Team 6 - Autonomous Aerial Vehicle

Design for Manufacturing, Reliability, and Economics

Due Date: April 4, 2013

Department of Mechanical Engineering:

Ken Anderson, Arielle Duen, Eric Milo,

Ernandes Nascimento and Matthew Yasensky

Department of Electrical Engineering:

Cristopher Timmons and Robert Woodruff

Project Advisors:

Department of Mechanical Engineering

Dr. Chiang Shih, PhD

Department of Electrical and Computer Engineering

Dr. Michael P. Frank, PhD

A FIPSE Sponsored Project

Table of Contents

Prototype Design and Components to be Manufactured 3

Plane Maintenance/Reliability 4

Extra Equipment On-Hand: 4

Battery: 4

MonoKote: 4

Rear Wheel: 4

Gimbal System Possible Improvements 5

Survivability 6

Appendix I: Pro E Drawings-Gimbal Bracket 7

Prototype Design and Components to be Manufactured

Upon taking on this project the team had evaluated many different ideas for a vessel to cargo our electronics. These ideas range from quadrotor aircrafts, to helicopters to gliders. Examples of the progression for aircraft ideas are shown below. Approximately a month into the fall semester it was learned that we inherited the aircraft that last year's team had used to conduct their research. After careful deliberation, it was decided that in the best interest of time and budget that the best decision was to utilize the Senior Telemaster for the remainder of the year. Team 6 has a goal of leaving behind the best possible project that can easily be carried over into a new school year. It is this mindset that channeled our decision in using the inherited plane. This allowed the team to focus on the essentials of the project knowing that a future project would have all the correct hardware and software in place and could then focus more on the aircraft itself.

Figure 1: The Progression of Decision Making To Result with the Current Aircraft Model

Plane Maintenance/Reliability

There are a few areas of possible failure on the plane that would be catastrophic and should be checked regularly. All screws/bolts connecting major components including but not limited to, motor to bracket, bracket to firewall, throttle servo/throttle rod, camera gimbal, camera, landing gear, propeller, and all flight surface connecting rods (i.e. ailerons, rudder, ect.) should be checked regularly and prior to each flight. The loss of some or any of these components could be detrimental to flight.

Extra Equipment On-Hand:

After multiple flights it was apparent that the propeller on the plane and the camera gimbal servos, are two likely points of failure and the team should therefore have spares on-hand at all times.

Battery:

The rechargeable battery used in the plane also has a useful lifespan of about 1-2 years and should be checked regularly. If for any reason it cannot hold a charge longer than 1 hour it will need to be replaced.

MonoKote:

If the MonoKote on the plane gets any holes/tears in it, they should be patched as soon as possible. The coating adds structural stability to the plane and is necessary.

Rear Wheel:

The rear wheel on the plane is essential to achieving an autonomous takeoff. The rear wheel will turn the plane on the runway if it is not straight. The wheel should be checked routinely to verify that it is oriented correctly. If the wheel is not straight the axle can be bent to the appropriate position.

Gimbal System Possible Improvements

The system responsible for moving the camera towards targets plays one of the most important roles in the entire mission. By having this idea in mind, the reasons for keeping improving the gimbal system becomes very obvious, especially when the performance of the device is not as good as it can be.

The first gimbal system inherited by team 6 was designed for a Sony block camera, which was oversized and excessively heavy for flying purposes. As the camera needed to be changed because of flat cable replacing problems, the system had its dimensions reduced and unnecessary parts removed. Although it became a lot more efficient, it still could be rebuilt (in case more time was available) in an even more effective way. One important step for upgrading it would be the change of the Futaba 180 degrees standard servos that runs the equipment for smaller ones. In the pictures below it is possible to see the current servo type (left) and the ideal one (right).

Figure 2: Current Servo (right). Ideal Servo (left)

The main advantage of this upgrade would be the increase in the side view angle of the system due to its reduced dimensions. Besides the fact that it implies redesigning the structural parts, there are several benefits: reducing weight on the plane; reducing electrical power consumption (less mass is being moved to change camera position); reducing fairing dimensions and consequently reducing the drag force caused by it. On the other hand, something that really needs special attention when it comes about building a much smaller gimbal is vibrations. Smaller and lighter devices tend to have bigger amplitude of vibrations (in some cases, by decreasing the mass, the system will end up increasing its amplitude of vibration, nearly conserving the kinetic energy). This brings the need of an appropriated damping system that could be built using rubber bands or springs.

Survivability

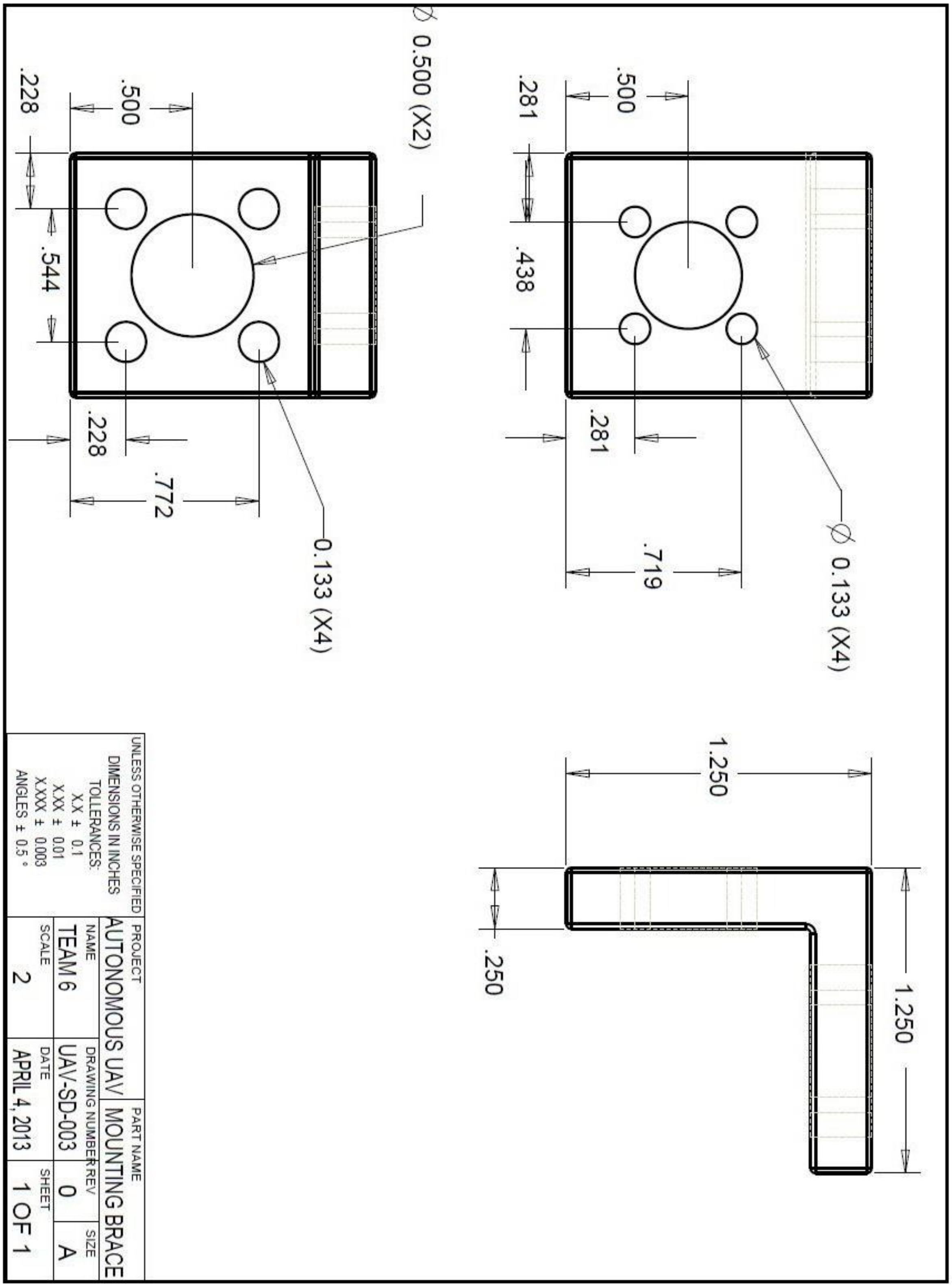
The long-term survivability of this project will primarily depend on the maintenance of the air vehicle and continued work on image processing software.

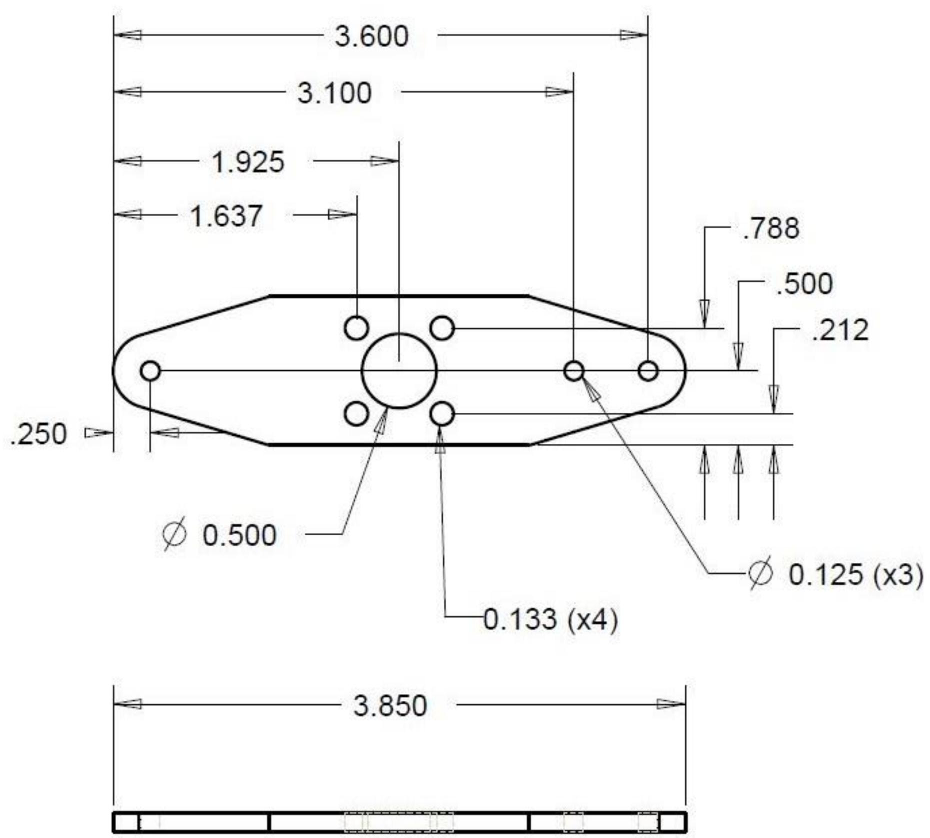
The frame of the air vehicle is the primary concern for long term survivability. In the recent weeks of flight testing, it has been observed that the MonoKote has begun to wrinkle, which could severely disrupt air flow and thusly, rob our air vehicle of lift. Long term solutions for this issue go beyond simply replacing the MonoKote, and include utilizing other similar materials (such as carbon fiber) which are designed for increased durability.

Another issue addressed by our team is the overall design of the air vehicle itself. The primary goal of our competition is to record and recognize ground targets as efficiently as possible, and though our air vehicle can operate within competition restraints, it is our team's belief that a design shift towards a glider would increase the efficiency of our project. Another supplemental reason for a glider design would be to drastically decrease speed (kinetic energy) and therefore effectively reduce the likelihood of damaging equipment during landing.

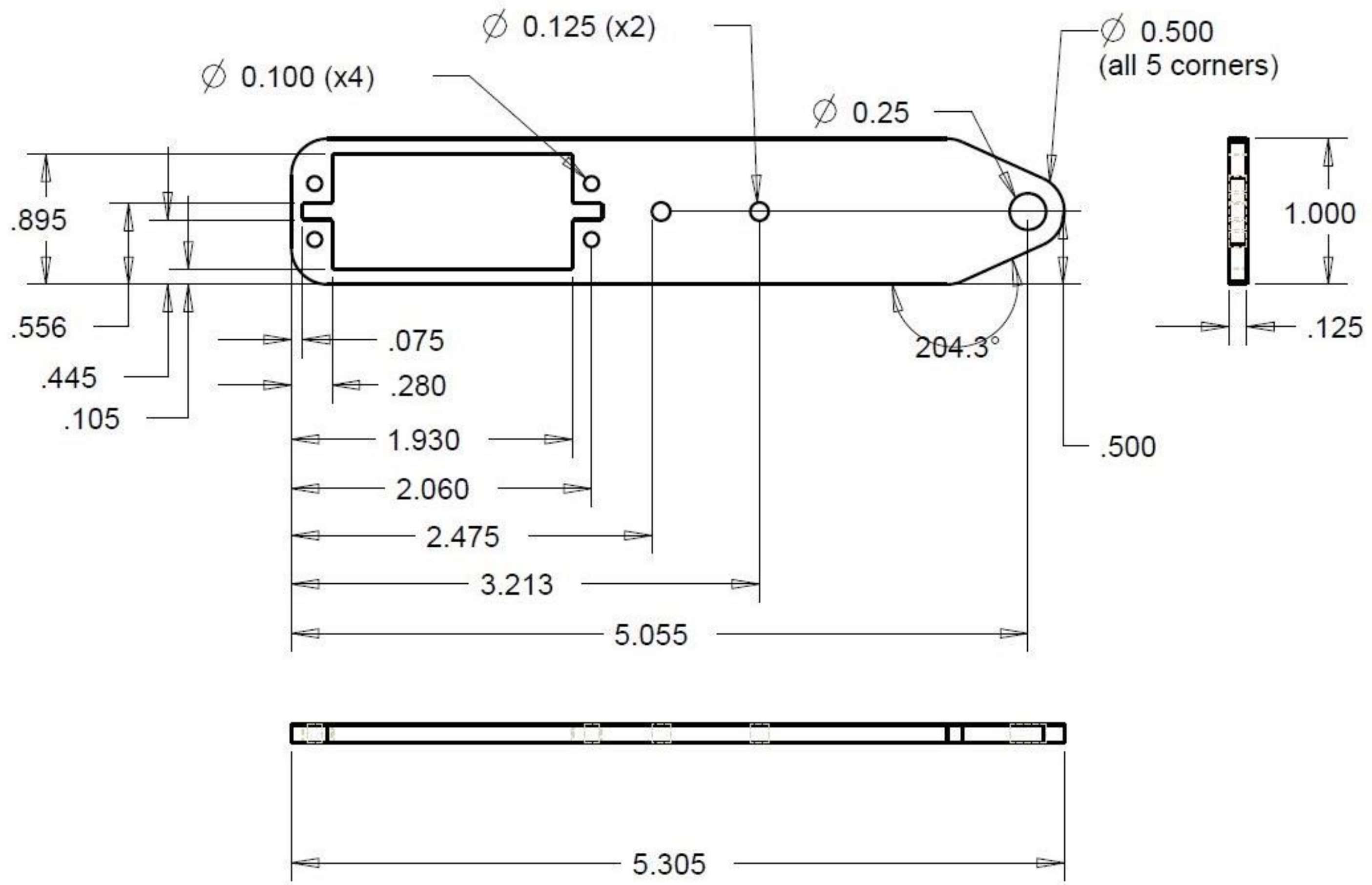
The image processing software used for our design, OpenCV is also an issue needed to be addressed for long-term sustainability of our project. By its very nature, OpenCV is an open sourced library of computer vision functions and is therefore constantly changing (and improving) with each iteration. This past semester alone, a re-installation of a newer version was required in order to fix a logic error in accessing external video sources (something our project is reliant upon).

Appendix I: Pro E Drawings-Gimbal Bracket





UNLESS OTHERWISE SPECIFIED	PROJECT		PART NAME	
DIMENSIONS IN INCHES TOLLERANCES: X.X ± 0.1 X.XX ± 0.01 X.XXX ± 0.003 ANGLES ± 0.5 °	AUTONOMOUS UAV		UPPER BRACKET	
	NAME TEAM 6	DRAWING NUMBER UAV-SD-002	REV 0	SIZE A
	SCALE 1	DATE APR 4, 2013	SHEET 1 OF 2	



UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES TOLLERANCES: X.X ± 0.1 X.XX ± 0.01 X.XXX ± 0.003 ANGLES ± 0.5 °	PROJECT AUTONOMOUS UAV		PART NAME LOWER BRACKET	
	NAME TEAM 6	DRAWING NUMBER UAV-SD-001	REV 0	SIZE A
	SCALE 1	DATE APR 4, 2013	SHEET 1 OF 1	