Where to Start with Drone Safety

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WOLF UAS

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Letter from the Author

Wolf UAS LLC is here to provide the latest information, theory, and practical implementation of safety risk management and program development for drone operators. One thing is clear, the industry is craving standardized approaches to unmanned system integration that protects and supports new sUAS programs. The more safety becomes the center of your operation the more effective and efficient you will be and the more the future holds for your young program.

With a “Mission First, Safety Always” approach to flight, Wolf UAS LLC has put together this short safety program that will help even nascent UAS programs. The following report helps put together a foundational knowledge and resource survey for anyone interested in developing a UAS program. For more information and help developing a program, contact Harrison Wolf at Wolf UAS LLC.

Developing an Ecosystem of Safety around the use of unmanned systems has become the overarching goal for Wolf UAS LLC. By providing Standard Operating Procedures (SOPs), Training, and Certification to the UAS industry, the industry becomes safer and more inclined to the type of success necessary to ensure future growth. Wolf UAS provides these services in several capacities – hourly, on retainer, and per project finding a way to work with any company and their budgetary constraints.

So, where has the most growth been? Well the answer is a complicated one, which is why we’ve included the following outline to help inform you about the direction of the marketplace. This e-book will help orient you to the best practices for developing your UAS program considering safety, industry knowledge, best practices, and practical implementation. While not comprehensive, it should serve as a way to familiarize yourself with important facets of safety programs related to drones and enable you to go forward with safety in mind.

Industry Update and Analysis

Technology Changes. Regulation Changes. Adoption Changes.

As a teacher with USC Aviation Safety & Security Program, I have had the luxury to be a part of this rapidly evolving drone community now for nearly a decade, and throughout that time lots have changed. I've met visionaries of volumetrics, chewed the fat with regulators and legislators, and provided reviewed research that drove real decisions in real time. Throughout all of this, we all took measure of the industry each day at home, and periodically throughout the year at the major community conferences. My personal mission at these events has evolved from representing University of Southern California to providing safety leadership on behalf of both Wolf UAS LLC and USC in the standards, regulatory, and commercial worlds. In 2010 ground and sea robotics were nearly as present as flying drones themselves. People were keen to pay $150 for small Chinese drone imports and military vendors dominated the field focused on automated support for the overseas soldier and special operations. We had no rules for small unmanned aircraft, the Pirker v. Huerta case was just a glimmer in the eye of legal experts from the drone community and BVLOS operations were still "Just around the corner."

Still in its infancy, the drone community came together around DJI, 3DR, and Parrot who provided hands-on experiences for the consumer shortly thereafter, and the race for the "Best Drone" was officially on. From the software companies who are no more, to the still dominant forces in attendance, the AUVSI showcase has provided the breeding ground for start-ups, education, regulators, and international business for years. Others have tried to copy the magic that is AUVSI, re-branded as XPONENTIAL, in Atlanta two years ago; some have had success focusing on the sUAS market like the folks over at sUAS News in San Francisco. Others have focused on the Commercial market alone like Interdrone, Commercial UAV Expo in Las Vegas, or the Drone World Expo in San Jose. One trend seems to be evident as the UAS story progresses – we're now in the specialization and industry verticals life-cycle phase of the industry.

Industry groups all come together at the largest commercial expo in the nation called XPONENTIAL led by the Association for Unmanned Vehicle Systems International (AUVSI). Deals are made, sales are placed, and new and old vendors a like come together to demonstrate their new technologies and innovations.

Industry verticals are the biggest game in town and the industry is responding. From three major conferences a plethora of industry specific, smaller meetings, webinars, and phone conferences, the unmanned systems community is recognizing that one size doesn't fit all. Even with larger verticals, such as the energy field, diverse needs and requirement drive enough content and lessons learned that oil and gas, wind production, distribution, and transmission have all developed expertise that can be shared beyond a 1 hour session on "Energy: Lessons Learned." The Energy Drone Coalition, with support from their own industry experts through their board of advisers, is putting together a conference in the heart of oil and gas country that highlights the needs of their industry.

Photo: Virginia Tech News 2017

The next step, will be a need for airworthiness certification and standardization within industries to provide competitive advantage away from consumer grade models and toward Industrial grade platforms. The beginnings of this are occurring as seen in Aerovironment's recent testing at the BVLOS Corridor in collaboration with Ligado's satellite connectivity platform and Dominion Powers expertise. Here we have a highly developed, systems engineering platform maintaining BVLOS grade connectivity while working with an industry leader on the East Coast for power provision (Dominion Power). Aerovironment's leadership has invested in systems grade engineering, fostered relationships where they matter most, and integrated a robust Safety Management System (SMS) to provide the industry with a quality product. The real question is, will anyone pay for it?

Aerovironment flight test teams work together to provide support for the BVLOS operations at the Virginia Beyond Horizons Corridor in 2017. What we've seen in the system development life-cycle is a realization of this evolution. The unquestionable leadership of DJI in the consumer space and industrial application has led to a specialization of their platform. We've seen the hardening of their technology for EMI interference, weather, and connectivity. The DJI Inspire 2 and the M210 address drawbacks to the DJI platforms at a price that undercuts any other industrial application UAS such as the Aeryon Scout and address the same Enterprise level operation requirements at consumer prices. As we look to the Sensefly platforms, we see a diversification away from consumer and toward specific mining, agriculture, and aquaculture. We've also seen this specialization in the consumer space with DJIs Spark production. This product has less impressive optical, data, specs than the dji phantom 4 professional outright, but it's ease of use, hand recognition piloting positions it as a uniquely qualified, exciting, and relevant selfie-drone at a price point within the reach of most consumers.

A CONOPS Approach to Drones

Mission. System. Environment. Personnel.

Much has changed over the last two years. The FAA published 14 CFR Part 107 enabling a whole new generation of pilots to take flight legally and in a standardized approach with small unmanned aircraft. While Wolf UAS LLC has a still viable 333 Exemption, our operators fly under 107 rules supplemented by waivers that could enable flying at night, in variable airspaces, and elsewhere. Private investment, M&A activity, and strategic partnerships are flourishing as new entrants, and old major players, enter the relatively new field of unmanned aviation. Hell, even Shark Tank Investors own one hardware drone company and invested in many more with payload applications and dreams.

At Wolf UAS, we've learned quite a bit teaching and one of the techniques we find most valuable is case study analysis. Case-study analysis allows us to look at what an end-user may not understand for different industries that are ripe for drone use, yet untapped in complexity. These industries will likely be in the news for drone enthusiasts, but may not be on the forefront of the tech-space community, or relatively unknown in the industries themselves. Sure, everyone in OUR world knows that wind-turbine inspections are taking place all-over the world by using innovative UAS companies, but many utility companies are unaware of the intricacies, evolving technologies, or even required support services for that application.


Photo: Savannahnow.com

Picking the correct system for the mission you're undertaking is vital in ensuring success and safety of your crew and the public. By thinking through your mission ahead of time, you can make a purchasing decision that emphasizes thoughtfulness, safety, and success rather than expedience in the field.

A great case-study comes from responders to natural disasters, industrial catastrophes, law enforcement actions, revolutions, and even transportation accidents to see how they are finding value through the use of unmanned aircraft, ground and underwater vehicles. DARPA has spent millions on the need for robotics through their DARPA robotics challenge leading to innovations in the hardware, software, and sensor platforms requisite for efficient and effective use. However, the lessons learned from these challenges, from use cases all over the world, and industry needs are not being taken into consideration for the design of these advanced systems for large companies. Simply put, off the shelf hardware is not sufficient for ensuring continued use in diverse conditions, weather conditions that limit use due to humidity or wind, and infrastructure that can be detrimental to performance.

Crisis response needs robust and hardened solutions – not consumer grade products that are unreliable even in the best conditions. They don't need uncontrolled flyaway due to incompatible wi-fi connections, they need safe and secure C2 links and ruggedized sensor platforms. First responders have certain requirements when it comes to their mission that all go to defining the most important element for drone use – the **Concept of Operations or CONOPS**. The CONOPS includes the most vital considerations for drone system design and operation. These considerations are also all required for operational certification and approval by Civil Aviation Authorities and therefore it simply makes sense to address the needs ahead of time, before investing in hardware/software. The following page outlines important elements in the First Response & Crisis Management CONOPS methodology.

What's the Point? - If you don't understand the complexities of your unique system, environment, personnel, and tasking then you simply won't be able to fully qualify the hazards and limitations of the flight. For crisis response, it may be that the mission is vital to save lives and higher risk thresholds are tolerable or it may be that the system you are employing must be more robust due to the highly volatile nature of the ever-changing situation. It may be that solar recharge plays a vital role in your success or that C2 must rely on radio rather than any redundant satellite connectivity. Whatever the challenge, a standardized CONOPS approach enables that knowledge gain by clearly identifying the limitations and enablers for your mission. The following items should all be considering in your CONOPS.

Definition of Flight Area and Airspace – *Population Density, Expected Air Traffic, Expected Surface Traffic, Types of Buildings or vital infrastructure in the area, any confined or obstructed areas, emergency landing areas or terminal flight areas*: Understanding these items makes planning flight time needs, sense-and-avoid technologies, and payload weights much easier and allows for a clear understanding of the system design with regard to battery size, motor control and size, and communications needs including GPS, directional links, etc.

Payloads or Sensor Needs – *Configurations, usability, lighting conditions, proximity to scanning environment, clarity and resolution needs, timeline for access to data, data security and management*: First responders to accidents, fires, or radioactive conditions may require data much quicker than those who are simply monitoring damage or assessing infrastructure cost estimates. The system should not remain the same, and likewise the hardware/software being used is not the same. The needs of firefighters in active conditions are not the same as a surveyor sent to monitor the site-conditions of a damage church. Some payloads are modular, others are not.

Type of Operation – *Visual Line of Sight, Extended Line of Sight, or Beyond Line of Sight:* For Crisis Management or First Response, say in the case of an earthquake that has devastated the country side, Line of Sight and Extended Line of Sight may be all that is required. This simplifies and directly impacts the type of communication links you need and the approval process by the state is much simpler. First Responders may need access to ***extended line of sight*** **or** ***beyond line of sight*** characteristics as their mission may include combining census data with topographical scans of damage for those in unreachable locations. By combining these two outlets of information instantly, operators can locate the most endangered populations – elderly homes, hospitals, and schools – with the most damage to do the best.

Conditions for Operations – *Wind Speed limitations (headwind, crosswind, gust), Turbulence restrictions, minimum visibility conditions, outside air temperature limits, outside air temperature limits*: Fundamentally one of the least considered sections when preparing fo crisis management. Applicants often find themselves with 75% on-site downtime due to inclement weather and a lack of preparation or planning for purchasing systems that can handle various weather. There is a reason Aerovironment's PUMA AE is expensive – it can allow mission success in difficult environments

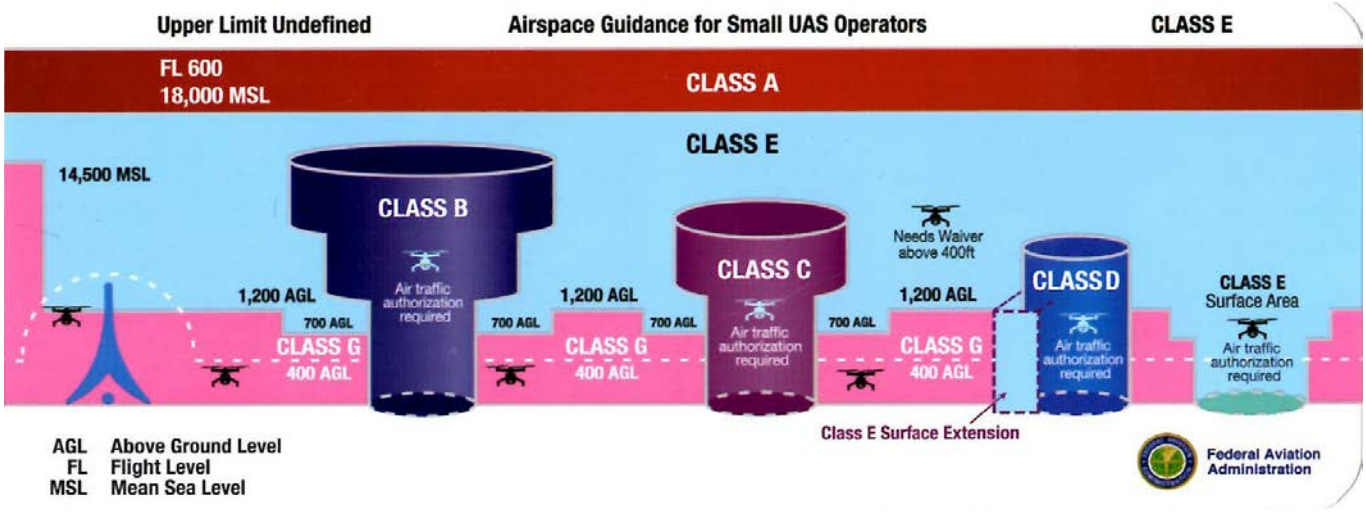
UAS Performance Characteristics – *Maximum altitude (not regulatory), Maximum airspeed, cruise or hover airspeed, maximum endurance, maximum range, maximum rate of climb/descent, maximum bank angle, turn rate limits, payload capacity, battery draw*: Notice that these are come last as all elements to be considered should DRIVE the characteristic requirements of the UAS. If you find that the drone you have selected is not directly related to the mission requirements, it is time to find a new system.

First Response is different for every organization – First response can be outsourced, can be insourced, and can be cooperatively managed across platforms, systems, and organizations. Team Rubicon approaches response much differently than the Red Cross. It is critical that the mission drives the system requirements. Whether you're flying in Nepal to assess earthquakes at 350 FT AGL in light weather conditions or flying near extensive and sensitive infrastructure in high wind events using micro-uav systems, your requirements will be different and you must consider the design and operations from the very beginning. Mostly importantly, you must go through a process oriented hazard identification mechanism if you want to meet the highest level of safety for your mission, and protect the resources and personnel involved in your program.

Regulations, Airspace, Access

Environment & Requirement

One of the most important elements of the CONCOPS approach to drones, and truly one of the most impactful characteristics of flight planning, is the effect of the environment. Though often this is considered through a lens of weather, physical stimuli, or direct area of operations about the public on the ground, perhaps the most complicated and difficult factor relates to air traffic, airspace, and regulations. While this document does not purport to provide the full consideration of airspace management, public oversight, or regulations the goal of a CONOPS is to get the mission planner asking the right questions in a standardized way. So, for a quick an easy approach to drone operations when considering environmental factors such as regulations, airspace, and authorized access, do the following prior to each and effort new flight location:



Clearly define where your operations will be: Prior to authorizing any flight, identify and transcribe where the proposed flight will take place noting the GPS coordinates (Latitude and Longitude). You can use any number of free tools for this including Google Maps. While you're at it, look at the general type of location where the flight will take place. Ask yourself, is it near a populated area? Are people likely to be walking under my flight? Do I trust my contractors, or myself, to fly in this environment? Are there any other risks in the immediate environment that I may be unaware of? Has anyone in my organization reported problems in similar areas?

Define your needs: There must be a reason you're flying in your location. If the reason is good enough, higher risk can be tolerated and you can define the flight environment to include greater risk of collision with objects. An example of this is that you need to fly within 100 FT of a power generation station, because you're taking images of the generation station. That may seem simple, but never take unneeded risk simply because it is easier. There may be no need to fly within 100 FT of that same generation station unless you're testing system performance or maneuvers near infrastructure.

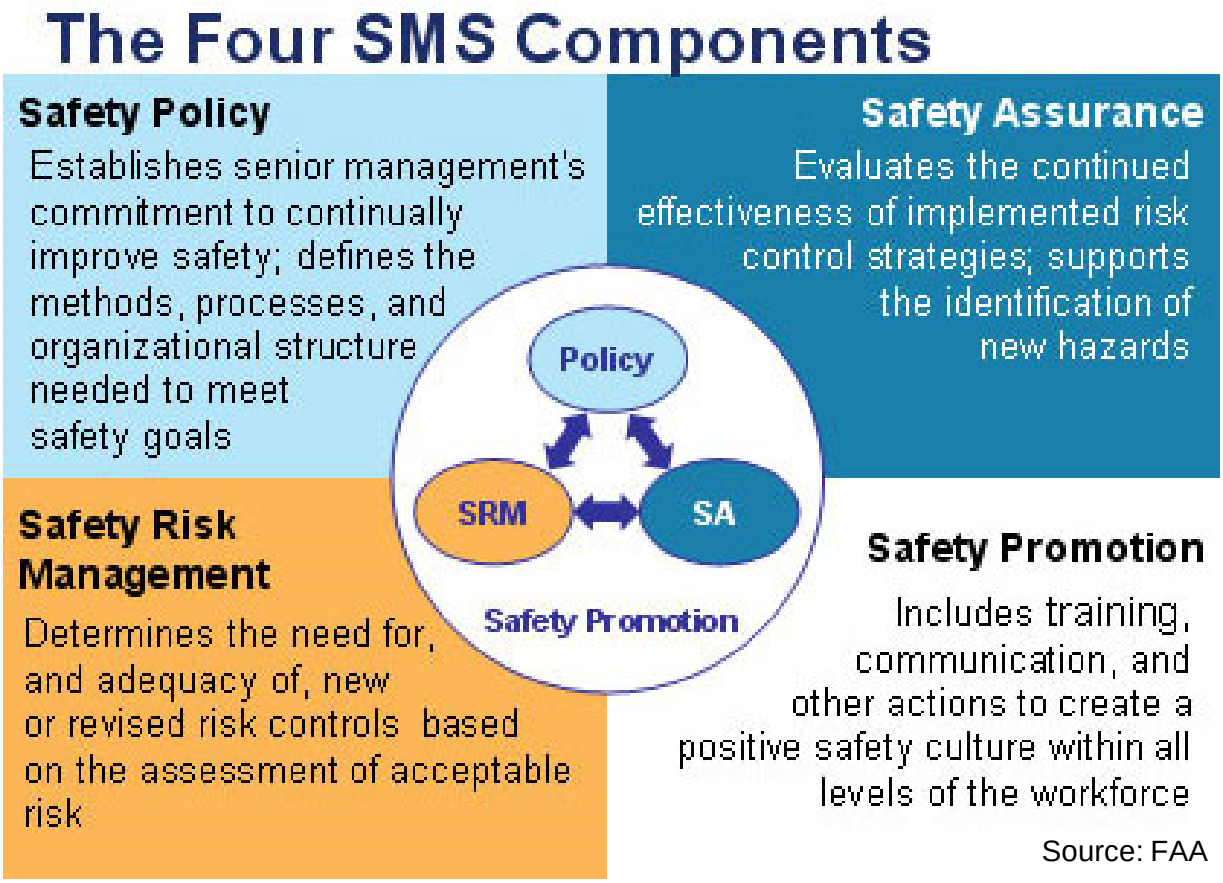
Address Your Airspace & Understand your authorizations: As your skills, program, and offerings grow you'll begin to look at authorizations and waivers into higher risk environments or operations that aren't initially allowable under 14 CFR Part 107. For these, you'll need to prove out your safety cases, apply under the waiver systems, and wait a good amount of time to operate. It will be important to understand that the better you know the airspace in your vicinity, and the more you understand basic safety theory as well as have Standard Operating Procedures (SOPs), the greater your likelihood will be for achieving success in the waiver process.

Safety Management Systems

Applying the Latest Safety Theory to Unmanned Systems

Developing a drone operation is hard work, but rebuilding one after a crash that damages sensitive infrastructure, hurts or kills someone, or even just diminishes the reputation of your company in the public eye and internally is far harder. To cultivate and protect your operation, there is no better opportunity than implementing a robust and healthy **Safety Management System** (SMS). SMS is considered the leading theory and practical application of industrial safety for the aviation, transportation, medical, and energy generation; fitting perfectly into any operation that find unmanned aircraft systems. Regulators, industry leaders, and manufacturers have all begun to recognize the importance of SMS and often provide incentive structures that identify SMS to lower your costs, access higher risk environments, and develop on-going and important financial relationships.

The four elements that define Safety Management Systems can be found in the International Civil Aviation Organization Safety (ICAO) Management Manual (SMM) Document 9859, in ICAO Annex 19, in the Federal Aviation Administration (FAA) SMS Framework, and of course in the President of Wolf UAS's industry leading textbook Drones: Safety Risk Management for the Next Evolution of Flight. These four elements always include Safety Policy, Safety Risk Management, Safety Assurance, and Safety Promotion. Within these are sub-elements which must be included and provide for the implementation of advanced safety theory at the practical level. Below are some examples of how drone operators can integrate SMS into their daily operations, providing operations standardized approaches to UAS operations.



Safety Policy: Safety policy exists to provide your organization an understanding of the importance that management plays on safety. Does your organization place safety above mission? Is your executive and management team invested in safety performance? By identifying and describing your leadership buy-in, your team members at all levels of an organization can begin to understand and adopt the same attitude toward organizational safety. Further, providing a meaningful safety policy for your organization enables the development and evolution of a safety culture that permeates all facets of business. As this positive safety culture develops, reporting and documentation becomes more pervasive and the information at all levels of the organization increases and becomes more refined. Without a positive safety policy, a dedication by upper management, and the develop a non-punitive safety culture your operation will not be as safe as it can be.

Safety Risk Management: All types of organizations evaluate risk differently. When it comes to aviation, there is one method that provides qualitative and quantitative evaluation meeting industry best practice standards. The first step is to identify as many hazards as exist to an operation. The CONOPS approach helps by providing a full understanding of your operation broken into the categories of **system, mission, environment, and personnel**. By analyzing your program's categories, you can identify the hazards present to your operations. These hazards (any condition or act that diminishes the overall safety condition of your operation) care then evaluated independently from one another for their most credible failure state. This failure state must be analyzed for the likelihood of the failure occurring (how likely is it to fail?) and the severity of the event when it occurs (How negative is the safety impact when it fails?). This combined analysis is called the risk score, and can then be put into rational terms for how tolerable it is. We can see that if the likelihood of an event occurring is very high, then the severity of that event must be lower to compensate for the event or else the risk will be too high to tolerate. If both elements are low, the hazard is probably tolerable. If both are high the event must not take place. Once the risk score has been identified, you can implement mitigations that will diminish the risk. This can be done to either of factors (severity or likelihood) or can be done tom both. If the problem is that our drone is very big and fast, and we're near people, then the mitigation would likely be to move away from people entirely – diminishing the likelihood of hitting someone even though the severity of the event is the same. There are any number of ways to diminish risk associated with each hazard.

Safety Assurance: Safety Assurance can be the most difficult element of the SMS framework to perform as it takes an on-going and attentive manager to ensure that it is done correctly. Safety assurance is a method for ensuring that what we say we're doing, is what we're doing. This is done by analyzing on-going data including hazard reports, risk analysis documents, audits, surveys, and oversight. One too that is extremely helpful is logbooks, data management platforms, and analytical tools to look at trends in performance. Managers should identify **certain Key Performance Indicators** or **Indexes** (KPIs). These KPIs can be as simple as "how many average hazards are reported" to "how many flights per month without an accident." You always want to encourage reporting so be careful not incentivize inconsistent reporting behavior. You'll get the hang of it!

Safety Promotion: While it may seem difficult at first, promoting safety throughout your organization can be a breeze if someone in your organization is actively thinking about what mechanisms can be used to improve your KPIs and drive home the concept of safety policy. We provide our clients with on-going methods that can support and improve your safety organization. Among the best safety promotion techniques are safety action group meetings discussing any safety issues or concerns that have arisen within the industry. Heck, you could bring this short e-book on safety and assign reading to the members of your organization. Industry knowledge, lessons learned by others, provide the opportunity to learn without having the pains of first-hand experience. Create a Priority Top 5 for safety spotlights, develop curriculum for your training program that focuses on safety, and implement voluntary non-punitive culture that can facilitate on-going, positive communication.

Working with People

The 5 Easy Cs of Crew Resource Management for Drone Ops.

Have you ever said something to someone and, though they understood the words coming out of your mouth, they didn't respond as if you were speaking the same language? Have you ever been talking about the same thing to a partner or colleague, yet didn't know it because of a language barrier? Have you ever known that your boss was wrong, and you had a fix, but you didn't feel comfortable relaying that message? If the answer to any of the above is "Yes," then you need Crew Resource Management aka CRM!

Okay, that may seem like a bad infomercial pitch but, really, CRM is one of the most underrated requirements for commercial drone flights, and a topic that doesn't get enough attention. As we all know, unmanned aviation sits at a crossroads between manned civil flight, remote control flight, military UAS, and commercial manned flights in such a way that best practices from the "few" do not always translate into adoption for the "many." CRM for manned aviation has been around a while and has been considered a requirement and best practice taught and exercised successfully with great results, yet has not proliferated throughout drone cultural as swiftly. Whether cost, time, or interests are the excuse, CRM is something that can be incorporated easily, cheaply, and without pain.

The 5 Cs of CRM for Drones

- **Concise "Go/No-Go" criteria**
- **Clear responsibilities and roles**
- **Common language for standard and emergency procedures**
- **Cross-check that gets everyone monitoring standard operations**
- **Checklists with cross-talk during operations with negatives and affirmatives**

Though FAA Notice 8900.227 identified CRM as a requirement for unmanned aircraft operational consideration prior to any outward facing codification, it is still widely unrecognized or considered by many drone crews. For the industry to flourish this will need to change, and the latest version of the sUAS Rule takes this into consideration. With 14 CFR 107 and referencing CRM requirements no less than 5 times (yes, I counted), the industry must see CRM as a "need-to-have" not a "good-to-have."

If you want the FAA's best take on CRM, you can go check out AC 120-51; It's long, cumbersome, and doesn't fit the needs of drone operations very well, as it's written for a manned aviation operation. This is just one reason why commercial UAS operations that incorporate CRM training are minimal at best, and non-existent at worst. Statutorily, what does this come down to? Well, at its most complex, *"The PIC of a UAS must ensure no activities other than those duties required for safe flight operation are performed, and that no UAS crewmember may engage in any activities unrelated to those required for safe operation of the aircraft.*" Easier said than done, which is why, whenever I approach CRM in the classroom or in the field, I make sure it's useful, scalable, and applicable to the operations at hand. CRM only works if it's custom; it's not an off-the-shelf template. It's not a word bank. It takes buy-in, leadership, and a willingness to improve.

The Top 3 from the Drone AC (AC 107-2)

Much and more has been written and discussed about the new drone final rules, 14 CFR 107. For the most part a lot of smart people have said a lot of great things. We have new regulations that will allow a robust ecosystem of drone programs to develop, companies to evolve on a foundation of clear and concise standards, and those same companies can find investors more easily with less uncertainty in the market.

After the regulations were published we've seen companies reporting record investment levels in the millions of dollars , partnerships between big-time players announced at an impressive clip, and the ever present ssnake-oil salesman offering training solutions for pilot licensing that really only requires a passion for knowledge, and a few nights looking over the FAA FAR AIM. For the test itself, I'd also recommend knowing AC 107-2 back and front… linked below!

What I haven't seen, however, is a proper nod to the document that came out alongside the 107 final rule, but which is just as, if not more, important for ensuring safe UAS operations – the accompanying **Advisory Circular 107-2. AC 107-2** provides all the knowledge and insight into UAS operations that you need to run an operation in accordance with the final rule. It provides checklists, risk assessment processes, and certification information you might need to go beyond the most basic 14 CFR 107 accorded operation. It enables any operator to provide a safe environment for flight, create a training program that enables rather than hinders your operation, and should be the first stop for any safety inspector, manager, or flight team lead looking to improve their safety record, improve their efficiency, and even raise their bottom line.

Hazard Identification Basic: While we provide additional hazard identifications techniques, and ultimately enable an operation to understand the role of hazard identification, AC 107-2 offers information largely based on the work done at ASTM and RTCA as well as in the field, tailored for specifics as the Hazard Identification Checklists. You can find here the FAA example approach, which is a great place to start any dialogue for going beyond the 14 CFR 107 frameworks. This starts on page A-7 entitled "Sample Hazard Identification and Risk Assessment."

Risk Assessment Appendix: Risk Assessments are the most important tool you have for keeping your operation safe and accessing higher risk environments through applications like the Section 333/COA process and the Waiver/Authorization process of 14 CFR Part 107. You'll need to understand the language of safety, and this 5-page appendix will get your risk vocabulary and understanding to a sufficient level quickly, and effectively. Starting on A-1 you'll understand severity and likelihood, how to analyze risk and develop mitigations that meet FAA recommendations or requirements, and even create visual analysis tools such as the one below.

Maintenance and Inspections: One of the biggest challenges we find with our clients prior to involvement is in the way they approach maintenance and inspections. We create end up developing policies and procedures for how to approach an air-frame and related system controls for inspections, maintenance tracking, and oversight. Appendix C, Pages C-1 to C-3, helps create the FAA implicitly approved example for these items. If you had nothing other than elements as you set out to create a drone program for business, you'd be complying with 14 CFR 107 and as you move forward in accessing riskier operations (higher altitude, closer to people, larger payloads or size) you'd be doing so with a strong step in the right direction.

Documentation & Program Building

Repeatable, Safety Focused, Mission Driven

When it comes to mission success, safety validation, and the future of your program no element is more important than providing a reliable, standardized, and trustworthy culture of safety through standard operation procedures (SOPs). SOPs provide sustainable and long-term approaches that are flexible, enable change if necessary, and add comfort to an operation that may otherwise provide discomfort to your operators. SOPs provide answers to questions that arise on-site, mid-mission, or during other important decision making processes such as pre-flight "Go-No-Go" decisions. The most important thing to remember throughout any newly developed program is that the more you document your challenges, success, and failures the more likely you are to succeed long term.

Preflight Briefing – A preflight briefing provides a mechanism to discuss how the mission will be run, common communication decisions, any identified hazards and their related risk scores, the decisions for "Go-No-Go" situations, any relevant approvals or waivers in effect, the role the weather may have on the mission, how best to approach a mission, and ultimately any specifics for the roles and responsibilities requisite during the operation. The pre-flight briefing should not be too onerous and should focus on the needs of each of the crew to effectively perform their tasking. Each pre-flight briefing should give all members an opportunity to voice concerns regarding the mission and to allow for positive communication throughout.

Preflight Inspection – A preflight inspection provides the easiest way to understand the condition of your unmanned aircraft, the orientation of the environment, the nature of how you personally feel as the pilot and/or VO, and to identify the difficulty level of your mission and other constraints. A good pre-flight checklist must include a visual and hands-on check of the unmanned aircraft system (including props, leading edges, controllers, connections, wires, and software being used in the flight). It must also include a fatigue and personnel management element that identifies hazards relevant to visual angles, controller inputs and other human interface focused environmental conditions.

Hazard Identification – The hazard identification worksheet, matrix, or exercise can be done in a variety of ways to allow for all hazards identified throughout the preflight inspections, and briefing, to be analyzed for their risk scores. This should be done for any unique hazards that may affects the mission and should be done prior to each flight. This does not have to take a long time, but it should adequately address any significant hazards for the worst-credible failure state. Wolf UAS helps develop these unique matrices for our clients.

Post Flight Debrief – The post flight debrief enables all crew members to discuss the mission after it is completed and to identify any hazards or unsafe conditions that they experience or witnessed to help prepare any future crews. Often, hazards arise throughout a flight that had not been identified and should be analyzed for their risk to develop plans. SMS managers and others involved in the safe program should review all post flight debriefs to see any number of important trends throughout their organization.

Conclusion

Your First Steps in Drone Safety Start Today!

Lots can go into a safety program for all facets of unmanned aircraft systems and much of the same lessons can be applied to ground and sea robotics. It is a good place to start with the information we've included in this document, however you'll want to continue to grow and develop your safety focused program by implementing continuously updated industry best practices from all of the world. ASTM, RTCA, FAA, ICAO, and your industry association of choice will all provide leading information to implement and you should remain on the leading edge of safety to protect and grow your organization.

By developing a formalized approach to your operations, and including a robust SMS for drones, you will lead the industry. By providing documentation and experience with safety, industries prone to safety conscious mentalities such as oil and gas, energy production and distribution, transportation, and constructions will adopt your platforms, services, and software with much greater ease.

We at Wolf UAS have provided this foundational safety information to help you take the first steps in developing your drone program. For more information, consulting, and program development we encourage you to reach out to us on our website at www.Wolfuas.com or email at hw@wolfuas.com.

Thank you!
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