**The Unmanned Aerial Systems Flight and Payload Challenge**

**Submission for**



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Abstract

This paper presents DV8-Tech's solution to the unmanned aerial systems (UAS) flight and payload challenge posted by the National Institue of Standards and Technology, Public and Safety Communications Innovation Accelerator. Significantly improving the effectiveness of first responders in emergency scenarios can be accomplished with our expertise and skillsets. By combining the benefits of gasoline and electric powerplant technologies into a multi-rotor platform the endurance and payload capacities increase, bettering the aid of firefighters and police officers in disaster areas. The standard electrical powerplant setup for heavy lift multi-rotors consume battery life quickly, but combining the power density of a gasoline generator we can recharge those batteries to increase the flight duration of the multi-rotor. The platform with a 20-pound payload we would like to see fly for 45 minutes, 15 pounds for 60 minutes, and finally 10 pounds for 75 minutes. Our team composition is highly qualified with multiple unmanned aircraft systems specialist that have experience building, innovating, and developing methods to advance the field of UAS. Complemented with a dedicated and professional business team that will also support the challenge.

**Project Description**

The unmanned aerial systems flight and payload challenge is going to take a specific set of skills to develop a prototype to be a viable solution for the challenge. Team DV8-Tech possesses the knowledge, skills, and capabilities it will take to succeed. The design team has developed the concept, and will create and test the aircraft. The business team will ensure the success of the design team with their planning and management expertise.

The current industry standard for powering an unmanned aerial vehicle (UAV) is the lithium polymer battery pack. When this technology was unleashed, a massive array of products hit the market that offered better power usability than traditional nickel-based systems. A growing industry however, is demanding more and more capability daily. This is exposing the inherent flaws with lithium systems, and how they can be improved.

The number one objective of any power storage method is volume specific power, also known as power density. The second objective is the power to weight ratio of a given battery package. UAVs require a very specific mix of both objectives. Power solutions that achieve very high-power densities are often extremely heavy in relation to their size, for example a lead acid car battery. On the other end of the spectrum, solutions that are light weight often cannot supply the current needed to keep a UAV airborne, for example AA batteries. This is where the Lithium battery found its niche in the UAV world; a battery light enough to be carried by aircraft, yet being able to supply electrical power in brute force quantities needed for flight. This brought a balance to the solution of a power source that had the energy available for longer flight times, without sacrificing payload capacity. This allowed for many systems to make use of the technology, and bring it into the market where more research and development was imminent.

The lithium cells were considered so advanced that research funding was put into other electrical systems of UAVs to create aircraft that could keep up with modern objectives. As a result, lithium cells are now the weak link in UAV power system demands. As operations require heavy lift capabilities and extended flight durations, the amount of power required by aircraft is becoming the priority issue. The power density of battery technology is severely limited in nature. Solutions to extending payload capacity and flight time need to focus around increasing power density.

Our solution focuses on maximizing the power density of the system, to better make use of the maximum useful load of the aircraft. This will be done by using liquid fuel in addition to the contemporary battery power source. Liquid fuels have a much higher power density than almost any form of energy storage. The caveat to using them, is inherent loss of usable power due to inefficiency during the conversion to the desired power method. This is overcome by the supplemental battery power bridging the gap. The liquid fuel is converted into mechanical energy via a small internal combustion motor, then into electrical energy through a generator. The technologies now available allow the transfer to be done with maximum efficiency. This system will use the high-power density of the liquid fuel to both power the main flight system, as well as maintain the battery voltage to ensure it stays in at the most optimal voltage condition for the longest period feasible.

The longest flight times come from balancing two of the most basic forces of flight; lift and weight. Our design focuses on making the most of the limited amount of weight the aircraft has available. It focuses on improving the very shortcomings and limitations that lithium batteries lack in power density. By making the most efficient use of the aircrafts weight in energy reserves, the amount of lift that can be produce is subsequently extended. This approach is the method needed to succeed in creating a full system that can lift advanced payloads, for extended durations of time.

Some commercial off the shelf heavy lift multi-rotors capabilities are being reported to fly with payloads of 20-pounds for up to 30 minutes in ideal situations with only lithium batteries. Typically, in a real-world situation the actual fight times are significantly lower than published, 20 to 25-minute flights with a 20-pound payload. By building a multi-rotor from individual components with the most efficiency plausible and adding an onboard generator we can greatly increase flight times with a 20-pound payload. Therefore, if we maximize this payload weight's flight time the, then the other two lighter weights, 5 and 10 pounds, will be able to fly for even longer periods of time making our solution a competitor in the challenge.

Finding the most efficient brushless motors is how we start to get the flight times increased. As throttle increases efficiency drops, but the amount of weight lifted is increased. The key then is to figure the aircrafts all up weight which must be under 35 pounds to meet part 107 regulations once the challenges highest 20-pound payload is added. We decided for the concept to use 6 motors in a collapsible hexa-copter configuration. Each motor must lift 7.5 pounds to make a 45-pound vehicle hover. We use 45-pounds all up as a target weight to ensure we have some extra weight available if needed. We fill it best to have the thrust needed to hover be capable at 50 percent throttle to allow for adequate control of the vehicle in climbs and decent. Looking at thrust chart data some of the best quality and efficient motors available hitting these requirements draw about 10 amperes with very large 30 plus inch propellers which really starts pushing the size requirements of the contest. Compromising efficiency for the size requirement then becomes the next factor to consider for the challenge, and it must be an equal balance to overcome the goals of the challenge. Looking at small still highly efficient motors, worst case scenario we will be using 20amperes to produce 7.5lbs of thrust per motor using an 18-inch propeller supplied with 24 volts. With all 6 motors we will be pulling 120 amperes to maintain a hover. To do this for 45 minutes as a target we must then use 90-ampere hours or current. This figure is our goal and if we use a 20-ampere hour lithium battery we must then be able to get the other 70-ampere hours of current from our generator. With the absence of small lightweight generators on the market. We plan to use a small gas 2 or 4 stroke engine to drive a permanent magnet generator to produce the needed amperes.

**Team Information**

DV8 Tech consists of seven highly qualified and individuals working together as a team. Our team has worked tirelessly to develop a model for innovative thinking and creation. At the beginning of every project DV8 Tech defines our goals and creates a clear vision for the entire group to work towards. Throughout the project our individuals steadily work through every obstacle with collective thinking and problem solving. Through strong leadership, communication, and motivation our seven individuals have created a synergistic relationship that has proven itself effective time and time again. As a team we have developed multiple UAV platforms specialized for confined spaces, livestock management, pest control, increased payload capacity, and long endurance flight.

For this challenge the DV8 Tech team is especially well suited. Two of our last three projects have included the main objective of carrying additional payload weight while keeping flight times high. As we complete each project we look forward to the next endeavor as a whole. To remain effective as a group DV8 Tech only takes on one project at a time. Our team is committed to performing at our highest capacity by devoting all of our time towards one specific task. By doing this our college graduates from the pioneering UAS program at Kansas State University (KSU) can produce their best work.

Technical expertise from exemplary graduates arising out of KSU's UAS program coupled with business savvy individuals with years of professional experience are responsible for DV8 Tech's reputation as a leader in expanding the field of UAS. Our team for the Unmanned Aerial Systems Flight and Payload Challenge consists of these seven individuals:



**Ryan Zoller**

**C.E.O**

**Education**

Bachelor of Science: Unmanned Aircraft Systems

*Kansas State University*

* + Recognized as an outstanding UAS major at KSU.

**Professional Experience**

Commercial experience in the Custom Unmanned Aerial Systems Industry.



**Luke Keener**

**Director of Business Development**

**Education**

**Bachelor of Science: Business Administration and Management**

*Fort Hays State University*

**Professional Experience**

**-Product Development,** Fuller Industries

* Oversees business expansion and growth projects



**Toby Tracy**

**Remote Systems Technical Lead**

**Education**

Bachelor of Science: Unmanned Aircraft Systems

*Kansas State University ~ Magna Cum Laude*

**Professional Experience**

-Former Lab Technician, Saxon Remote Systems

* In charge of day to day operations for remote system maintenance.
* Lab infrastructure setup.
* Multirotor and Fixed-wing mission flights.

-Former UAS flight Instructor for K-State University

* Helped develop the multi-rotor flight instruction procedures and requirements.
* Trained fellow students to be competent in multi-rotor operations.



**Jeremy Spink**

**Chief Engineer**

**Education**

Bachelor of Science: Unmanned Aircraft Systems Engineering Technology

*Kansas State University*

**Professional Experience**

-Chief engineer, Stockbridge Advanced Underwater Robotics.

* Directed an engineering team of 4 to design, build and troubleshoot a UROV & UAV.
* Traveled with team of 8 to Republic of Palau in search of WWII MIAs in the Southern Pacific Ocean while coordinating with military entities to coordinate project logistics.

- Welding fabrication intern Eaton Aerospace fluid conveyance division.

* Inspected discrepant material reports and created routers to correct manufacturing methods
* Worked in a high-performance work team environment to solve problems and dilemmas



**Truc Quac**

**Remote Systems R&D and 3D Design**

**Education**

**Certification: Machining Technology**

*Wichita Area Technical College*

**Professional Experience**

-Koch-Glitsch,Wichita, KS — *Post Design / 3D Design*

* Draft blueprints & paperwork for separate parts of assemblies. Creating weldings programs for a robotic arm.
* Automating the creation of 3D models using C++ in AutoDesk Inventor. Developing new 3D processes and techniques in AutoDesk Inventor. Generating and Maintaining an extensive library of hardware and punch tools.

-US Army,Ft. Bragg, NC —*Information Technology Specialist*

* Oversaw the daily performance of more than 50 computer systems. Setup, tested, and configured new desktops, phones, and printers. Trained new employees in effective diagnostic and repair procedures. Microsoft SharePoint webmaster responsible for creating, designing, and the administration of web portals.



**Conner Matthie**

**UAS Test Pilot and Technician**

**Education**

**Bachelor of Science: Computer Science**

*Kansas State University*

**Professional Experience**

-Welding Technician for C&T Custom Fabrication

* Lathe Machining, Drafting, Fiber Optic Laser, Welding, Solidworks

-Part 107 Remote Pilot Rating



**Christopher Maddy**

**Sensor Specialist**

**Education**

**Bachelor of Science: Unmanned Aerial Systems**

*Kansas State University*

**Professional Experience**

**-**UAS consultant, Barger Drone LLC, Clydesdale Agronomy LLC

* Selected UAV platforms, software, and hardware for a range of applications concerning crop data gathering, livestock management, and different payload capabilities.

-Part 107 Remote Pilot Rating