Handling Emergencies

Session Time: Three, 50-minute sessions

DESIRED RESULTS

ESSENTIAL UNDERSTANDINGS

A remote PIC is responsible for ensuring that—prior to every flight—a UAS is in a condition that will allow it to be flown safely in the National Airspace System (NAS).
Remote pilots must be aware of potential emergency situations, and have plans in place to allow for the safe retrieval of their vehicles in the event of a malfunction or failure.

ESSENTIAL QUESTIONS

1. What are some of the common emergencies—both on the ground and in flight—that remote PICs might be required to face?
2. How can remote pilots plan for abnormal situations and/or emergencies, and work to ensure that they are resolved safely?

LEARNING GOALS

Students Will Know

- Common abnormalities and emergencies that can occur during UAS operations, both on the ground and in flight.
- How to handle different UAS malfunctions and/or failures, including battery fires, engine failures, and lost links.
- The importance of developing checklists and plans to prepare for potential emergencies before they occur.

Students Will Be Able To

- *Recall* common abnormalities and emergencies that might occur during a UAS operation. [DOK-L1]
- *Summarize* ways that remote pilots could safely and effectively respond to potential emergencies. [DOK-L2]
- *Apply concepts* within the lesson to research and build emergency checklists for a UAS. [DOK-L4]

ASSESSMENT EVIDENCE

Warm-up
Students will engage in a classroom discussion about the priorities manned pilots use when emergencies occur (aviate, navigate, and communicate) and consider how these apply to remote pilots.

Formative Assessment
Students will answer questions to demonstrate their knowledge of topics from the lesson, including how to plan ahead and respond appropriately to various UAS emergencies.

Summative Assessment

Students will answer questions and apply their knowledge of topics from the lesson, including how to respond appropriately to various UAS emergencies and how to research and create checklists to plan for emergencies for specific UAS makes and models.

LESSON PREPARATION

MATERIALS/RESOURCES

- Handling Emergencies Presentation
- Handling Emergencies Student Activity 1
- Handling Emergencies Student Activity 2
- Handling Emergencies Student Activity 3
- Handling Emergencies Teacher Notes 1
- Handling Emergencies Teacher Notes 2
- Handling Emergencies Teacher Notes 3

LESSON SUMMARY

Lesson 1: Preflight and Maintenance
Lesson 2: UAS Crew Resource Management and Communication
Lesson 3: Handling Emergencies
Lesson 4: Human Factors and ADM

The lesson will begin with a warm-up in which students are asked to recall the phrase manned pilots use when facing emergency situations: “aviate, navigate, and communicate.” The class will then discuss the similarities between procedures that manned pilots and remote pilots follow when faced with emergencies.

Following the Warm-Up, students will split into groups to conduct Internet research related to emergency situations, and how they could potentially affect the classroom UAS. This research should include both information about a specific problem a pilot could encounter when operating it, as well as how they might safely address it.

During the next part of the lesson, students will be introduced to a variety of common UAS emergencies a remote pilot may encounter and how to respond appropriately to them. The topics covered will include the following: battery fires, lost links, flyaways, lost GPS, engine failures, and collisions.

Finally, students will apply what they learned throughout the lesson and organize the research they conducted in Activity 1. Student groups will share and discuss emergency procedures for the specific emergencies they researched earlier. The class will then agree on an appropriate checklist for the various emergencies a remote pilot using the classroom UAS may face. The final emergency checklist will then be added to the Classroom Flight Operations Manual.

BACKGROUND

In response to the explosion in the popularity of consumer drones in the 2010s, the FAA created rules and regulations for hobbyist and commercial unmanned aerial vehicles so they could safely share the airpace with manned aircraft. Part 107 regulations took effect in August 2016. Because UAS technology is changing rapidly, the FAA continues to introduce new regulations and technologies that prioritize safety as manned and unmanned aircraft continue to share the National Airspace System (NAS). Just like manned pilots, remote pilots must become familiar with anticipating and handling emergencies so they can prioritize safety for UAS flights in the NAS.

As students learned previously in the semester, Part 107 (like manned regulations) allows remotes pilots to deviate from regulations in the case of an emergency; safety should always be considered paramount, and restrictions (e.g. altitude, airspace) should be considered of secondary importance when a remote pilot is confronted with a potentially dangerous situation.

A final parallel between unmanned and manned flight safety involves the use of checklists. Checklists help pilots ensure that important steps and/or considerations are not missed during an operation. Unlike flight manuals for manned aircraft, however, drone flight manuals are unlikely to include emergency checklists from the manufacturer. For this reason, remote pilots must research and assemble their own procedural lists. Students will go through this process over the course of this lesson.

MISCONCEPTIONS

Drone use increased rapidly during the 2010s. As of January 1, 2020, there were more than 1.5 million recreational and commercial drones registered with the FAA and more than 160,000 FAA-certificated remote pilots. As UAS uses increase, so do UAS-related incidents, accidents, and emergencies.

Because many new UAS have built-in safety features such as propeller guards, auto hover, collision avoidance, geofencing, GPS, and return to home, some students may incorrectly assume that preparing for UAS accidents and emergencies is not an important part of flight operations. Knowing how to react if an emergency arises will aid a remote pilot's UAS flight operations.

Another common misunderstanding students might have is the difference between the terms "lost links" and "flyaways." Lost links occur when there is a loss of control communication between the remote pilot's ground controller and the UAV. Flyaways occur when loss of link control does not recover or other interference occurs, causing the remote pilot to lose control of a UAV while it is still in flight, and they may result in the loss of the aircraft. Lost links can happen briefly and are not typically emergencies. A flyaway is a loss of UAS control and is an emergency.

DIFFERENTIATION

To prepare students for the formative assessment in the **EXPLAIN** section, place students into small groups and encourage them to quiz each other on the types of emergencies they may face as a PIC and how they would respond.

To aid in student comprehension of the lesson, have them write down at least one UAS accident or emergency situation they can think of that was not discussed in class. Challenge them to find the answer online via a website or video to share with the class.

LEARNING PLAN

ENGAGE

Teacher Material: Handling Emergencies Presentation

Session 1

Slides 1–3: Introduce the topic and learning objectives of the lesson.

Slides 4–6: Conduct the **Warm-Up**.

Warm-Up

Lead the class in a discussion about the three priorities that pilots must recall and follow whenever flying an aircraft: aviate, navigate, and communicate. Remind students of the definitions for these three priorities regarding manned aircraft before relating them to unmanned aircraft.

- The first and most important priority for pilots of manned aircraft is to aviate, or fly the aircraft.
- The second priority is to navigate the aircraft. This entails understanding where the aircraft is and where the pilot wants to go.
- The third priority is to communicate as able with ATC or other relevant entities.

Students should understand that the aviate priority is just as important with UAS as it is with manned aircraft. Piloting and directing the UAV is paramount. Navigation and communication are secondary and matter little if the remote pilot loses control and crashes a UAV.

Then, watch the following video of a distracted RC pilot who forgets, only briefly, to aviate and as a result crashes his plane into a tree.

- "distracted RC pilot crashes plane in tree" (Length 0:50)
  https://video.link/w/zGk0

For teachers unable to access Safe YouTube links, the video is also available here:
https://www.youtube.com/watch?v=oEFpv2cpLac

Remind students that avoiding distractions will go a long way in preventing and minimizing emergencies while flying.

Ask: How might the pilot in this video have avoided this crash?

At this point, questions are only meant to stimulate class discussion. It is not necessary for students to provide correct answers. Common preflight checklist tasks will be examined throughout the lesson.

EXPLORE

Teacher Materials: Handling Emergencies Presentation, Handling Emergencies Teacher Notes 1
Student Material: Handling Emergencies Student Activity 1

Slide 7: Distribute **Handling Emergencies Student Activity 1**. In this activity, small groups (2–3 students/group) will work together to conduct online research for a specific situation or emergency a remote pilot could face when operating the classroom UAS. Each group should research the situation or emergency assigned to it by the teacher and how the emergency would affect the classroom UAS. Additionally, each group will create a checklist pertaining to the situation or emergency that they researched. Groups will save their research for Part 2 of this activity later in the lesson (Session 3: EXTEND), during which time they will report their findings to the class.

Questions to initiate a classroom discussion, along with sample responses and other notes for the instructor, are available in **Handling Emergencies Teacher Notes 1**.

Teaching Tips

Remind students:

- FAA Part 107 Emergency Procedures state that during an emergency, a remote pilot is permitted to deviate from any part of 14 CFR Part 107 to respond to the emergency. When a remote pilot does deviate from a rule due to an emergency, the remote will report the emergency if asked to do so by the FAA.
- The drone manufacturer's website will be a useful source of information about the classroom UAS.

Advanced preparations will help remote pilots respond effectively to a variety of situations or emergencies that may occur. In addition, if a remote pilot has multiple drones or has customized a UAS, it's important to create custom

emergency preparations and checklists. Custom emergency preparations and checklists will ensure that pilots address the needs relevant to their specialized equipment and circumstances.

EXPLAIN

Teacher Materials: Handling Emergencies Presentation, Handling Emergencies Teacher Notes 2
Student Material: Handling Emergencies Student Activity 2

Session 2

Slide 8: UAS ground emergencies occur while the UAV is on the ground, either before or after flight. Ground emergencies might be the result of a variety of factors, including:

- Lithium polymer (LiPo) battery fire
- Failure of the UAS to turn off
- Interference by the public in the flying area
- PIC or crew incapacitation

Slide 9: LiPo batteries store a lot of energy and are lightweight and rechargeable, making them ideal for UAS use. Although LiPo battery fires are uncommon, the batteries can pose a risk and should be handled with care. The quick recharge/discharge cycle of a LiPo battery can generate heat and stress the internal components. Remote pilots should conduct regular battery inspections for swelling, damage, and excessive heat.

Slide 10: LiPo batteries are made of lithium polymer sheets that can be folded into various shapes and sizes, which is useful for the many sizes of UAVs. LiPo batteries are a type of lithium battery that uses the metal lithium as its primary ingredient. The element lithium is good for batteries because it is a lightweight metal that is also highly reactive, easily losing and replacing electrons, making it ideal for recharging.

Slide 11: It is a good idea for remote pilots to use multiple LiPo batteries for a single UAS. This will reduce the stress of continually discharging and recharging a single battery. Batteries should be numbered and rotated so they have a chance to cool down after they have been used and before being recharged.

Slide 12: Lithium's reactive nature also makes LiPo batteries highly flammable and subject to thermal runaway. Thermal runaway is a chain reaction in which heat or a fault in one cell of a battery causes the next cell to become unstable, resulting in the disintegration of the entire battery. A thermal runaway in a LiPo battery is extremely dangerous and can result in smoke, fire, or even a small explosion.

Slide 13: In rare circumstances, due to excessive heat, damage, or a fault in the battery itself, a fire can result. If a LiPo battery emits smoke or catches fire, take the following emergency measures:

- Do not use water in an attempt to extinguish the fire because it can react with lithium and make the fire worse.
- Extinguish a LiPo battery fire with a class D fire extinguisher.
- Use sand, dirt, or a fire blanket to smother a LiPo battery fire.

Slide 14: Always follow the manufacturer's instructions and guidelines. In the event that a battery begins to smoke, make noise, or swell, promptly relocate the battery away from flammable substances. Additional precautions to prevent battery fires are as follows:

- Store batteries in special fireproof, explosion-proof, LiPo safe bags or cases away from flammable materials.
- Keep batteries from being crushed, damaged, punctured, or misplaced.
- To prevent short circuits, keep metal objects such as coins and keys from coming in contact with battery charging terminals.
- Store batteries in individual bags or use protective plastic covers to cover charging terminals.
- Never leave charging batteries unattended.

Slide 15: Even experienced remote pilots who have a thorough knowledge of their UAS may encounter unique situations or emergencies. Sometimes a UAS or its battery may not properly shut down. Additionally, the propellers may continue to spin after the UAV has landed when they normally should stop. Shutdown issues such as these could be caused by a software glitch or miscommunication between the controller and the UAV. Sometimes, a faulty battery is to blame.

The following are possible solutions to these situations:

- Use an emergency shutoff or combination stick command (CSC) on the remote to shut off the UAV motors.
- Cycle through the startup and shutdown control sequence.
- Only attempt to shut off or remove the battery if the propellers are not spinning.
- If all else fails, let the battery run out.

Slide 16: Remote pilots should prepare in advance for the possibility of interference by non-participants in and around the UAS operational area. There are many reasons why this may happen: people are often curious about drones and may want to ask the PIC questions or simply view the control screen. Other times, people and animals may not be aware of the UAS operation and wander under or near where the UAV is being flown. Sometimes, people may feel their privacy is being violated, or they may feel the drone is a nuisance and wish to complain. Additionally, law enforcement may wish to communicate with the PIC about the UAS for any number of reasons.

Slide 17: The remote pilot should be prepared to cancel flight operations or land the UAV if any disruptions would make it unsafe. Alternate landing sites should be used if landing at the planned site poses a risk to people or property.

To make a UAS's launch and landing site visible and clear to the public, a landing pad or orange safety cones should be used. This added measure will help communicate to bystanders where the UAV will land. Brightly colored PIC safety vests and UAS warning signs can also be used.

Slide 18: Ask students: What are some in-flight emergencies that remote pilots may face, and how should they respond to these emergencies?

Students should answer aloud. It is not important to correct student answers at this point because these concepts will be explored during the lesson.

Slide 19: While operating a UAV, a remote pilot may encounter many unexpected in-flight situations that will require immediate attention or action. These include the following:

- Transmission interruptions
- Loss of GPS signal
- Loss of video link
- Unforeseen proximity to other manned or unmanned aircraft

Slide 20: If left unchecked, in-flight emergencies can be dangerous for people and property. These include the following:

- Loss of control link
- Flyaway
- UAV failure (mechanical failure, structural failure, etc.)
- Imminent collision with other aircraft
- Battery fire
- Bird strike or attack

Teaching Tips

Inform students that drone manufacturers provide a lot of safety information online. The image accompanying slide 21 was taken from the DJI Flying Safe blog post "10 Tips for Preventing Drone Crashes."

Slide 21: In the event of an unexpected situation or emergency, remote pilots should always follow a manufacturer's safety tips, guidelines, and instructions. If manufacturer information is not available, remote pilots should use online resources to create custom emergency checklists. Remote pilots should conduct research on and prepare for emergency situations before flying.

Slide 22: Although rules and regulations have been put in place to promote safety and prevent accidents, the FAA understands that emergencies do happen. The rules should not keep remote pilots from using their best judgement in an emergency situation. Remind students that FAA Part 107 states that:

- During an emergency, a remote pilot is permitted to deviate from any part of 14 CFR Part 107 to respond to the emergency. When a remote pilot does deviate from a rule due to an emergency, the remote pilot will report the emergency if asked to do so by the FAA.

Slide 23: Ask students to recall from earlier in the lesson the saying manned pilots use to prioritize what is most important: "aviate, navigate, and communicate." Remote pilots should use this system. First, they should concentrate on safely flying the UAV. Then, they should navigate the UAV if possible to deal with an emergency. Last, remote pilots should communicate with any ground crew, pedestrians, and, if necessary, local ATC.

Slide 24: UAS aircraft and remote control ground stations use complex communications systems. Without an actual pilot, a UAV uses radio transmission signals that the remote pilot inputs. A network of global positioning system (GPS) satellites relays altitude, latitude, and longitude position information to the UAV and the ground control station. This information also works with onboard computers keep the UAV stable in wind and locatable to the PIC. Mobile devices connected to the remote control are often used to display data along with the UAV's point of view (POV) camera imagery so the PIC can see what the drone sees. When any of these systems stops receiving or transmitting these signals, a lost link has occured between the PIC's ground station remote control and the UAV.

Slide 25: A lost link between any communications systems of a UAS may be temporary. Intermittent transmission interruptions can happen for a number of reasons, including radio interference, loss of some GPS satellite signals, distance of the UAV to the ground controls, and obstacles blocking a signal. Often, repositioning the UAV closer or simply waiting will help reestablish a lost link. When a link is terminated or the UAS stops responding to remote pilot inputs, a UAV flyaway can occur.

Slide 26: Because of the likelihood that a remote pilot will experience a lost link at some point, it is important to have a plan in place prior to every flight. If a ground crew is involved, the PIC should discuss these plans during the preflight briefing.

The following are potential courses of action for lost links:

- Preplanning for alternate landing locations
- Switching remote control radio frequencies
- Being aware of possible obstacles that could interfere with communications
- Ensuring the ability to communicate with ATC via radio or phone if necessary
- Ensuring backup communications equipment and power sources are available

Slide 27: GPS is a technology that some UAVs use to remain properly positioned in the air. However, if GPS communications fail, the PIC should be ready to operate the UAV with manual controls. To prepare for this, remote pilots should practice flying their UAV with GPS turned off. This should be done on short, low-altitude test flights so a remote pilot can become familiar with how a UAS will respond if such a situation were to arise on a longer flight. Additionally, local NOTAMs should be checked for any known GPS service disruptions before flying.

To avoid a GPS signal loss before flight, remote pilots should wait for as many GPS satellites to connect with the UAS as possible. UAS control displays will often indicate how many satellites are connected. Direct students to the UAS remote

control graphic on the slide. Have them note the red arrow pointing to the number of satellites connected to the UAS and the signal strength indicator. A remote pilot should always note this information if it is available. If there are not a lot of satellites connected, or if the signal strength is weak, flight should not be attempted. The specific number of satellites required can vary depending upon the model of drone.

Slide 28: Inform students that they will be watching a video discussing tips on how to safely manage drone flyaways. Instruct students to take notes during the video and to refer to these notes when creating an emergency checklist for the classroom UAS later in the lesson.

- "Tips for a Fly Away Drone | Filmmaking Tips" (Length 7:16)
  https://video.link/w/H6r0

For teachers unable to access Safe YouTube links, the video is also available here: https://www.youtube.com/watch?v=gsdi-TG5de4&feature=youtu.be

Briefly discuss the video, and then ask students to consider how these tips could assist a remote pilot experiencing a flyaway with the classroom UAS. Student answers should mention some of the tips from the video and how they might apply to the specific make and model of the classroom UAS.

Slide 29: Flyaways are a distressing emergency in which the remote pilot loses input control and the UAV flies off, landing—or perhaps crashing—in an unknown location. Flyaways may occur for any of the following reasons:

- Flyways frequently start as transmission interruptions or lost links.
- Increased wind speed can make it hard to control the UAV.
- Battery failure may require landing in an unknown location.
- GPS loss or compass calibration error can disorient the UAS.
- Flyaways can occur when preset lost-link commands have not been established or are not being executed by the UAV.
- Software or hardware malfunctions might cause a flyaway.

Flyaways are an unpredictable emergency situation. If a flyaway happens while flying in restricted airspace requiring authorization, the local ATC should be notified. Remote pilots should have flyaway procedures prepared before each flight.

Slide 30: Engine failures can result in a forced landing or a crash of the UAV. Engine failures may result from a mechanical issue, but they are often caused by loss of battery power. Different types of UAS will react differently to an engine failure. Quadcopters will usually lose control if one of the four motors malfunctions. A remote pilot operating a multirotor UAV with more than four motors may be able to maintain control. Fixed-wing UAVs with only one propeller should be able to glide after engine failure.

Preflight preparation should include a survey of the operations area to locate potential landing sites in the event a UAV motor fails. These areas should be in an open area away from people and property if possible.

Slide 31: Flight termination occurs when a remote pilot is forced to quickly end a UAV's flight prior to its planned conclusion. Flight termination systems (FTS) consist of components on the UAV that provide the ability to end flight in a controlled manner. Typically, flight terminations are a last-resort action the remote pilot takes to avoid imminent danger to people, property, or an approaching aircraft. If a remote pilot has partial control of a UAS during a flyaway, the pilot may terminate the flight to avoid losing a UAV in water or a heavily wooded or difficult-to-reach area. Flight termination over people and property should be avoided at all costs.

A remote pilot of a fixed-wing UAV may intentionally terminate a flight to save power and glide the aircraft safely to the ground. Before remote pilots intentionally terminate a flight, they should always take speed, altitude, wind, and other factors into consideration. Some companies manufacture parachute systems allowing UAV operators to make flight termination less of a risk to people, property, and the UAV itself. An FTS should always be independent, with its own dedicated communications datalink. This way, even if there is an autopilot or communications error, the flight can still be terminated.

Slide 32: Complete the **Formative Assessment**.

Formative Assessment

Distribute **Handling Emergencies Student Activity 2**. Students will work individually to answer the questions to demonstrate their understanding of the information and concepts covered in the lesson so far. Sample answers are provided in **Handling Emergencies Teacher Notes 2**.

[DOK-L1; *recall*]

EXTEND

Teacher Materials: Handling Emergencies Presentation, Handling Emergencies Teacher Notes 1
Student Materials: Handling Emergencies Student Activity 1, **Internet-connected computer, paper and pens for note-taking**

Session 3

Slide 33: Distribute **Handling Emergencies Student Activity 1**. In this activity, small groups (2–3 students/group) will work on part 2 of **Handling Emergencies Student Activity 1**.

In this activity, student groups will present to the class a refined and organized version of the procedural checklist they made in part 1 of this activity. Through classroom discussion—as well as by asking and answering questions—students will decide on and create an emergency checklist for the classroom UAS. This checklist will address each of the irregular situations or emergencies assigned to the groups. This will allow a remote pilot to properly prepare for and react to different irregular situations or emergencies if they occur during operations with the classroom UAS.

Teaching Tips

This activity is the second part of **Handling Emergencies Student Activity 1**. If students still have their research work from **Handling Emergencies Student Activity 1** conducted during the previous **EXPLORE** session, you will not need to distribute it.

EVALUATE

Teacher Materials: Handling Emergencies Presentation, Handling Emergencies Teacher Notes 3
Student Material: Handling Emergencies Student Activity 3

Slides 34–53: Quiz students on the FAA Remote Pilot Knowledge Test questions on slides.

Slide 54: Conduct the **Summative Assessment**.

Summative Assessment

Students will answer written questions. Provide students with **Handling Emergencies Student Activity 3**. Correct answers and sample responses are provided in **Handling Emergencies Teacher Notes 3**.

[DOK-L3; *assess,* DOK-L2; *summarize*]

Summative Assessment Scoring Rubric

- Follows assignment instructions
- Postings show evidence of the following:
  - Knowledge of common abnormalities and emergencies that can occur during UAS operations, both on the ground and in flight
  - Provides details about how to handle different UAS malfunctions and/or failures, including battery fires, engine failures, and lost links
  - Provides explanation of ways that remote pilots could safely and effectively respond to potential emergencies
- Contributions show understanding of the concepts covered in the lesson
- Contributions show in-depth thinking including analysis or synthesis of lesson objectives

Points	Performance Levels
9–10	Answers 10-12 questions thoroughly and correctly. Shows a strong understanding of the lesson objectives.
7–8	Answers 7-9 questions correctly; shows a sufficient understanding of the lesson objectives.
5–6	Answers 5-6 questions correctly; shows an insufficient understanding of the lesson objectives
0–4	Answers 4 or less of the questions correctly; shows little or no understanding of the lesson objectives.

STANDARDS ALIGNMENT

COMMON CORE STATE STANDARDS

- **RST.11-12.2** - Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- **RST.11-12.4** - Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11-12 texts and topics*.
- **RST.11-12.7** - Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
- **RST.11-12.9** - Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
- **WHST.11-12.6** - Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.
- **WHST.11-12.7** - Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
- **WHST.11-12.8** - Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

- **WHST.11-12.9** - Draw evidence from informational texts to support analysis, reflection, and research

REFERENCES

A-N-C
https://www.faa.gov/news/safety_briefing/2018/media/SE_Topic_18-07.pdf

First Crash and Accident Prevention
https://www.history.com/this-day-in-history/first-airplane-flies
http://www.arlingtoncemetery.net/thomaset.htm
https://www.wired.com/2010/09/0917selfridge-first-us-air-fatality/
https://www.faa.gov/about/history/brief_history/
https://www.transportation.gov/content/federal-aviation-act
https://www.airspacemag.com/daily-planet/brief-history-quadrotors-180963372/
https://www.ainonline.com/aviation-news/aerospace/2016-06-21/faa-issues-part-107-final-regulation-commercial-drones

Batteries
https://carolinadronz.com/blogs/news/quick-facts-on-lipo-drone-battery-use-for-uavs
https://www.youtube.com/watch?v=eKLHD7_zzCE
https://batteryuniversity.com/learn/article/safety_concerns_with_li_ion