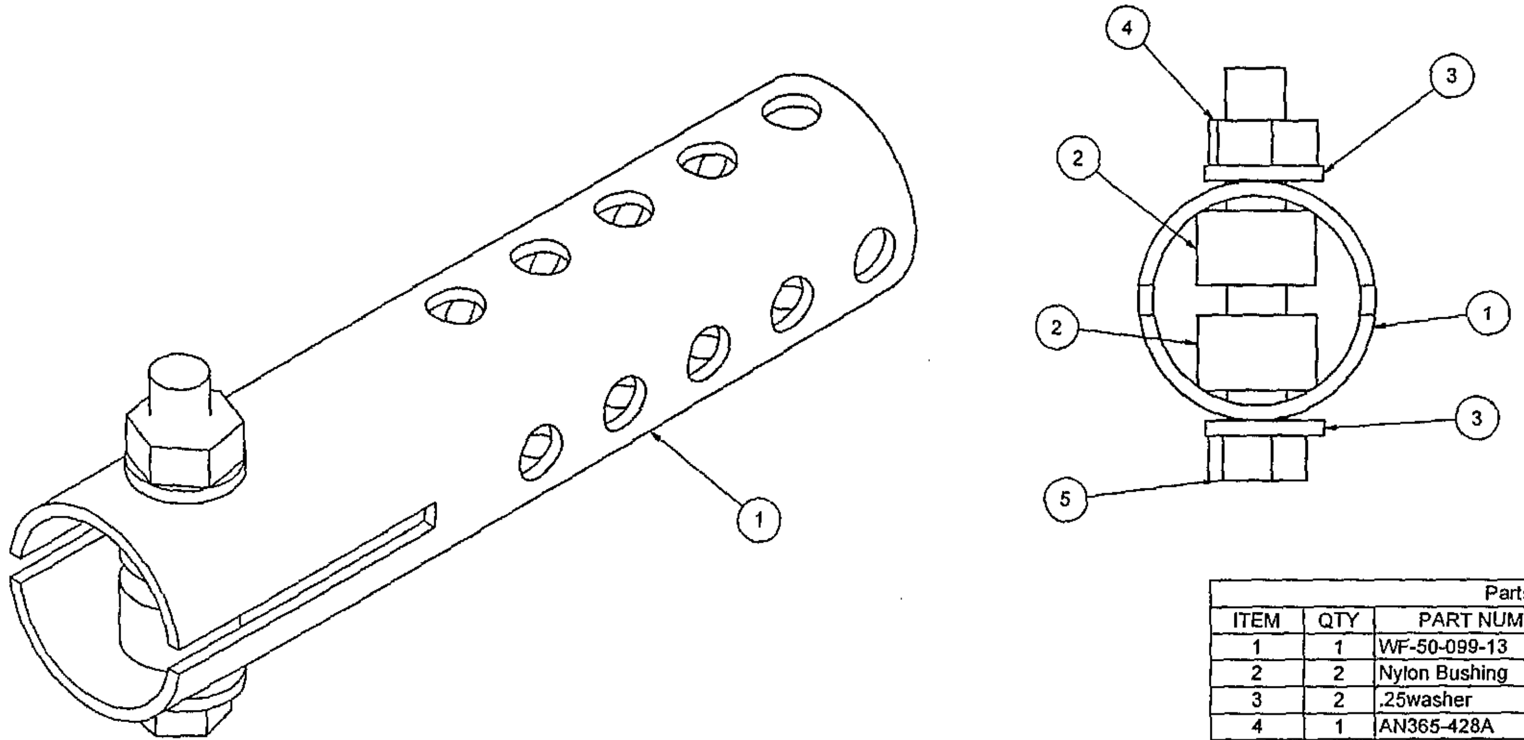
SHEET 1 **of** 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*		
DRAWN BY: David Beck Christensen			
MATERIAL: Steel, Mild	*PART DESCRIPTION:* Tube, Mount, Spar, Lead	*PART NUMBER:* WF-50-099-04A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*		
DRAWN BY: David Beck Christensen			
MATERIAL: Steel, Mild	*PART DESCRIPTION:* Tab, Mount, Spar, Lead	*PART NUMBER:* WF-50-099-06A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-099-13	Tube, Fitting
2	2	Nylon Bushing	Bushing, Nylon
3	2	.25washer	Washer, misc
4	1	AN365-428A	Nut
5	1	AN4-14	Bolt

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1˚

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Tube Fitting Assembly

PART NUMBER: WF-50-000-04

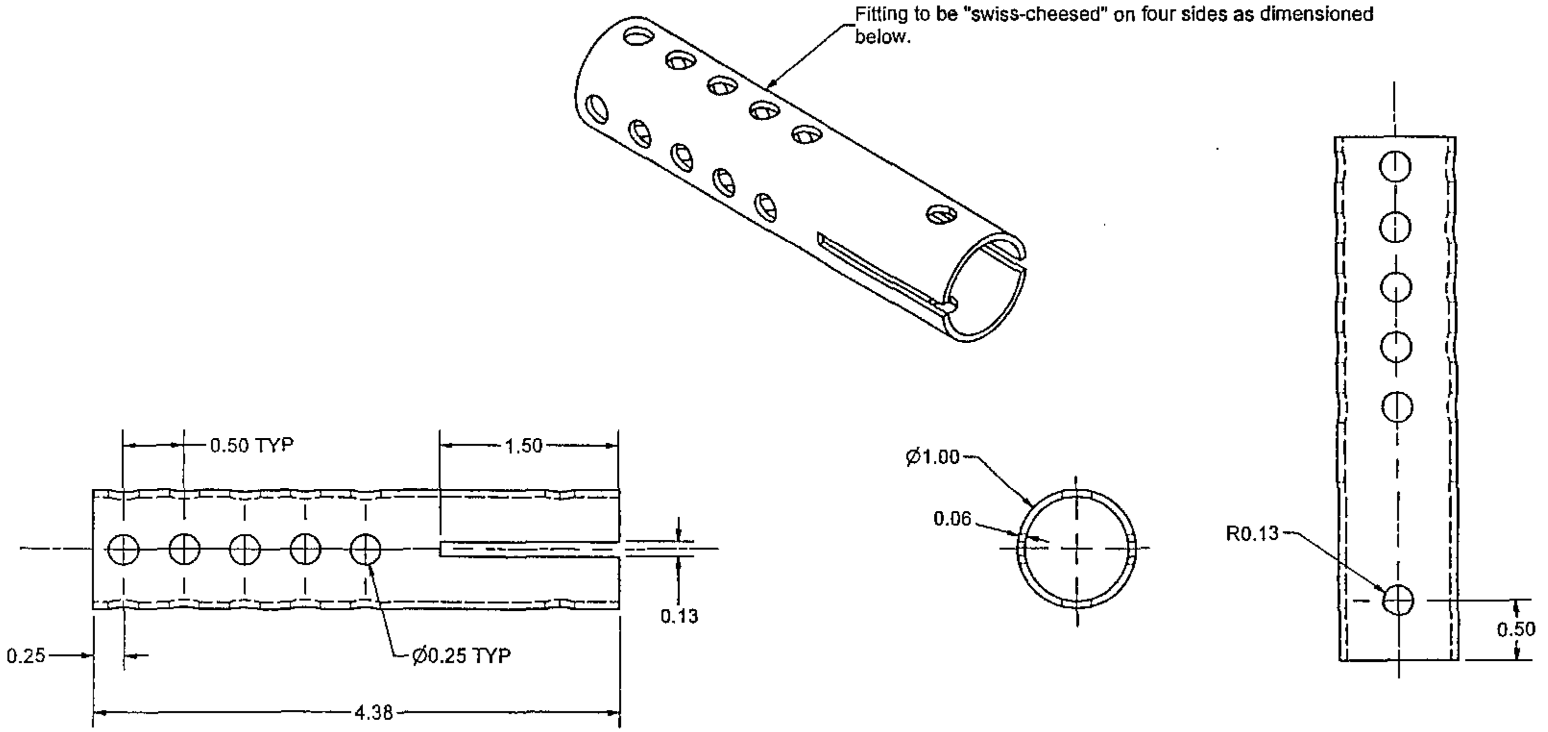
REV A

DATE: 2/17/2002

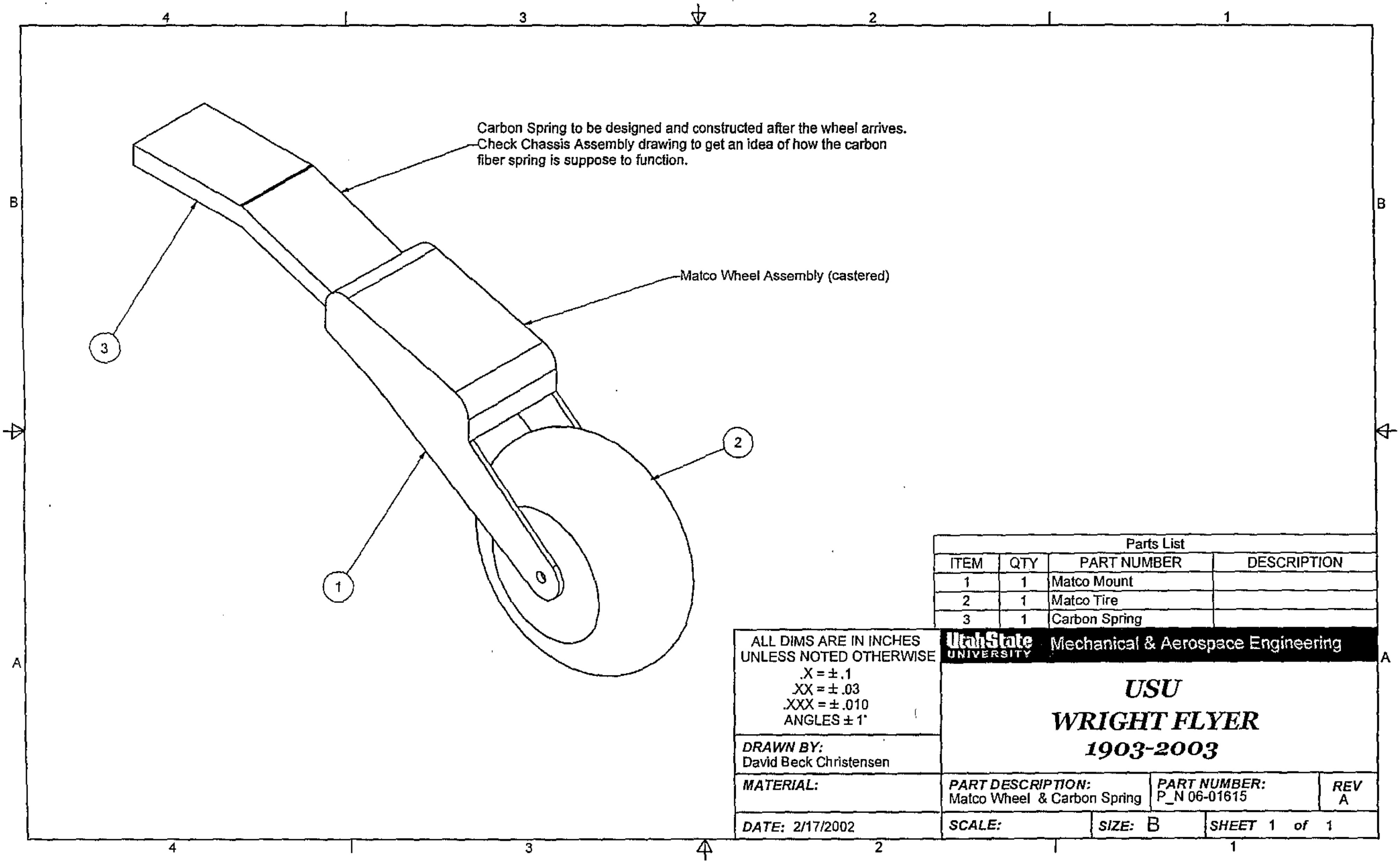
SCALE:

SIZE: B

SHEET 1 **of** 1



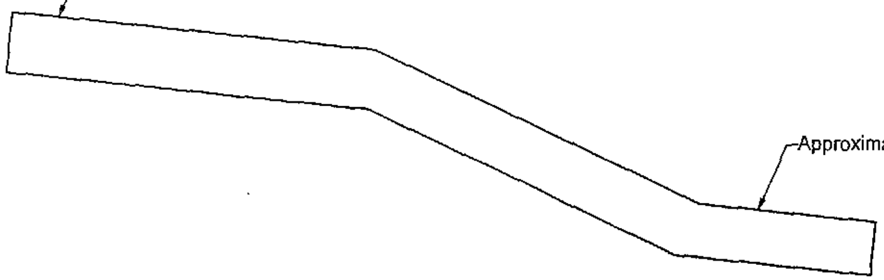
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*		
DRAWN BY: David Beck Christensen			
MATERIAL: Steel, Mild	***PART DESCRIPTION:*** Tube, Fitting	***PART NUMBER:*** WF-50-099-13	***REV*** A
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 ***of*** 1

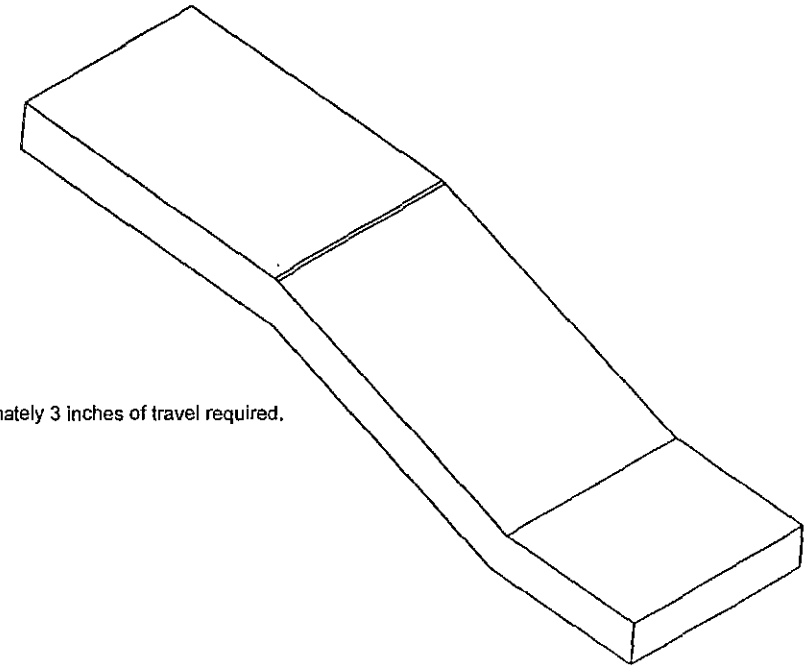


Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	Matco Mount	
2	1	Matco Tire	
3	1	Carbon Spring	

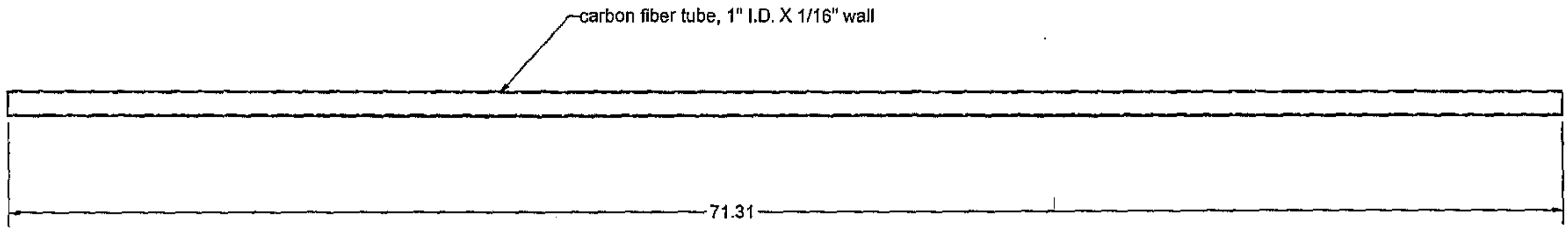
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1˚	UtahState UNIVERSITY Mechanical & Aerospace Engineering **USU WRIGHT FLYER 1903-2003**		
DRAWN BY: David Beck Christensen			
MATERIAL:	*PART DESCRIPTION:* Matco Wheel & Carbon Spring	*PART NUMBER:* P_N 06-01615	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1

This spring will need to be fashioned after the arrival of the Matco wheels. It will need to be constructed much like the carbon fiber landing gear munt that Dave Widauf showed to David Christensen. It will need to have holes drilled to match WF-50-099-10B. It will be mounted by being "sandwiched" at the indicated locations, inbetween the skid and the mounting plate. Longer machine screws will also need to be used.

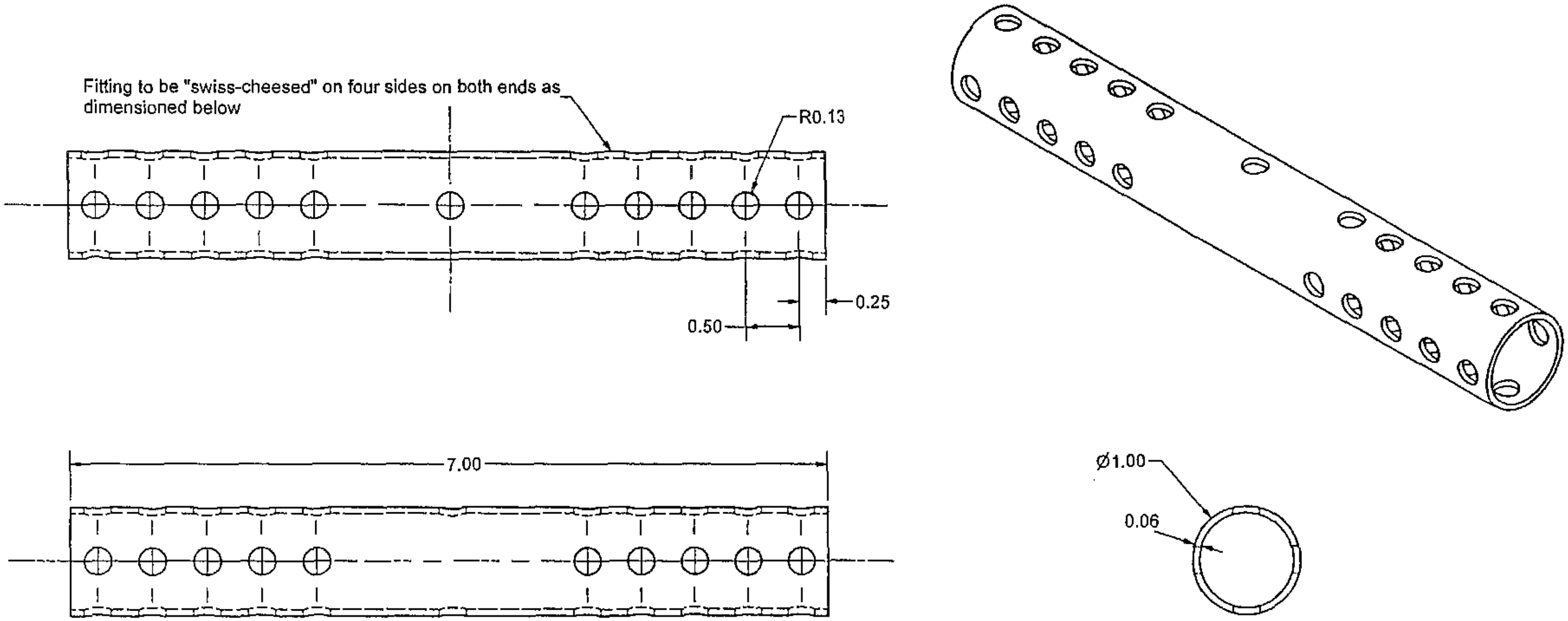




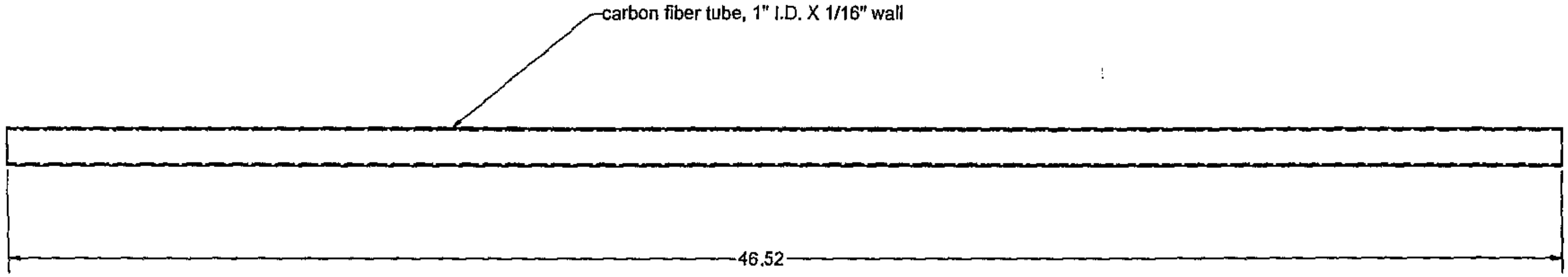
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState University Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003			
DRAWN BY: David Beck Christensen				
MATERIAL: Carbon Fiber	PART DESCRIPTION: Castered Wheel Leaf Spring		PART NUMBER: Carbon Spring	REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	



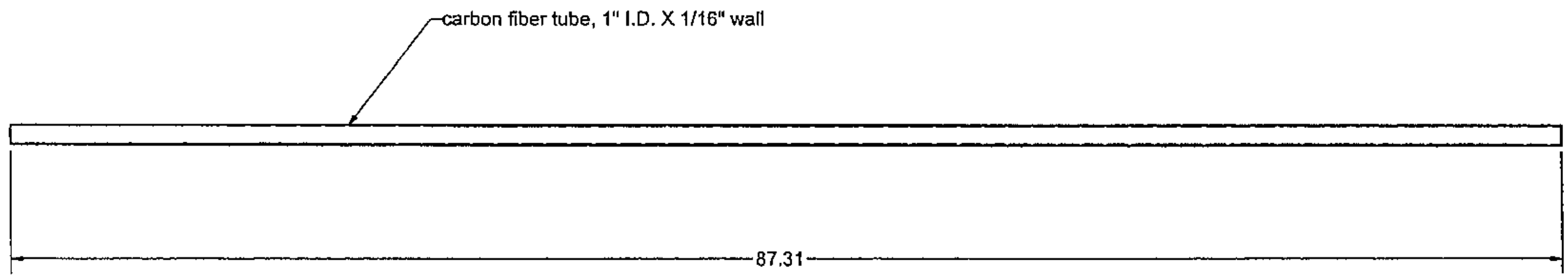
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering			
DRAWN BY: David Beck Christensen	USU WRIGHT FLYER 1903-2003			
MATERIAL: Carbon Fiber	PART DESCRIPTION: Strut		PART NUMBER: WF-50-099-14B	REV
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1˚	UtahState University Mechanical & Aerospace Engineering		
DRAWN BY: David Beck Christensen	***USU WRIGHT FLYER 1903-2003***		
MATERIAL: Steel, Mild	*PART DESCRIPTION:* Fitting, Splice	*PART NUMBER:* WF-50-099-18	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering USU WRIGHT FLYER 1903-2003			
DRAWN BY: David Beck Christensen				
MATERIAL: Carbon Fiber	*PART DESCRIPTION:* Strut		*PART NUMBER:* WF-50-099-14A1	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	

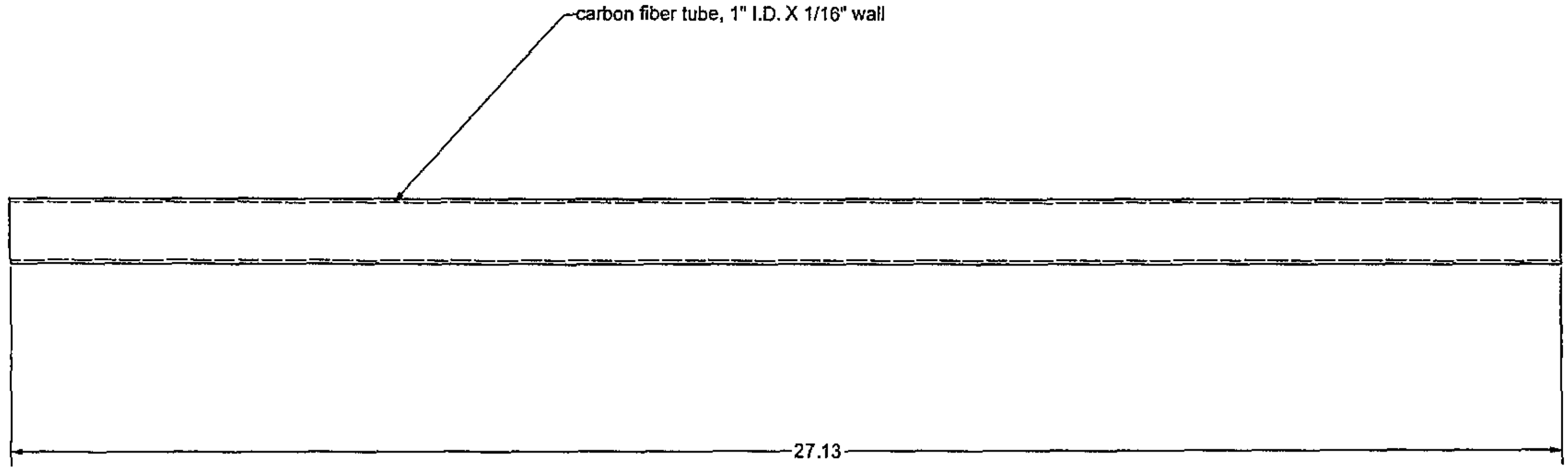


ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

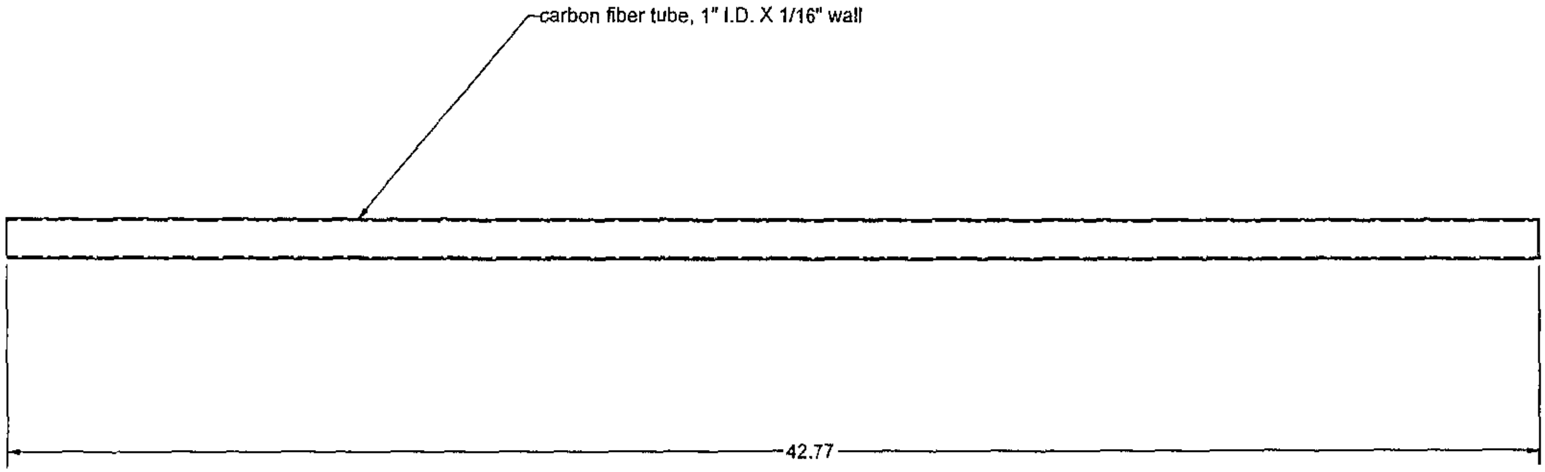
UtahState University — Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

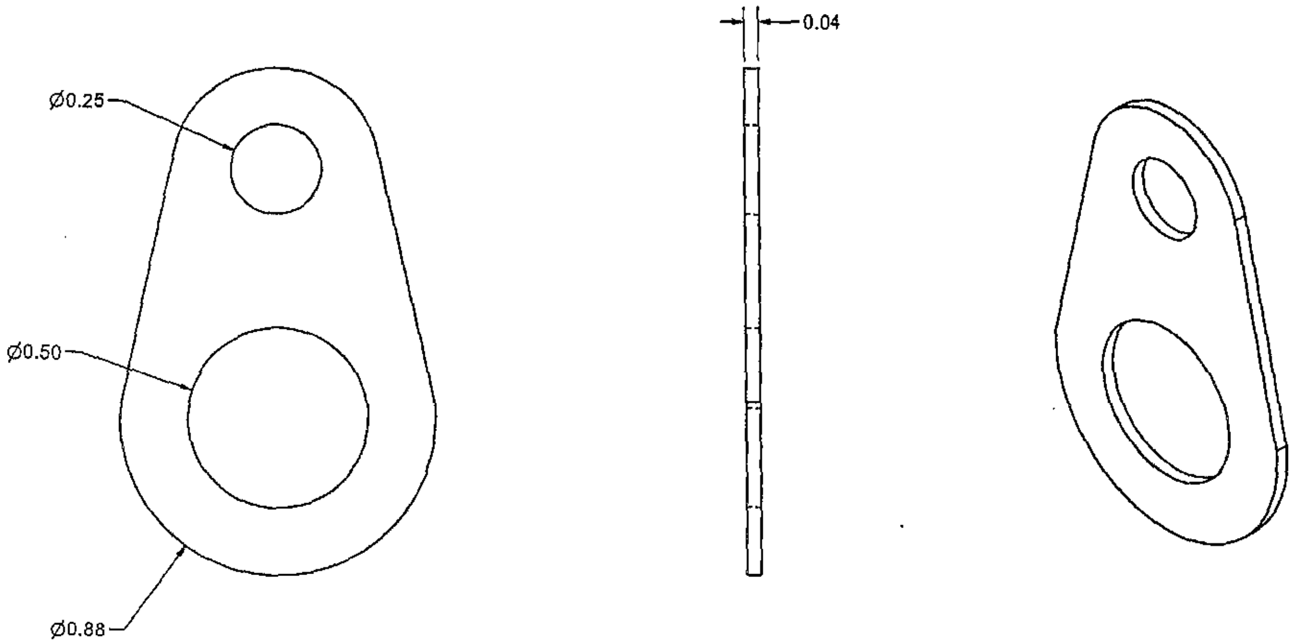
DRAWN BY: David Beck Christensen			
MATERIAL: Carbon Fiber	*PART DESCRIPTION:* Strut	*PART NUMBER:* WF-50-099-14A2	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1



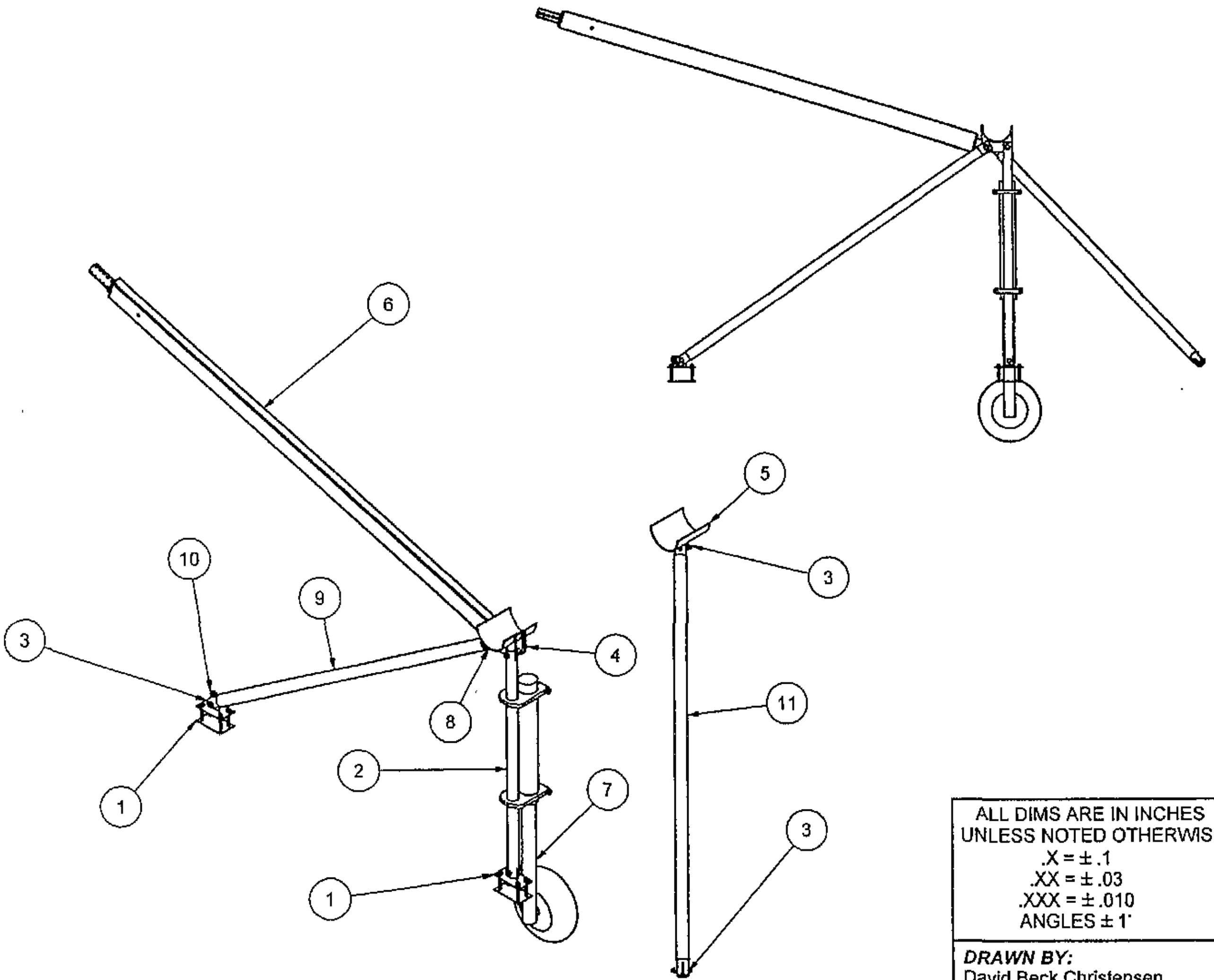
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering ***USU WRIGHT FLYER 1903-2003***		
DRAWN BY: David Beck Christensen			
MATERIAL: Carbon Fiber	***PART DESCRIPTION:*** Strut	***PART NUMBER:*** WF-50-099-14C2	***REV***
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 ***of*** 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1˚	UtahState UNIVERSITY Mechanical & Aerospace Engineering ***USU WRIGHT FLYER 1903-2003***			
DRAWN BY: David Beck Christensen				
MATERIAL: Carbon Fiber	***PART DESCRIPTION:*** Strut		***PART NUMBER:*** WF-50-099-14C1	***REV***
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 of 1	



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	**UtahState UNIVERSITY** Mechanical & Aerospace Engineering ***USU*** ***WRIGHT FLYER*** ***1903-2003***		
DRAWN BY: CKESPLIN			
MATERIAL: Aluminum-6061	***PART DESCRIPTION:*** CABLE PLATE, 1-PRONG	***PART NUMBER:*** CABLE PLATE - 1PRONG	***REV*** .25hole
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 ***of*** 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	WF-50-000-05	Skid Hardpoint Assembly
2	1	WF-50-000-07	Tube & Mount Assembly
3	3	WF-50-000-06	Tube Fitting Assembly
4	1	WF-50-000-02-01	Spar Hardpoint Assembly, Left
5	1	WF-50-099-04-01	Hardpoint, Spar, Leading, Left
6	1	WF-50-099-11	Tube, Mounting, Cockpit
7	1	WF-50-000-10	Shock & Wheel Assem.
8	1	WF-50-099-02	Tube, Fitting
9	1	WF-50-099-14D	Strut
10	1	CABLE PLATE - 1PRONG .25holemount	CABLE PLATE, 1-PRONG
11	1	WF-50-099-14F	Strut

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Middle Struts, Left

PART NUMBER: WF-50-000-00C

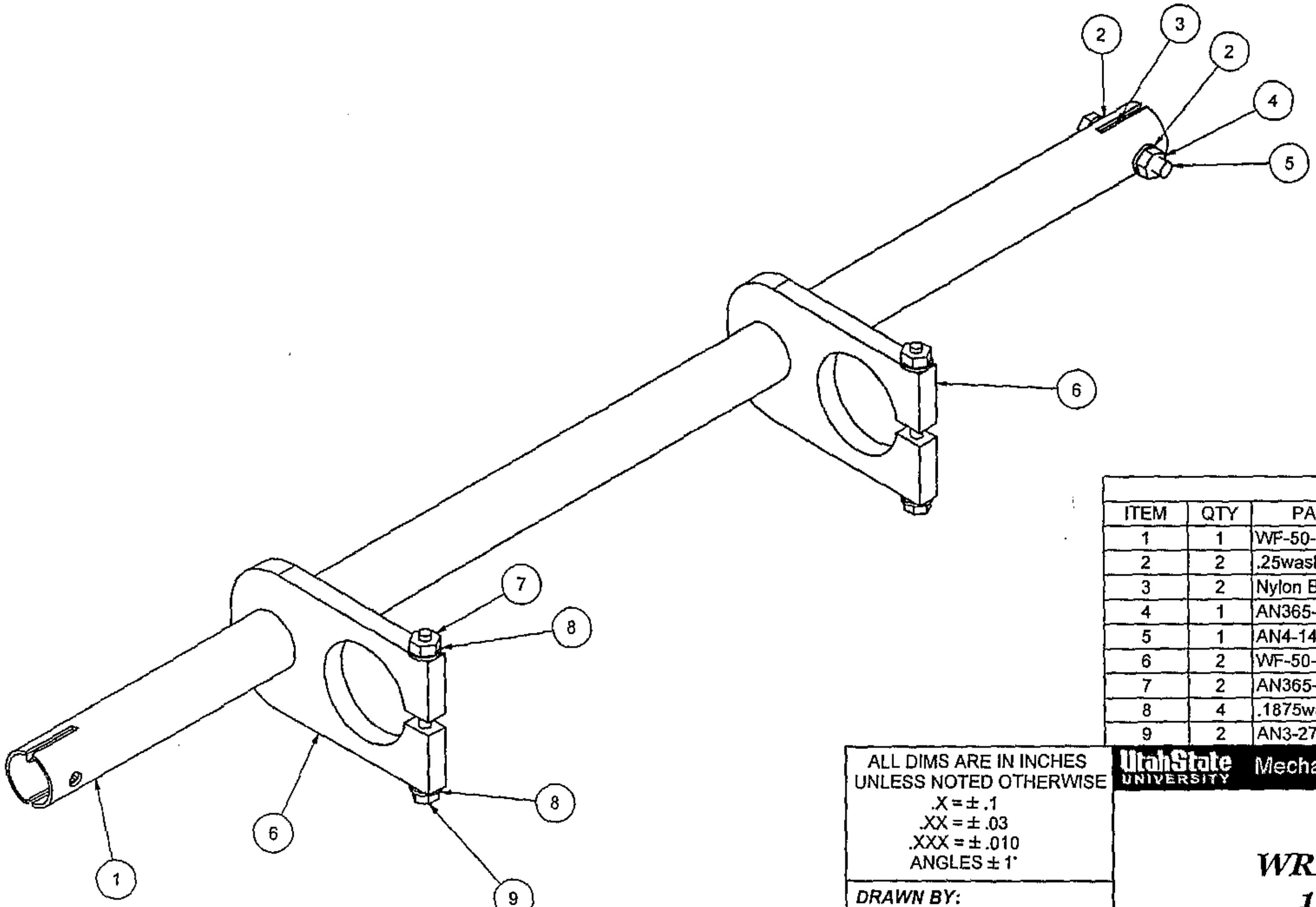
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 ***of*** 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-099-14E	Strut
2	2	.25washer	Washer, misc
3	2	Nylon Bushing	Bushing, Nylon
4	1	AN365-428A	Nut
5	1	AN4-14	Bolt
6	2	WF-50-099-19A	Mount, Shock
7	2	AN365-1032A	Nut
8	4	.1875washer	Washer, misc
9	2	AN3-27	Bolt

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Tube & Mount Assembly

PART NUMBER: WF-50-000-07

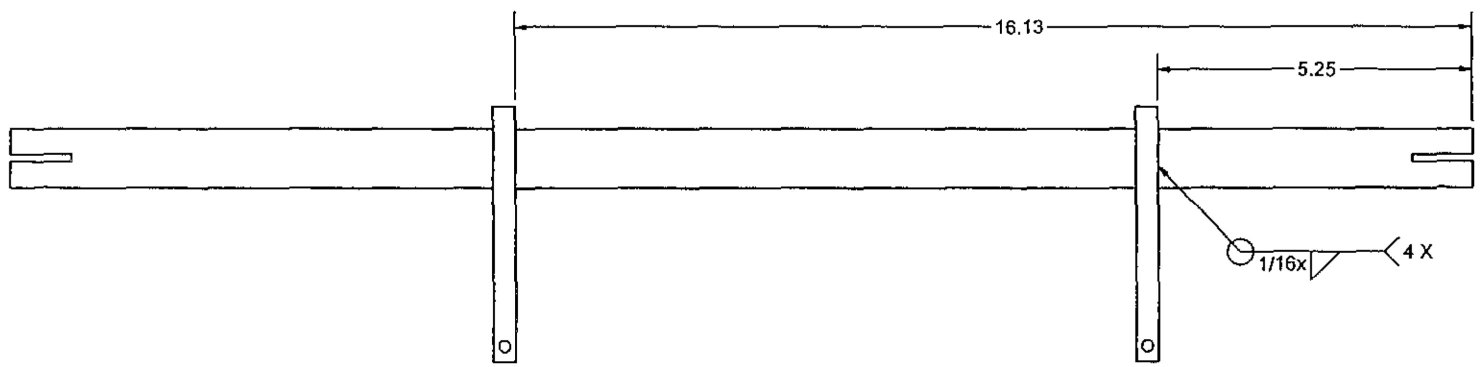
REV A

DATE: 2/17/2002

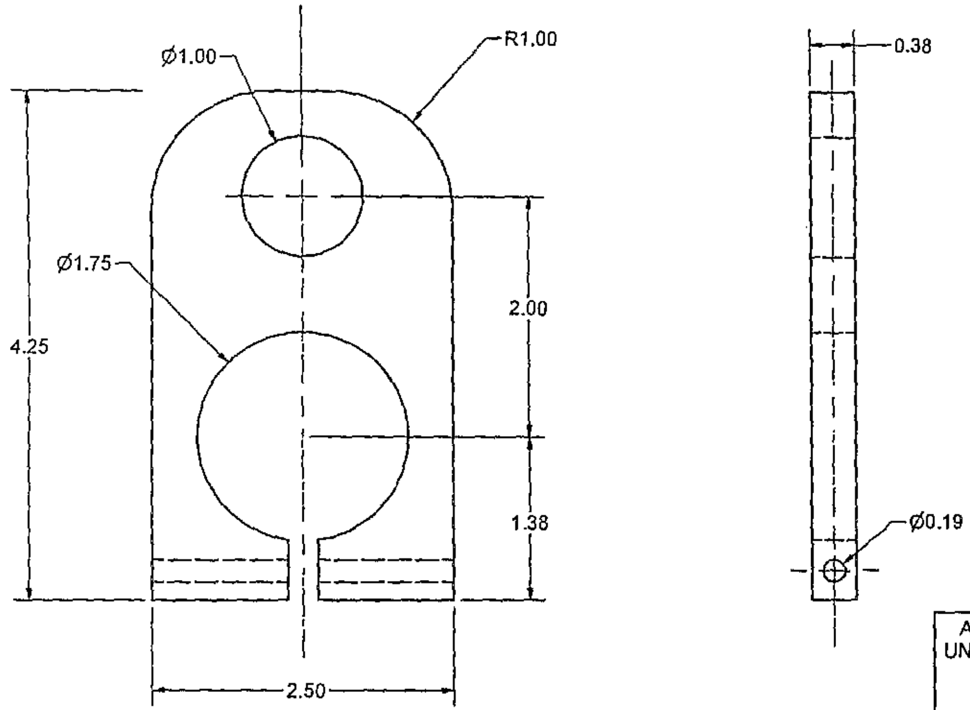
SCALE:

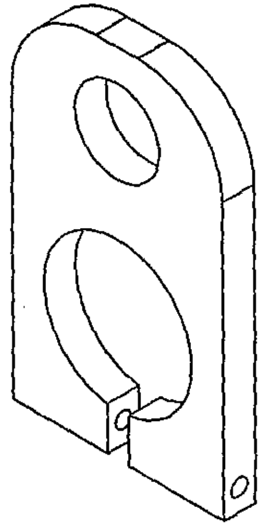
SIZE: B

SHEET 1 ***of*** 1

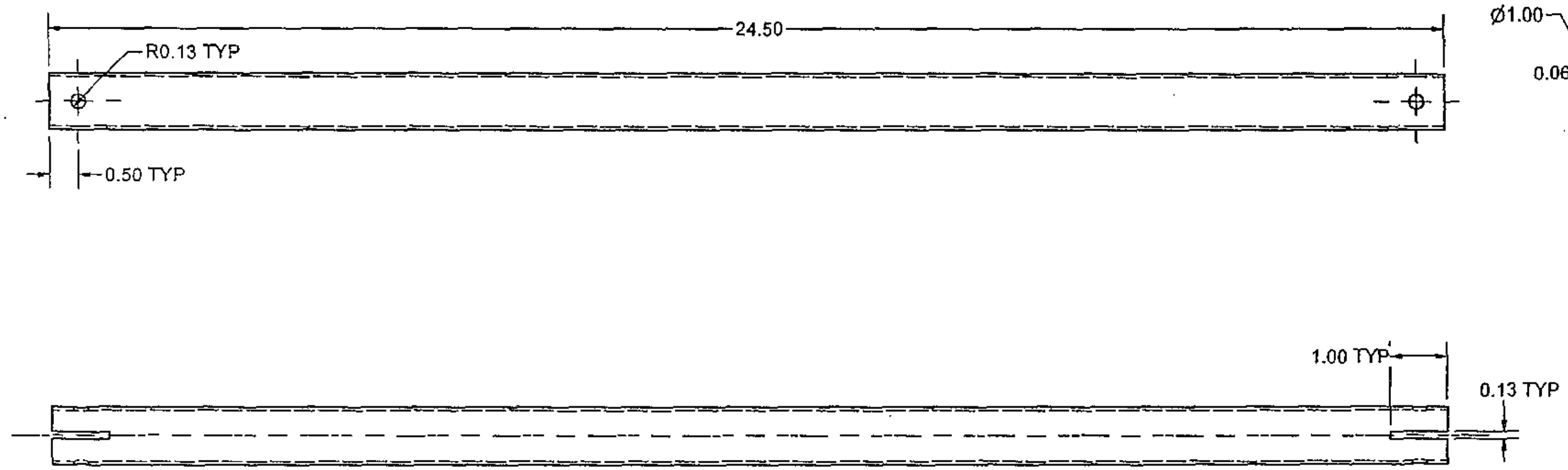


ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*			
DRAWN BY: David Beck Christensen				
MATERIAL:	***PART DESCRIPTION:*** Tube and Shock Mount Assem.	***PART NUMBER:*** WF-50-099-19		***REV*** A
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 ***of*** 1	

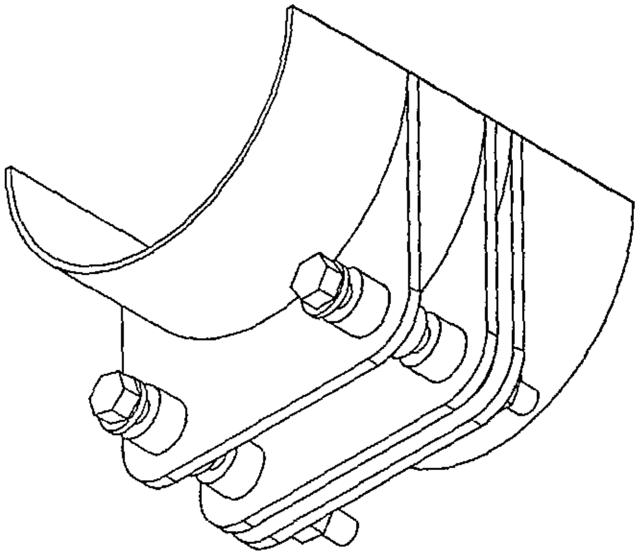


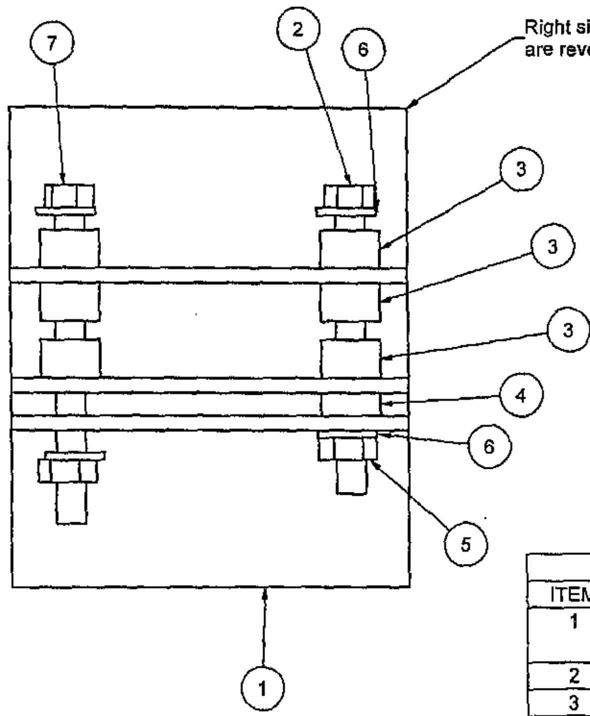


ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	**UtahState UNIVERSITY** Mechanical & Aerospace Engineering ***USU WRIGHT FLYER 1903-2003***		
DRAWN BY: David Beck Christensen			
MATERIAL: Steel, Mild	***PART DESCRIPTION:*** Mount, Shock	***PART NUMBER:*** WF-50-099-19A	***REV*** A
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 ***of*** 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1˚	UtahState UNIVERSITY Mechanical & Aerospace Engineering			
DRAWN BY: David Beck Christensen	***USU WRIGHT FLYER 1903-2003***			
MATERIAL: Steel, Mild	*PART DESCRIPTION:* Strut		*PART NUMBER:* WF-50-099-14E	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	





Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-099-06	Hardpoint, Spar, Lead, Bottom
2	1	AN4-23	Bolt
3	6	Nylon Bushing	Bushing, Nylon
4	1	Nylon Bushing 2	Bushing, Nylon
5	2	AN365-428A	Nut
6	4	.25washer	Washer, misc
7	1	AN4-25	Bolt

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

Utah State University — Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Spar Hardpoint Assembly, Left

PART NUMBER: WF-50-000-02-01

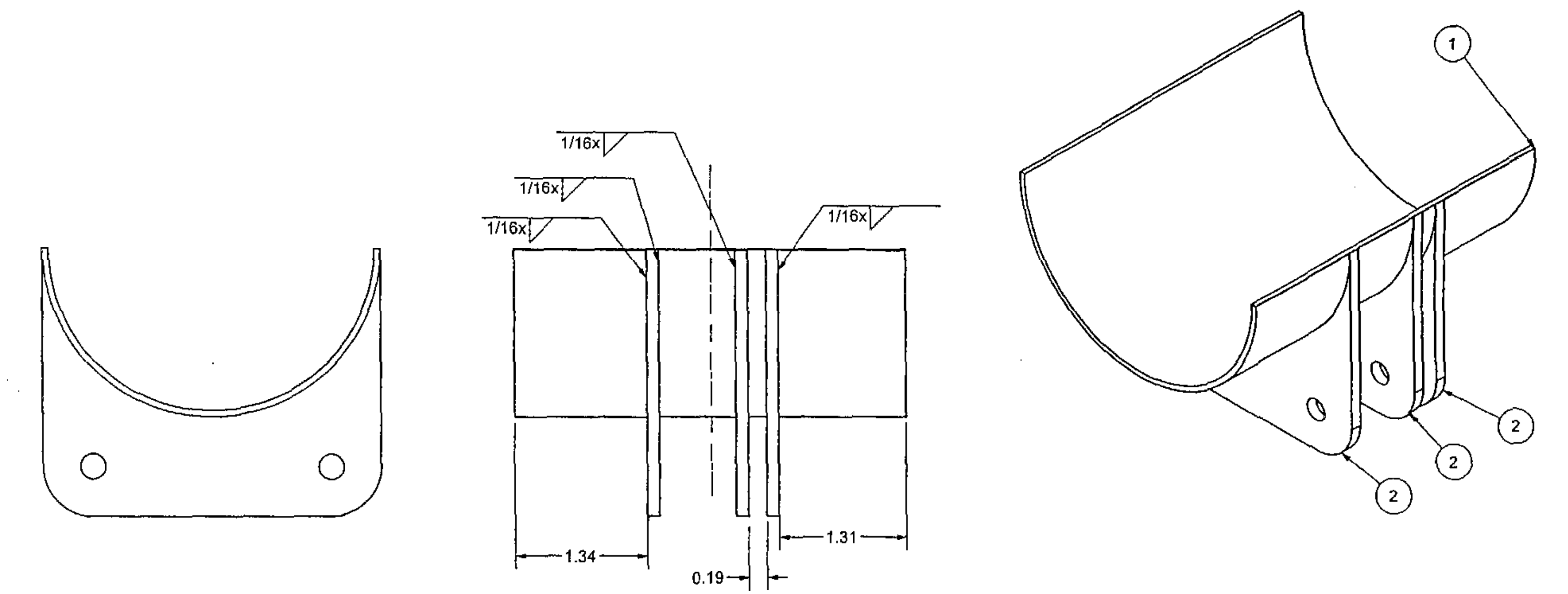
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 of 1



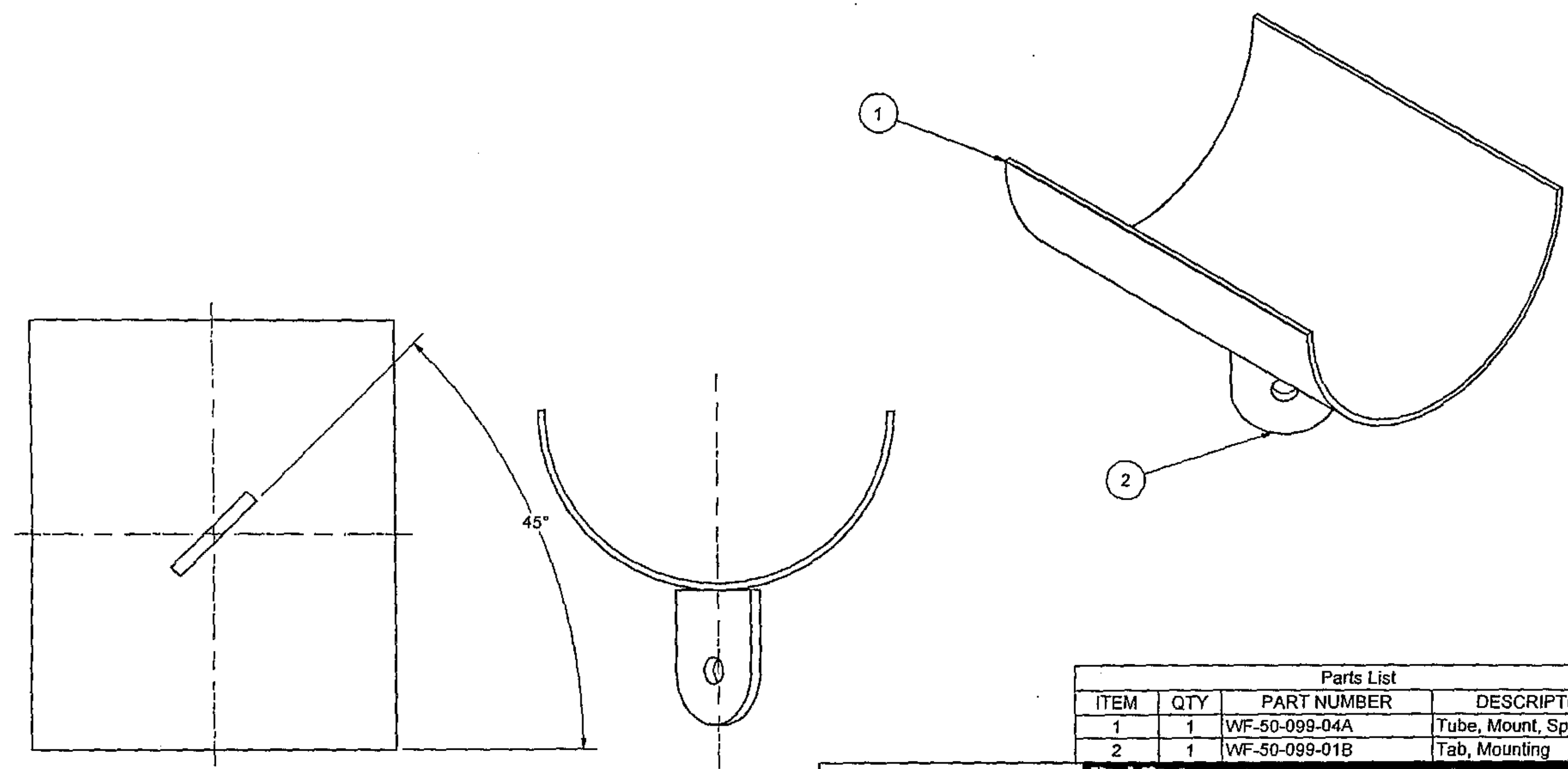
Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-099-04A	Tube, Mount, Spar, Lead
2	3	WF-50-099-06A	Tab, Mount, Spar, Lead

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

Utah State University — Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: David Beck Christensen	
MATERIAL:	***PART DESCRIPTION:*** Hardpoint, Spar, Lead, Bottom
	PART NUMBER: WF-50-099-06
	REV A
DATE: 2/17/2002	***SCALE:***
	SIZE: B
	SHEET 1 ***of*** 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-099-04A	Tube, Mount, Spar, Lead
2	1	WF-50-099-01B	Tab, Mounting

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Hardpoint, Spar, Leading, Left

PART NUMBER: WF-50-099-04-01

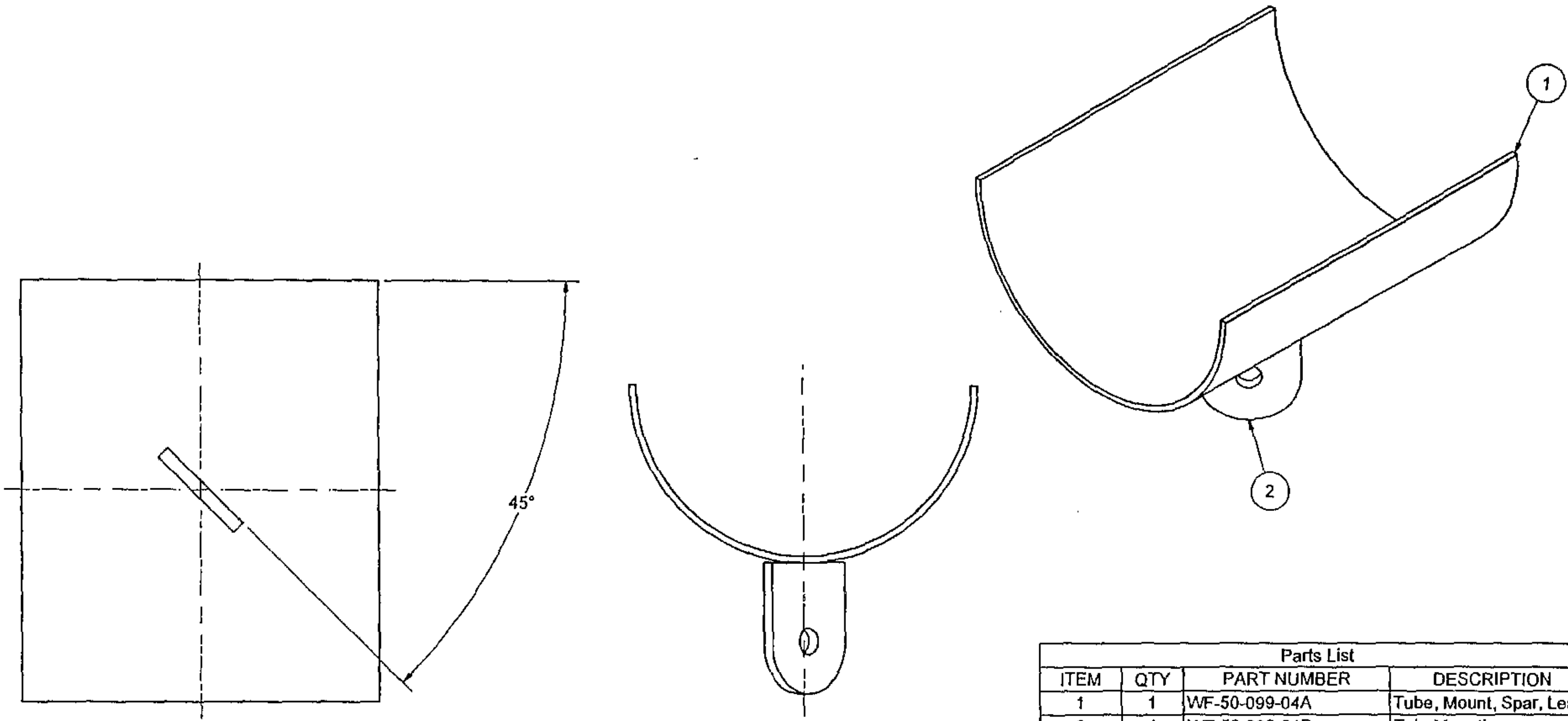
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 of 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-099-04A	Tube, Mount, Spar, Lead
2	1	WF-50-099-01B	Tab, Mounting

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1˚

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Hardpoint, Spar, Leading, Right

PART NUMBER: WF-50-099-04-02

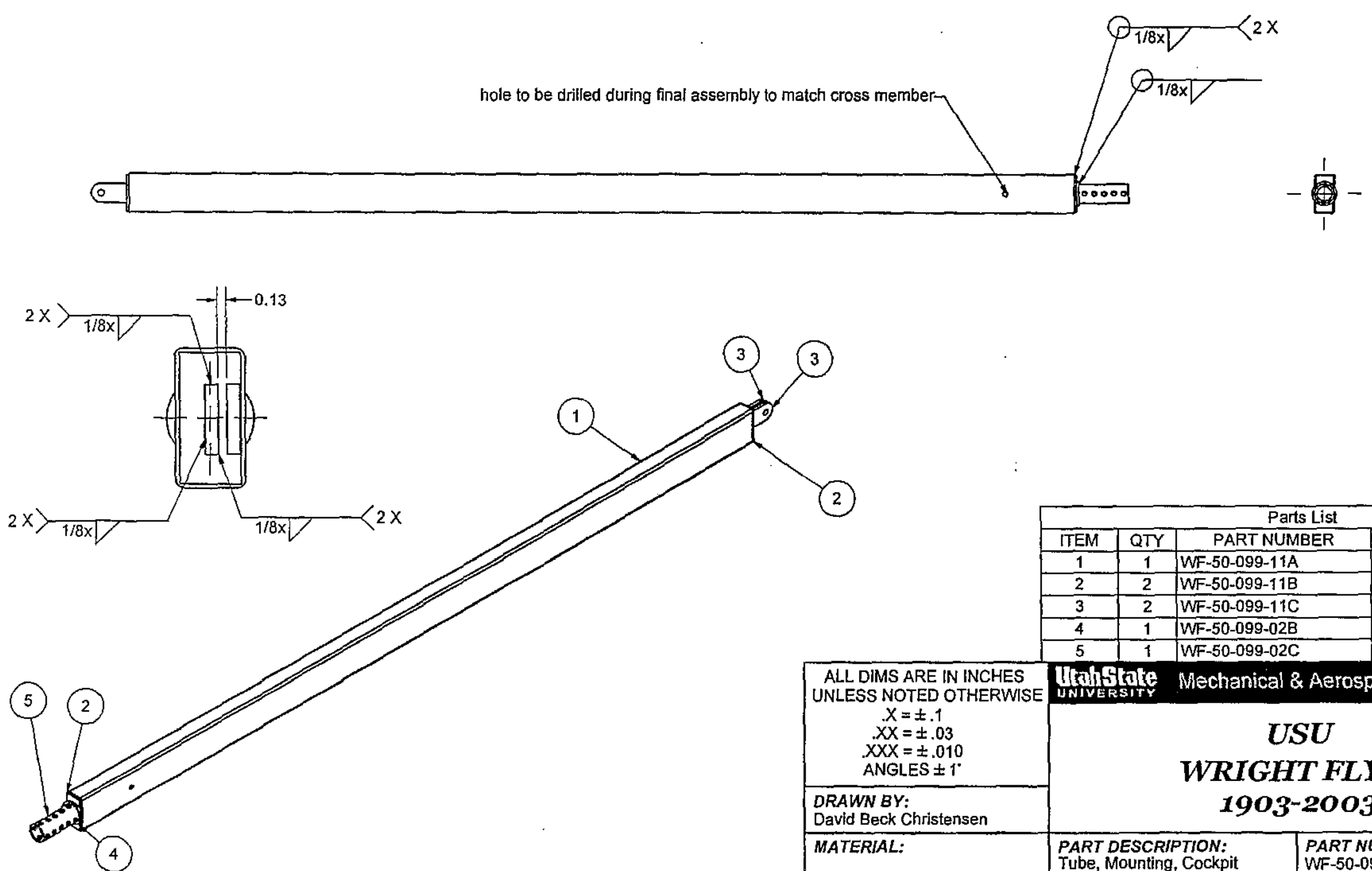
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 of 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-099-11A	Bar, Support, Cockpit
2	2	WF-50-099-11B	Plate, Rectangular
3	2	WF-50-099-11C	Tab, Mounting
4	1	WF-50-099-02B	Plate, Circular
5	1	WF-50-099-02C	Tube, Fitting

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

Utah State University — Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Tube, Mounting, Cockpit

PART NUMBER: WF-50-099-11

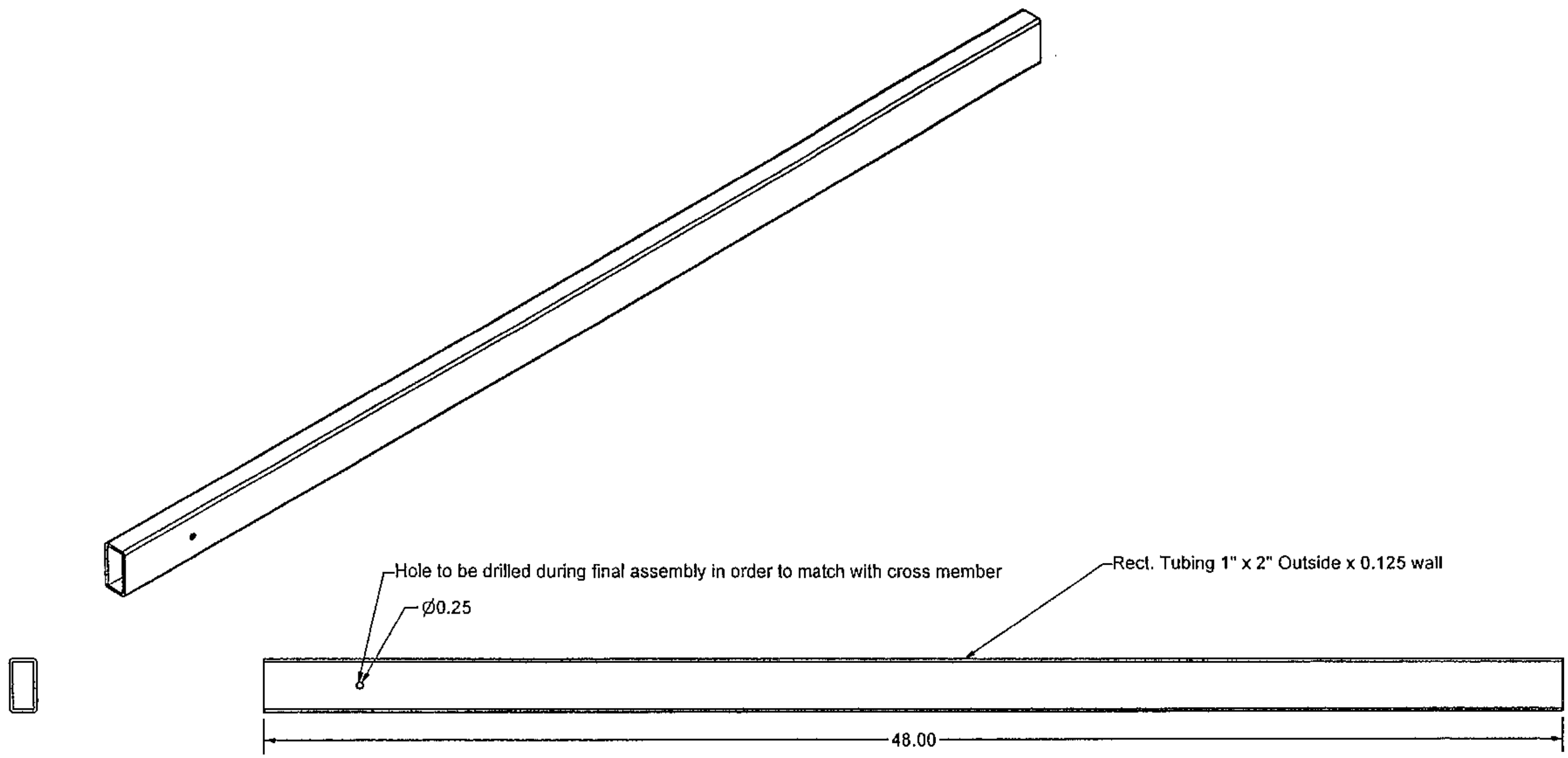
REV

DATE: 2/17/2002

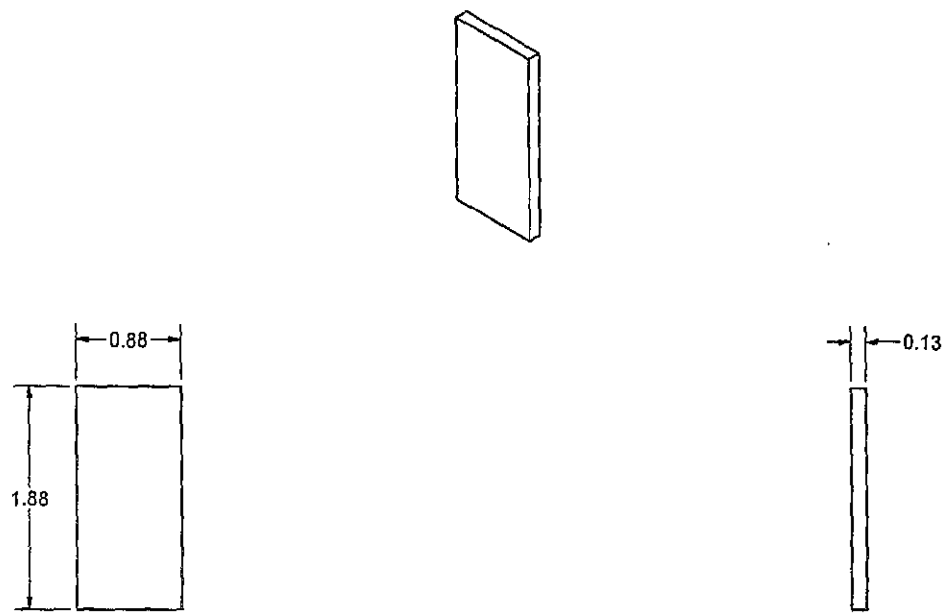
SCALE:

SIZE: B

SHEET 1 *of* 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*			
DRAWN BY: David Beck Christensen				
MATERIAL: Aluminum-6061	***PART DESCRIPTION:*** Bar, Support, Cockpit		***PART NUMBER:*** WF-50-099-11A	***REV***
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 ***of*** 1	

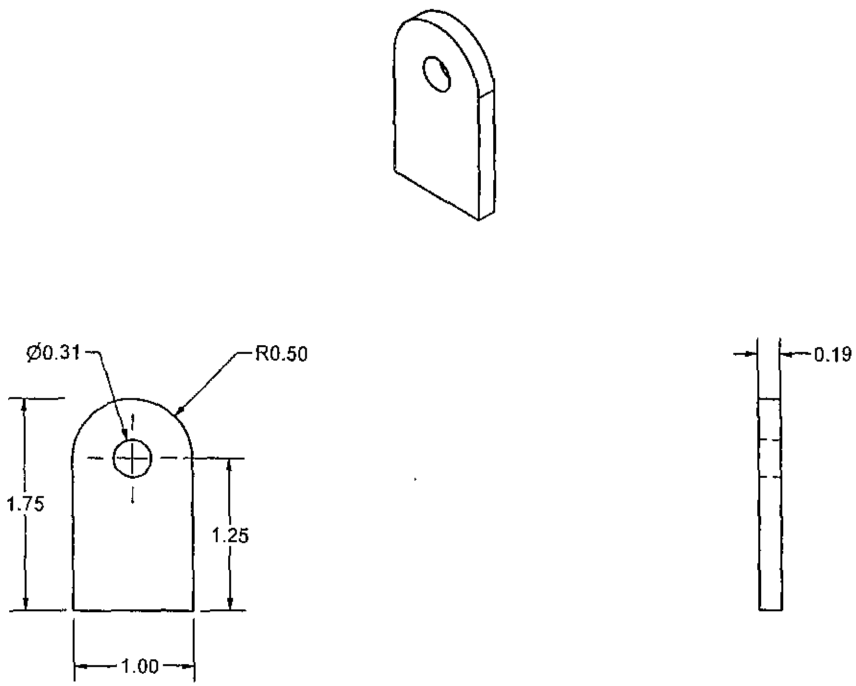


ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1˚

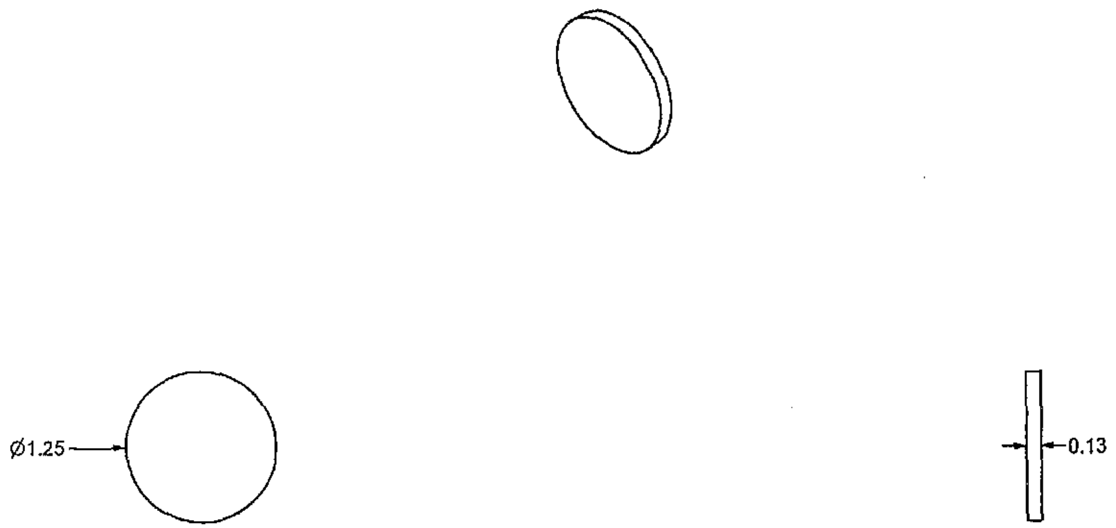
Utah State University — Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

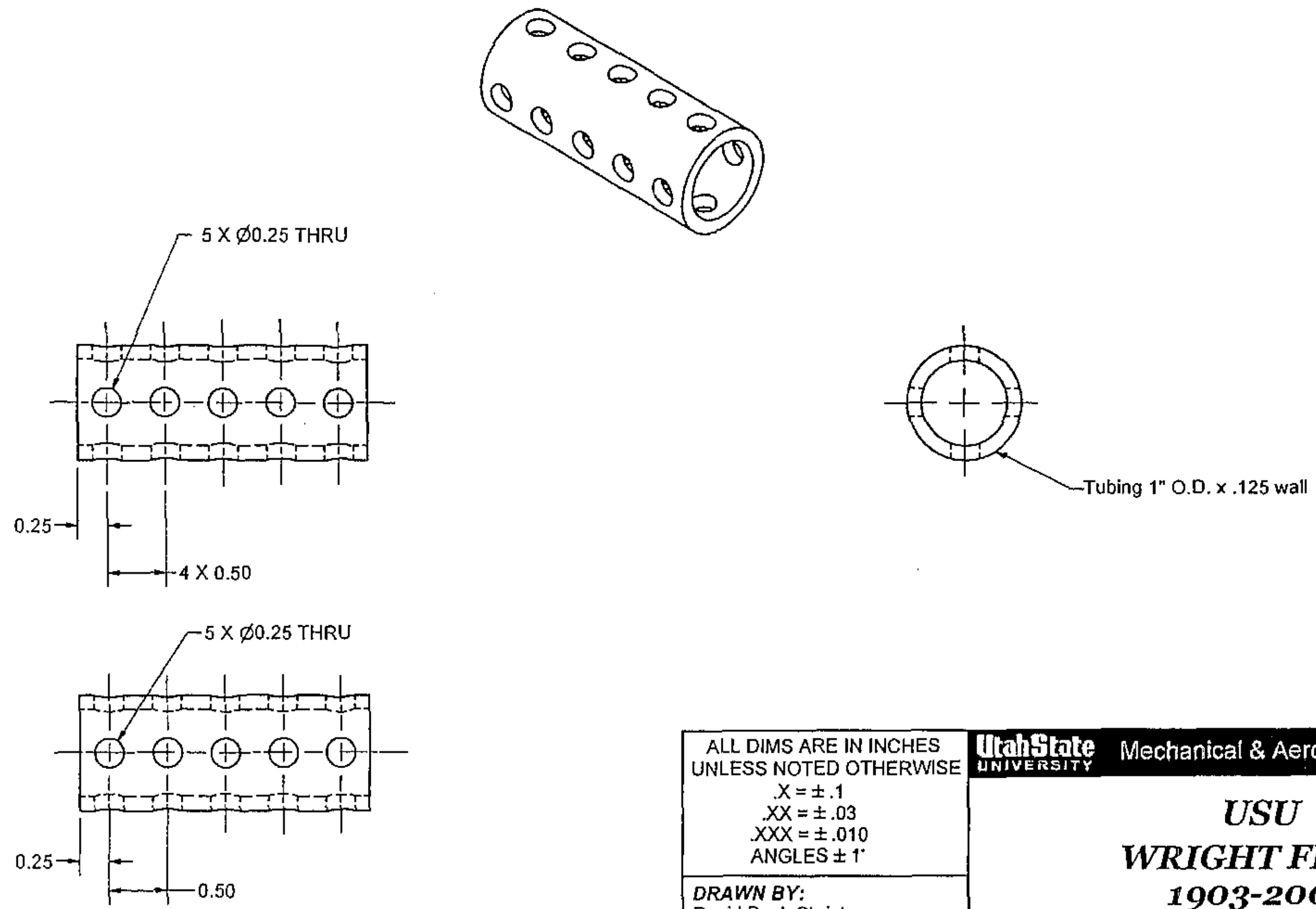
DRAWN BY: David Beck Christensen			
MATERIAL: Aluminum-6061	*PART DESCRIPTION:* Plate, Rectangular	*PART NUMBER:* WF-50-099-11B	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1



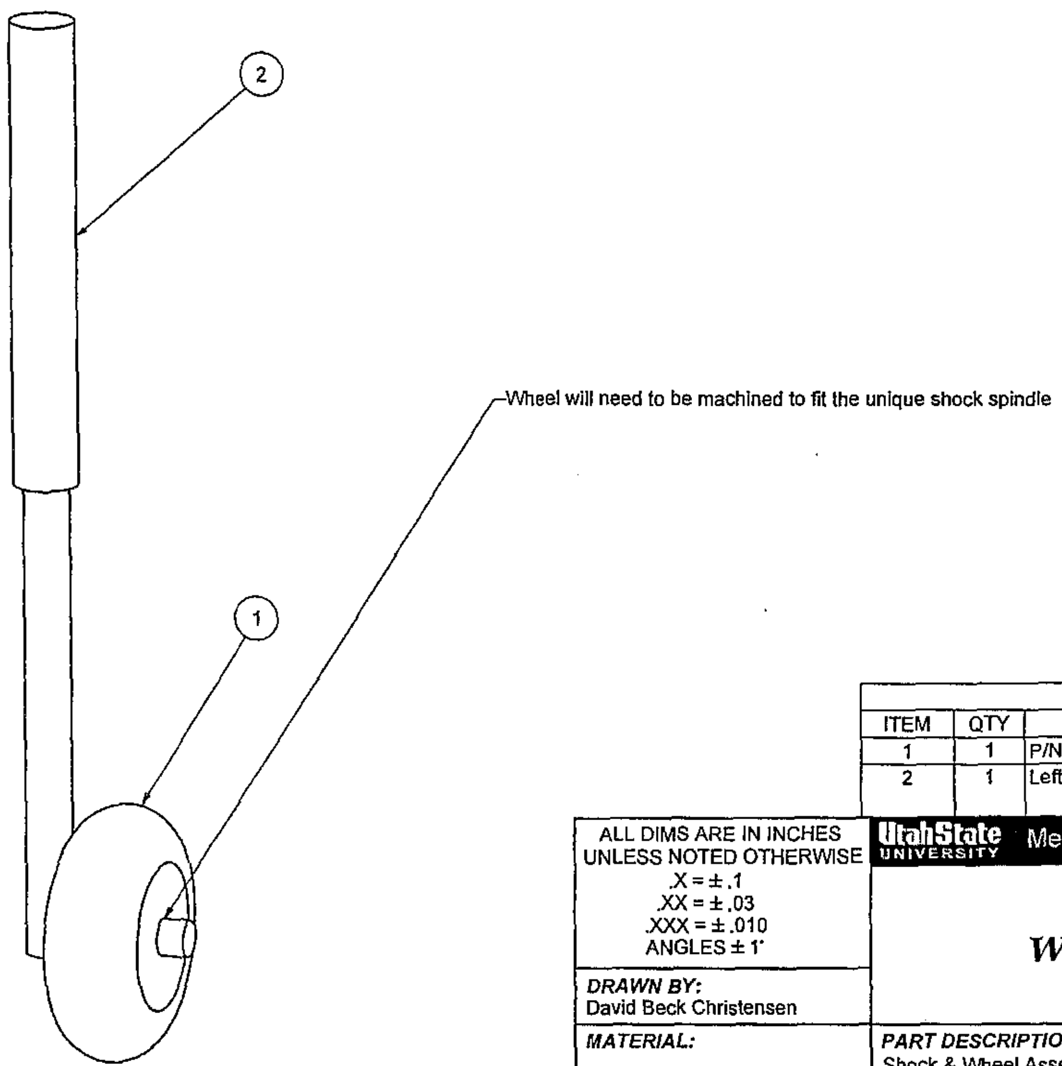
ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*			
DRAWN BY: David Beck Christensen				
MATERIAL: Aluminum-6061	*PART DESCRIPTION:* Tab, Mounting		*PART NUMBER:* WF-50-099-11C	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering			
DRAWN BY: David Beck Christensen	USU WRIGHT FLYER 1903-2003			
MATERIAL: Aluminum-6061	PART DESCRIPTION: Plate, Circular		PART NUMBER: WF-50-099-02B	REV
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE	UtahState UNIVERSITY Mechanical & Aerospace Engineering		
.X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	*USU WRIGHT FLYER 1903-2003*		
DRAWN BY: David Beck Christensen			
MATERIAL: Aluminum-6061	***PART DESCRIPTION:*** Tube, Fitting	***PART NUMBER:*** WF-50-099-02C	***REV***
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 ***of*** 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	P/N 06-0600	Azusalite Nylon Wheel
2	1	Lefty Shock	Cannondale Mt. Bike Sh ock

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Shock & Wheel Assem.

PART NUMBER: WF-50-000-10

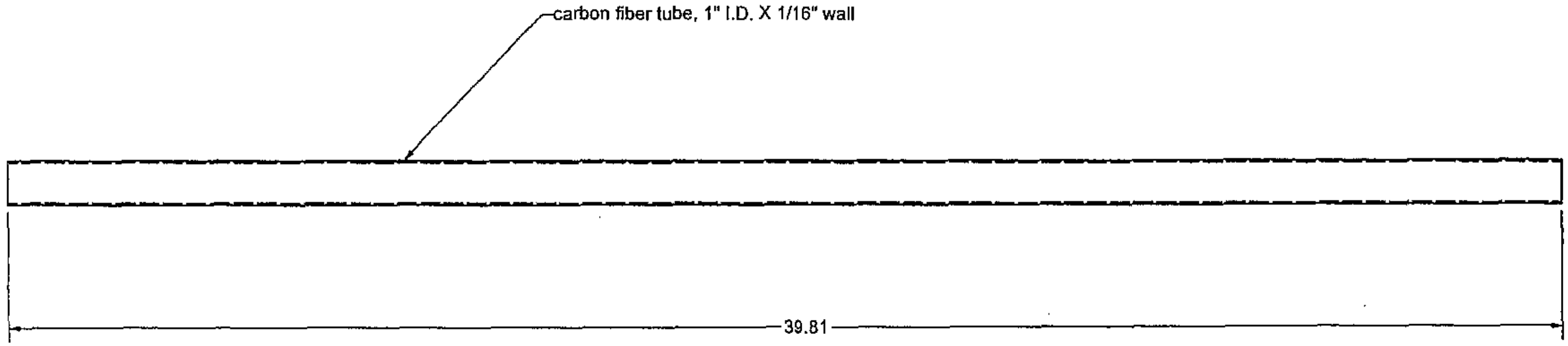
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 *of* 1



ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL: Carbon Fiber

PART DESCRIPTION: Strut

PART NUMBER: WF-50-099-14D

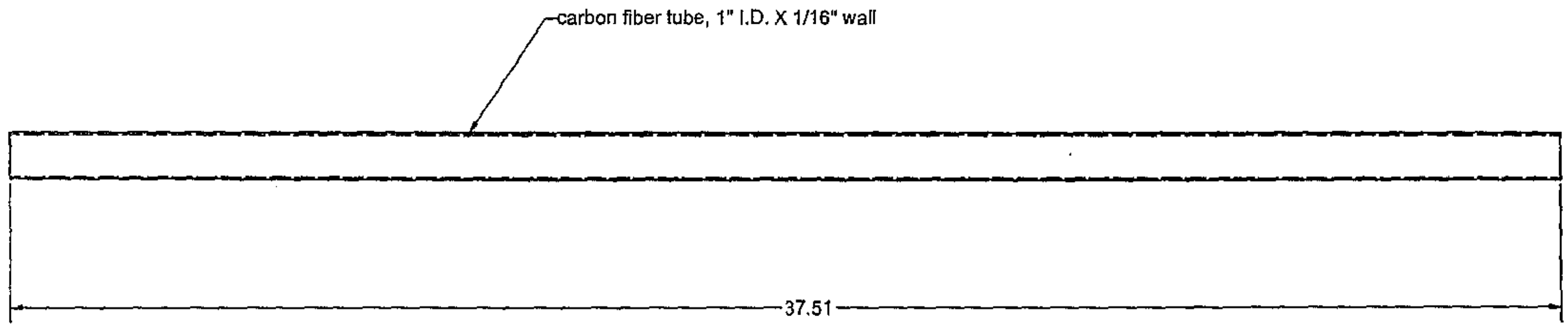
REV

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 **of** 1

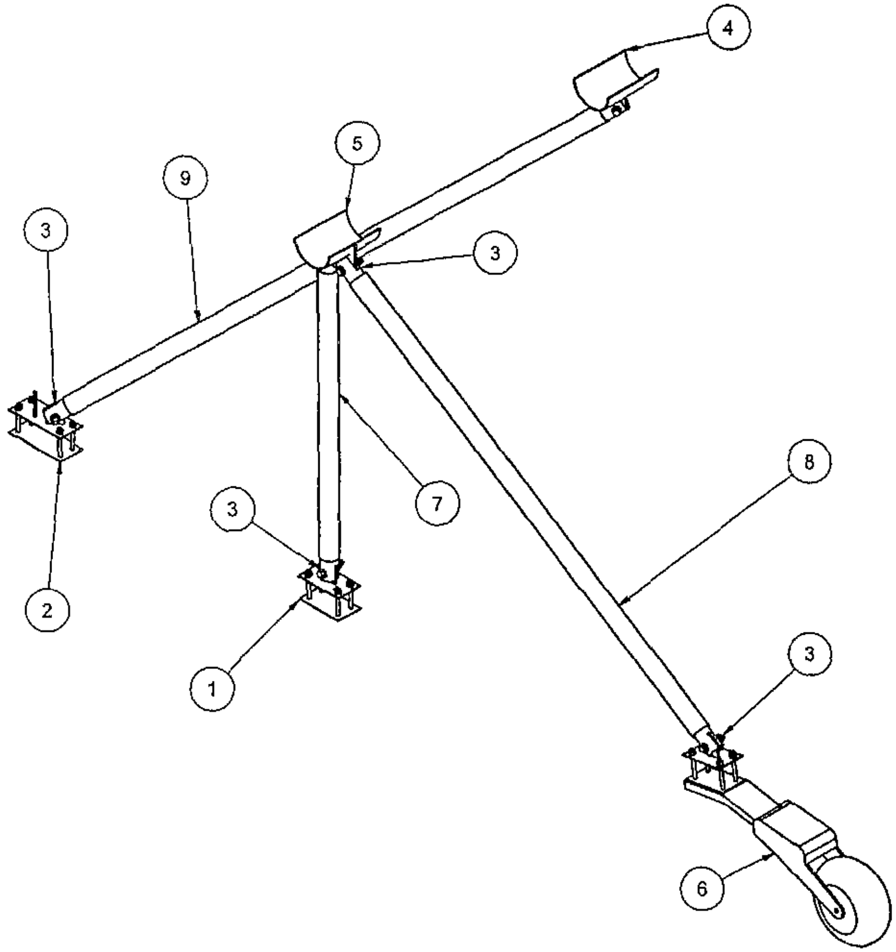


ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

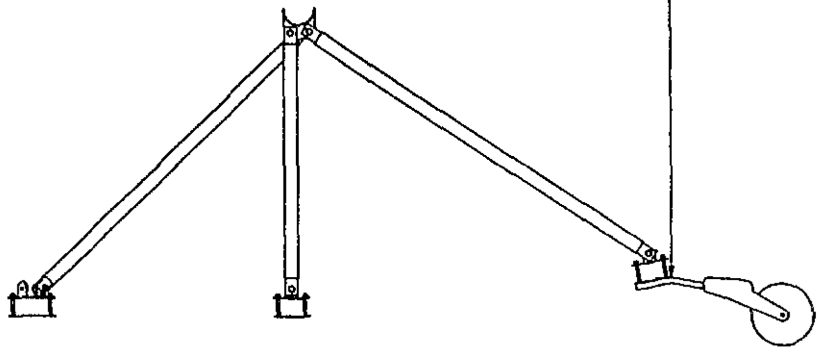
UtahState University Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen				
MATERIAL: Carbon Fiber	*PART DESCRIPTION:* Strut		*PART NUMBER:* WF-50-099-14F	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	



Carbon leaf spring to be bonded to skid hard point and "sandwiched" with another steel backing plate not shown.



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	WF-50-000-05	Skid Hardpoint Assembly
2	1	WF-50-000-01	Angled Hard Point Assembly
3	6	WF-50-000-06	Tube Fitting Assembly
4	1	WF-50-099-05-01	Hardpoint, Spar, Rear, Left
5	1	WF-50-099-08	Hardpoint, Spar, Rear
6	1	P_N 06-01615	Matco Wheel & Carbon Spring
7	1	WF-50-099-14I	Tube, Strut
8	1	WF-50-099-14H	Strut
9	1	WF-50-099-14G	Strut

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Rear Struts, Left

PART NUMBER: WF-50-000-00D

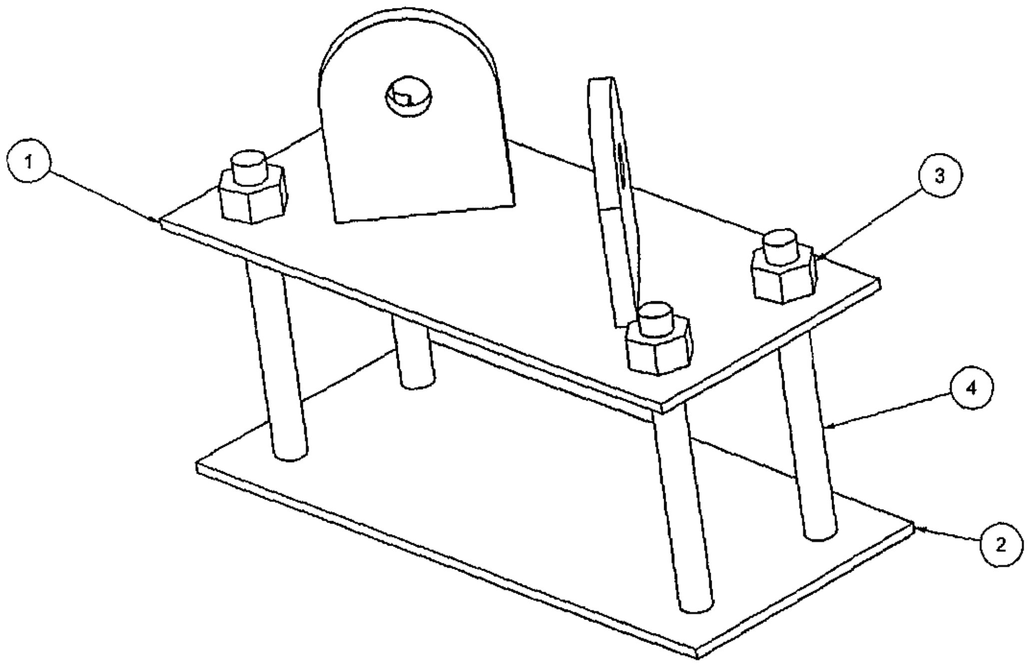
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 *of* 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-099-01	Skid, Hardpoint
2	1	WF-50-099-01C	Plate, Backing
3	4	AN365	Nut
4	4	MS24694	Screw, Machine

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Angled Hard Point Assembly

PART NUMBER: WF-50-000-01

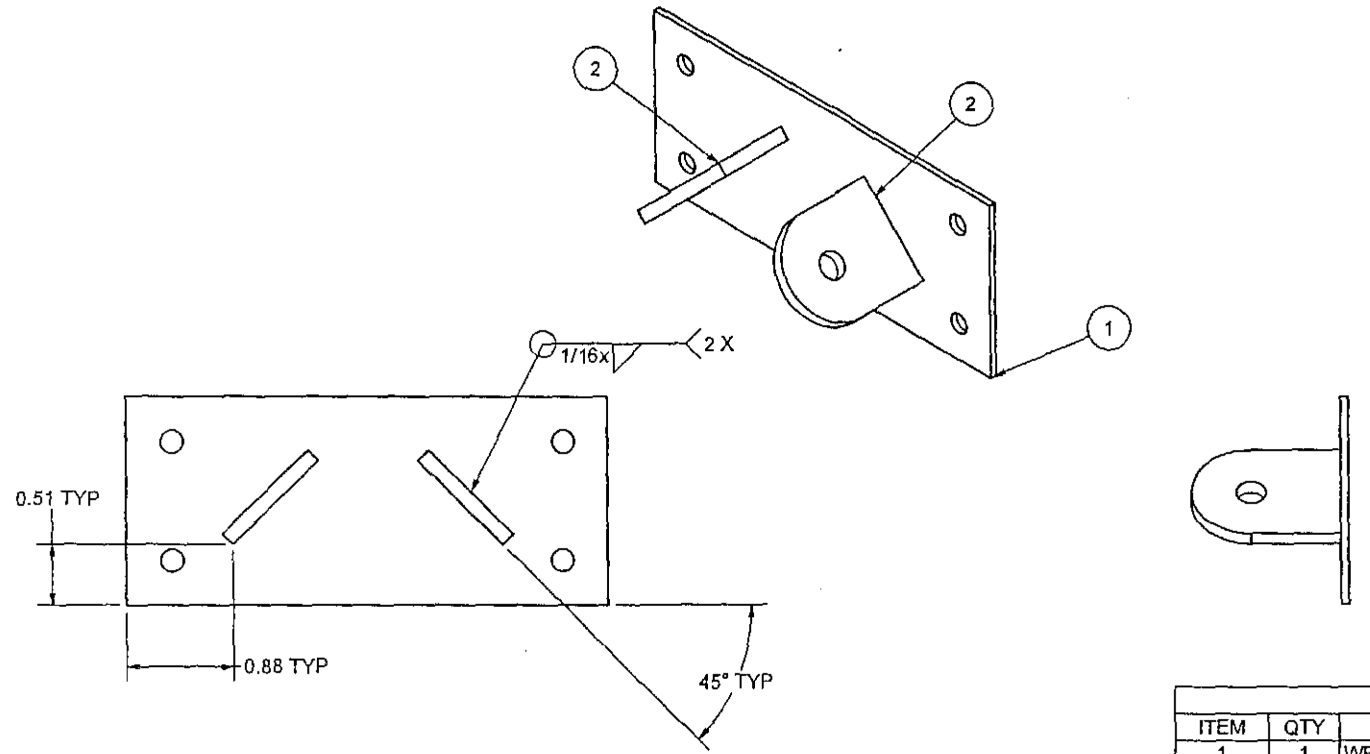
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 **of** 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-099-01A	Plate, Mounting
2	2	WF-50-099-01B	Tab, Mounting

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

Utah State University Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Skid, Hardpoint

PART NUMBER: WF-50-099-01

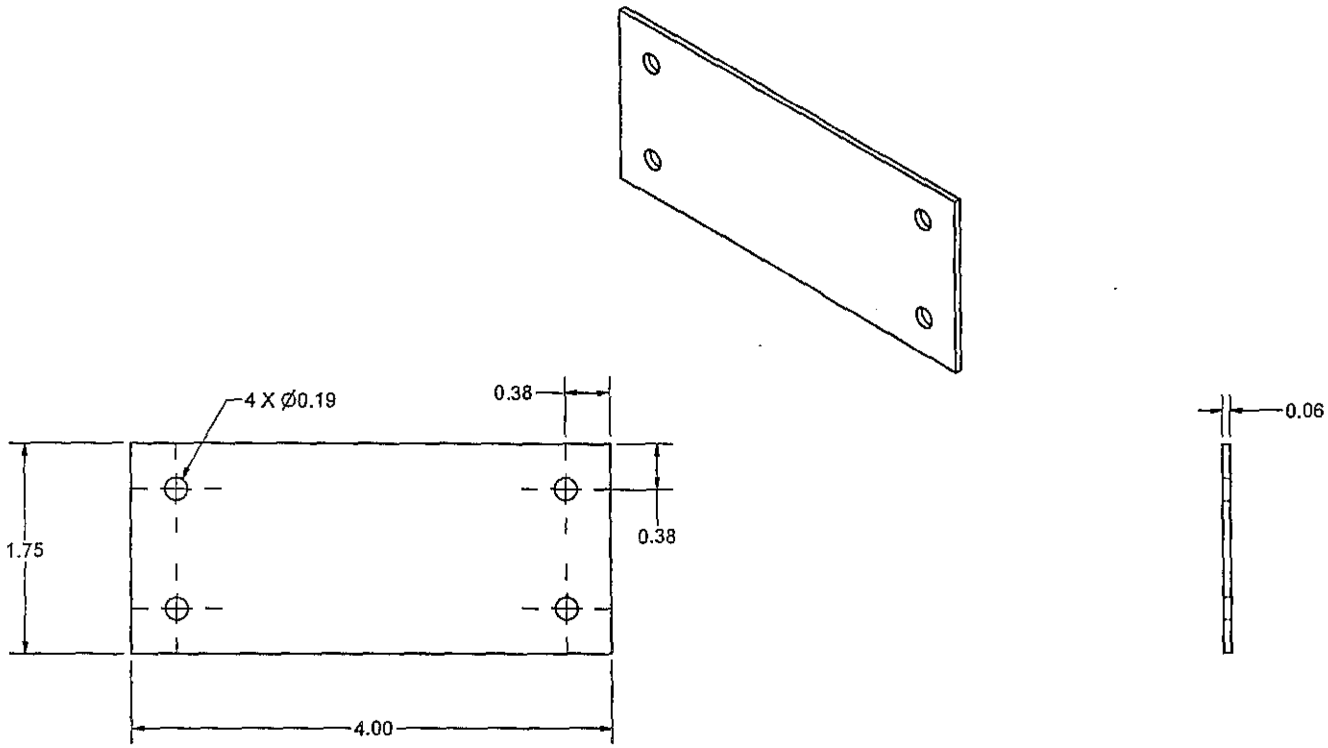
REV A

DATE: 2/17/2002

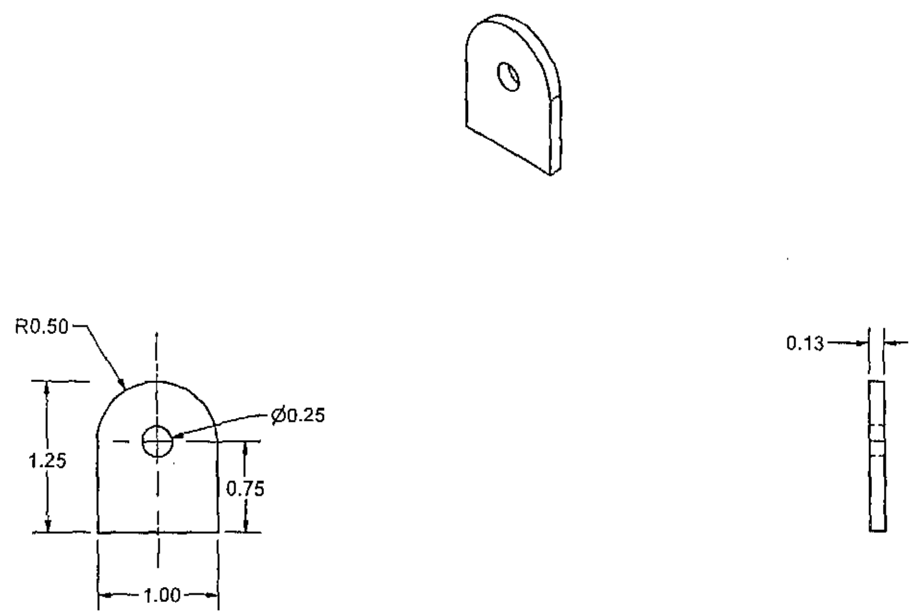
SCALE:

SIZE: B

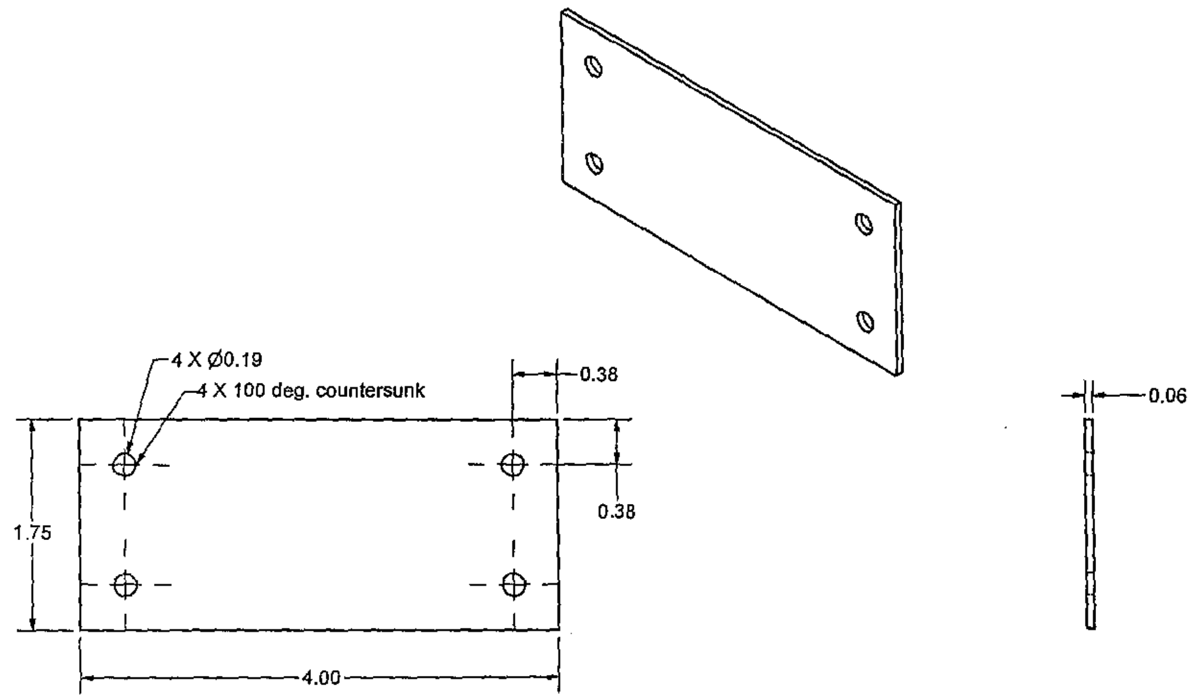
SHEET 1 ***of*** 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU* *WRIGHT FLYER* *1903-2003*			
DRAWN BY: David Beck Christensen				
MATERIAL: Steel, Mild	***PART DESCRIPTION:*** Plate, Mounting		***PART NUMBER:*** WF-50-099-01A	***REV*** A
DATE: 2/17/2002	***SCALE:***	***SIZE:*** B	***SHEET*** 1 ***of*** 1	



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1'	UtahState UNIVERSITY Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*			
DRAWN BY: David Beck Christensen				
MATERIAL: Steel, Mild	PART DESCRIPTION: Tab, Mounting		PART NUMBER: WF-50-099-01B	REV A
DATE: 2/17/2002	SCALE:	SIZE: B	SHEET 1 of 1	

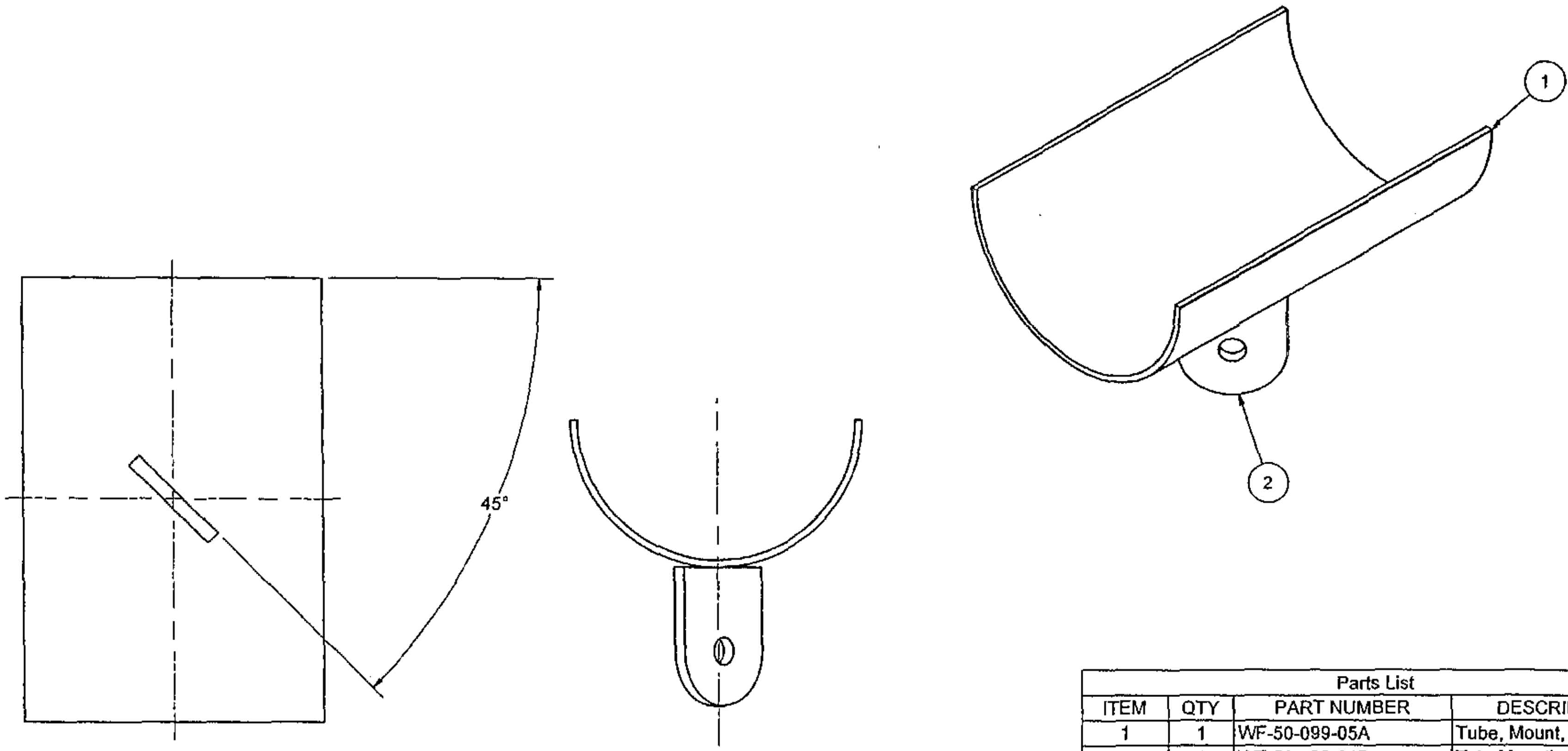


ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen			
MATERIAL: Steel, Mild	*PART DESCRIPTION:* Plate, Backing	*PART NUMBER:* WF-50-099-01C	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-099-05A	Tube, Mount, Spar, Rear
2	1	WF-50-099-01B	Tab, Mounting

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

DRAWN BY: David Beck Christensen

MATERIAL:

DATE: 2/17/2002

Utah State University · Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

PART DESCRIPTION: Hardpoint, Spar, Rear, Left

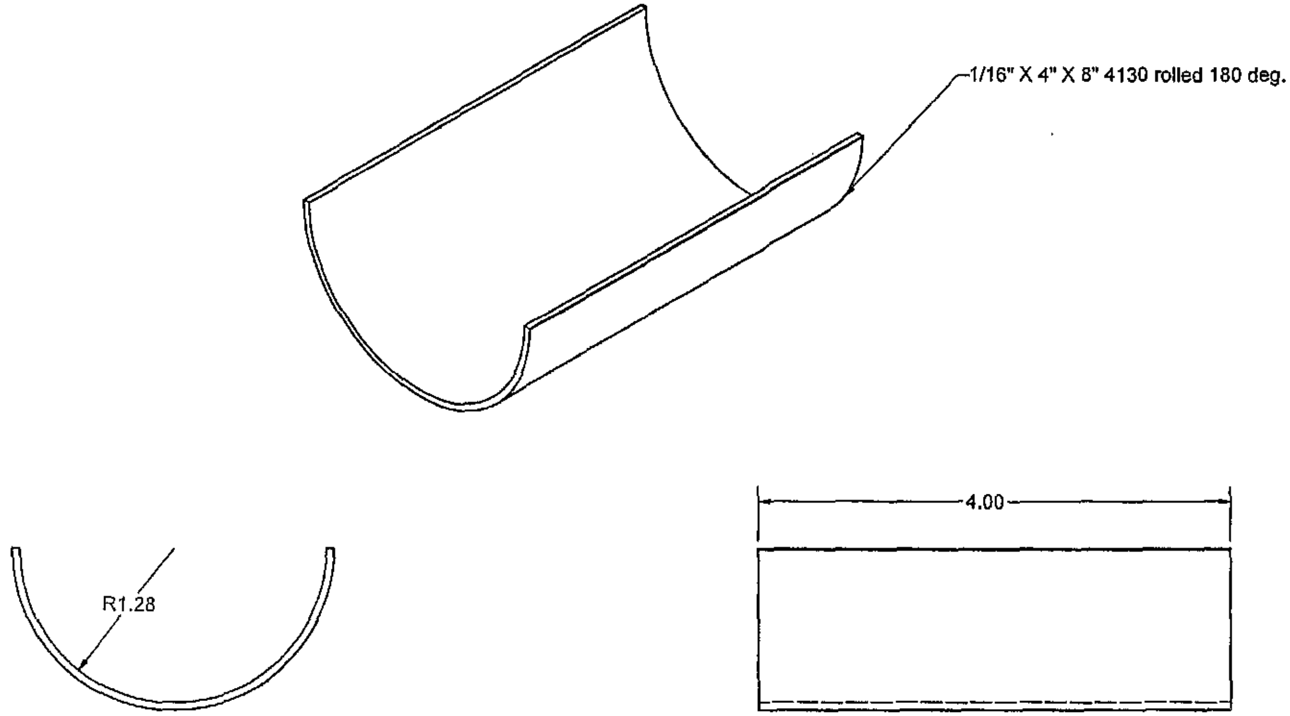
PART NUMBER: WF-50-099-05-01

REV A

SCALE:

SIZE: B

SHEET 1 of 1



ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL: Steel, Mild

PART DESCRIPTION: Tube, Mount, Spar, Rear

PART NUMBER: WF-50-099-05A

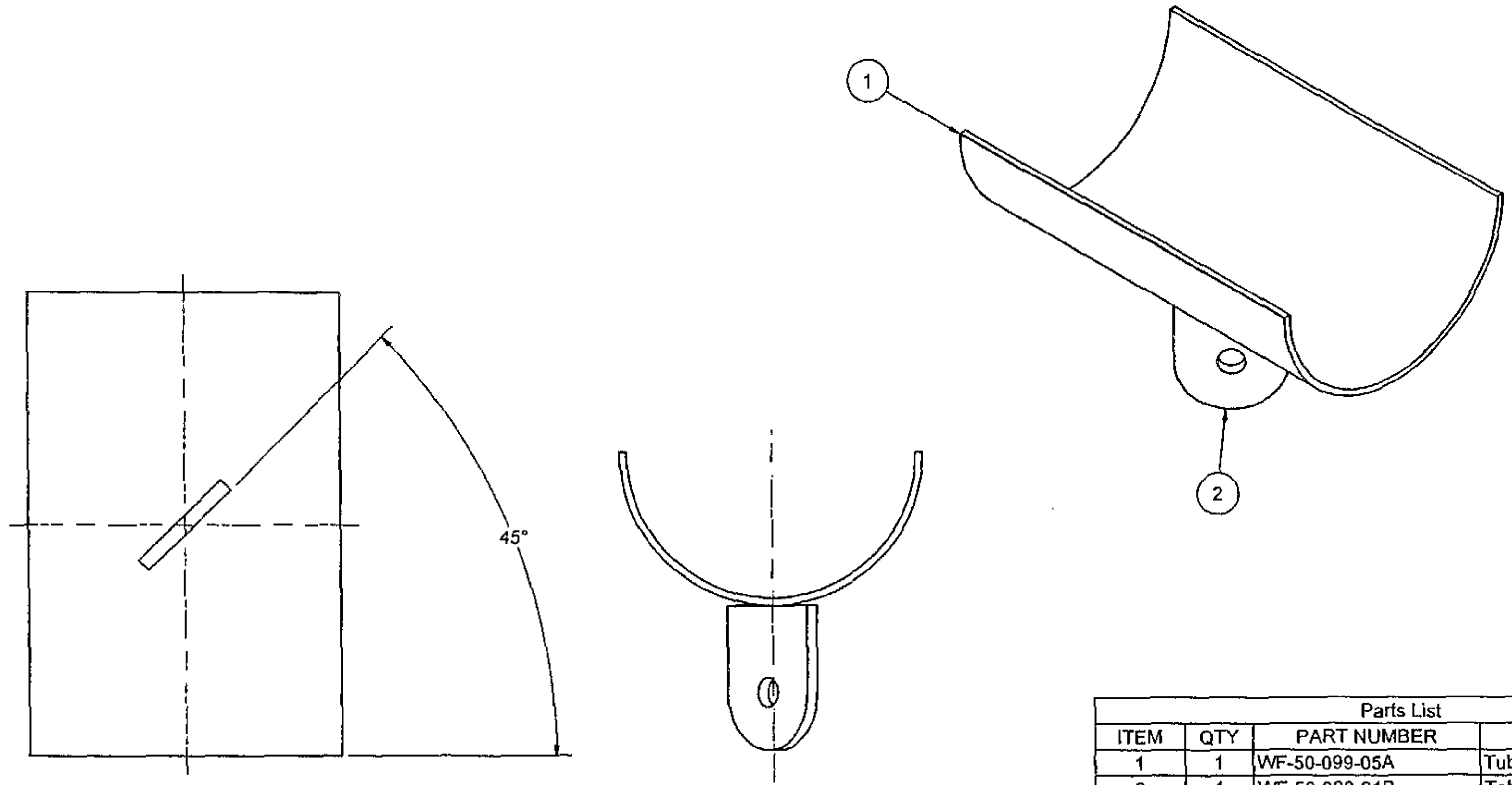
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 of 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-099-05A	Tube, Mount, Spar, Rear
2	1	WF-50-099-01B	Tab, Mounting

ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Hardpoint, Spar, Rear, Right

PART NUMBER: WF-50-099-05-02

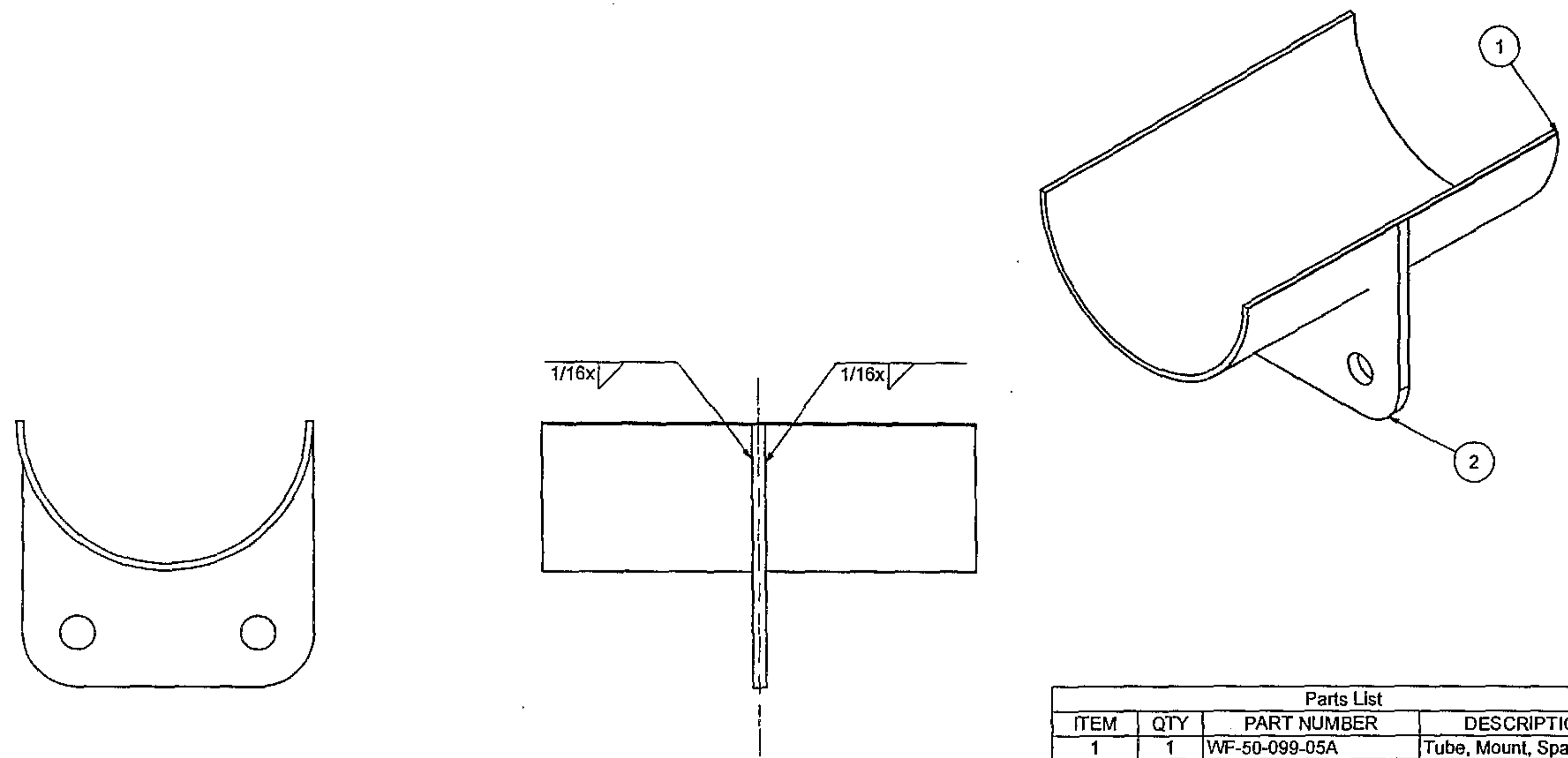
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 ***of*** 1



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	WF-50-099-05A	Tube, Mount, Spar, Rear
2	1	WF-50-099-08A	Tab, Mount, Spar, Rear

ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1°

UtahState University — Mechanical & Aerospace Engineering

USU WRIGHT FLYER 1903-2003

DRAWN BY: David Beck Christensen

MATERIAL:

PART DESCRIPTION: Hardpoint, Spar, Rear

PART NUMBER: WF-50-099-08

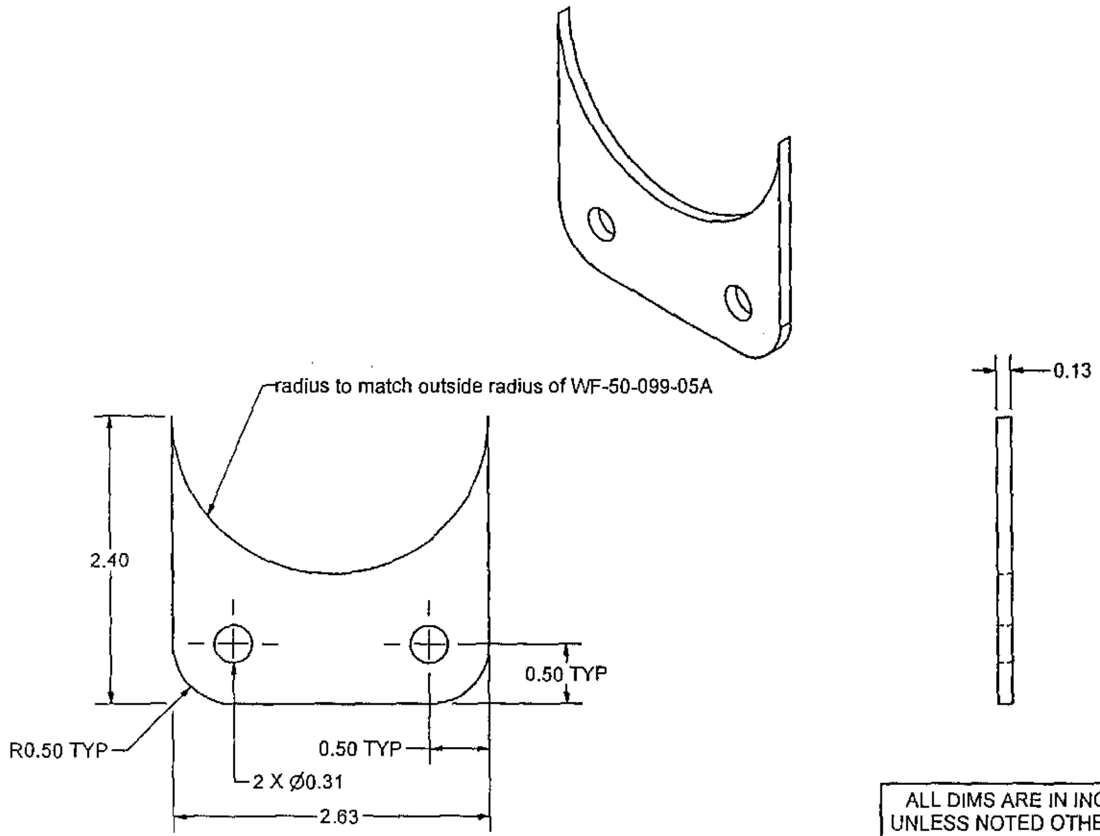
REV A

DATE: 2/17/2002

SCALE:

SIZE: B

SHEET 1 ***of*** 1

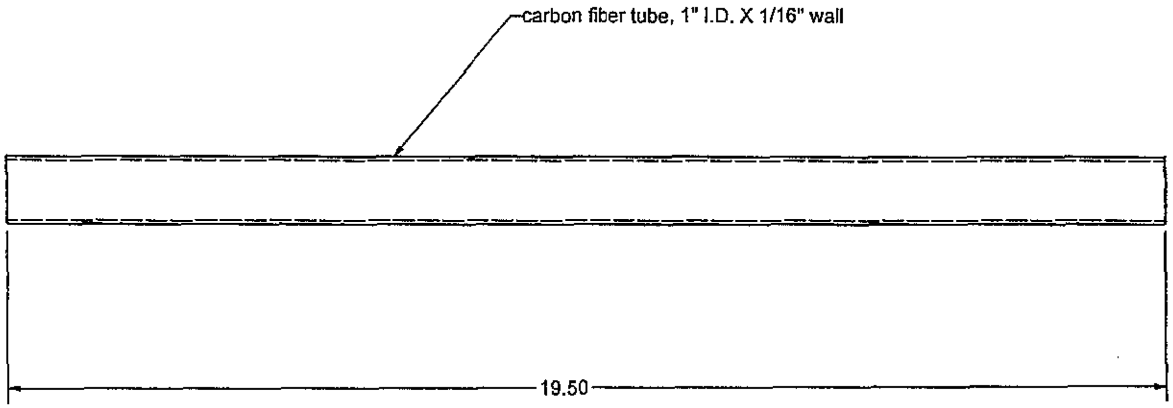


ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

UtahState University — Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen			
MATERIAL: Steel, Mild	*PART DESCRIPTION:* Tab, Mount, Spar, Rear	*PART NUMBER:* WF-50-099-08A	*REV* A
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1



ALL DIMS ARE IN INCHES
UNLESS NOTED OTHERWISE
.X = ± .1
.XX = ± .03
.XXX = ± .010
ANGLES ± 1'

UtahState UNIVERSITY Mechanical & Aerospace Engineering

USU
WRIGHT FLYER
1903-2003

DRAWN BY: David Beck Christensen

MATERIAL: Carbon Fiber

PART DESCRIPTION: Tube, Strut

PART NUMBER: WF-50-099-141

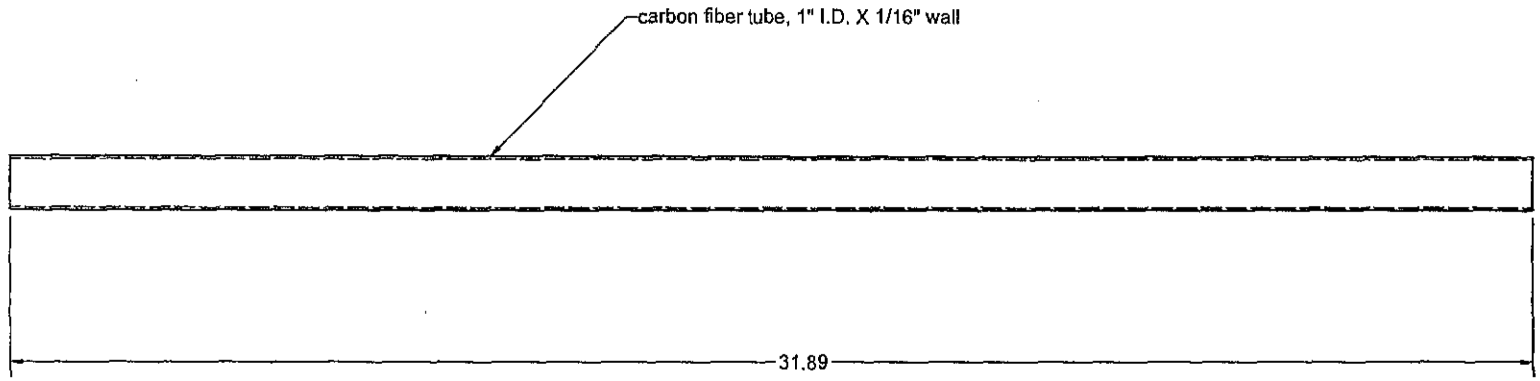
REV A

DATE: 2/17/2002

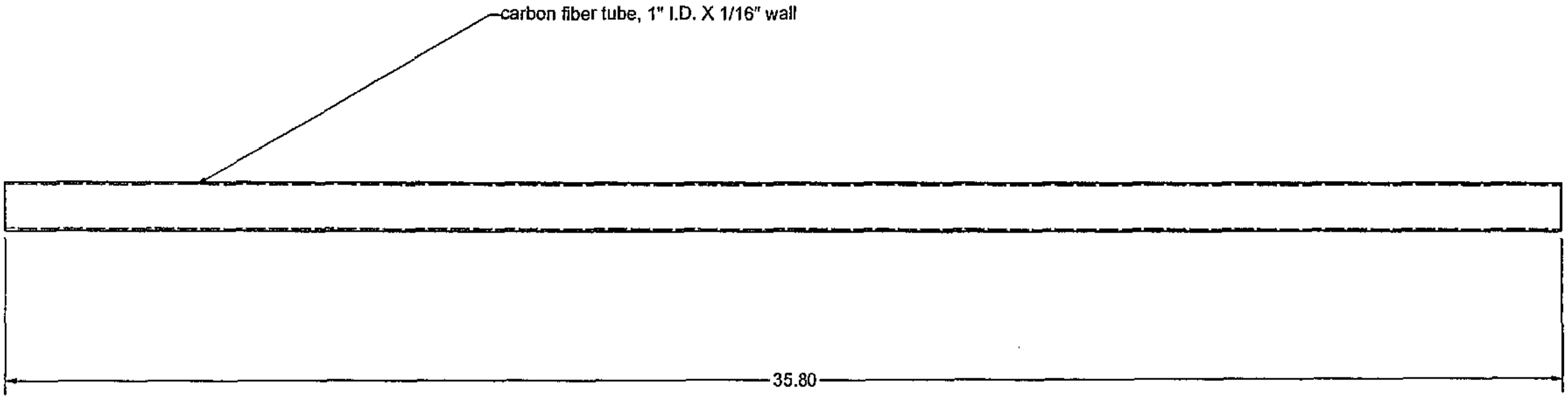
SCALE:

SIZE: B

SHEET 1 ***of*** 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	Utah State University — Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*	
DRAWN BY: David Beck Christensen		
MATERIAL: Carbon Fiber	*PART DESCRIPTION:* Strut	*PART NUMBER:* WF-50-099-14H — *REV*
DATE: 2/17/2002	*SCALE:* — *SIZE:* B	*SHEET* 1 *of* 1



ALL DIMS ARE IN INCHES UNLESS NOTED OTHERWISE .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES ± 1°	UtahState University — Mechanical & Aerospace Engineering *USU WRIGHT FLYER 1903-2003*			
DRAWN BY: David Beck Christensen				
MATERIAL: Carbon Fiber	*PART DESCRIPTION:* Strut		*PART NUMBER:* WF-50-099-14G	*REV*
DATE: 2/17/2002	*SCALE:*	*SIZE:* B	*SHEET* 1 *of* 1	

APPENDIX A

Original 1905 Wright Flyer Drag Calculations

Reference: White, Frank. Fluid Mechanics. Fourth Edition. *Pages* ***458-460***.

Important Notes:
1.) All aerodynamic areas are frontal unless otherwise specified.
2.) Any diagonal member is modeled using a vertical projection of the area.
3.) A YELLOW cell contains a changeable property.

Air Properties (@ 1 atm, and 68 F):

velocity, V =	**28** mph	or	41.076 ft/s
density, ρ =	0.002377 slugs/ft^3		
viscosity, μ =	0.000000376 lb*s/ft^2		
kinematic viscosity, ν =	0.000158183 ft^2/s		

$q_o =$ $^1/_2\rho V^2 =$ 2.0053 slugs/ft/s^2

Characteristic Length			Reynolds
0.25 in	or	0.020833 ft	541
1 in	or	0.083333 ft	2164
2 in	or	0.166667 ft	4327
18 in	or	1.5 ft	38951

Main Wing:

Part Description	*Modeled as a...*	C_D	*Area* (in^2)	*Area* (ft^2)	*Quantity*	*Drag* (lb)	*Drag* (%
Top Wing	Generic Wing	0.047	---	251.50	1	23.703	20.8%
Bottom Wing	Generic Wing	0.047	---	251.50	1	23.703	20.8%
Propeller Supports	Cylinder	1.2	32.81	0.23	8	4.386	3.9%
Struts	Rounded Nose Secti	0.8	70	0.49	18	14.037	12.3%
Wires (collective)	Cylinder	1.2	175.2	1.22	1	2.928	2.6%
					Subtotal =	68.758	60.5

Front Rudder (Canard):

Part Description	*Modeled as a...*	C_D	*Area* (in^2)	*Area* (ft^2)	*Quantity*	*Drag* (lb)	*Drag* (%
Top Wing	Generic Wing	0.03	---	41.50	1	2.497	2.2%
Bottom Wing	Generic Wing	0.03	---	41.50	1	2.497	2.2%
Control Shaft	Cylinder	1.2	76.5	0.53	1	1.278	1.1%
Blinkers	Rounded Nose Secti	0.8	22.3	0.15	2	0.497	0.4%
Struts	Rounded Nose Secti	0.8	33.75	0.23	9	3.384	3.0%
Wires (collective)	Cylinder	1.2	15.68	0.11	1	0.262	0.2%
					Subtotal =	10.414	9.2

1905 Flyer Drag Calculations Continued...

Rear Rudder:

Part Description	Modeled as a...	CD	Area (in2)	Area (ft2)	Quantity	Drag (lb)	Drag (%)
Left Wing	Generic Wing	0.0017	---	17.40	1	0.059	0.1%
Right Wing	Generic Wing	0.0017	---	17.40	1	0.059	0.1%
Struts	Rounded Nose Secti	0.8	22.5	0.16	6	1.504	1.3%
Wires (collective)	Cylinder	1.2	15.68	0.11	1	0.262	0.2%
					Subtotal =	1.885	1.7%

Engine and Drive Train:

Part Description	Modeled as a...	CD	Area (in2)	Area (ft2)	Quantity	Drag (lb)	Drag (%)
Engine	---	---	---	---	---	---	
Block	Rectangular Plate	1.2	250	1.74	1	4.178	3.7%
Radiator	Flat Nose Section	0.8	101.6	0.71	1	1.132	1.0%
Fuel Tank	Cylinder	0.8	76.56	0.53	1	0.853	0.8%
Drive Train	---	---	---	---	---	---	
Guide Tubes (collective)	Cylinder	1.2	200	1.39	1	3.342	2.9%
Sprockets	Disk	1.17	99.4	0.69	2	3.239	2.8%
Propellers (non-rotating)	Flat Plate	0	---	4.00	2	0.000	0.0%
					Subtotal =	12.744	11.2%

Pilot:

Part Description	Modeled as a...	CD	Area (in2)	Area (ft2)	Quantity	Drag (lb)	Drag (%)
Orville	Human(sitting)	1.2		---	2	4.813	4.2%

Airframe Structural Supports:

Part Description	Modeled as a...	CD	Area (in2)	Area (ft2)	Quantity	Drag (lb)	Drag (%)
Skids	Flat Nose Section	1.6	38.75	0.27	2	1.727	1.5%
Wires (collective)	Cylinder	1.2	96.78	0.67	1	1.617	1.4%
Control Wires (collective)	Cylinder	1.2	80.36	0.56	1	1.343	1.2%
Center Strut	Rounded Nose Secti	0.8	14	0.10	1	0.156	0.1%
Vertical Struts (collective)	Rounded Nose Secti	0.8	728.1	5.06	1	8.111	7.1%
Horizontal Struts	Rounded Nose Secti	0.8	63.75	0.44	3	2.131	1.9%
					Subtotal =	15.085	13.3%

Total Drag Force = **113.70** lb

Moment arms on the next sheet, sheet 2

USU Wright Flyer Drag Calculations

****Drag of wings ***counted*** on this sheet

Reference: White, Frank. Fluid Mechanics. Fourth Edition. *Pages* ***458-460***.

Important Notes:
1.) All aerodynamic areas are frontal unless otherwise specified.
2.) Any diagonal member is modeled using a vertical projection of the area.
3.) A YELLOW cell contains a changeable property.

Air Properties (@ 1 atm, and 68 F):

velocity, V =	45 mph	or	66.015 ft/s
density, ρ =	0.002377 slugs/ft^3		
viscosity, μ =	0.000000376 lb*s/ft^2		
kinematic viscosity, ν =	0.000158183 ft^2/s		

q_o = $^1/_2\rho V^2$ = 5.1795 slugs/ft/s^2

Characteristic Length			Reynolds #:
0.25 in	or	0.020833 ft	8694
1 in	or	0.083333 ft	34778
2 in	or	0.166667 ft	69556
18 in	or	1.5 ft	626001

Main Wing:

Part Description	*Modeled as a...*	C_D	*Area* (in^2)	*Area* (ft^2)	*Quantity*	*Drag* (lb)	*Drag* (%)
Top Wing	usu 402509-3040.13	0.0073	---	230	1	8.6963125	5.7%
Bottom Wing	usu 402509-3040.13	0.0073	---	230	1	8.6963125	5.7%
Propeller Supports	Stream Lined Body	0.12	50	0.347222	16	3.452973	2.3%
Struts	Stream Lined Body	0.12	100	0.694444	16	6.905946	4.6%
Wires (collective)	Round Cylinder	1.2		0		0	0.0%
					Subtotal =	27.751544	18.3%

Front Rudder (Canard):

Part Description	*Modeled as a...*	C_D	*Area* (in^2)	*Area* (ft^2)	*Quantity*	*Drag* (lb)	*Drag* (%)
Top Wing	usu 993009-3040.13	0.0451	---	27.5	1	6.4174151	4.2%
Bottom Wing	usu 993009-3040.13	0.0451	---	27.5	1	6.4174151	4.2%
Struts	Stream Lined Body	0.12	24	0.166667	2	0.2071784	0.1%
					Subtotal =	13.042009	8.6%

USU Flyer Drag Calculations Continued...

Rear Rudder:

Part Description	*Modeled as a...*	C_D	*Area* (in²)	*Area* (ft²)	*Quantity*	*Drag* (lb)	*Drag* (%)
Left Wing	NACA 0009	0.0017	---	21	1	0.1849067	0.1%
Right Wing	NACA 0009	0.0017	---	21	1	0.1849067	0.1%
Struts	Round Cylinder	1.2	20	0.138889	1	0.8632432	0.6%
Wires (collective)	Round Cylinder	1.2		0		0	0.0%
					Subtotal =	1.2330567	0.8%

Engine and Drive Train:

Part Description	*Modeled as a...*	C_D	*Area* (in²)	*Area* (ft²)	*Quantity*	*Drag* (lb)	*Drag* (%)
Engine	---	---	---	---	---	---	
Block	Bluff Body	1	180	1.25	1	6.4743244	4.3%
Fuel Tank	Bluff Body	1	100	0.694444	1	3.5968469	2.4%
Drive Train	---	---	---	---	---	---	
Transmission	Bluff Body	0.5	216	1.5	1	3.8845946	2.6%
Sprockets	Round Cylinder	1.2	28.25	0.196181	2	2.4386622	1.6%
					Subtotal =	16.394428	10.8%

Pilot:

Part Description	*Modeled as a...*	C_D	*Area* (in²)	*Area* (ft²)	*Quantity*	*Drag* (lb)	*Drag* (%)
Orville	Person	6		---	2	62.153514	41.1%

Airframe Structural Supports:

Part Description	*Modeled as a...*	C_D	*Area* (in²)	*Area* (ft²)	*Quantity*	*Drag* (lb)	*Drag* (%)
Skids	Square Cylinder	2.1	12	0.083333	2	1.8128108	1.2%
Wires (collective)	Round Cylinder	1.2		0		0	0.0%
Control Wires (collective)	Round Cylinder	1.2		0		0	0.0%
Vertical Struts (collective)	Round Cylinder	1.2	271	1.881944	2	23.393892	15.5%
Diagonal Struts	Round Cylinder	1.2	65	0.451389	2	5.6110811	3.7%
					Subtotal =	30.817784	20.4%

Total Drag Force = 151.39 lb

APPENDIX B

AIRCRAFT PERFORMANCE ANALYSIS

Thrust Required

$$V := \begin{pmatrix} 5 \\ 15 \\ 25 \\ 35 \\ 40 \\ 45 \\ 50 \\ 55 \end{pmatrix} mph \qquad V_1 := \begin{pmatrix} 5 \\ 15 \\ 25 \\ 35 \\ 40 \\ 45 \\ 50 \\ 55 \end{pmatrix}$$

$$\rho := .0023769 \frac{slug}{ft^3} \qquad C_{Do.L} := 0 \qquad C_{Do} := 0.0411$$

Note: Cdo was obtained from drag spreadsheet. The parasitic drag for steady level flight (50 mph) was then non-dimensionalized with respect to the main wings.

$$R_A := \frac{40.5ft}{6ft} \qquad b := 40.5ft \qquad S_w := 461.1ft^2$$

$$W := 890lbf \qquad e := .82$$

$$W_1 := 890$$

$$T_R := \left(\frac{.5 \cdot \rho \cdot V^2 \cdot C_{Do}}{\frac{W}{S_w}} + C_{Do.L} + \frac{\frac{W}{S_w}}{.5 \cdot \pi \cdot e \cdot R_A \cdot \rho \cdot V^2} \right) \cdot W \qquad T_R = \begin{pmatrix} 1.547 \times 10^3 \\ 182.649 \\ 92.11 \\ 90.895 \\ 101.67 \\ 117.191 \\ 136.579 \\ 159.331 \end{pmatrix} lbf$$

Power Required

$$P_R := \left(\frac{.5 \cdot \rho \cdot V^3 \cdot C_{Do}}{\frac{W}{S_w}} + C_{Do.L} \cdot V + \frac{\frac{W}{S_w}}{.5 \cdot \pi \cdot e \cdot R_A \cdot \rho \cdot V} \right) \cdot W \qquad P_R = \begin{pmatrix} 20.626 \\ 7.306 \\ 6.141 \\ 8.484 \\ 10.845 \\ 14.063 \\ 18.21 \\ 23.369 \end{pmatrix} hp$$

$$P_{R1} := \frac{\left(\frac{.5 \cdot \rho \cdot V^3 \cdot C_{Do}}{\frac{W}{S_w}} + C_{Do.L} \cdot V + \frac{\frac{W}{S_w}}{.5 \cdot \pi \cdot e \cdot R_A \cdot \rho \cdot V} \right) \cdot W}{1hp} \qquad P_{R1} = \begin{pmatrix} 20.626 \\ 7.306 \\ 6.141 \\ 8.484 \\ 10.845 \\ 14.063 \\ 18.21 \\ 23.369 \end{pmatrix}$$

Power/Thrust Available

$T_s := 282.034\text{lbf}$ $T_1 := 5.025\frac{\text{lbf}\cdot\text{sec}}{\text{ft}}$ $T_2 := -.144\frac{\text{lbf}\cdot\text{s}^2}{\text{ft}^2}$

$$T_A := 282.034 + 5.025V_1 - .144V_1^{\ 2}$$

Note: Thrust available (Ta) data was obtained from propeller manufacturer.

$$P_A := \frac{282.034V_1 + 5.025V_1^{\ 2} - .144V_1^{\ 3}}{550}$$

$$T_A = \begin{pmatrix} 303.559 \\ 325.009 \\ 317.659 \\ 281.509 \\ 252.634 \\ 216.559 \\ 173.284 \\ 122.809 \end{pmatrix} \qquad P_A = \begin{pmatrix} 2.76 \\ 8.864 \\ 14.439 \\ 17.914 \\ 18.373 \\ 17.718 \\ 15.753 \\ 12.281 \end{pmatrix}$$

Rate of Climb

$$Vc := \frac{P_A - P_{R1}}{W_1}\cdot 550\,60 \qquad Vc = \begin{pmatrix} -662.457 \\ 57.766 \\ 307.694 \\ 349.677 \\ 279.151 \\ 135.541 \\ -91.117 \\ -411.118 \end{pmatrix} \frac{\text{ft}}{\text{min}}$$

Power failure and gliding flight

Vs = Sink Rate

$$Vs := \frac{C_{Do}\cdot\rho\cdot V^3}{2\cdot\frac{W}{S_w}} + C_{Do.L}\cdot V + \frac{2\cdot\frac{W}{S_w}}{\pi\cdot e\cdot R_A\cdot\rho\cdot V} \qquad Vs = \begin{pmatrix} 764.78 \\ 270.895 \\ 227.686 \\ 314.558 \\ 402.109 \\ 521.436 \\ 675.22 \\ 866.477 \end{pmatrix} \frac{\text{ft}}{\text{min}}$$

The glide ratio for zero wind is equal to the Lift to Drag ratio. Assuming that the wright flyer will not be flying in windy conditions, we say that $R_G = L/D = C_L/C_D$. Cl and Cd were obtained from WINGS2001 output after the plane was balanced.

$C_L := .241$ $\qquad C_D := .05018$ $\qquad R_G := \frac{C_L}{C_D}$ $\qquad R_G = 4.803$

Steady Coordinated Turn

$C_{Lmax} := 0.706$ Added Cl of each surface when plane was balanced for 29 mph.

$V := 45\text{mph}$ Design flight speed.

n_{maxS} is the stall limited, Maximum allowable load on the wings.

r_t is the stall limited Minimum turning radius

This equation does not account for tip stall.

$$n_{maxS} := \frac{0.5 \cdot \rho \cdot V^2}{\frac{W}{S_w}} \cdot C_{Lmax} \qquad n_{maxS} = 1.894$$

$$r_t := \frac{V^2}{g \cdot \sqrt{n_{maxS}^{\,2} - 1}} \qquad r_t = 84.199\text{ft} \qquad \text{PercentWingSpan} := \frac{r_t}{b} \cdot 100$$

$$\text{PercentWingSpan} = 207.898$$

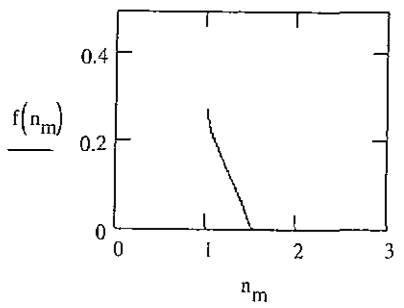
**** PercentWingSpan wing span is not very much, the inner wing could easily be stalling, so we have to try again using the equations that take tip stall into account !!!.

The following equation finds the max load allowable on a wing, taking into account the bank angle and turning radius to avoid stalling the tip of the inside wing (See Eq. 3.9.46 and the preceding paragragh, pg. 76.

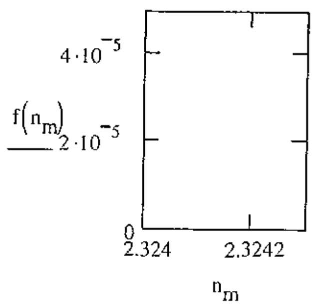
When '$f(n_{max})$' equals zero, n_{max} is the correct value =>

$$f(n_m) := n_m - \left(\frac{b \cdot g}{2 \cdot V^2} \cdot \sqrt{n_m^{\,2} - 1}\right) - \sqrt{\frac{2 \cdot \frac{W}{S_w}}{\rho \cdot V^2 \cdot C_{Lmax}} \cdot \sqrt{n_m^{\,3}}}$$

Over view graph:



ZOOM view graph:



This is to verify a guess taken from the graph above:

Guess from graph:

$n_{max} := 2.32421$

$$f(n_{max}) := n_{max} - \left(\frac{b \cdot g}{2 \cdot V^2} \cdot \sqrt{n_{max}^2 - 1}\right) - \sqrt{\frac{2 \cdot \frac{W}{S_w}}{\rho \cdot V^2 \cdot C_{Lmax}} \cdot \sqrt{n_{max}^3}} \qquad f(n_{max}) = -0.565$$

$$r_t := \frac{V^2}{g \cdot \sqrt{n_{max}^2 - 1}} \qquad r_t = 64.53\text{ft} \qquad \text{PercentWingSEMISpan} := \frac{r_t}{\frac{b}{2}} \cdot 100$$

$\text{PercentWingSEMISpan} = 318.665$

**The load on the wing structure is the weight of the plane times the load factor, n.

$$\text{WingLoad} := n_{max} \cdot W \qquad \text{WingLoad} = 2.069 \times 10^3 \,\text{lbf}$$

g forces on the wings:

$$Gs := \frac{\text{WingLoad}}{W} \qquad Gs = 2.324$$

Take Off Performance

$g = 32.174 \frac{ft}{s^2}$

$t_{rotate} := 1\text{sec}$

$t_{react} := 2\text{sec}$

$V_{hw} := 0 \frac{ft}{sec}$

$V_{stall} := 44 \frac{ft}{sec}$

$V_{LO} := 1.1 \cdot V_{stall}$

$V_{LO} = 48.4 \frac{ft}{s}$

$\mu_r := .1$

$\mu_{brakes} := .1$

Note: Rolling and brake friction are unknown at this time. The values listed are an estimate. If $\mu brake = \mu r$ then a zero brake analysis is being done.

$hw := 5\text{ft}$

Note: Uncertain what value is correct for the height of wings from ground for biplane configuration. An average of the two is being used here.

$$C_L := \pi \cdot e \cdot R_A \cdot \left[\frac{1}{2 \cdot \left(\frac{16 \cdot hw}{b}\right)^2} + \frac{1}{2}\right] \cdot (\mu_r - C_{Do.L}) \qquad C_L = 1.092$$

$$C_D := C_{Do} + C_{Do.L} \cdot C_L + \frac{\left(16 \cdot \frac{hw}{b}\right)^2}{1 + \left(16 \cdot \frac{hw}{b}\right)^2} \cdot \frac{C_L^2}{\pi \cdot e \cdot R_A} \qquad C_D = 0.096$$

$$K_0 := \frac{T_s}{W} - \mu_r \qquad K_0 = 0.217$$

$$K_1 := \frac{T_1}{W} \qquad K_1 = 5.646\times 10^{-3}\,\frac{s}{ft}$$

$$K_2 := \frac{T_2}{W} + \frac{\rho}{2\cdot\frac{W}{S_w}}\cdot\left(C_L\cdot\mu_r - C_D\right) \qquad K_2 = -1.535\times 10^{-4}\,\frac{s^2}{ft^2}$$

$$K_R := 4\cdot K_0\cdot K_2 - K_1^{\,2} \qquad K_R = -1.65\times 10^{-4}\,\frac{s^2}{ft^2}$$

$$f_s := K_0 \qquad f_s = 0.217$$

$$f_{LO} := K_0 + K_1\cdot V_{LO} + K_2\cdot V_{LO}^{\,2} \qquad f_{LO} = 0.131$$

$$f_{s2} := K_1 \qquad f_{s2} = 5.646\times 10^{-3}\,\frac{s}{ft}$$

$$f_{LO2} := K_1 + 2\cdot K_2\cdot V_{LO} \qquad f_{LO2} = -9.211\times 10^{-3}\,\frac{s}{ft}$$

$$K_w := \frac{1}{\sqrt{-K_R}}\cdot\ln\left[\frac{\left(f_{LO2} - \sqrt{-K_R}\right)\cdot\left(f_{s2} + \sqrt{-K_R}\right)}{\left(f_{LO2} + \sqrt{-K_R}\right)\cdot\left(f_{s2} - \sqrt{-K_R}\right)}\right] \qquad K_w = 213.757\frac{ft}{s}$$

$$K_T := \frac{1}{2\cdot K_2}\cdot\ln\left(\frac{f_{LO}}{f_s}\right) - \frac{K_1\cdot K_w}{2\cdot K_2} \qquad K_T = 5.584\times 10^{3}\,\frac{ft^2}{s^2}$$

$$s_a := \frac{K_T - V_{hw}\cdot K_w}{g} \qquad s_a = 173.543ft$$

$$s_g := s_a + \left(V_{LO} - V_{hw}\right)\cdot t_{rotate}$$

Take Off Distance

$$s_g = 221.943ft$$

Landing Performance

$$V_{TD} := 1.15\cdot V_{stall} \qquad V_{TD} = 50.6\frac{ft}{s}$$

$$s_f := \left(V_{TD} - V_{hw}\right)\cdot t_{react} \qquad s_f = 101.2ft$$

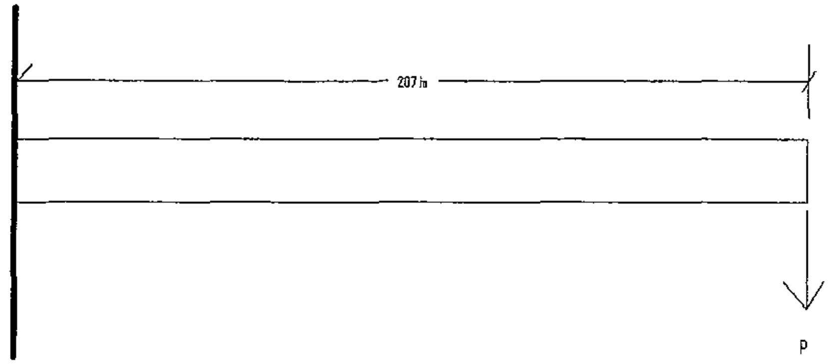
$$s_b := \frac{\frac{W}{S_w}}{\rho\cdot g\cdot\left(C_D - \mu_{brakes}\cdot C_L\right)}\cdot\ln\left[1 + \frac{\rho\cdot V_{TD}^{\,2}}{2\cdot\frac{W}{S_w}}\cdot\left(\frac{C_D}{\mu_{brakes}} - C_L\right)\right] \qquad s_b = 447.454ft$$

$$s_{g2} := s_f + s_b$$

Landing Distance

$$s_{g2} = 548.654ft$$

APPENDIX C



% of Total Weight Carried (800 lbs) Assumptions

***Canard : 15%**
***Front Spars : 30%**
***Cables/Skin : 50%**
***Back Spars : 20%**

Calculations for front spar thickness and weight

$P := \frac{800\,\mathrm{lbf}\cdot .30}{4}$ Assumed load on wingtip test (2.5 g load) [P(%)/number of spars]

$L := 207\cdot\mathrm{in}$ Length of beam (assumed to be rigid at frame mount)

$a := 207\cdot\mathrm{in}$ Distance down the beam that the deflection is measured

$\delta := 20\cdot\mathrm{in}$ Deflection

$\rho := .0643065798\frac{\mathrm{lb}}{\mathrm{in}^3}$ Density

$d_o := 3.109\,\mathrm{in}$ Outer diameter (should be within 3.0 to 3.2 inches diameter)

$R_o := \frac{d_o}{2}$ Outer Radius

$E_x := 100\cdot 10^9\cdot\mathrm{Pa}$ X-dir modulus of the graphite (in line with the fibers)

(EI value required)

$$\mathrm{Stiffness} := \frac{P\cdot a^2}{6\cdot\delta}\cdot(3\cdot L - a)$$

$$\mathrm{Stiffness} = 2.545\times 10^4\,\frac{\mathrm{kg\,m}^3}{\mathrm{s}^2}$$

(Ri = inner radius according to smearing method)

$$R_i := \sqrt[4]{\frac{-\mathrm{Stiffness}\cdot 4}{\pi\cdot E_x} + R_o^4}$$

$$R_i = 1.5\,\mathrm{in}$$

(Thickness)

$t := R_o - R_i$ $\qquad t = 0.055in$ (About 10 layers)

(Volume)

$V := \pi \cdot \left(R_o^{\ 2} - R_i^{\ 2}\right) \cdot 486\,in$ $\qquad V = 254.786in^3$

(Weight)

$W_f := \rho \cdot V$ $\qquad$ [redacted]

(Diameter of Mandrel)

$d := R_i \cdot 2$ $\qquad d = 3\,in$

Back Spar Calculations

$P := \frac{800\,lbf \cdot .20}{4}$ $\qquad \rho := .0643065798 \frac{lb}{in^3}$

$L := 207 \cdot in$ $\qquad d_o := 2.55 \cdot in$

$a := 207 \cdot in$ $\qquad R_o := \frac{d_o}{2}$

$\delta := 25 \cdot in$ $\qquad E_x := 90 \cdot 10^9 \cdot Pa$

(EI value required)

$Stiffness := \frac{P \cdot a^2}{6 \cdot \delta} \cdot (3 \cdot L - a)$ $\qquad Stiffness = 1.358 \times 10^4 \frac{kg\,m^3}{s^2}$

(Ri = inner radius according to smearing method)

$R_i := \sqrt[4]{\frac{-Stiffness \cdot 4}{\pi \cdot E_x} + R_o^{\ 4}}$ $\qquad R_i = 1.215in$

(Thickness)

$t := R_o - R_i$ $\qquad t = 0.06in$ (About 12 layers)

Assume that one must add 3 more 'strength layers' on the center 72 inches of the spar...

$t_i := t + .015\,in$ $\qquad R_{ocenter} := R_o + t$

(Volume)

$V := \pi \cdot \left(R_o^{\ 2} - R_i^{\ 2}\right) \cdot 414\,in + \pi \cdot \left(R_{ocenter}^{\ \ 2} - R_i^{\ 2}\right) \cdot 72 \cdot in$ $\qquad V = 262.328in^3$

(Weight)

$W_b := \rho \cdot V$

$W_b = 16.869\text{lb}$

(Diameter of Mandrel)

$d := R_i \cdot 2$

$d = 2.431\text{in}$

Total estimated spar weight

$TOTAL_{spar} := 2 \cdot W_b + 2 \cdot W_f$

$TOTAL_{spar} = 66.508\text{lb}$

Rib Weight Calculations

$\rho_{foam} := 37165 \frac{gm}{m^3}$

$N_{ribs} := 60$

$x_{ribs} := 69.576\text{in}$

$y_{ribs} := 2.5 \cdot \text{in}$

$z_{ribs} := .5 \cdot \text{in}$

$V_{ribs} := x_{ribs} \cdot y_{ribs} \cdot z_{ribs}$

$m_{foam} := V_{ribs} \cdot \rho_{foam} \cdot N_{ribs}$

$m_{foam} = 7.006\text{lb}$

$\rho_{kevlar} := .0072 \cdot \frac{gm}{cm^2}$

$LAYER_{kevlar} := 1$

$A_{ribs} := .1122 \text{m}^2$

$m_{kevlar} := \rho_{kevlar} \cdot LAYER_{kevlar} \cdot A_{ribs} \cdot N_{ribs}$

$m_{kevlar} = 1.069\text{lb}$

$TOTAL_{ribs} := m_{foam} + m_{kevlar}$

$TOTAL_{ribs} = 8.075\text{lb}$

(adjust for epoxy)

APPENDIX D

I-deas Beam Models

Figure 1 refers to p/n WF-50-099-11A. The chassis beam is loaded with 120-lbf at two points spanning ten inches. The 2 – 120-lbf loads (240-lbf) is due to two men standing on the Footrest assembly, estimating 240-lbf per passenger noting there are two chassis bars supporting the reaction.

Figure 2 refers to p/n WF-50-099-11A. The chassis beam is loaded with 120-lbf at two points spanning ten inches. The 2 – 120-lbf loads (240-lbf) is due to two men standing on the Footrest assembly, estimating 240-lbf per passenger noting there are two chassis bars supporting the reaction.

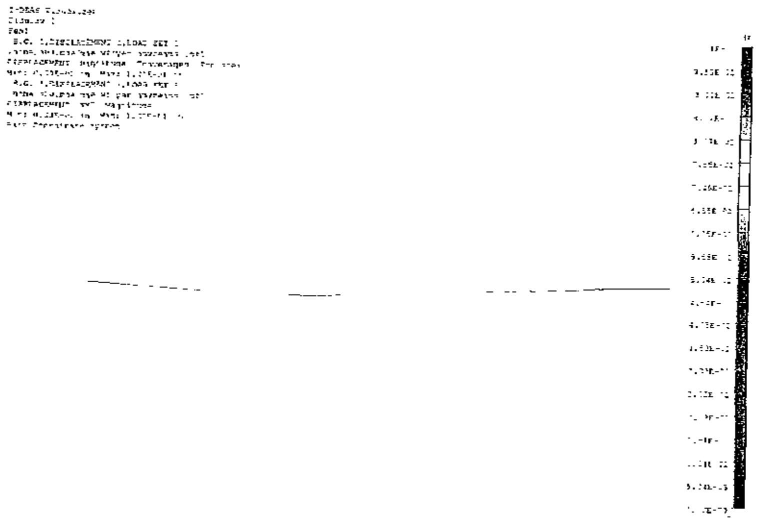


Figure 1: Chassis when both standing.

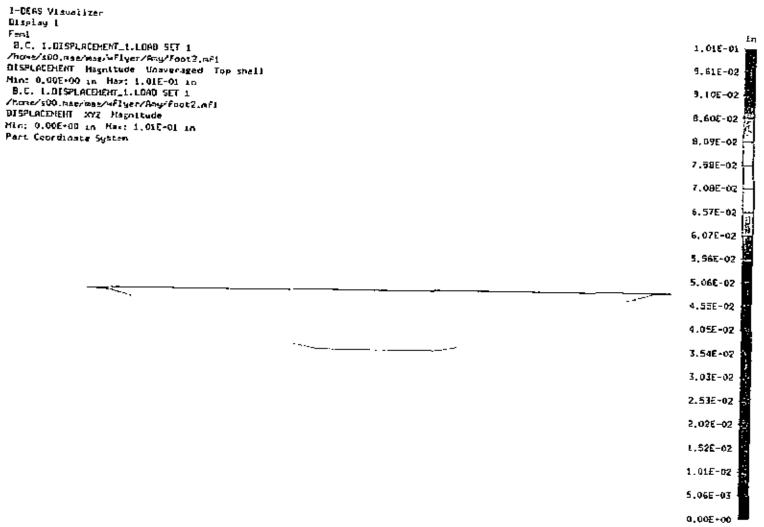


Figure 2: Footrest bar both standing.

Figure 3 refers to p/n WF-50-099-11A. The beam is loaded with two horizontal forces of 120-lbf each, modeling two passengers sitting on the span bar. The distance between loads is about twelve inches. Assuming that the pilot and passenger are 240-lbf each and there are four mounting points, two on each chassis bar.

Figure 4 refers to p/n WF-30-003. The beam is loaded with 2 distributed loads of 120-lbf across 18 inches each, along with two point loads 20 lbf each for the engine. The distributed loads are if both the pilot and passenger are standing on the footplates. 120-lbf is approximately one half the weight of a large man (note: one half because there is a front and back beam supporting the foot plates.) The 20-lbf point loads are two engine mounts on the beam, estimated 80-lbf engine divided by four mounting points.

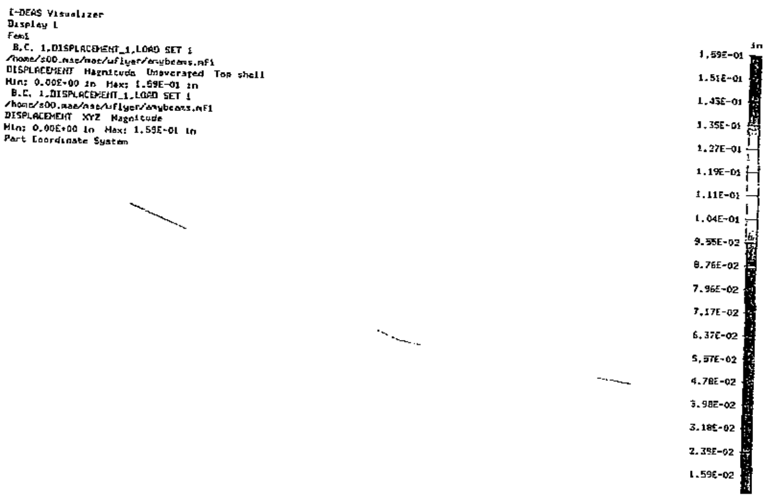


Figure 3: Chassis bar both sitting.

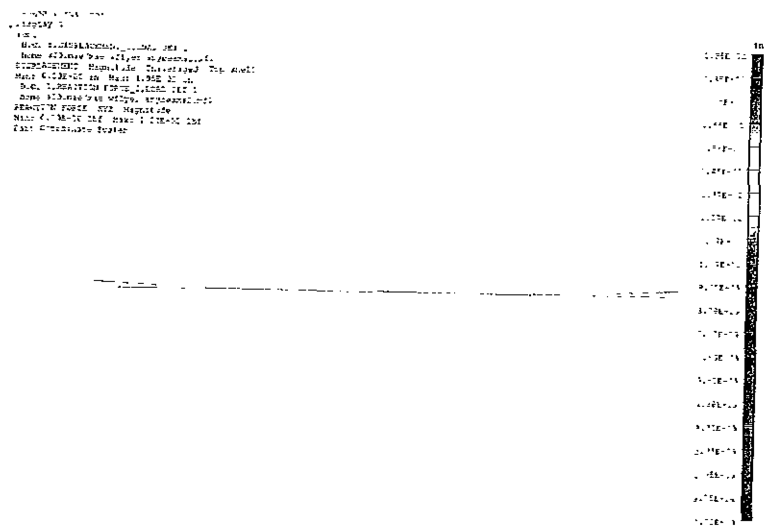


Figure 4: Span bar both standing.

Control Throw vs. Surface Deflection

Component: **Canard**
Action: **Elevation**
Need Canard rotation of +/- 15 degrees

Control Side Tabs	1.5	2	2.5	3	3.5	4
Canard control radius	1.5	2.5	**3.5**	4.5	5.5	6.5

Control Stick Throw (degree)	Cable Displacement hole1 (in)	hole 2 (in)	hole 3 (in)	hole 4 (in)	hole 5 (in)	hole 6 (in)
-30.0	-0.750	-1.000	-1.250	-1.500	-1.750	-2.000
-25.0	-0.634	-0.845	-1.057	-1.268	-1.479	-1.690
-20.0	-0.513	-0.684	-0.855	-1.026	-1.197	-1.368
-15.0	-0.388	-0.518	-0.647	-0.776	-0.906	-1.035
-10.0	-0.260	-0.347	-0.434	-0.521	-0.608	-0.695
-5.0	-0.131	-0.174	-0.218	-0.261	-0.305	-0.349
0.0	0.000	0.000	0.000	0.000	0.000	0.000
5.0	0.131	0.174	0.218	0.261	0.305	0.349
10.0	0.260	0.347	0.434	0.521	0.608	0.695
15.0	0.388	0.518	0.647	0.776	0.906	1.035
20.0	0.513	0.684	0.855	1.026	1.197	1.368
25.0	0.634	0.845	1.057	1.268	1.479	1.690
30.0	0.750	1.000	1.250	1.500	1.750	2.000

Canard rotation @ 3.5" radius (hole 3) hole1 (degree)	hole 2 (degree)	hole 3 (degree)	hole 4 (degree)	hole 5 (degree)	hole 6 (degree)
-12.37	-16.60	-20.92	-25.38	-30.00	-34.85
-10.44	-13.97	-17.57	-21.24	-25.00	-28.88
-8.43	-11.27	-14.14	-17.05	-20.00	-23.01
-6.37	-8.51	-10.65	-12.82	-15.00	-17.21
-4.27	-5.69	-7.12	-8.56	-10.00	-11.45
-2.14	-2.85	-3.57	-4.28	-5.00	-5.72
0.00	0.00	0.00	0.00	0.00	0.00
2.14	2.85	3.57	4.28	5.00	5.72
4.27	5.69	7.12	8.56	10.00	11.45
6.37	8.51	10.65	12.82	15.00	17.21
8.43	11.27	14.14	17.05	20.00	23.01
10.44	13.97	17.57	21.24	25.00	28.88
12.37	16.60	20.92	25.38	30.00	34.85

Component: **Wing Warp**
Action: **Roll**
Properties:

Stick Dimensions	
Total Vertical Height	15 in
Lg radius	12 in
sm radius	3 in

Wing Warp Differential		
hole 1	1.75	in
hole 2	3	in
hole 3	4.5	in
hole 4	6	in
hole 5	7.5	in
hole 6	9	in
hole 7	10.5	in

Need: +/- 8 inches of cable travel.

(degree)	Control Side (attach at hole 1) (inch)	Bell Rotation (degree)	Cable Travel, Wing Side: hole 2 (inch)	hole 3 (inch)	hole 4 (inch)	hole 5 (inch)	hole 6 (inch)	hole 7 (inch)
-30.0	1.50	59.00	2.57	3.86	5.14	6.43	7.71	9.00
-25.0	1.27	46.43	2.17	3.26	4.35	5.43	6.52	7.61
-20.0	1.03	35.90	1.76	2.64	3.52	4.40	5.28	6.16
-15.0	0.78	26.34	1.33	2.00	2.66	3.33	3.99	4.66
-10.0	0.52	17.32	0.89	1.34	1.79	2.23	2.68	3.13
-5.0	0.26	8.59	0.45	0.67	0.90	1.12	1.34	1.57
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.0	-0.26	-8.59	-0.45	-0.67	-0.90	-1.12	-1.34	-1.57
10.0	-0.52	-17.32	-0.89	-1.34	-1.79	-2.23	-2.68	-3.13
15.0	-0.78	-26.34	-1.33	-2.00	-2.66	-3.33	-3.99	-4.66
20.0	-1.03	-35.90	-1.76	-2.64	-3.52	-4.40	-5.28	-6.16
25.0	-1.27	-46.43	-2.17	-3.26	-4.35	-5.43	-6.52	-7.61
30.0	-1.50	-59.00	-2.57	-3.86	-5.14	-6.43	-7.71	-9.00

Component: Rudder
Action: Yaw

Properties:

Pull Cable Differential		
hole 1	1	in
hole 2	1.5	in
hole 3	2	in
hole 4	2.5	in
hole 5	3	in

Rudder		
Coupler Radius	2.512	in

Need Rudder rotation of +/- 15 degrees.

	Cable Displacement (in)					Rudder Deflection (degree)				
(degree)	hole 1	hole 2	hole 3	hole 4	hole 5	hole 1	hole 2	hole 3	hole 4	hole 5
-30.0	-0.50	-0.75	-1.00	-1.25	-1.50	-11.48	-17.37	-23.46	-29.84	-36.66
-25.0	-0.42	-0.63	-0.85	-1.06	-1.27	-9.69	-14.62	-19.66	-24.87	-30.31
-20.0	-0.34	-0.51	-0.68	-0.86	-1.03	-7.83	-11.78	-15.80	-19.90	-24.11
-15.0	-0.26	-0.39	-0.52	-0.65	-0.78	-5.91	-8.89	-11.89	-14.93	-18.00
-10.0	-0.17	-0.26	-0.35	-0.43	-0.52	-3.96	-5.95	-7.95	-9.95	-11.97
-5.0	-0.09	-0.13	-0.17	-0.22	-0.26	-1.99	-2.98	-3.98	-4.98	-5.97
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.0	0.09	0.13	0.17	0.22	0.26	1.99	2.98	3.98	4.98	5.97
10.0	0.17	0.26	0.35	0.43	0.52	3.96	5.95	7.95	9.95	11.97
15.0	0.26	0.39	0.52	0.65	0.78	5.91	8.89	11.89	14.93	18.00
20.0	0.34	0.51	0.68	0.86	1.03	7.83	11.78	15.80	19.90	24.11
25.0	0.42	0.63	0.85	1.06	1.27	9.69	14.62	19.66	24.87	30.31
30.0	0.50	0.75	1.00	1.25	1.50	11.48	17.37	23.46	29.84	36.66

APPENDIX E

Quality Assurance

As with any manufacturing process there can be inconsistencies in the final product. In order to avoid these inconsistencies, quality assurance inspection forms were created for the purpose of tracking, documenting, and ensuring the quality of each and every part on the USU Flyer. A few examples of these forms are attached for reference. The purpose of each form explains why the quality assurance is needed for each part. The requirements list specific items that must be met in order for the part to continue in the manufacturing process. Four individuals (Technician, Design Engineer, Manufacturing Manager, and Project Manager) inspect and pass off these requirements to ensure that no faulty part continues in the process. If parts are do not conforming to these requirements, their quality assurance forms can aid in determining the root cause of the non-conformance.

QUALITY ASSURANCE
Inspection and Certification Form

Sheet Number: _________ **Date:** _________

Part Number: WF-20-015

Description: Canard Surface Left

Purpose: a) Certify that left canard surface is manufactured according to specifications.
b) Verify dimensions.
c) Certify that the surface has the correct aerodynamic shape and size.

Requirements: Verify the correct material of the surface. Inspect the aerodynamic shape to verify that it is the correct shape and size and reduced accordingly. Verify that the spar holes are in the correct position as specified in the drawing.

Part Number	Item Number	Weight	Tech.	Str. Eng.	Man. Eng.	Proj. Man.
WF-20-015	#1					
WF-20-015	#2					

Signatures:

_______________________________ ___________
Technician Date

_______________________________ ___________
Structural Engineer Date

_______________________________ ___________
Manufacturing Engineer Date

_______________________________ ___________
Project Manager Date

QUALITY ASSURANCE
Inspection and Certification Form

Sheet Number:__________ **Date:**__________________

Part Number: WF-30-101 **Weight:**________________

Description: 4130 Steel control system main housing. The case supports control mechanisms for roll and elevation. It is attached to the chassis with large pillow blocks.

Purpose:
a) Certify part has been anodized.
b) Certify part is correct length.
c) Certify all drilled holes are within tolerances of datum.

Signatures:

______________________________	____________
Technician	Date
______________________________	____________
Structural Engineer	Date
______________________________	____________
Manufacturing Engineer	Date
______________________________	____________
Project Manager	Date

QUALITY ASSURANCE
Inspection and Certification Form

Sheet Number:__________ Date:_________________

Part Number: WF-50-099-03

Description: Skid to Canard hardpoint

Purpose:
a) Check that four sides on tab are welded
b) Check integrity of welds
c) Check dimensions with drawing specifications
d) Check overall part with drawing specifications

Requirements: This part is a weldament, consisting of three welded pieces and several drilled holes. It may or may not be painted at the time of this inspection.

Part Number	Item Number	Weight	Tech.	Str. Eng.	Man. Eng.	Proj. Man.
WF-50-099-03	#1					
WF-50-099-03	#2					

Signatures:

_____________________________________ _____________
Technician Date

_____________________________________ _____________
Structural Engineer Date

_____________________________________ _____________
Manufacturing Engineer Date

_____________________________________ _____________
Project Manager Date

APPENDIX F

The Wright Flyer Design Team

Front Row (LR): Nick Filimoehala, Jon Holfeltz, Carson Esplin, Ben Case, Wayne Goodrich, Eric Peterson, Nick Alley (project manager), Mark Karpowich (modeler), Adam Richards.
Back Row (LF): Amy Hintze, Nate Holman, David Christensen, Weston Allen (Draftsman).

Poster on the Hill – Capital Rotunda

Poster on the Hill participants

Utah State University Wright Flyer

The Structural Design

Cockpit design

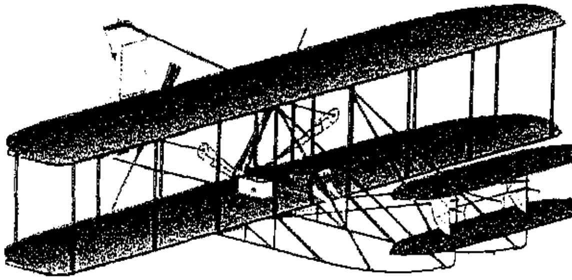
In 1905 the pilot lay prostrate on the lower wing. Hand levers controlled the canard, creating elevation and the rudder, creating yaw. The pilot's side-to-side hip motion activated the wing warp mechanism, creating roll. Design was focused on original aesthetics and modern techniques.

- Aerodynamic analysis showed it is not feasible to have a pilot lying across the wing of the aircraft
- For ease of use, modern control mechanisms are to be used
- A passenger is added
- To make the aerodynamics constant from rider to rider, the cockpit is placed on the center of gravity

The cockpit will be suspended in front of the main wing on the center of gravity, and constructed out of carbon fiber composite.

Rudder Modification

- Reduce the drag during turns by replacing the flat panels with a basic symmetric airfoil shape.
- Convert the rudder wings to separate pivot points reducing the amount of downwash one rudder induces on the other during a high angle of rotation
- Lighten the rudder to help move the center of gravity in front of the leading edge of the wings



Power Plant & Power Train

The basic concept used by the Wright Brothers in 1905 to deliver power to the propellers was quite efficient, considering the resources available at the time. A similar design will be used.

- A two-stroke Rotax engine will be the power plant, delivering twice the horsepower at one-half the weight of the original home built engine
- Power will be transmitted via highly efficient drive belts to the counter-rotating propellers in place of the heavy and inefficient bicycle chains once used
- Ultimately this power will be converted to thrust through two eight-foot diameter propellers, using the latest technology and materials available

All components used in the power transmission will be of the highest quality and lightest weight materials to ensure more efficient and safe operation.

The Project

In honor of the 100th anniversary of powered flight, our engineering team is participating in the design and construction of a unique replica of the 1905 Wright Flyer. Our efforts are to maintain the original flyer's aesthetics, while employing modern materials, analysis, and design techniques. Due to the infancy of aeronautical and other sciences the original Wright Flyer, in comparison to the modern airplane, had a very limited performance.

Our design team consists of two divisions, aerodynamics and structures. The structures team is incorporating space-age materials to strengthen and reduce the weight of the aircraft. Increased stability and performance is the main focus of the aerodynamics team.

Wings

The goal of the wing design is to provide the strength, control, and mechanics necessary to most closely follow the theoretical aerodynamic design while staying true to the 1905 Wright Flyer appearance. Some of the changes being made from the original are as follows:

- The use of composite materials for nearly all parts of the wing
- A new wing design that will allow warping with a minimal amount of wrinkling in the fabric skin
- Airfoil shaped struts to reduce drag

Internal structure added to reduce the amount of external cabling that was required on the 1905 Wright Flyer.

Chassis

The 1905 Wright Flyer had no suspension to dampen landing shock. The landing gear simply consisted of wooden skids that slid across the ground during take off and landing. In the redesign, a suspension will be incorporated into the original skids to dampen impact.

Concept 1: Place a carbon fiber leaf spring inch in combination with a lightweight mountain bike shock, allowing the skid to deflect up to 4 inches. A glass-fiber mock up of the leaf spring showed the design to be too heavy and left concerns with rigidity between the canard and wing.

Concept 2: Mount a mountain bike shocks to a rigid chassis made of carbon fiber tubes and aluminum fittings. A simplified Concept 1 that allows the chassis to remain perfectly rigid and still absorb the large landing impact.

Canard

The original canard actually changed shape depending on the angle of attack, increasing lift. No longer needing the excess lift, the new canard will be made of a solid lightweight foam core, composite skins and linkages for simultaneous motion.

The Aerodynamic Design

Why the 1905 Wright Flyer need to be changed?

- Unstable in pitch, approximately -8% static margin
- CG behind aerodynamic center of the aircraft
- Thin, highly cambered airfoil did not create much lift

Design Criteria

- Aesthetically similar to the 1905 Wright Flyer from 100 ft away
- Approximately + 8% static margin
- Minimum stall speed less than 40 mph

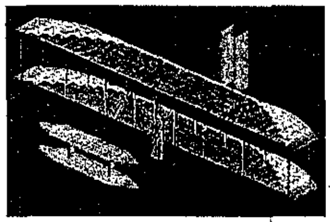
Applications

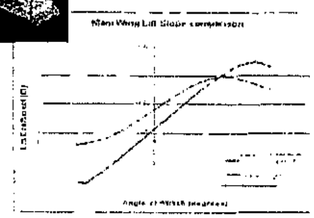
- Airfoils were analyzed for lift, moment, drag, and stall at multiple angles of attack using a web based analysis program called Calcfoil. The module behind this web page uses a 2nd order panel method.

Original Airfoil

Modified Airfoil

- Full plane models were analyzed using the USU potential flow program WINGS2001





Changes Made

- Obtaining + 8% Static Margin
  - The canard was moved 1.75 ft closer to the wing to reduce the leverage that it had over the planes pitch dynamics
  - Shrinking the chord 7 inches and the span 3 ft reduced the canards surface area, and thus reduced its effect on pitch stability
- Decreasing the Minimum Stall Speed
  - Shortening the chord 6 inches and designing an airfoil with a reflex trailing edge reduced the negative pitching moment of the wing. This decreases the load that the canard has to carry
  - Increased the lift produced by the plane through thicker airfoils and more camber in the canard

Acknowledgements

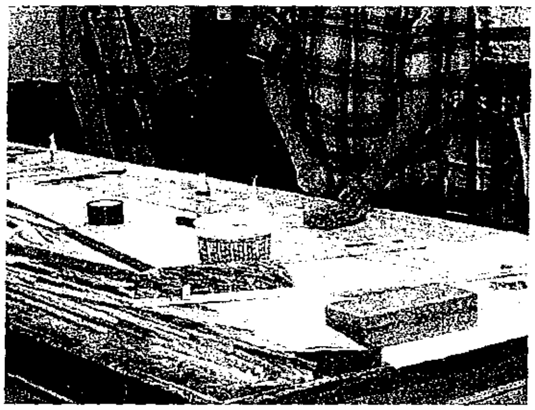
Advisors and Consultants

- Dr. Dave Widauf
- Professor Chuck Larsen
- Dr. Warren Phillips
- Nick Alley

USU Wright Flyer Sponsors

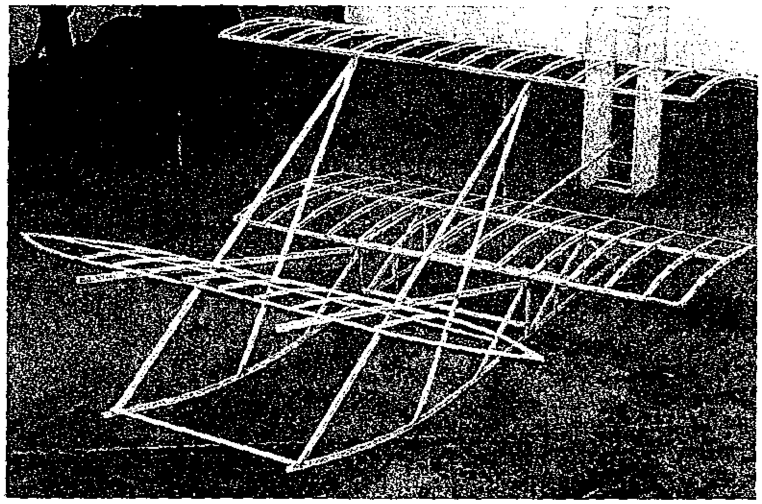
- Utah State University
- USU Foundation
- Space Dynamics Laboratory
- Metal Mains Composites
- US Air Force
- Hexcell Corporation
- Rocky Mountain NASA Space Grant Consortium
- USU College of Engineering

A Model of the 1905 Wright Flyer

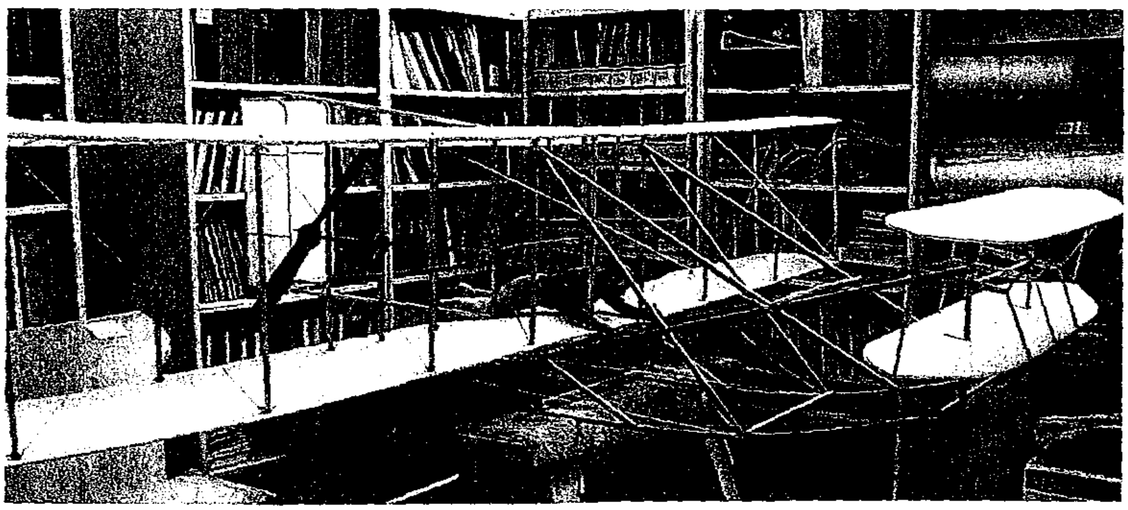


Gluing Model

Building Model



Model being assembled.

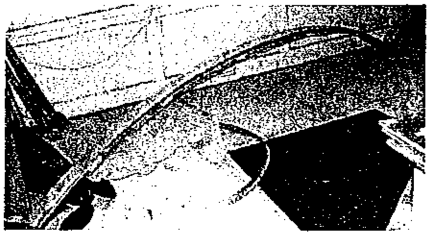


Complete Model (1:4 scale)

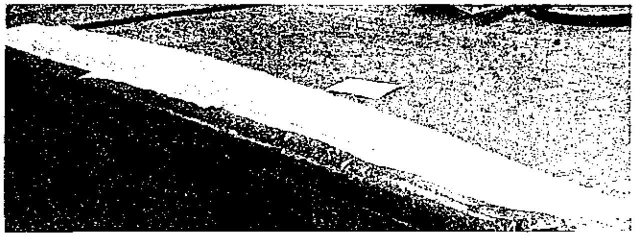
Designing, and Testing Ideas

Adam and Nick discuss the power train with Randy Chesley.

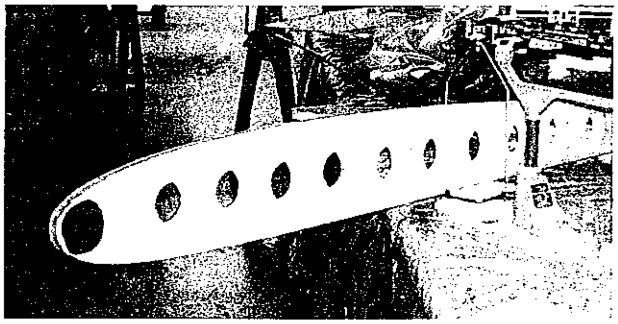
Carson and Chuck Larsen converse about the wing ribs.



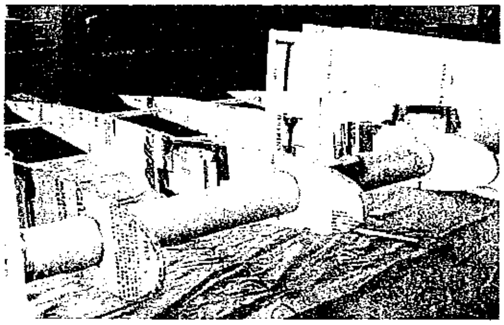
Fiberglass leaf spring



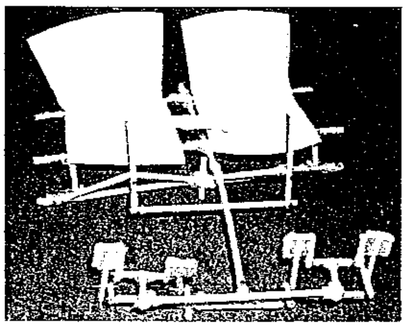
Wing rib lay-up



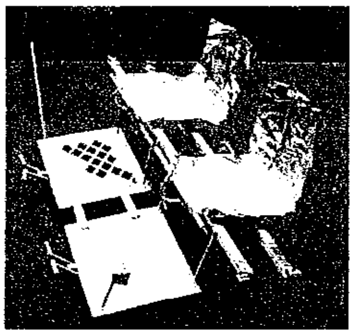
Measuring the rib weight



Wing Warp concept in cardboard



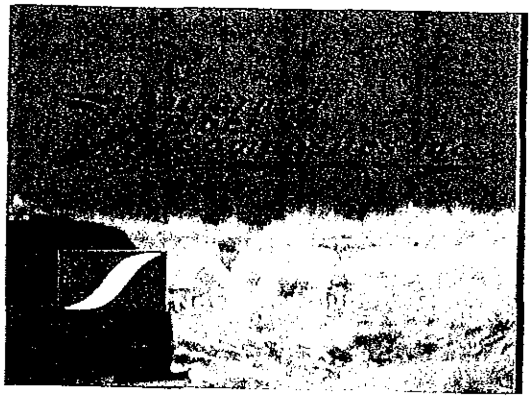
Cockpit concept in pink



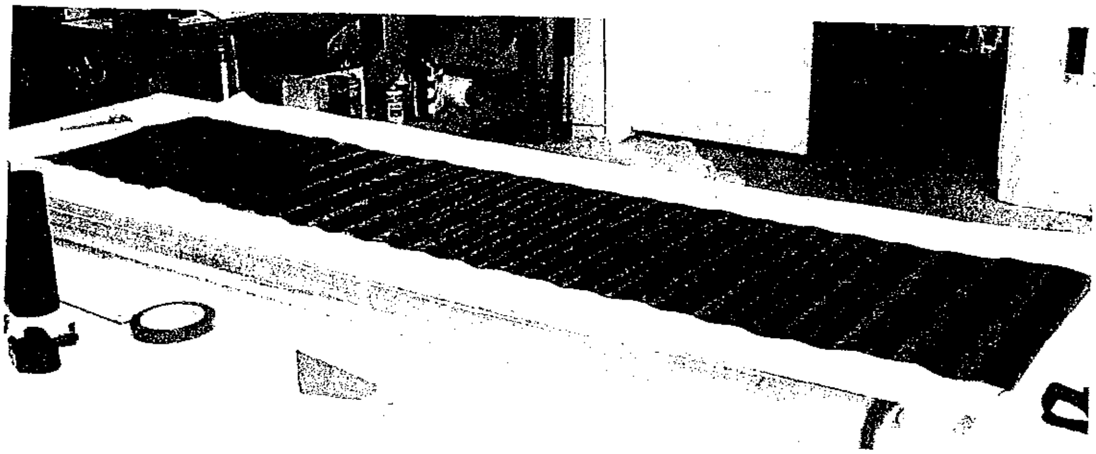
Mockup of cockpit concept

Prototyping

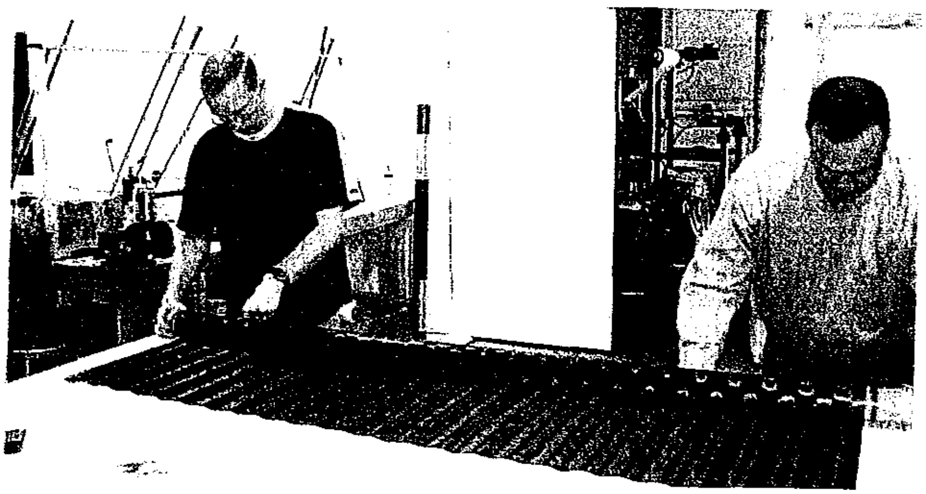
Wings and Carbon Fiber Tubes



Sponsor of Wavy Composites



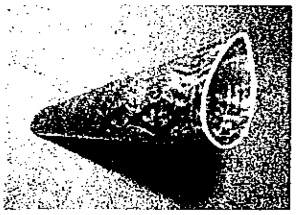
Wavy carbon fiber lamina



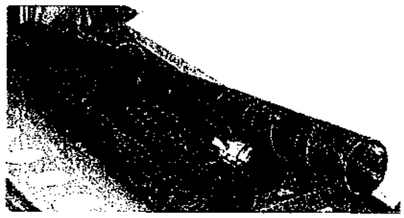
Eric and Bill Pratt rolling fibers onto a spar.

Wrapping a cardboard mandrel

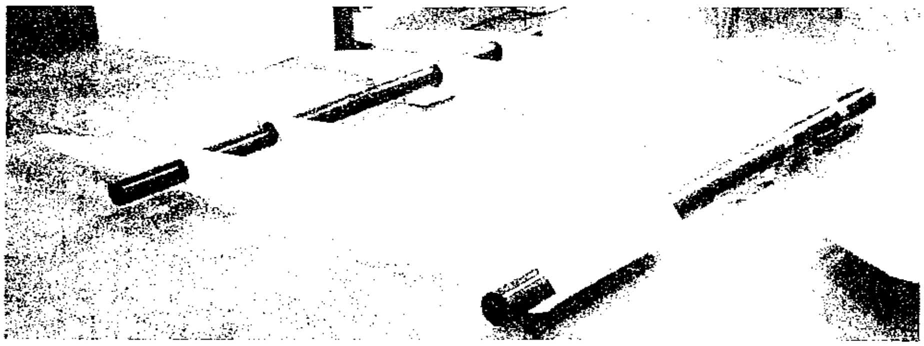
A wrapped mandrel



A streamline carbon fiber strut tube

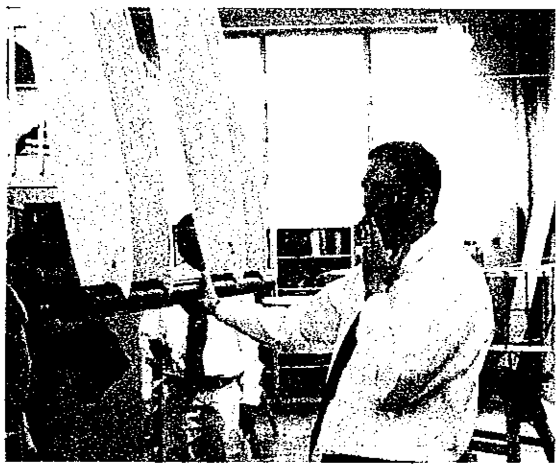


Completed carbon fiber spars



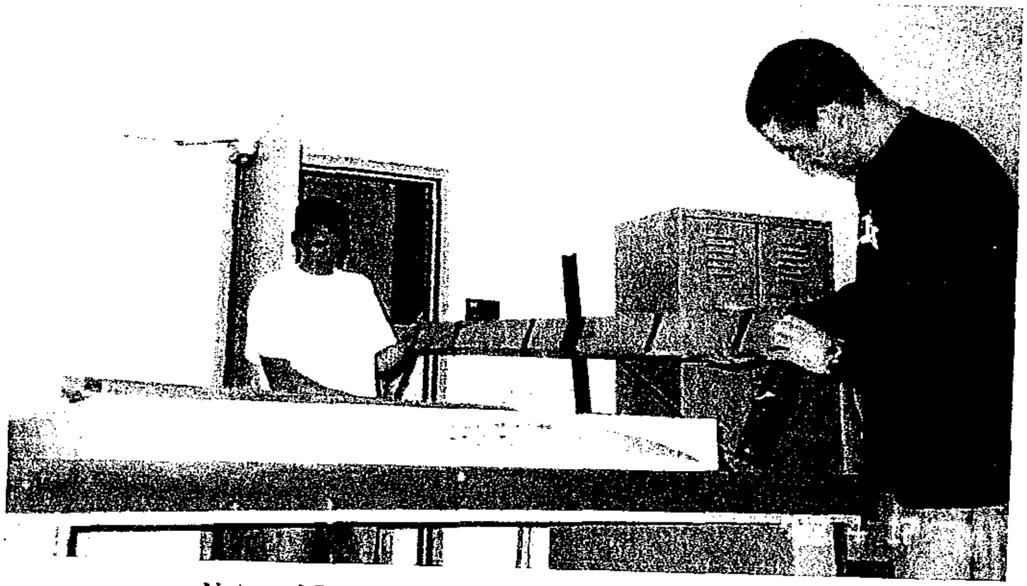
Assembled wing section

Carson holding light wing section.

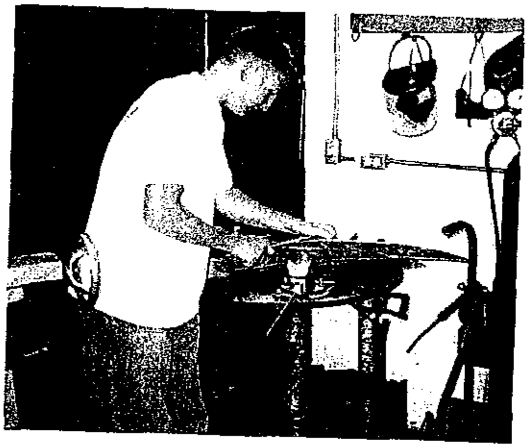


Too Easy!

Canard

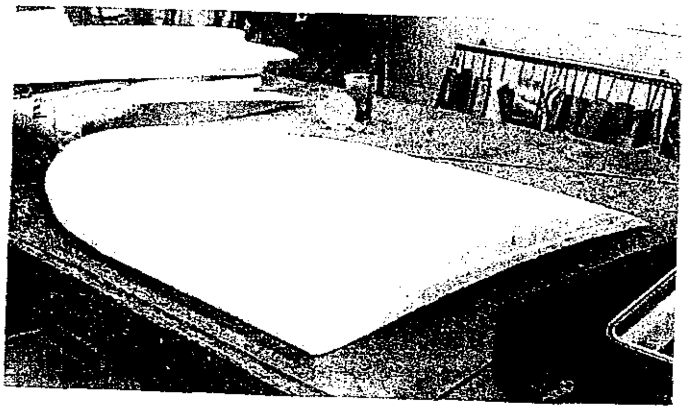


Nate and Jon hot wiring a canard section out of foam.

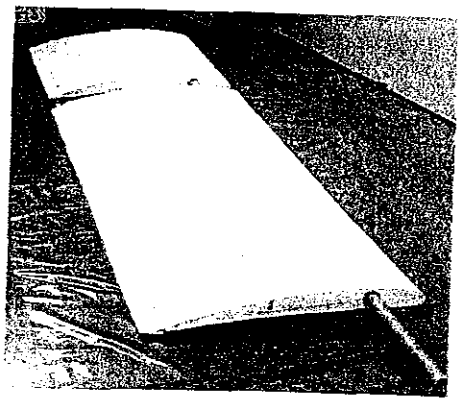


Nate making canard airfoil template.

Nate sanding the canard



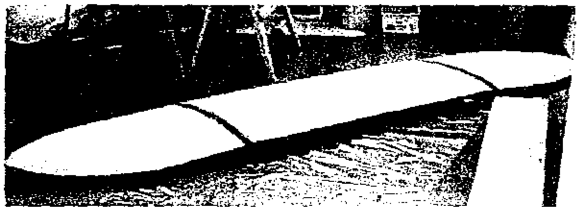
A canard end section



Canard mid-section

Nate is cutting out canard end plates.

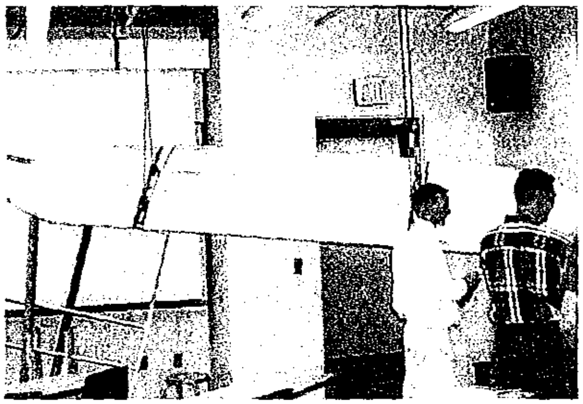
Canard center section covered in fiberglass



Finished canard section

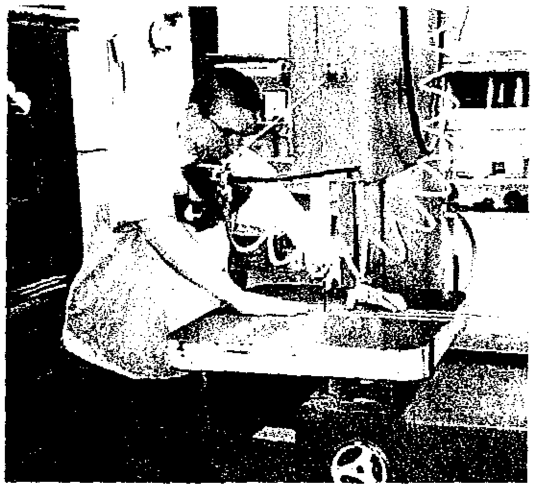
Surfs up, DUDE!

Jon and Nate designed and built the canard.



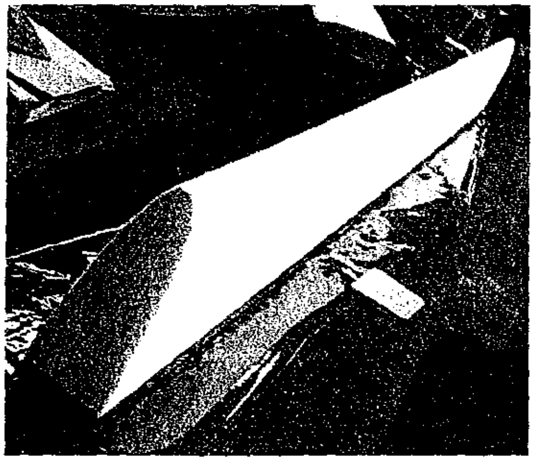
Canard on display

The Rudder



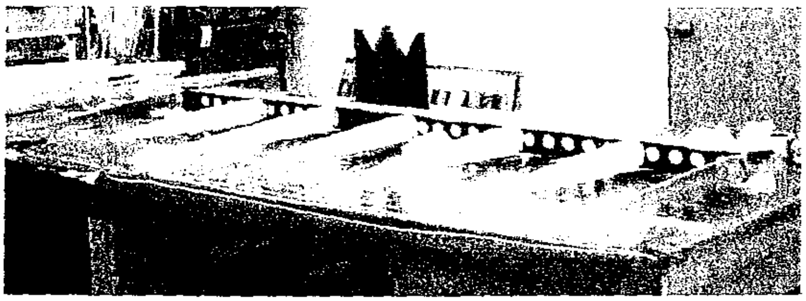
Jon is cutting the rib profiles.

Eric and Jon are gluing foam together.

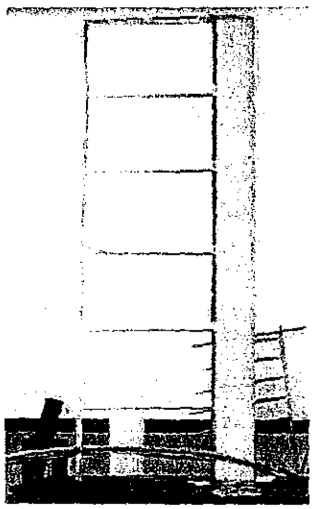


Leading edge of a rudder section

Jon is cutting Kevlar to cover each rib.

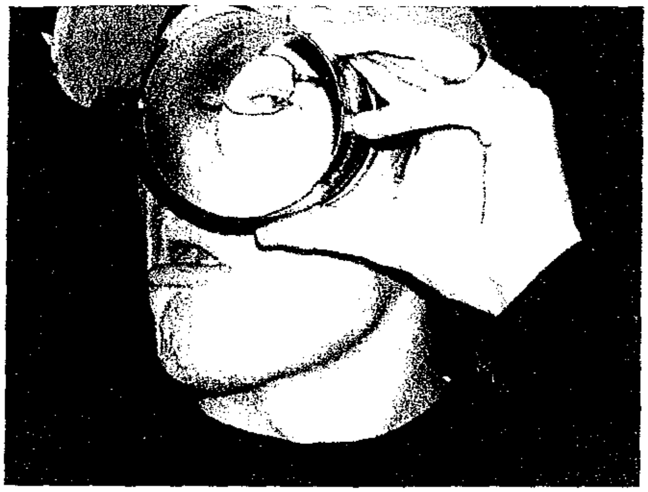


Assembled rudder section



Finished rudder section

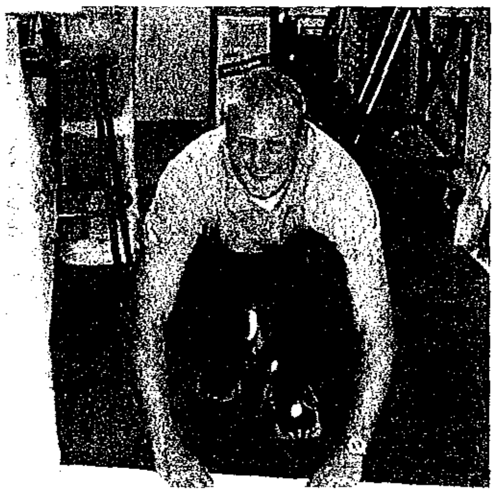
Random Shots



Carson --*????*

Jon at work

Eric – *CHEESE!*



Nick (the Boss)

"Prophet, Citizen, and *Aeronautical* Pioneer!"

The Salt Lake Tribune – April 23, 2002

GETTING IT WRIGHT

Al Hartmann The Salt Lake Tribune

USU engineering student Wayne Goodrich tweaks a quarter-scale replica of the original Wright Flyer, the Wright brothers' plane that flew the world's first powered flight. A full-size version will be built by USU students.

Marking a Milestone

USU students revamping historic plane for centennial fest

BY GREG LAVINE
THE SALT LAKE TRIBUNE

LOGAN – Even a century later, Utah State University grad student Nick Alley marvels at the piloting skills of Orville and Wilbur Wright. The wood and canvas biplane – which sputtered into history at Kitty Hawk, N.C., with the world's first successful powered flight – was unstable and hard to control.

"It's really amazing the Wright brothers were able to fly it as well as they did," Alley said.

USU is giving one of the first Wright Flyers a 21st century makeover to honor 100 years of powered flight. A USU replica of the 1905 Wright Flyer is slated to fly at the Inventing Flight Celebration at Dayton, Ohio, in July 2003.

A team of 10 [illegible] engineering students, most of whom had no experience in aerodynamics, were selected [illegible] the Wright brothers' original plans. The 1903 and 1904 Wright biplanes crashed on landing. The 1905 model was the first to have controlled landings.

At 5 p.m. today in Room 120 of USU's Cazier Science and Technology Library, the students will present their plans. Part of the presentation will include a flight-worthy, quarter-scale model of the 1905 Wright Flyer. A similar model of the USU version will soon be built to compare flight characteristics of the planes.

"We were asked to redesign it aerodynamically and structurally," said Alley, who led the student design efforts. "From 50 feet away, we want it to look like the Wright Flyer."

David Widauf, aviation programs coordinator in the industrial technology and education department at USU, said groups elsewhere are building exact replicas. USU sought a more modern approach.

"What if the Wright brothers were alive today?" Widauf said. "What would they have built the plane out of today?"

Carbon-fiber composites and Kevlar-coated foam replace most of the wooden parts of the original biplane.

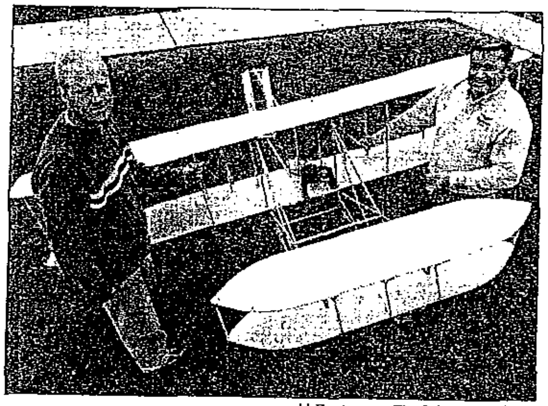
Amy Hintze, a senior on the project, designed the new cockpit. In 1905, the pilot laid down flat on the wing to control the plane. The new cockpit will move forward and will include a pair of seats.

"Lying on the wing is not good for the stability of the plane," Hintze said.

The trimmed-down USU version is expected to weigh about 400 pounds, vs. the Wright brothers' 700 pounds. USU's flyer will cruise at 45 mph while the original plodded along at 35 mph.

While the original Wright planes needed a catapult to launch them, the USU craft should take off under its own power.

See USU, Page B-3



Al Hartmann/The Salt Lake Tribune

USU graduate student Nick Alley, left, and aviation program coordinator Dave Widauf show off a replica of the Wright Flyer.

USU Project More Than a Flight of Fancy

Continued from B-1

"It was too good an opportunity to pass up," Alley said. "I've lost sleep over this. It's been really stressful."

The student designers have collectively logged about 4,000 work hours. Some of the soon-to-be-graduating students will stick around this summer to build the plane.

Widauf said USU has big plans for the souped-up biplane. Once the plane is built, it will go on a barnstorming tour of Utah schools.

"Maybe we can light the fire in some kid's eyes to be an engineer," he said.

If money can be found, Widauf would like to show off the plane on the way to or from the Dayton flying festival. Just don't expect to see the Wright Flyer soaring over Interstate 80, as the plane will probably travel via truck.

"We're going to have an airplane flying, hopefully by the end of summer," Widauf said.

The Deseret News – March 10, 2002

USU students ready to fly into the past

By Leah L. Culler
Deseret News staff writer

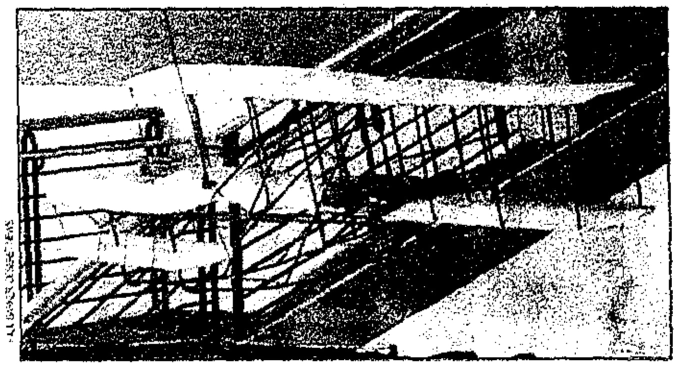
A group of college students is honoring the world's first aviators by turning back the clock and re-creating Orville and Wilbur Wright's original flying wonder.

Nearly 100 years after the brothers made their first 12-second flight, Utah State University students are building a modern-day replica of their flying machine, a feat believed never attempted.

"Other groups are building replicas using original materials," said David Widauf, a USU associate professor overseeing the project. "We thought, 'Why not build a replica with materials that would be available if the Wright brothers were constructing an airplane today?' "

The team is using the latest Kevlar and graphite materials instead of the muslin and spruce used by the Wrights a century ago.

Please see PLANE on B2



USU students are building a replica of the Wright Brothers' original biplane.

PLANE

Continued from B1

The two-year project got under way last semester and will culminate when the plane is flown during the Wright Flyer centennial celebration in Dayton, Ohio, in 2003.

The students spent 1,900 hours last semester getting to know everything about the original Wright plane, according to Nick Alley, a USU graduate student and the design project manager. Five of the 10 students are focusing on the structural aspect of the project, while the other five are working on the plane's aerodynamics. This semester, the students have built a quarter-scale model and soon will start work on the actual full scale plane. The quarter-scale model was on display at "Dinotek 2002," a free high-tech exhibit at the Ogden Dinosaur Park, through Feb. 22.

When they finish that plane, former Sen. Jake Garn wants to be the one in the pilot seat on at least one of its flights. They hope that flight will go farther than the 120 feet the Wright brothers managed.

Garn, who says aviation has always been a part of his life, said it would complete his aviation career to fly a replica of the original Wright plane. Garn has "flown all sorts of things," including hang gliders and experimental and home-built aircraft. In 1985, he had the opportunity to be the first public official to fly aboard the Space Shuttle.

And Garn said he's not worried about the safety of the plane.

"After all the things I've flown, I'm not the least bit concerned about it crashing," he said. "I feel much safer in an airplane than a car."

Garn said he does recognize that these students face a challenge in designing a plane identical to one built 100 years ago.

"There's a lot of differences in the way (the Wright brothers) flew and the aviation technology we have today," he said. "Sure there's some obstacles to overcome, but I'm confident they will overcome them."

The students themselves definitely recognize the challenges they face.

Alley said the design team is restricted more than anything by aesthetics, because they want the plane to look like the Wrights' original. Another concern is the center of gravity.

"The Wrights had very little understanding of aerodynamics," Alley said.

In the original plane, the center of gravity was behind the main wing, Alley said the team has had to design around that by making the tail end of the plane as light as possible.

Carson Esplin is in charge of the structural design of the wings and has to deal with changing the wing-warping mechanism of the original plane to accommodate a new airfoil design.

Alley, Adam Richards and Ben Case developed software to check how the original plane performed in steady flight. They used that program to find trends in how changing things about the aircraft would affect its flight performance. One of the biggest changes they're making is reducing the weight from its original 710 pounds to 310 pounds.

"We're trying to make the plane as light as possible," Alley said. "Anybody can build a plane that weighs 700 or 800 pounds."

Alley said the challenge is designing an aircraft that has to carry a human being.

Quarter-scale models of the plane will be taken on tour in Utah as soon as this October. Trina Paskett of the Space Dynamics Laboratory in Logan said the tour will reach an estimated 200,000 students who will have the opportunity to learn about aviation through specialized lesson plans and essay and art contests.

On its way to Ohio for the centennial, the full size plane will follow a historical path, stopping to show off at various spots on the way. For that tour, the plane will have to fit in a 53-foot van, which means it will have to be disassembled and reassembled. Paskett said the project's organizers are still working on an exact path and dates for the tours.

But for now, the students are just concerned about getting the plane off the ground.

"When we see the plane up and flying, it will really be worth all the effort we've put in," Case said.

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Wright plane getting ready to roll

By Lisa Ogden
Senior Writer

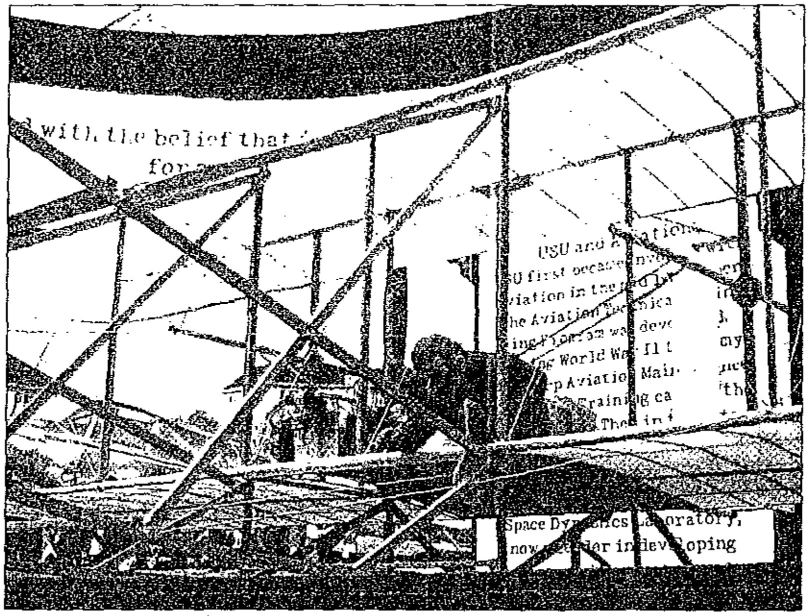
Senior mechanical engineering and aviation technology students are experimenting with "The Wright Stuff" to construct a modern-day replica of the 1905 airplane flown by the Wright brothers.

Ten students from Utah State University were chosen to work on the project out of 21, said Nick Alley, a first-year master's student in mechanical and aerospace engineering, and the project's manager.

At a presentation Tuesday evening, Alley said the students have put in 4,000 hours to produce the research required to build a working aircraft.

"I hope everyone realizes what these students have done here," Alley said.

What they have done is to redesign the original aircraft using modern materials to improve the stability, stall susceptibility, drag and to make it safer and more user friendly, Wayne Goodrich, a student working on the project, said.



A QUARTER-SCALE MODEL of the USU Flyer was on display in the Science and Technology Library Tuesday. The flyer is a model for a full-size replica of the original Wright brothers 1902 Kitty Hawk flyter which will be completed this year./*Angele Christensen photo*

"And it'll still be good lookin'," Goodrich said.

Using computer programs and simulations such as Wings 2000, students analyzed the effects of their redesigns.

Eric Peterson, a senior in mechanical engineering said they have great confidence in the reliability of the computer models' predictions because they have been tested against wind tunnel experience and compared to other programs.

Although the plane will actually be flown, Dave Widauf, aviation programs coordinator in the industrial technology and education department, said the plane will not be making any cross-country flights because the fuel tank capacity will only allow for flights of about an hour, and the plane will not be able to handle cross winds more than five miles per hour.

"It's to prove a concept and to celebrate the Wright brothers," Widauf said. "If it gets off the ground and flies around a football field, we'll be happy."

Widauf said USU is the only organization to do anything like this.

"There are three or four others doing exact replicas, but they're more for historic value. We're doing something unique," Widauf said.

The group is using local materials such as Kevlar and graphite because Widauf said they thought those would be what the Wright brothers would use if they were building the plane today.

A quarter-scale replica model of the 1905 plane was displayed at the presentation, and students will begin full-size construction of the USU version this summer.

Another student working on the project, Ben Case, said the group hopes to have the plane built by the end of summer, but it will all depend on how the building process goes.

To this point, Case said many of the students have been putting in 20 to 30 hours each week, and many spent 60 hours over the Olympic Break working on the project.

Alley said the students worked on the project out of "personal devotion" because they only received two hours of credit for their participation.

Amy Hintze, the only female working on the project, said they have been required to spend 12 hours each week since September, even during school breaks.

"It's been a lot of work," Case said. "But it's more than just a senior project. It's been really fun because of the magnitude of the project. It's an actual plane that will be used."

Alley said he only knew two of the students when he put together the team.

"I basically went on faith and lucked out," Alley said. "But I also

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talked to the faculty."

Hintze said she enjoys seeing the models and mock-ups actually built.

"The best part is seeing your ideas and thoughts in real life," Hintze said.

Already the group has been featured at several Olympic venues and has received second place with their presentation at the Western Regional American Institute of Aeronautics and Astronautics Student Conference on April 4 through 6.

Eventually Widauf said he hopes to use the plane to provide education and to get kids excited about technology, engineering and aviation.

"My vision is to have an outreach tour throughout Utah," Widauf said.

Widauf said the project will also highlight USU and their mechanical engineering and aerodynamics programs.

"We've got a great program here. I think we're one of the best-kept secrets around," he said.

Tuesday the group presented their project to the university.

More information will be available in a few weeks on the group's Web site at www.usuwrightflyer.org.

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