“Willie”

2012 AUVSI SUAS Student Competition
Journal Paper

By Team “Willie”: Kansas State Salina’s small Unmanned Aerial Systems Club

Abstract:

“Willie”, Kansas State University Salina’s Unmanned Helicopter has been redesigned, modified, and tested by the 2012-2013 KSU UAS Club. Our primary goal was to redesign our current T-Rex 700 airframe to meet the Key Performance Parameters outlined in the Competition Guidelines for the 2013 AUVSI sUAS student competition. “Willie” consists of an airframe, ground station, data links, operating procedures, people and training. Last year marked our first year at the competition and we learned from our mistakes on how to better prepare for this year’s systems engineering based competition. In the following pages we will discuss in detail exactly how we modified our airframe, adapted our crew resource management and prepared for this competition.

Cover letter

Team “Willie” from Kansas State University in Salina, KS proudly presents “Willie”, our VTOL sUAS. The team approached this year’s competition applying lessons learned from last year’s competition to improve upon “Willie” based on the competition guidelines. Shortly after the 2012 competition we had an unscheduled recovery of “Willie”. This gave us an opportunity to rebuild, modify and improve upon our previous platform. “Willie” is composed of many commercial; off the shelf components. A T-Rex 700 fuselage is used with an 800 series tail boom, a Piccolo SL autopilot system, TVS flat bottom blades and a Sony block camera in a gimbaled housing. Many parts of the frame were custom built in the UAS lab at Kansas State University Salina.

The VTOL system utilizes 900MHz CC (command and control) telemetry links, manual and control of the aircraft for safety purposes. Data relay and video transmission are accomplished by using a 5.8 GHz Wifi data link. The Piccolo autopilot onboard “Willie” is capable of providing lost link procedures for the overall safety of an operation. “Willie” is an electric powered aircraft utilizing two 25 volt 20,000 mAh batteries in series for a total of 50 volts for the flight batteries. “Willie” has a total endurance of 21 minutes for safety purposes we fly less than 18 minutes, providing a 3 min battery bingo window.

The KSUS team “Willie” has performed over 30 cycles; with 25+ in fully autonomous flights. “Willie” has proven to meet and exceed all objectives specified in the competition guidelines.

0.1 Table of Contents

1.0 Description of Systems/Engineering Approach

1.1 Mission Requirements/Analysis

The Kansas State University Salina’s “Willie” helicopter built for last year’s competition was modified for this year’s competition based on lessons learned. Our systems engineering approach was tailored to meet each individual parameter established by the Student Unmanned Aerial Systems Competition rulebook. The Key Performance Parameters (KPPs) are the most important requirements for likely mission accomplishment. The KPPs were autonomy, imagery, target location, mission time and operation availability, and inflight re-tasking. As per the rules, the mission is broken into two limits, threshold and objective requirements. The threshold requirements are the minimum that must be completed during the mission. The objective requirements are preferred but not required. Defined by these two limits we based our goals off of the threshold requirements with the objective requirements to be attained secondary without jeopardizing the threshold requirements.

Parameter		**Threshold**		**Objective**
Autonomy		Waypoint Navigation & Area Search		All phases of Flight, Including Take-Off and Landing
Imagery		2 Target Characteristics		5 Target Characteristics
Target Location		Within 250ft		Within 50ft
Mission Time		< 30 Minutes		20 Minutes
Operational Availability		50% of Mission Complete		100% (no time outs)
In-Flight Re-tasking		Add a Waypoint		Adjust Search Area

1.1.1 Autonomy

The T-REX 700 is capable of autonomous takeoff, landing, altitude changes and waypoint navigation. To complete this, the team selected a Piccolo SL autopilot for the autopilot integration. Our mindset was to not spend time developing a new technology but rather integrate a familiar autopilot system that we use at Kansas State. This is a proven commercial autopilot distributed by Cloud Cap Technologies that was ideal for our VTOL system because of its size, capability of waypoint/altitude navigation, and support of VTOL aircraft via the onboard internal GPS and inertia sensors, a data link radio, rotary wing flight controller firmware, and electromagnetic interference (EMI) shielded enclosure. The EMI shielded enclosure is particularly important due to the close proximity of all the sensors onboard the helicopter. The autopilot fits perfectly in between the frame of the T-REX 700. Due to the high frequency vibration of the rotary wing platform, the autopilot is positioned on top of a vibration dampening foam to minimize the amount of vibration in between the airframe and the autopilot.

1.1.2 Imagery

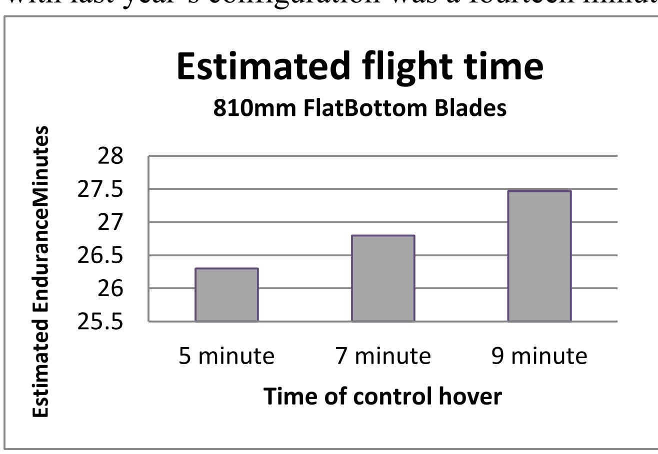
A Sony IX-11A block camera was selected for the video. The camera's composite video signal is converted to an IP format using the Axis® M7001 Video Encoder. The Sony block camera provides clear images at a substantial distance with 10x optical zoom and 4x digital. It is housed inside a gimbal turret allowing 360 degree pan and a 60 degree tilt. The zoom feature of the camera is controlled via an RS-232 connection to the autopilot. Our current goal is to provide all 5 characteristics such as shape, background color, orientation, alphanumeric, and alphanumeric color. With this camera we are able to achieve this goal during the competition and surpass the threshold minimums.

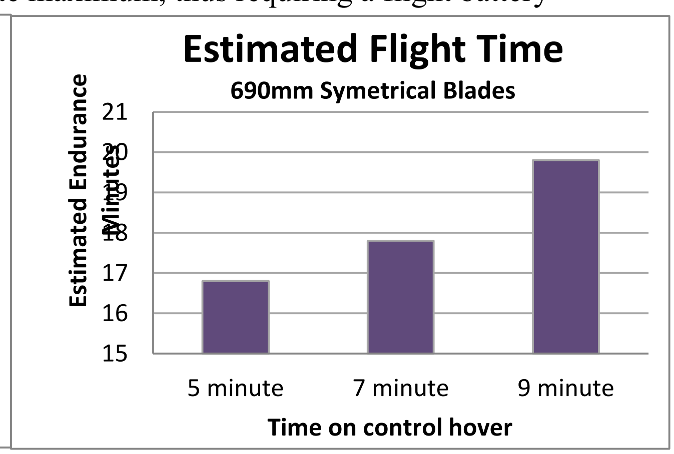
1.1.3 Target Location

According the rule book's key performance parameters the threshold requirement is to find the target within 250 feet. To meet this requirement the club took target data from practice missions and compared this data to the actual location of the target. The first tests of our target location showed that the location of the majority of the targets were 50ft-100ft from the actual position of the target. After inspection the club found the camera mount had been 8 degrees lower than the airframes level position. In order to fix this the gimbal calibration setting needed to be adjusted in PCC.

1.1.4 Mission Time

Having performed over 20 simulated piccolo exercises we found that the competition objectives could be satisfactorily completed in approximately twenty minutes. However, our flight time with last year's configuration was a fourteen minute maximum, thus requiring a flight battery





change midway through flight time. This flight battery change cost our team approximately six minutes during the 2012 competition. Our goal for this year’s redesign was to substantially increase our maximum endurance to meet our mission objective. We have achieved a 33% increase in endurance.

1.1.5 Operational Availability

To obtain a superior level of operational availability we practiced many things to ensure our success. Crew Resource Management (CRM) embraces communication, leadership and decision making. This allowed Team “Willie” to operate efficiently, effectively and safely. Team “Willie” utilized CRM in operational availability by practicing together and identifying specific problems and creating a safe and effective resolution. One risk identified were distractions in the GCS. We put in place a sterile cockpit practice from mission start to mission end. During this time we only communicate mission critical information. Another issue was communication between AVO and MPO during operations. We put in place a mission coordinator to help communicate more effectively between the two positions. After identifying problems critical to the mission we created a resolution to minimize downtime and maintenance downtime. This allowed us to negate the potential loss of equipment, injury or life and objectives critical to mission success.

1.1.6 In-Flight Re-Tasking

The Piccolo has the ability to alter, move, or add, waypoints while in-flight. Team “Willie”, utilizes this ability often while conducting UAS operations. We find in-flight re-tasking critical in all operations as it provides superior flexibility. This particular skill will play an important role to obtain targets in the competition search area.

1.2 Design Rationale

The design rationale for “Willie” started with the decision to redesign last year’s platform. The previous year’s platform only had an endurance of 14 minutes. We found that this was not sufficient because of the valuable six minutes wasted to swap out the batters. To solve this problem we needed to increase the endurance of the platform. To do this we decided that we must decrease our weight and increase the lift. By doing this we would increase the payload capacity of the platform therefore allowing us to carry larger batteries to increase our flight time. To decrease our weight we bought a lighter landing gear, redesigned our gimbal mount, housing system, and made a carbon fiber battery tray. To increase our lift we changed our blades from a smaller symmetrical airfoil to a larger flat bottom airfoil. The tradeoff of changing the blades was that we would consume more power because we are swinging larger blades. The increase in lift outweighed the increase in power consumption. By doing this we were able to increase our endurance to 18 minutes with a three minute bingo. Also by streamlining the gimbal housing we were able to reduce the risk of having a team member accidently plug a cable into the wrong port. There are now only three power cables on the aircraft that have to be plugged in for flight. We feel that the design of this aircraft is well suited to meet at a minimum the threshold requirements of the KPPs.

2.0 Description of Willie Design

2.1 Air Vehicle

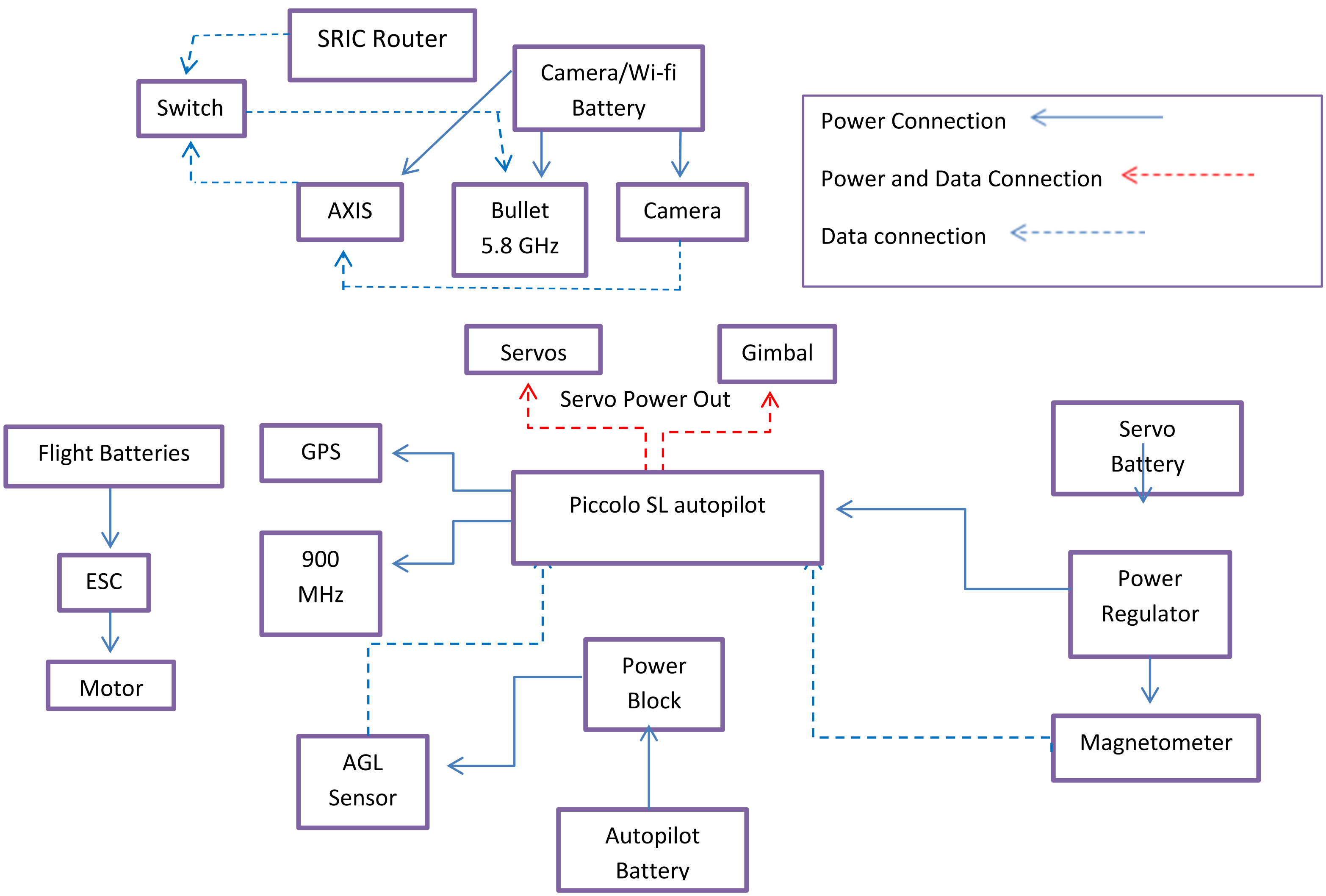
Last year, the Kansas State University Salina UAS Club changed the power system of an Align T-REX 700 RC Helicopter from a nitro methane internal combustion engine to an electric brushless motor. The power plant for this airframe is a brushless DC motor the Scorpion HK III-4035 – 450Kv. The durability of the aircraft is very important in case of a complete system malfunction. The club chose the T-REX 700 helicopter chassis as the base platform for integration because of the quality, durability, and the availability of the parts. The airframe and components are made of carbon fiber and CNC machined aluminum. If the T-REX 700 was recovered from a system malfunction the airframe and components on board the aircraft may possibly be re-used because of the strength of the materials used to build the airframe and components. "Willie" utilizes the VTOL method of launch and recovery which allows the helicopter to be launched from virtually anywhere with ease.

In the configuration we utilized at last year's competition, "Willie" operated on a fully electric system utilizing four 25.2 volt 5,000mAh Lithium polymer batteries. The batteries were paired in series, and then the two series pairs were connected in parallel to give the electrical equivalent of one 50 volt battery. This year we are using two, 20,000 mAh LiPo batteries in series instead. These batteries are significantly heavier but provide the airframe with more power and allow for 21 minutes of endurance with just two batteries. This is compared two fourteen minutes from last year; a 33% increase in flight time. Three 12.6 volt 2,200 mAh batteries are used to separately power the camera, autopilot, and servos. This provides individual power supply to each component of the aircraft. This is done to prevent loss of the aircraft from a single point failure.

This year we have changed the main rotor blades from, symmetrically air foiled 690mm symmetrical blades to 810mm flat bottom blades. These blades provide more lift allowing willing to carry a larger payload. This allows "Willie" to carry the larger batteries therefore increasing our flight time. We bought a lighter landing gear made out of aluminum tubing and painted it to a high visibility color to fit the minimum standards as per the rules.

"Willie"

In an effort to reduce the weight of the aircraft we designed a new gimbal mount. The old mount was made from aluminum; while aluminum is light weight, we were able to reduce the weight even more by making a carbon fiber PVC foam core plate that extends the length of the aircraft. During early testing of this new design we made the plate with a 1/4inch Styrofoam foam core. This plate proved inefficient in its rigidity causing an aircraft oscillation during flight. To fix this problem we used a ½ inch PVC foam core. To reduce the overall aircraft weight while providing weight for vibration dampening we designed a housing for the Axis® video encoder and Bullet® Wi-Fi transceiver. The gimbaled camera system hangs from this housing providing a streamlined design the can easily be swapped out in case of a malfunction or if a different payload is needed.

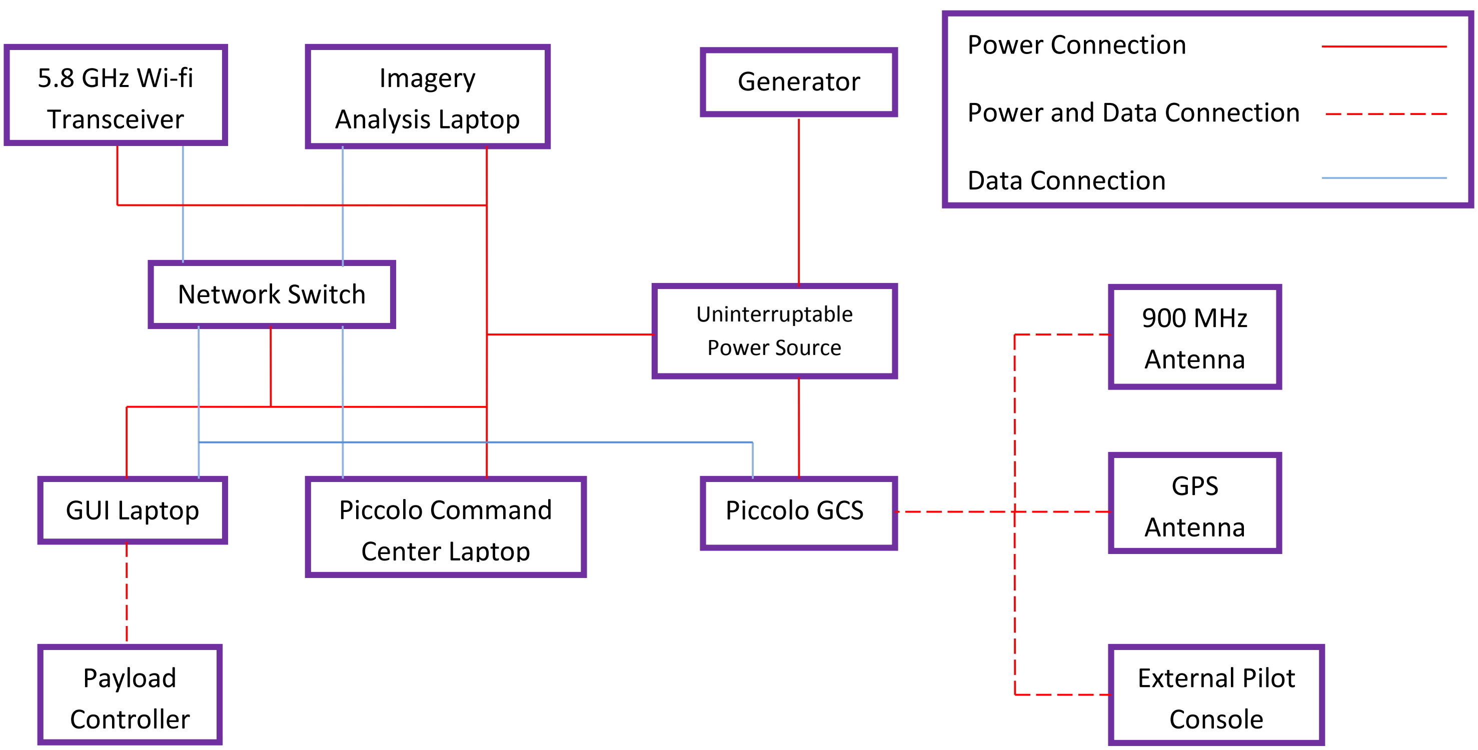


During last year's testing we found a large portion of time was spent on figuring out why we were losing video feed while in flight. Our first solution addressed one of our issues, but created another much more severe problem. The issue we resolved early this year was that the encoder was not fully being powered, and resulted in a partially functional video system. We modified this year's encoder by powering it from an independent 12.6 volt LIPO battery. The second problem we encountered was because of vibration issues. We noticed a slow oscillation frequency in our video. Our fix was to weigh down the gimbal isolators to substantiate their required load for correct isolation of the low frequency vibrations.

2.2 Ground Control Station

All flight operations are carried out through the Ground Control Station (GCS). The GCS is operated by the use of three laptop computers connected to the Piccolo portable ground station. Each computer has an assigned purpose for each part of the mission. One computer is designated to operate the Piccolo Command Center Software. This provides aircraft navigation and operation: from this computer, the operator inputs commands, monitors telemetry and flight data. The second computer operates the ViewPoint GUI software that controls the video payload of the aircraft. This station is manned by the payload operator who orients the gimbal-mounted camera to obtain desired intelligence. Both computers have external monitors with large screens connected to allow easier data acquisition. The third computer is used for imagery analysis and to connect to the SRIC. This computer is hooked up in a network with the payload computer to allow access to the files on the payload computer and access to the Wifi.

The Piccolo Portable Ground Control station (PGCS) is a transceiver enclosed in a protective case. Here, all appropriate cables and antennas are connected to facilitate communication between the aircraft and the ground station. The PGCS connects to the ground station laptops through serial cables. Three antennas are connected to the PGCS and then mounted on the outside of our trailer, one 900 MHz antenna for transmitting and receiving data, one GPS antenna that provides the ground station position and a 5.8GHz Wifi antenna.



2.3 Data Link

Effective communication to and from the aircraft is paramount. Without the ability to send and receive data flying the aircraft would simply be a folly since there would be no way to control its operations or collect any type of intelligence necessary for reconnaissance operations.

The autopilot transmits on a 900 MHz ISM frequency band between the aircraft and the ground control station. This requires two antennas for operation, one on the aircraft and one on the GCS. This link allows two-way communication; it transmits flight data including altitude, attitude, GPS location and waypoint information from the aircraft, while sending commands from the operator in the control station.

The imagery data is sent by a 5.8 GHz Wi-Fi modem capable of two way communication. This provides long range transmission of data from the aircraft to the receiver. Live video is sent real time to the payload operator.

2.4 Payload

2.4.1 Gimbal

In order to obtain imagery up to 60 degrees FOV in all directions from vertically below the air vehicle, an ultra-light weight two axis ball turret camera was selected. In order to utilize the pan/tilt functions and image stabilization, two spare servo PWM ports were configured through the autopilot for pan and tilt. To stabilize the image for pitch and yaw variations, the IMU gyros inside the autopilot that are used for flight stability are also utilized to stabilize the gimbal by sending control commands to the servos. In order to independently stabilize the camera from the airframe, the gimbal is attached to a housing which sits on top of vibration dampening mounts. This minimizes the amount of vibration seen through camera image. To find the target location, we calibrated to the gimbal at the 0 position. To find the target position the auto pilot uses the azimuth, angle of the camera and height above the ground to calculate the position. This information is necessary to compute this data through the autopilot.

2.4.2 Camera

A Sony IX-11A block camera was selected for the video. The camera composite video signal is converted to IP format using the Axis® M7001 Video Encoder. This encoder is connected to an Ubiquiti Networks® Bullet wireless transceiver that transmits live video to the ground station via a 5.8 GHz Wi-Fi network. This camera is capable of 10x optical zoom and 4x digital. The zoom feature of the camera is controlled via an RS-232 connection to the autopilot.

This camera was chosen mainly for its size, its dimensions allowed it to fit perfectly into the gimbal installed on the aircraft, and weighing only 3.4 ounces meant that added payload would be very small. The camera also boasts a 2.1 Watt power consumption that allows several flight operations on one battery charge.

2.4.3 Viewpoint

Viewing the live video feed from the camera is achieved by Cloud Cap Technology ground based control software called ViewPoint. The reason for selecting this software was because we knew that it would be compatible with the current set up of our platform, it allows us to view target location when pointing our camera at a specific location on the ground, and it supports IP video input through the Axis® video encoder and Bullet® Wi-Fi transceiver. In addition, it also allows image mosaicking and target tracking functions for easier target acquisition and identification.

2.4.4 SRIC

Our SRIC system is comprised of a D-Link DAP-1350 pocket router and a Zuni 5 port micro switch. We wanted to adapt to our current operating frequency of 5.8 GHz for video transmission, so we networked our SRIC D-Link router into the same Bullet transmitter. The AXIS video internet protocol encoder and the D-Link router are connected to the Zuni switch, which then sorts out the data to pass on to the Bullet transceiver simultaneously. By doing this we did not have to add an additional transmitter to pass the SRIC information on or have to worry about conflicting data frequencies. When the D-Link router is within range of the SRIC station, we receive a notification of a new network and we simply have to refresh our internet browser to accomplish File Transfer Protocol of the desired secret message, meanwhile our video feed remains untouched for the Sensor operator to continue looking for available targets. The SRIC is controlled through our imagery analyst's computer where the image analysis is also being performed to ensure a central source for all targets/data to be compiled for the judges.

2.5 Mission Planning

A risk assessment tool designed by KSU Salina's safety officer is used before every flight. After completion, this tool gives the operation a go/no go decision based on mission type, environmental factors, and crew readiness. The risk assessment tool relies on a point system where low numbers represent small risk, and larger numbers represent high risks. When added together these points help decide a go/no go decision.

Likewise every mission performed by the "Willie" helicopter always begins and ends with a checklist. A point is made to never commit anything to memory so that no item is ever missed. Before the flight portion of the mission begins, a crew briefing is held, here the crew assignments are verbalized along with type of takeoff, mission objectives, emergency procedures, and recovery methods. In the event of an emergency or unintended movement, the crew is instructed to take shelter inside, or behind the GCS to prevent being struck by the aircraft. Fire extinguishers are on hand in case of fire to the aircraft or GCS.

Crew assignments are a very important part of mission safety. It is imperative that every person participating in a flight test is given an assignment to keep crew focused on the task at hand, and know what their role is in case of an emergency.

The team consists of a Mission coordinator, Crew chief, Safety officer, Safety pilot, Air vehicle operator and payload operator. The mission coordinator works between all positions to ensure effective communication allowing team members to focus on their responsibilities. This allows us to more effectively utilize CRM providing an increased level of situation awareness to all crew members. The Crew chief is responsible for preflight of the aircraft and recovery of the aircraft as well as any troubleshooting that may occur. The Safety officer is responsible for safe operation practice in an around the GCS. The Safety pilot is responsible for safe operation of the aircraft during all phases of flight and also acts as a spotter during autonomous flight. The Air vehicle operator is responsible for manipulation of the aircraft while flying and working in conjunction with the payload operator and the mission coordinator. The payload operator is responsible for payload operations and communicating desired flight movements via the mission coordinator.

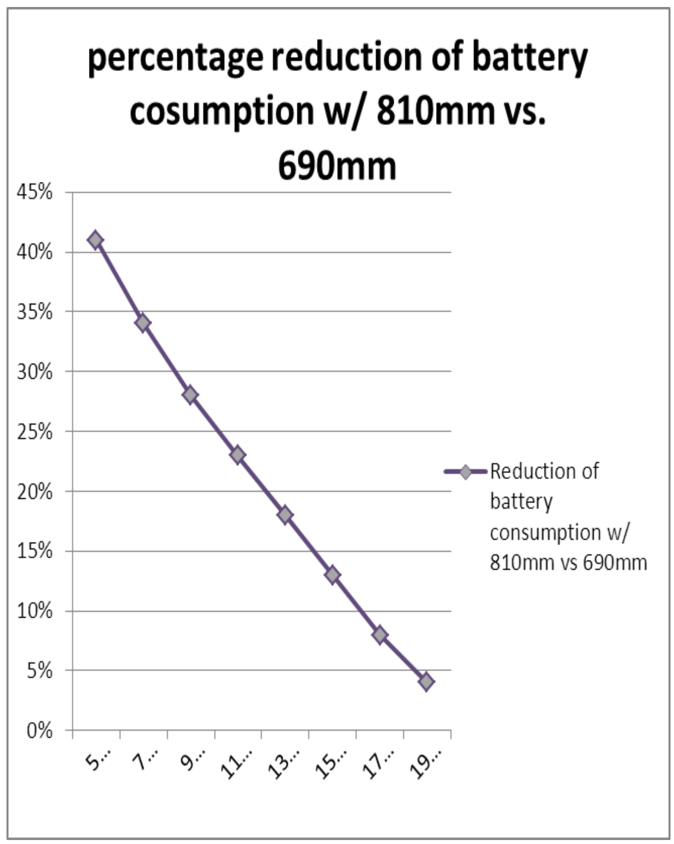
Ground crew members are responsible for the handling of the aircraft when not flying. They are tasked to transport the aircraft, charge batteries and test systems before each flight. Once all checklists are complete, the ground crew must move to inside or behind the ground control station during flight operations.

2.6 Data processing

All data processing is accomplished by the ground control station via the onboard autopilot. All flight data is processed through the onboard autopilot. The payload operator collects snapshots from the onboard camera in flight. Theses snapshots are then saved into a shared folder. Using a computer in the network the image processor analyzes the data and puts it in a format that can be presented to the judges.

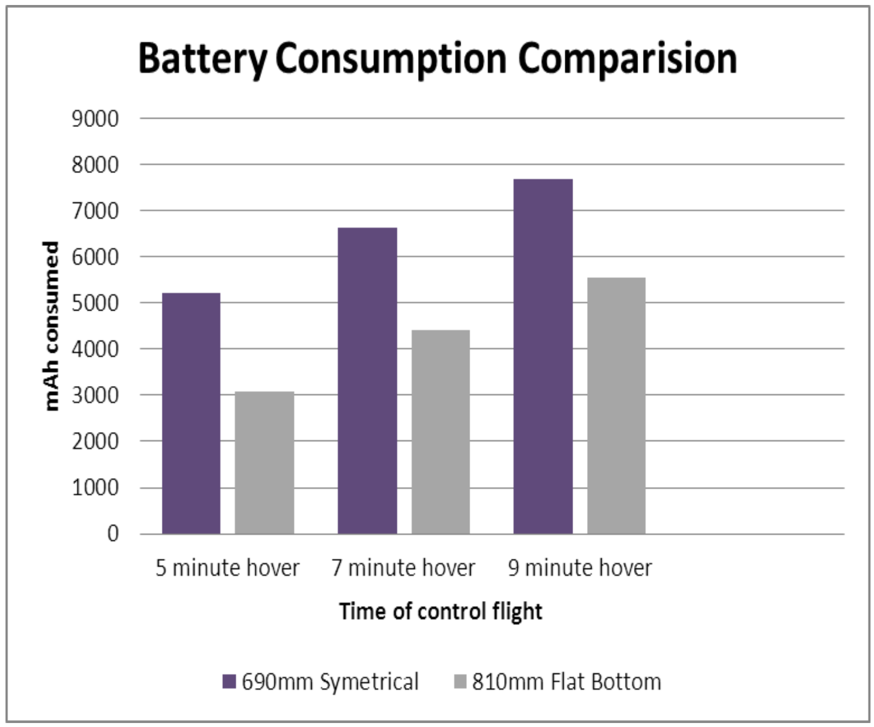
2.7 Method of Autonomy

The T-REX 700 is capable of autonomous takeoff, landing, altitude changes and waypoint navigation. To complete this, the team selected a Piccolo SL autopilot for the autopilot integration. This is a proven commercial autopilot distributed by Cloud Cap Technologies that was ideal for our VTOL system because of its size, capability of waypoint/altitude navigation, and support of VTOL aircraft via the onboard internal GPS and inertia sensors, a data link radio, rotary wing flight controller firmware, and electromagnetic interference (EMI) shielded enclosure. The EMI shielded enclosure is particularly important due to the close proximity of all the sensors onboard the helicopter. The autopilot fits perfectly in between the frame of the T-REX 700. Due to the high frequency vibration of the rotary wing platform, the autopilot is positioned on top of vibration dampening foam to minimize the amount of vibration in between the airframe and the autopilot. To provide accurate altitude sensor data to the autopilot, a laser altimeter provided by latitude engineering was integrated. This improves the accuracy of autonomous take off and landings.



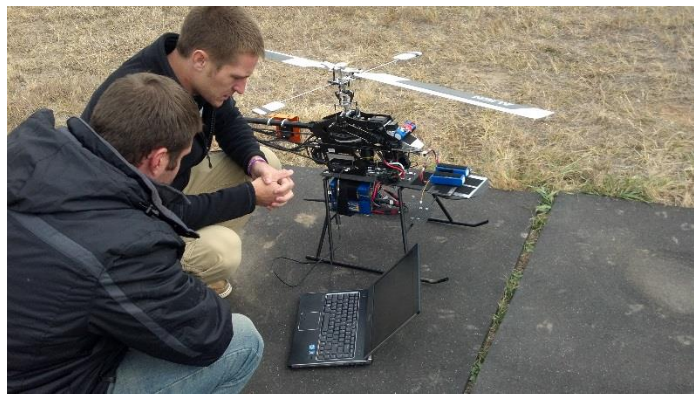
3.0 Testing and Evaluation

To establish testing criteria for the 2013 competition, scenario based testing was performed on a computer simulation of the piccolo command center. The flight characteristics of a helicopter allow it to provide a wide flight envelope, tight turning radius, and take off and land vertically. The simulator is often used for training using a helicopter configuration to practice. Information obtained from the previous year's competition was used to build a scenario in the simulator. With this information GPS data was used to gather distance and elevation information. The previous competition waypoints were put into the computer, and the aircraft model was commanded to track them while all phases of flight are timed. These times were recorded, and were used to establish an endurance number based on desired outcomes. Using last year's way points we were able to fly the waypoint course and transition into the search in just under five minutes. A flight testing schedule was planned out that began with establishing a maximum endurance in several different configurations. For all initial endurance testing, all flights were limited to a hover. Hovering was chosen as the mode of flight during endurance testing for several reasons. Hovering is a phase of flight that requires the most power, provides the most linear information when gathering data, and it is safest since it remains in one location at a relatively low altitude in case of undesired flight characteristics. Hover tests were conducted at several different time intervals in two configurations. Flight durations of Five, Seven and Nine minutes were used with fully charged batteries and a uniform takeoff weight. After each flight the batteries were recharged and the amount of milliamps it took to change the battery were recorded. The milliamps that it took to recharge were then subtracted from the milliamps available. We also downloaded our Castle Creations speed controller data from each flight and displayed it in graphical data, and this led us to interpret that we were correct in our assumptions of our estimated flight duration calculations. After establishing the average discharge rate of the batteries in flight, the maximum endurance was calculated to 21 minutes. This was verified by conducting a flight to demonstration to calculate our maximum flight time endurance. Although linear graphs reflect the endurance should be around 28 minutes this is shown to be false because battery consumption is not linear and rather exponential. All benefits of the bigger blades are lost after approximately 21 minutes as represented in our here on our graph.



Once endurance testing was finished, the imaging payload was installed. Initial testing of the payload included a range test. Considering the limitations of video transmissions over a Wifi signal, it had to be made certain that clear video could be transmitted during the entire mission. From the GPS data taken from the scenarios practiced in simulation. The aircraft was flown to 3,500ft from the GCS, the maximum distance from the ground station that was expected to be encountered in competition. Upon reaching maximum distance it was observed that the video quality was fair. During the rage test, the video quality was closely monitored to see if there was any interference from vibration transferred to the gimbaled camera. Initial observations indicated that there was high frequency vibration making the image quality slightly blurry. This was remedied by replacing the vibration dampening mounts and placing weight on the payload. After the optimal configuration of the aircraft was determined, scenario based flights were conducted. Since the last competition 31flights were conducted totaling eight hours and twenty minutes of flight time, each flight done completely autonomously. Waypoint tracking was practiced and timed to insure that data gathered from simulation was accurate; the average time to track previous competitions waypoints was four and one half minutes.

With the imagery payload installed on the aircraft, target recognition exercises were performed, using targets that were manufactured to represent a small size, shape, and color of targets that are expected in competition, and the parameters of the previous year’s search area were overlaid on our practice field. With an estimated 13 minutes of endurance remaining after waypoint tracking, it was determined that in order to acquire all targets, they would have to be recognized in 45 seconds. As practicing progressed the average recognition time was reduced to 30 seconds, with that allowed time 20 targets could be recognized.



After concluding the testing schedule, it has been determined that in the current configuration of the aircraft all objectives of the competition are able to be met.

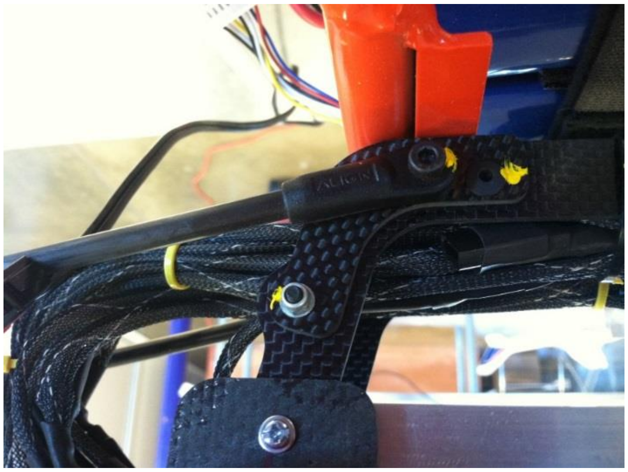
4.0 Safety Considerations/Approach

In the Kansas State University Salina UAS department, safety is applied intrinsically. By the use of checklists and redundancy in its systems safety is constantly monitored and addressed. This type of safety carried over to club operations, and is applied to all components of our missions. For this competition, safety was addressed in three parts: Aircraft airworthiness, Mission Safety and redundancy. Safety is always the most important consideration during all phases of UAS operations. During design, assembly, testing and mission, safety will always be addressed by our club.

<u>4.1 Safety Culture and Crew Resource Management</u>

Team “Willie” has a standalone safety culture. By incorporating our unique CRM process management into our UAS applications we are able to offer efficient and effective UAS operations. A large factor in CRM is communication amongst team members. We have found utilizing effective leadership, communication and a sterile cockpit atmosphere we are able to avoid and mitigate many risks. Since we have a large portion of our team involved with manned aviation utilizing checklist, verifying commands and making safety a top priority comes as second nature.

4.2 Airworthiness



Torqe Paint, Wire Sleeves, Zip Ties and High Visibility Paint

During the assembly phase of the “Willie” helicopter, close attention was paid to insure the aircraft was properly assembled as per the instructions. The torque specifications were checked, Loctite was used where applicable, and torque seal was used as a visual indicator of insuring all screws stayed within specification. Also on the aircraft, special attention was paid to making sure all loose cables and components are properly secured to reduce the risk of unintended movement during flight operations. To prevent wires from abrasion every wire on the system was wrapped flame retardant braided shielding.

Additional safety precautions that were taken on the aircraft included high visibility paint. Wherever possible, metal components were painted a high visibility orange, and the batteries are wrapped in a bright blue to promote high visibility to both operators and onlookers. Before integrating the autopilot system, several external pilot test flights were conducted on the aircraft to insure functionality of the helicopter, along with payload and endurance tests mentioned in the design portion.

4.3 Mission Safety

Before every mission performed by the “Willie” helicopter always begins and ends with a checklist. A point is made to never commit anything to memory so that no item is ever missed. To ensure upmost safety practices. Before the flight portion of the mission begins a crew briefing is held, here the crew assignments are verbalized along with direction of takeoff, mission objectives, and emergency procedures. In the event of an emergency or unintended movement, the crew is instructed to take shelter inside, or behind the GCS to prevent being struck by the aircraft. Fire extinguishers are on hand in case of fire to the aircraft or GCS.

Before each flight the communication system is set up with an attenuator to test the signal strength. This is done to ensure a reliable signal throughout all phases of flight.

Crew assignments are a very important part of mission safety. It is imperative that every person participating in a flight test is given an assignment to keep crew focused on the task at hand, and know what their role is in case of an emergency. The ground station crew is responsible for all operations of the aircraft, unless operations are transferred the external pilot. In the event of an emergency, the GCS crew is required to stay inside the station to prevent injury.

The safety pilot’s responsibility is to handle the external pilot transmitter at all times. When necessary the safety pilot assumes control of the aircraft, and is ultimately responsible for the safety of flight operations. While in flight, the safety pilot operates as a spotter to insure clearance from danger.

5.0 Conclusion

“Willie” has over 30 cycles of controlled/autonomous flights and 21 minutes of endurance, which shows the modifications made throughout the year have improved likely mission accomplishment. With careful design considerations and extensive testing of systems on the ground and in flight, the “Willie” helicopter will be a system capable of carrying out all threshold requirements of the competition. The custom improvements on our airframe and implementation of new roles throughout the group such as the Mission Coordinator, and the Imagery Analyst, should help our chances of mission success. Overall Team “Willie” redesigned, modified, and tested a better UAS than last year.

As we developed our Unmanned Systems Safety Culture we used our previous knowledge of FAA standards to guide our decisions.

Appendix

sUAS RISK ASSESSMENT

3/20 10 **Kansas State University at Salina**

UAS Crew / Station: ______________________ / ________ ______________________ / ________

Mission Type	SUPPORT 1	TRAINING 2	PAYLOAD CHECK 3	EXPERIMENTAL 4	
Hardware Changes	NO 1			YES 4	
Software Changes	NO 1			YES 4	
Airspace of Operation	Special Use 1	Class C 2	Class D 3	Class E, G 4	
Has PIC Flown This Type Aircraft	YES 1			NO 4	
Flight Condition	DAY 1			NIGHT 4	
Visibility	≥ 10 MILES 1	6 - 9 MILES 2	3 - 5 MILES 3	< 3 MILES 4	
Ceiling in feet AGL	≥ 10,000 1	3,000 - 4,900 2	1,000 - 2,900 3	< 1,000 4	
Surface Winds		0 - 10 KTS 2	11 - 15 KTS 3	> 15 KTS 4	
Forecast Winds		0 - 10 KTS 2	11 - 15 KTS 3	> 15 KTS 4	
Weather Deteriorating	NO 1			YES 4	
Mission Altitude in feet AGL		< 1000 2	1,000 - 2900 3	≥ 3,000 4	
Are All Crew Members Current	YES 1		NO 3 →	CURRENCY FLIGHT REQUIRED	
Other Range/ Airspace Activity	NO 1			YES 4	
Established Lost Link Procedures	YES 1			NO NO FLIGHT	
Observation Type	Line of Sight & Chase 1		Chase Only 3	Line of Sight Only 4	
Total					

RISK LEVEL			
16 - 26 **LOW**	27 - 36 **MEDIUM**	37 - 46 **SERIOUS**	47 - 60 **HIGH**
Go	**Go**	**No-Go**	**No-G0**

Aircraft Number: ________________________ Aircraft Type: __________________________

Flight Released By: ________________________________ Date _____________ Time__________

Operations Risk Assessment Form