Unmanned Aircraft Systems in Disaster Management

Participant Guide

Version 1.0

FEMA

NATIONAL DISASTER PREPAREDNESS TRAINING CENTER

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Unmanned Aircraft Systems in Disaster Management

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FEMA's National Training and Education Division (NTED) offers a full catalog of courses at no-cost to help build critical skills that responders need to function effectively in mass consequence events. Course subjects range from Weapons of Mass Destruction (WMD) terrorism, cybersecurity, and agro-terrorism to citizen preparedness and public works. NTED courses include multiple delivery methods: instructor led (direct deliveries), train-the-trainers (indirect deliveries), customized (conferences and seminars) and web-based. Instructor-led courses are offered in residence (i.e. at a training facility) or through mobile programs in which courses are brought to state and local jurisdictions that request the training. A full list of NTED courses can be found at http://www.firstrespondertraining.gov.

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Course Introduction

Unmanned Aircraft Systems (UAS) are an emerging technology that will likely revolutionize disaster management. This course aims to explain the variety of UAS applications in disaster work, from mitigation and preparedness to response and recovery, while detailing different types of UAS and how each is appropriate for different applications. The course also explains the current Federal Aviation Administration regulations on who can use UAS and how to apply for authorization to use UAS.

This course will introduce first responders to the various types and uses of UAS in disaster management and mitigation as well provide general guidance for first responders to navigate the regulatory and application process required to integrate UAS into legal and effective use.

The course material will familiarize participants with the main types and abilities of various rotary and fixed-wing UAS as well as the types of payloads and missions that generally are best for each. The material also provides attendees with information on various payloads and sensors available to first responders with examples of how certain payloads have been or could be used in relevant situations.

Participants will learn what is covered under UAS regulations, who may operate UAS, what the major issues are for UAS integration, how UAS can aid in disaster management, and what the key elements and challenges are to creating a successful UAS program. Participants will learn how to apply for authorization to operate UAS and what this authorization allows.

The material also includes a background on the legal and regulatory issues that first responders must navigate in order to properly use UAS in their areas of responsibility. Finally, this course will discuss how to best integrate essential privacy, civil rights, and civil liberties protections into the program to avoid liability and to garner public support.

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Unmanned Aircraft Systems in Disaster Management

Module 1: Welcome, Introduction, and Administration

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Module 1: Welcome, Introduction, and Administration – Administration Page

Slide 1-1. Welcome, Introduction, and Administration

Duration

50 minutes

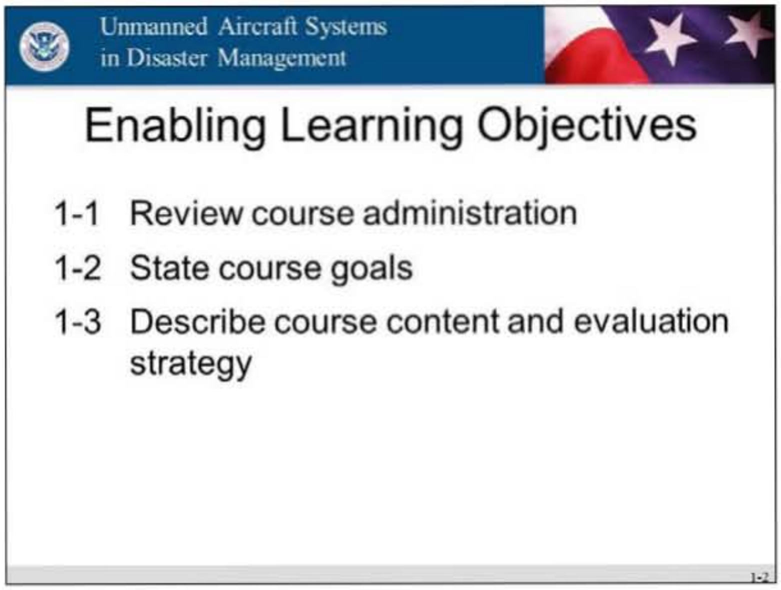
Scope Statement

In this module, participants and instructors will complete course administrative requirements, and participants will learn how their performance will be evaluated. Instructors will administer a pre-test, which is essentially a self-evaluation to assist participants in determining their level of knowledge on the course material prior to the course. This module also allows the opportunity for instructors to present an overview of the course and for participants and instructors to introduce themselves.

Terminal Learning Objective (TLO)

Participants will be able to state the course goals and objectives.

Enabling Learning Objectives (ELO)



Slide 1-2. Enabling Learning Objectives

At the conclusion of this module, participants will be able to:

1-1 Understand the administration details of the course

1-2 State the goals of the course

1-3 Describe the course content and explain how performance is evaluated

Resources

- Instructor ID
- Class roster
- Instructor Guide (IG)
- Module 1 presentation slides
- Laptop with presentation software installed and CD-ROM capability
- Audio-visual (A/V projection unit)
- Projector screen
- Chalkboard (and chalk), whiteboard (and dry erase markers), or easel and easel paper (and permanent markers)
- Correction tape dispensers (two)
- Letter-size manila envelopes (four; one each for the course registration forms, pre-tests, post-tests, and Level 1 evaluations)
- One of each of the following items per participant:
  - Participant Guide (PG) available for download from http://ndptc.hawaii.edu/
  - Participant Handouts

- Participant Registration Forms
- Pre-test answer sheet corresponding to pre-test version

Instructor-to-Participant Ratio

2:40

Reference List

None

Practical Exercise Statement

Not Applicable

Assessment Strategy

- Instructor observation of participant involvement in the classroom discussion.
- Instructor-led discussion to ensure that participants understand both how their performance will be evaluated and how that evaluation will impact participants' outcomes.
- Instructor administration of objectives-based pre-test to assess participants' knowledge of course content.

Unmanned Aircraft Systems in Disaster Management

Icon Map

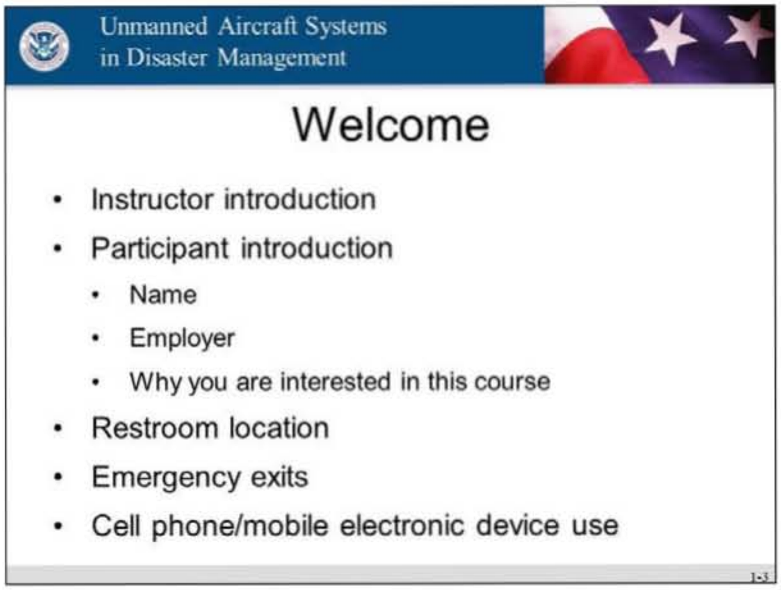
Knowledge Check: Used when it is time to assess participant understanding.

Example: Used when there is a descriptive illustration to show or explain.

Key Points: Used to convey essential learning concepts, discussions, and introduction of supplemental material.

Participant Note: Used to indicate text that has been included as additional information for the participant. The text may not be directly addressed in the slide presentation or during class discussion.

Participant Notes:

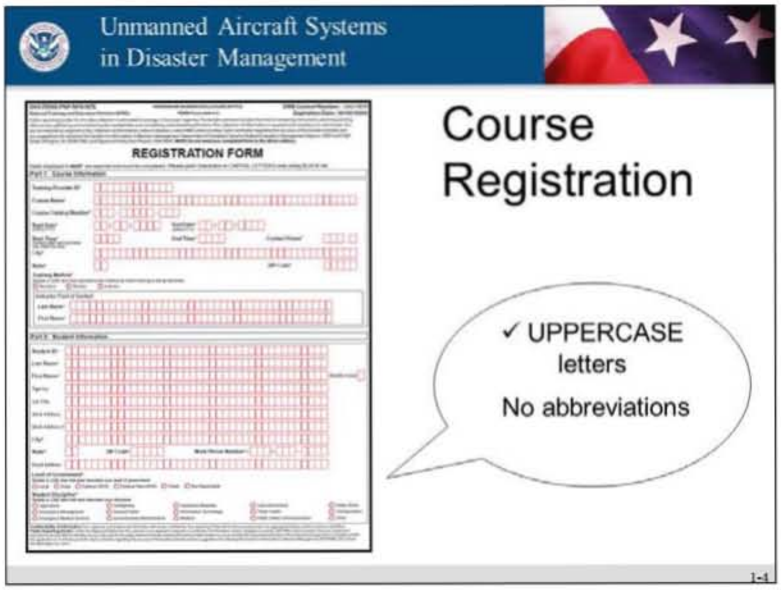


Slide 1-3. Welcome

Cover the class protocols.

- Tell participants to set cellphones to vibrate mode.
- Explain the location of bathrooms.
- Explain the location of emergency exits.
- Encourage participants to ask questions at any time during the class.

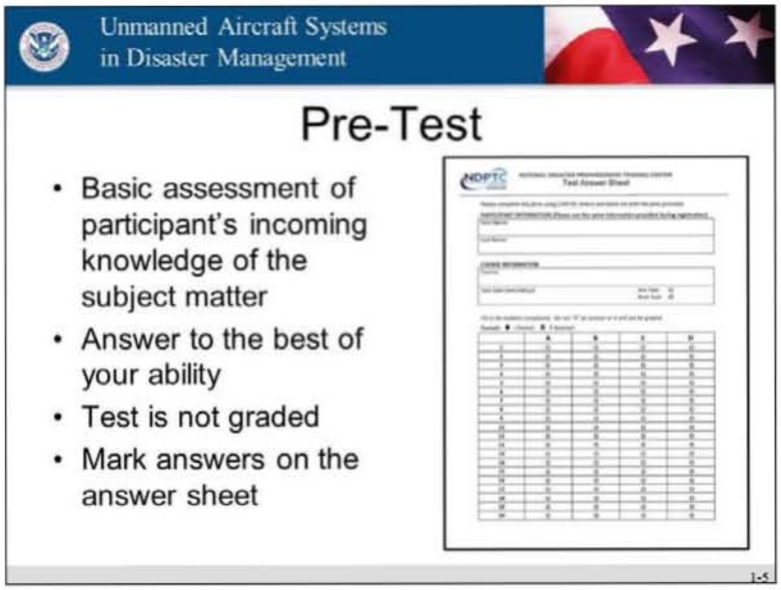
Participant Notes:



Slide 1-4. Course Registration

The instructor will distribute the course registration forms for those participants who have not already completed the online registration. The instructor will then collect the registration forms.

Participant Notes:



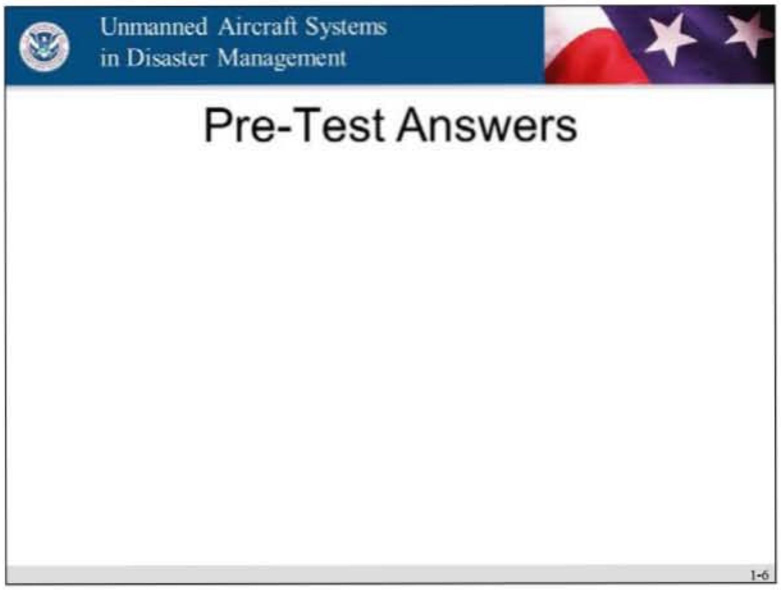
Slide 1-5. Pre-Test

The instructor will inform the participants that, working independently, they will have 10 minutes to complete the pre-test.

Participants should follow these instructions as they take the pre-test and indicate their answers on the test answer sheet:

- Write legibly using uppercase letters.
- Use the same first name, last name, and date of birth provided on the participant registration form. This information is used to generate a unique participant identification number.
- Complete the Test Date field in the upper right-hand portion of the sheet by writing the day the test is actually administered.
- Write the test document ID number in the Test Doc ID field. The ID number is located in the test handout footer.
  - The instructor should confirm that all participants are using the same test version.
- Fill-in the Pre-test answer bubble.
- Completely fill-in each bubble, making certain the darkened bubble is correctly aligned to the selected answer letter on the test answer sheet.

Participant Notes:



Slide 1-6. Pre-Test Answers

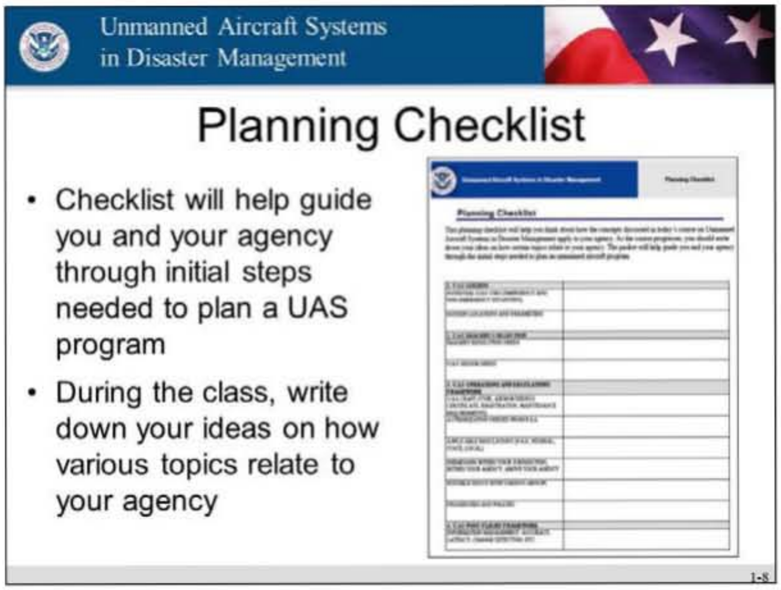
Participant Notes:

Slide 1-7. Course Goals

The goal of this course is to guide agencies and organizations through the process of creating a UAS program, including:

- Understanding how UAS can be used in disaster management
- Deciding if UAS are right for their mission
- Determining which UAS types are appropriate
- Setting up MOUs with necessary groups
- Understanding FAA UAS regulations
- Ensuring privacy, civil rights, and civil liberties policies are in place
- Ensuring communication with the community
- Learning how to apply for FAA authorization

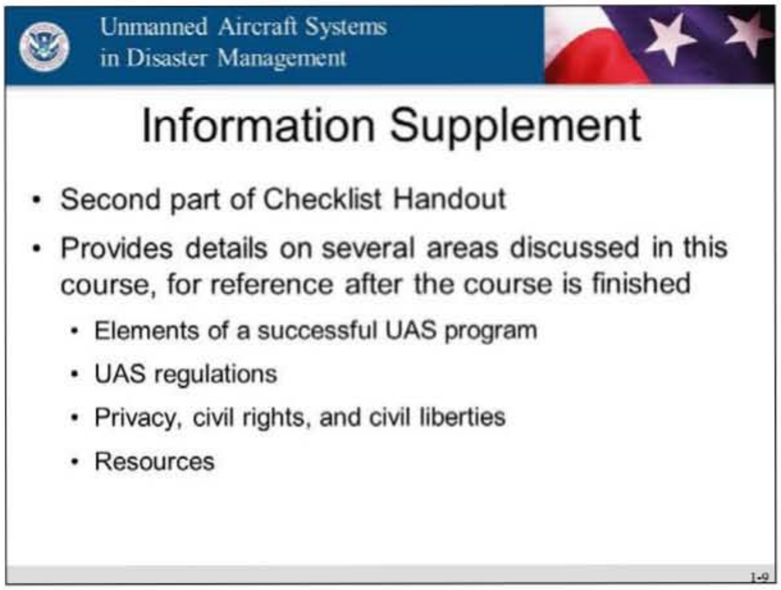
Participant Notes:



Slide 1-8. Planning Checklist

Periodically during the course, the instructor will stop and have participants write down their ideas on how certain topics relate to their agencies. The packet will help guide participants and their agencies through the initial steps needed to plan an unmanned aircraft program. Make sure you thoroughly read the checklist ahead of time so you know when to refer to it during the course. Keep it out during the course to reference throughout the day.

Participant Notes:



Slide 1-9. Information Supplement

The Information Supplement, which is the second section of the Checklist Handout that each participant received, provides details on several areas discussed in this course. Participants can use it as a reference when they return to their agencies and begin deciding to develop a UAS program.

The pages of the Information Supplement include:

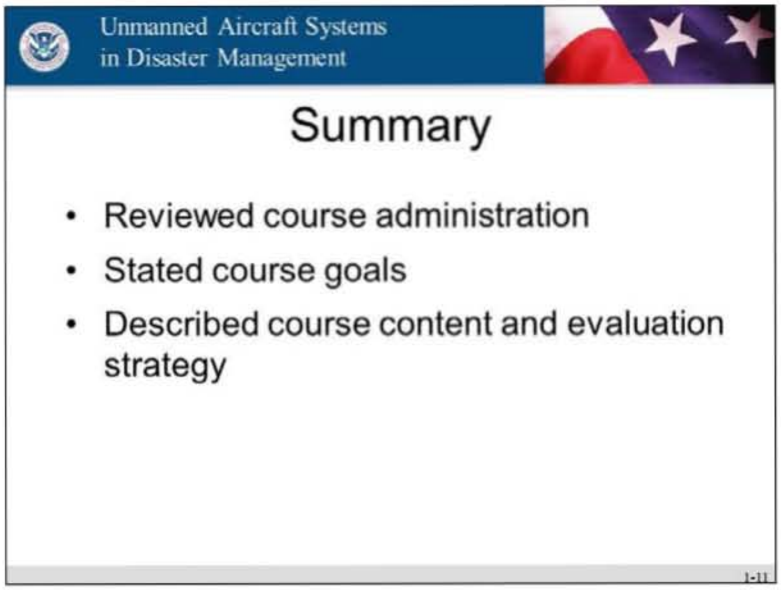
- Elements of a successful UAS program
- UAS regulations
- Privacy, civil rights, and civil liberties
- A list of resources and websites to obtain more information

Participant Notes:

Module	Title	Duration
1	Welcome, Introduction, and Administration	50 minutes
-	Break	10 minutes
2	Types of Unmanned Aircraft Systems	50 minutes
-	Break	10 minutes
3	UAS Options in the Disaster Management Cycke	75 minutes
-	Lunch	60 minutes
4	UAS Regulations	65 minutes
-	Break	10 minutes
5	Essential Elements for UAS Success	60 minutes
-	Break	10 minutes
6	Applying for UAS Authorization	40 minutes
7	Evaluation and Conclusion	40 minutes
	TOTAL	8 Hours

Slide 1-10. Course Agenda

Participant Notes:



Slide 1-11. Summary

Several administrative requirements were completed. Participants learned how their performance will be evaluated during this course, and they completed one such evaluation tool by taking the pre-test. The pre-test provided participants with an idea of their strengths and weaknesses regarding the course subject matter. Instructors reviewed the course structure and agenda so participants were aware of the course goals and had a general understanding of how the course content would be presented.

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Module 2: Types of Unmanned Aircraft Systems

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Module 2: Types of Unmanned Aircraft Systems – Administration Page

Slide 2-1. Types of Unmanned Aircraft Systems

Duration

50 minutes

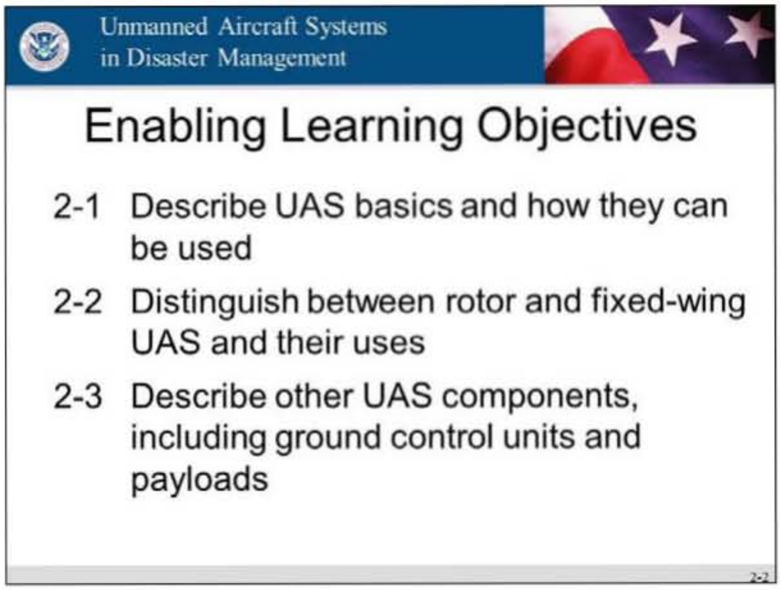
Scope Statement

This module will familiarize participants with what Unmanned Aircraft System (UAS) are and the general types that might be used in disaster management. More specifically, participants will learn about the different types of UAS by size, cost, flight design, and abilities. This module will help participants understand how to select which types of systems will be most suitable in carrying out their specific objectives.

Terminal Learning Objective (TLO)

The participant will be able to explain in basic terms what UAS are and their different types.

Enabling Learning Objectives (ELO)



Slide 2-2. Enabling Learning Objectives

At the conclusion of this module, participants will be able to:

- 2-1 Describe UAS basics and how they can be used
- 2-2 Distinguish between rotor and fixed-wing UAS and their uses
- 2-3 Describe other UAS components, including ground control units and payloads

Resources

- Instructor Guide (IG)
- Module 2 presentation slides
- Laptop with presentation software installed and CD-ROM capability
- Audio-visual (A/V projection unit)
- Projector screen
- Chalkboard (and chalk), whiteboard (and dry erase markers), or easel and easel paper (and permanent markers)
- One of each of the following items per participant:
  - Participant Guide (PG) available for download from http://ndptc.hawaii.edu/
  - Participant Handout

Instructor-to-Participant Ratio

2:40

Reference List

Adams, Stuart M., and Carol J. Friedland. "A Survey of Unmanned Aerial Vehicle (UAV) Usage for Imagery Collection in Disaster Research and Management." Presentation at the 9th International Workshop on Remote Sensing for Disaster Response. Stanford University, Sep. 14-16, 2011.

Bott, Ian, Cleve Jones, and John Burn-Murdoch. "Great and Small. The Many Types of Drone." Financial Times, Oct. 8, 2013.

Federal Aviation Administration. "FAA Approves First Unmanned Quadrotor." July 4, 2014.

Ferworn, A., J. Tran, A. Ufkes, and A. D'Souza. "Initial Experiments on 3D Modeling of Complex Disaster Environments Using Unmanned Aerial Vehicles." Safety, Security, and Rescue Robotics (SSRR), 2011 IEEE International Symposium on. Nov. 1-5, 2011, pp. 167-171.

Pratt, K., R. R. Murphy, et al. "Requirements for Semi-Autonomous Flight in Miniature UAVs for Structural Inspection." AUVSI's Unmanned Systems North America. Orlando, Florida, Association for Unmanned Vehicle Systems International. 2006.

Tuna, Gurkan, Tarik Veli Mumcu, and Kayhan Gulez. "Design Strategies of Unmanned Aerial Vehicle-Aided Communication for Disaster Recovery." 2012 9th International Conference on High Capacity Optical Networks and Enabling Technologies (HONET), Dec. 12-14, 2012, pp. 115-119.

UAVGlobal. "All UAV Datasheets." www.uavglobal.com

Practical Exercise Statement

There is a practical exercise at the end of Module 2 that presents two possible scenarios in which UAS could be used. Participants will apply information learned in the course to help answer the questions. The instructor will ask participants either to break into groups to discuss the two scenarios and then discuss the possible answers together as a class, or not break into groups and discuss the questions together, at the discretion of the instructor.

Assessment Strategy

- Instructor observation of participants' involvement in the classroom exercise and discussion.
- Instructor-led discussion to ensure participants' understanding of module lesson topics.

Unmanned Aircraft Systems in Disaster Management

Icon Map

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Example: Used when there is a descriptive illustration to show or explain.

Key Points: Used to convey essential learning concepts, discussions, and introduction of supplemental material.

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Participant Notes:

Slide 2-3. What is an Unmanned Aircraft System?

Although historically the development of UAS has focused on military applications, recent advances in technology make UAS both affordable and easy to operate, enabling UAS to go "mainstream." In the United States and worldwide, governments and civilians are finding new and exciting ways to use UAS for non-military applications.

UAS for disaster response and mitigation have proven very valuable in collecting data quickly, cost effectively, and in many ways that were previously unavailable or too dangerous for manned systems. This course will focus on the use of small UAS (sUAS) in disaster management.

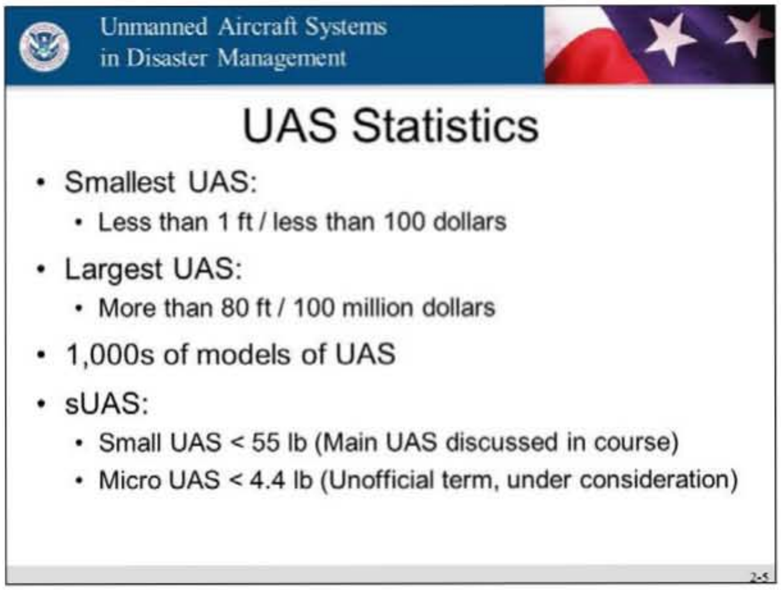
e.g. **Example:** In the picture above, an Aerovironment Puma is flying in support of ground operations. sUAS are capable of carrying multiple and diverse payloads that could provide important information in support of ground operations.

Participant Notes:

Slide 2-4. Components of an Unmanned Aircraft System

UAS are comprised primarily of an aircraft, ground controller, operator (and often an observer), sensor payload and other possible components, which may include launchers or recovery equipment. Although many systems fit into backpacks, some systems require trucks or shipping containers.

Participant Notes:



Slide 2-5. UAS Statistics

UAS come in a wide range of size and cost. Some very small systems can be bought at a hobby store or online for less than $100, and some military-derived systems can cost millions.

Some experimental nano UAS systems can easily fit into the palm of one's hand while a system such as the Northrup Grumman Global Hawk has a wingspan of 116 feet, is 44 feet long, and costs about $131 million. Micro UAS is not an official FAA term, but has been discussed as a possible category.

In this course, we are focusing on small UAS or sUAS for a number of reasons.

1. The size, cost, and ability to assist disaster management applications make integration of sUAS into disaster situations a very economical and powerful tool for responders.
2. Because of the rapidly expanding market of systems and payloads, first responders should be aware of what is available to make effective decisions regarding the integration of UAS into disaster management.
3. sUAS are the focus of many changing and confusing regulations that affect who can use systems, where, and how. One of the main goals of this course is to inform people in disaster management about the most efficient and effective ways to create a UAS program, select UAS, and use them in a variety of ways in disaster management.

Participant Notes:

Unmanned Aircraft Systems
in Disaster Management

Sample of Manufacturers and Features of UAS

Company	Model	Rotor/ Fixed	Size (ft)	Weight (lb)	Time (min)	Misc. Specs	Cost ($)
DJI (China)	Phantom 2 Vision+	R	0.8 x 0.8	2.8	25	33 mph	1,299
3D Robotics (US)	3DR Aero	F	6.1 x 4.2	4.4	40	56 mph	1,350
Draganfly (Can.)	Draganflyer X4-C	R	1.5 x 1.5	2.8	25	0.7 lb payload	2,995
PSI (US)	InstantEye Mk2	R	0.8 x 0.8	1.2	30	35 mph, 3 cameras	6,000
Mikrokopter (Ger.)	Oktokopter XL	R	2.3 x 2	4.2	22	3.5 lb payload	6,500
SenseFly (Swit.)	Swinglet CAM	F	2.6	1.1	30	22 mph	10,600
Aerovironment (US)	Puma AE	F	9.2 x 4.6	13.5	210	52 mph	436,012

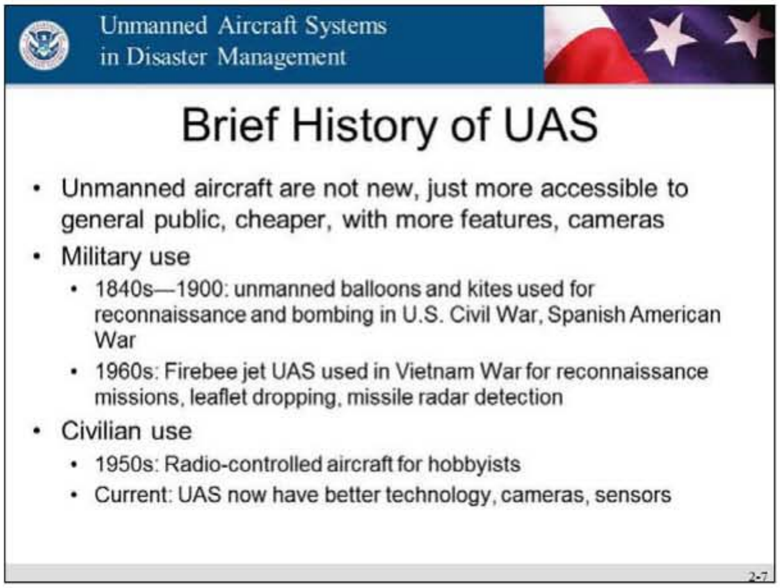
2-6

Slide 2-6. Sample of Manufacturers and Features of UAS

e.g.

Example: This table contains examples of the size and price differences in available UAS systems. Some systems are military grade, such as the Puma, and some are hobbyist and professional, such as the DJI, which both hobbyists and professionals use. Systems like the Puma and InstantEye offer multiple vehicles in a system (Puma-3, InstantEye-2). Some systems include basic payloads such as day/low-light cameras; and some include ruggedized and weatherproof controllers, spare parts, and heavy duty transport cases. Systems like the Phantom include only a UAV and basic controller without a video monitor, and purchasers have to spend additional funds for upgrades.

Participant Notes:



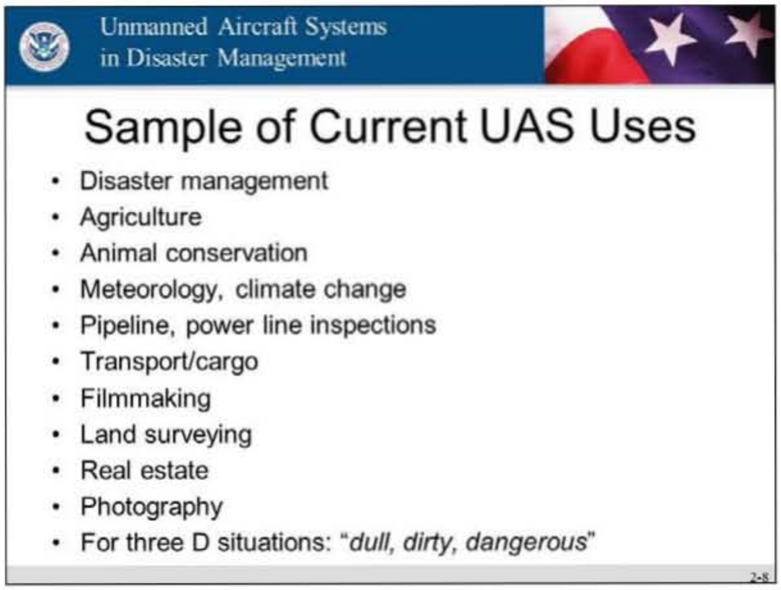
Slide 2-7. Brief History of UAS

Many people are not aware that unmanned aircraft have been in use for over 150 years, because UAS have been getting media attention only in the past few decades. UAS began as simple craft in the 1800s—balloons and kites with cameras attached—then became complex systems for the military during the 1900s, and now are being simplified for commercial, governmental, and hobbyist use.

Although UAS have a long history of use, advances in software, cameras, and power management result in systems that are user-friendly and affordable. Payload miniaturization also plays a critical role in the ability to fly and gather data with sensors that used to be too heavy for sUAS to carry, but now are lighter weight and more affordable to public agencies and commercial service providers.

Modern UAS present first responders with a promising and powerful asset able to improve disaster response and relief operations. When a disaster occurs, UAS may be used to provide situational awareness, perform search and rescue, assess damaged infrastructure, deliver supplies, and provide communications, among many other potential applications. UAS also can be used for pre-event monitoring and mitigation and are applicable in areas too risky for personnel.

Participant Notes:



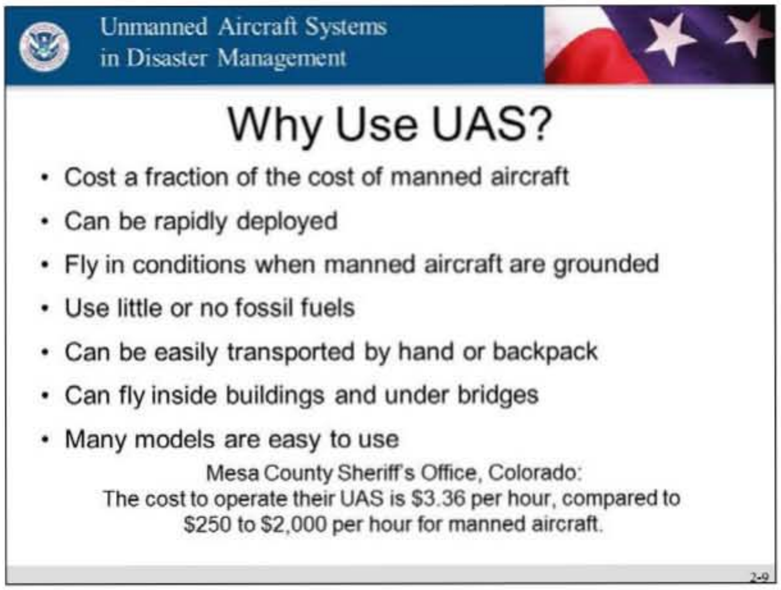
Slide 2-8. Sample of Current UAS Uses

This slide lists fields in which UAS have been utilized. The instructor should focus on the wide range of industries and disciplines in which UAS have been used in applications that show how they can be more efficient, cheaper and safer than other alternatives. In disaster situations, UAS may complement use of other assets, such as helicopters, airplanes, and personnel on the ground, cooperating in a way that best utilizes resources on hand. The cost differences of operating UAS versus helicopters are tremendous. UAS can be operated from the field and in remote locations providing critical data that without UAS may not have been possible or efficient to gather. The slide lists examples of ways UAS are being used:

e.g. **Examples:**

- Disaster management: damage assessment, search and rescue, continuing threat monitoring
- Precision agriculture: smart harvesting, water management, pest identification/infestation, spraying
- Animal conservation: population tracking/monitoring, anti-poaching support
- Meteorology, climate change: weather monitoring, hurricane/cyclone research
- 3 D's. Pipeline and power line inspection: Dull going over large areas at a time. Nuclear/Bio Hazard inspections. Dirty and Dangerous

Participant Notes:



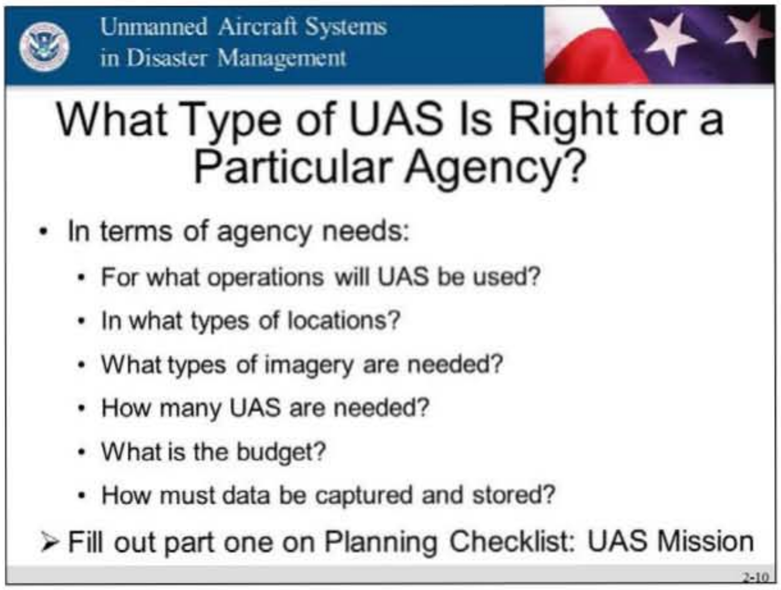
Slide 2-9. Why Use UAS?

Key Point: As the cost of UAS systems decreases and the capabilities increase, the case for integrating UAS into disaster management activities has become quite compelling. This slide illustrates the comparative cost to operate a manned aircraft to a UAS system.

Key Point: Some UAS can be folded and placed in a backpack for easy transport around a disaster scene.

Key Point: Rotorcraft UAS can get up close to a building or hover under a bridge for damage assessment and disaster mitigation work.

Participant Notes:



Slide 2-10. What Type of UAS Is Right for a Particular Agency?

As UAS are becoming more common in disaster response and mitigation, operators should first analyze how UAS would best help their agency or operations. Agencies must determine what types of information and imagery are needed, and legally can be collected, so they can select the best sensors and aircraft for their work. Storage and retention of data generated by UAS may raise privacy or civil liberties issues. We will discuss this later in the course. Potential operators should also take into consideration the locations where they will be operating, which affect the selection of aircraft.

Going through this process helps agencies choose the type of system that is most suitable to their needs. Once the system is in use, it is likely that agencies will discover other uses not initially envisioned.

Participant Notes:

Slide 2-11. Rotorcraft or Fixed Wing

When determining what type of UAS is most suitable for an operator's needs, two main questions must be answered.

1. Which payloads provide the data desired?
2. Would a rotorcraft or fixed-wing UAS provide the flight characteristics most suitable for the type of data needed and in the conditions in which operations will be conducted?

This section deals with the second question and will provide the information necessary to determine what type of UAS would best fit the user's needs whether for government, commercial or recreational use.

Basic descriptions of rotorcraft and fixed-wing aircraft:

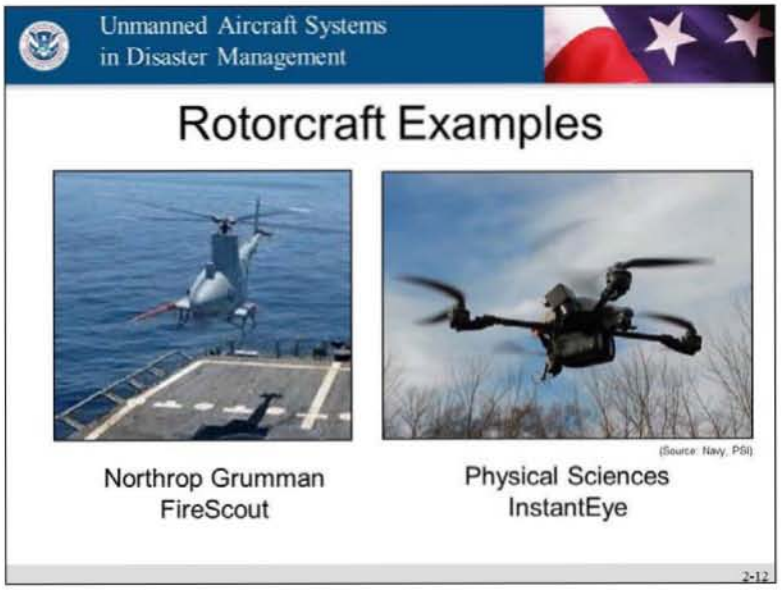
Key Point: A rotorcraft is an aircraft that uses lift generated by rotor wings or blades that rotate around a vertical axis. Most recognizable example of this is a helicopter.

Key Point: A fixed-wing aircraft is one that has its wings fixed in place rather than rotating wings, such as most airplanes.

e.g. **Example:** Northrup Grumman Fire Scout Helicopter is pictured on the left.

e.g. **Example:** Insitu Scan Eagle on catapult launcher is pictured on the right.

Participant Notes:



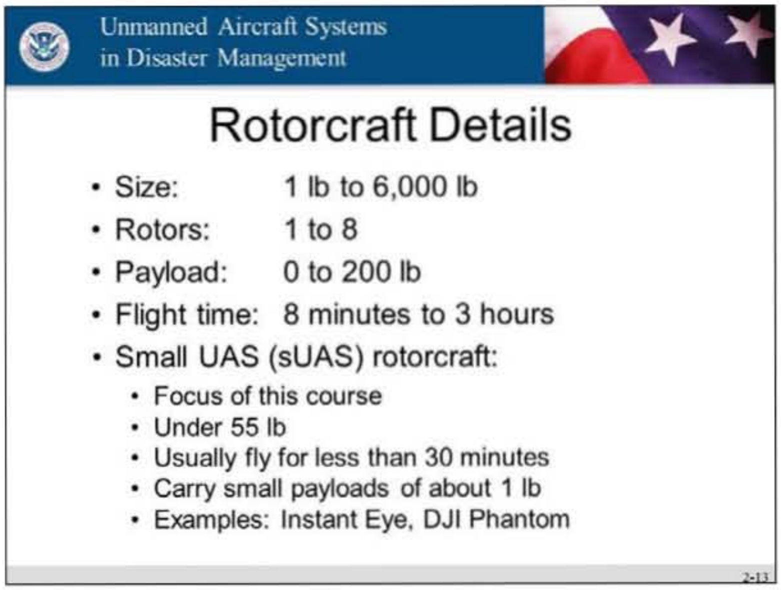
Slide 2-12. Rotorcraft Examples

This slide shows a few different styles of rotorcraft. The instructor should point out that rotorcraft can have different numbers of rotors: single, double, triple, quad, hexa, octo, etc. The advantage of multiple rotor rotorcraft (such as quadcopters), and the reason that they are proliferating, is the stability and flight control advantages they offer, making them easier to operate efficiently with less training.

Multiple rotor rotorcraft are not only easier to operate but because of the shorter length of wings/blades, they are less likely to cause serious injury if an accident occurs.

e.g. **Example:** A rotorcraft can have multiple rotors, and these are two examples of a helicopter and quadcopter. Some configurations can have eight or more rotors.

Participant Notes:

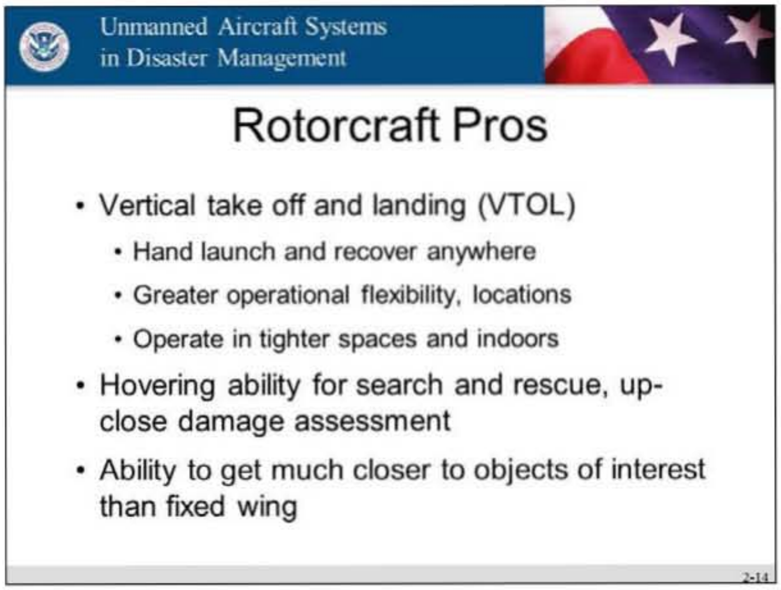


Slide 2-13. Rotorcraft Details

These are general ranges of size and capability of rotorcraft. From miniature aircraft that could fit in the palm of one's hand to the 6,000 lb. Fire Scout, they come in all shapes, sizes, configurations, and capabilities.

Key Point: This course focuses on Small UAS (sUAS) rotorcraft, as this class of UAS is one of the most promising and powerful technologies available to first responders in disaster situations.

Participant Notes:



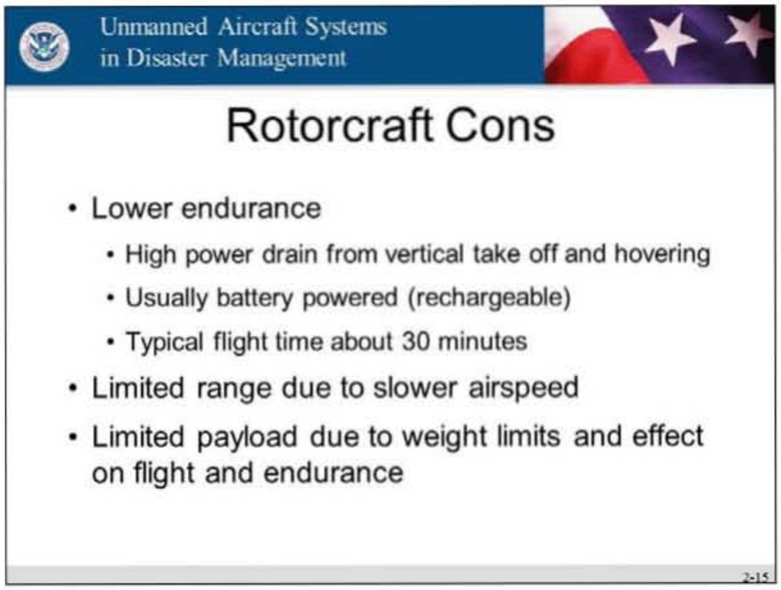
Slide 2-14. Rotorcraft Pros

Example: Rotorcraft have the ability to take off and land through small clearings in foliage. A few new fixed-wing systems have combined the ability to take off and land vertically with rotors, and then fly with the benefits of fixed-wing endurance. In an urban setting, VTOL provides similar advantages when operating in “urban canyons.”

Example: The ability to hover and “perch and stare” is not possible with fixed-wing UAS. In search and rescue operations, the ability to hover and slowly cover a smaller area of interest at closer range is possible with a rotorcraft, but not a fixed-wing UAS.

Example: In damage assessment situations, such as inspecting bridges or other critical infrastructure, the ability to get very close to objects and get detailed information is another advantage of rotorcraft over fixed-wing UAS.

Participant Notes:

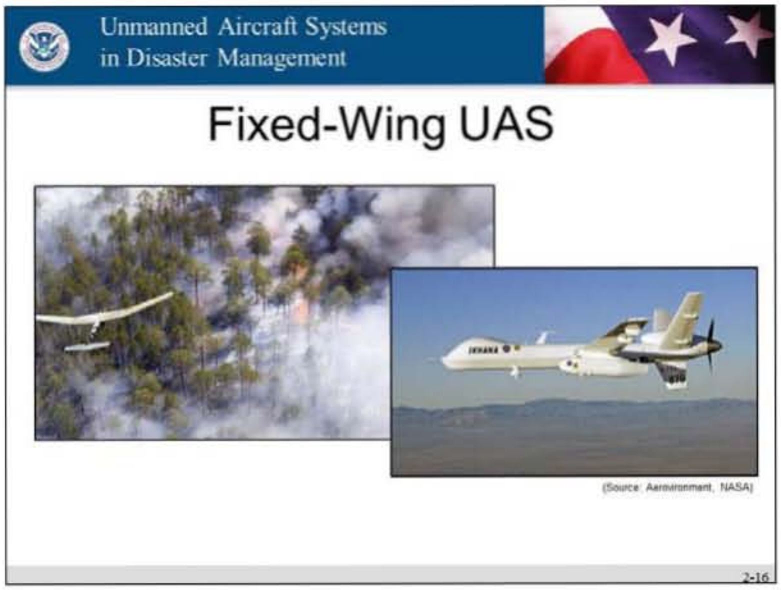


Slide 2-15. Rotorcraft Cons

Key Point: Combination of slower flight speed and less efficient use of power combine to use battery power quickly, which lowers flight times and reduces the area of coverage of rotorcraft versus fixed-wing UAS. If the area of operation is near the operator, a quick battery change and flight check is all that is needed to get aircraft back in the air again.

Key Point: Large payloads are difficult for rotorcraft UAS because they use battery power more quickly as the rotorcraft struggles to maintain lift. Nevertheless, there are some large rotorcraft that can carry heavy payloads.

Participant Notes:



Slide 2-16. Fixed-Wing UAS

Fixed-wing UAS will be discussed in the following few slides. This slide shows two very different examples of fixed-wing UAS. On the left is the Aerovironment Puma with a wingspan of about nine feet, top speed of 52 mph, range of approximately 15 km and endurance of two hours. On the right is NASA's Ikhana, a General Atomics Predator B UAS modified to support scientific research and advanced aeronautical technology development. Ikhana has a wingspan of 66 feet, can operate above 40,000 feet carrying payloads (internal and external) weighing nearly 2,400 lbs. with an endurance of more than 20 hours.

This slide illustrates the broad range of fixed-wing UAS available to operators. In disaster situations, fixed-wing UAS can be used to gather critical data for the prevention, monitoring, assessment, response, and mitigation of disasters.

Key Point: Although medium and large UAS are available and being used in disaster management with great efficacy, the focus in this course is on the impact and utility of small UAS for first responders.

Participant Notes:

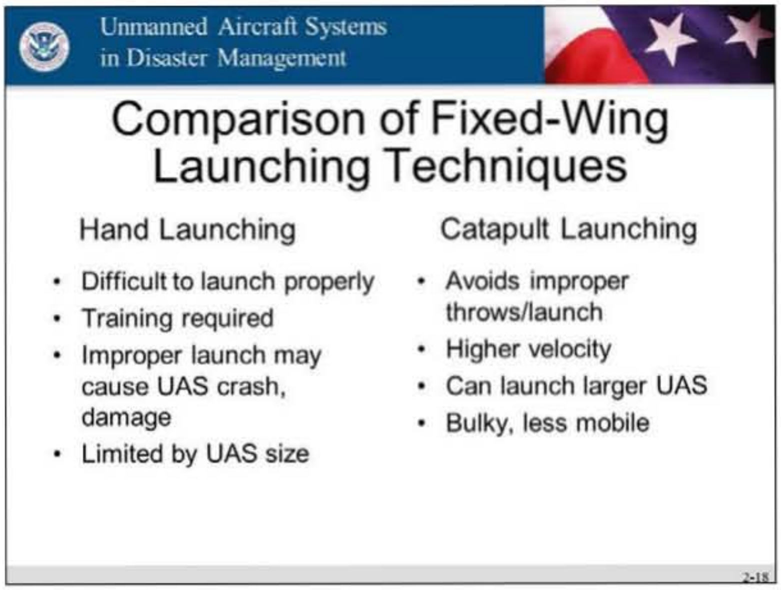
Slide 2-17. Launching Fixed-Wing UAS

Hand launching and catapult launching are basic techniques for launching fixed-wing UAS. Although some fixed-wing UAS still take off conventionally by using a runway or cleared strip of land, these alternative forms of launch offer more flexibility and less space. They also would allow launching from small boats for water operations or even off of trucks or trailers in some cases.

e.g. **Example:** On the left is a Puma being hand launched.

e.g. **Example:** On the right is a Scan Eagle prepared to launch from a catapult.

Participant Notes:



Slide 2-18. Comparison of Fixed-Wing Launching Techniques

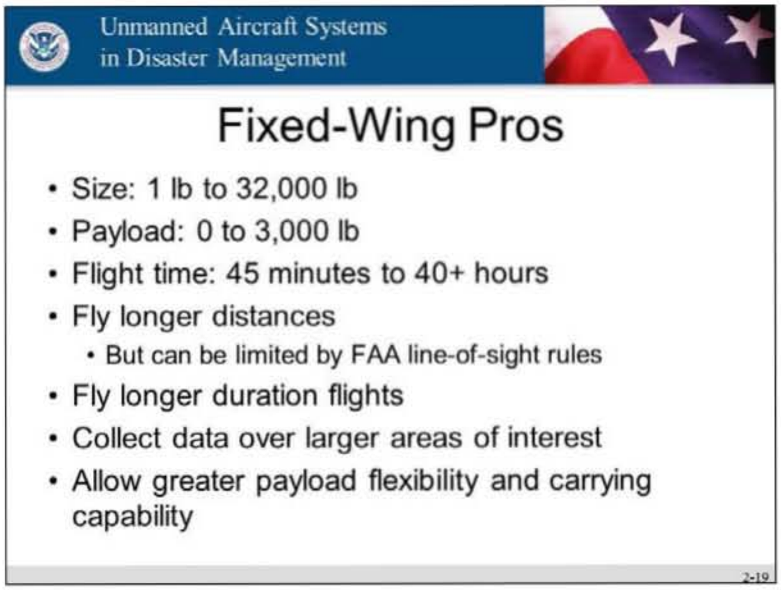
Some ways that hand launching can fail:

- Person launching may twist the UAV when launching (must throw straight) causing plane dive down and sideways.
- Person may not have enough strength to create the necessary velocity required for proper launch.
- Hand launch may be at too shallow or steep an angle for proper launch.

Key Point: Some catapults may be set up in the field and are not necessarily as bulky as the Scan Eagle's launcher. Bungees are sometimes used to launch fixed-wing UAS with some systems.

Key Point: The lack of mobility and increased bulk is the major limiting factor affecting systems requiring a catapult. This could possibly be overcome by the superior flight range of fixed-wing over rotorcraft UAS.

Participant Notes:



Slide 2-19. Fixed-Wing Pros

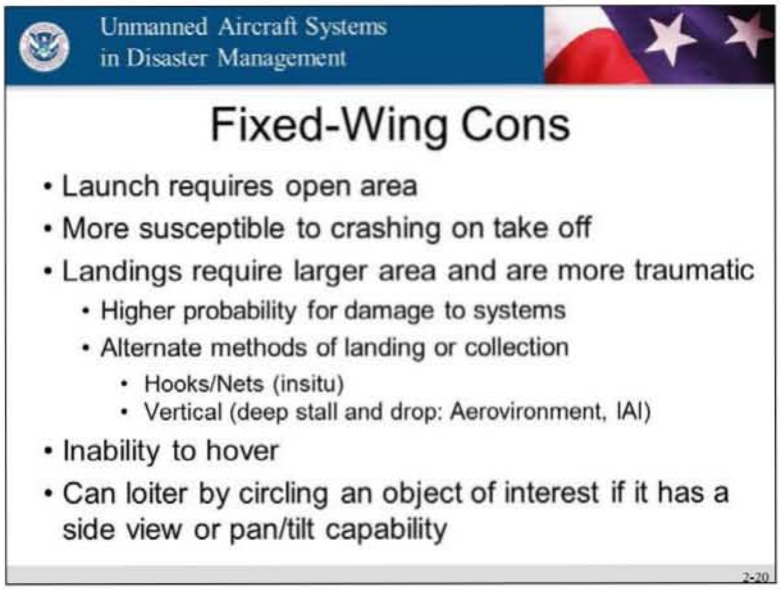
Key Point: The largest advantage of fixed-wing UAS in disaster situations is their ability to cover large areas as compared to rotorcraft. Major factors contributing to greater coverage are:

- Higher power efficiency that leads to longer flight time.
- Higher speed that leads to larger area covered in less time.
- Higher flight altitudes, generally, providing sensors a larger coverage area.

Key Point: Ask the class: How might you use a fixed-wing UAS for a disaster?

Answers may include imagery for overall situational awareness, damage assessment, and large area search and rescue in response to flooding, earthquake, hurricane, forest fires, etc. Also fixed-wing UAS could be used for disaster mitigation by imaging coastlines and other areas for risk assessment.

Participant Notes:



Slide 2-20. Fixed-Wing Cons

Key Point: Instructor should also point out that fixed-wing UAS generally require more skill and training to operate versus rotorcraft.

oint: Higher cost of ownership and down time should also be ted with a fixed wing due to the greater risks of damage on landing and operator error.

Participant Notes:

Slide 2-21. Fixed Wing Recovery Methods

Some fixed-wing UAS have alternate recovery methods:

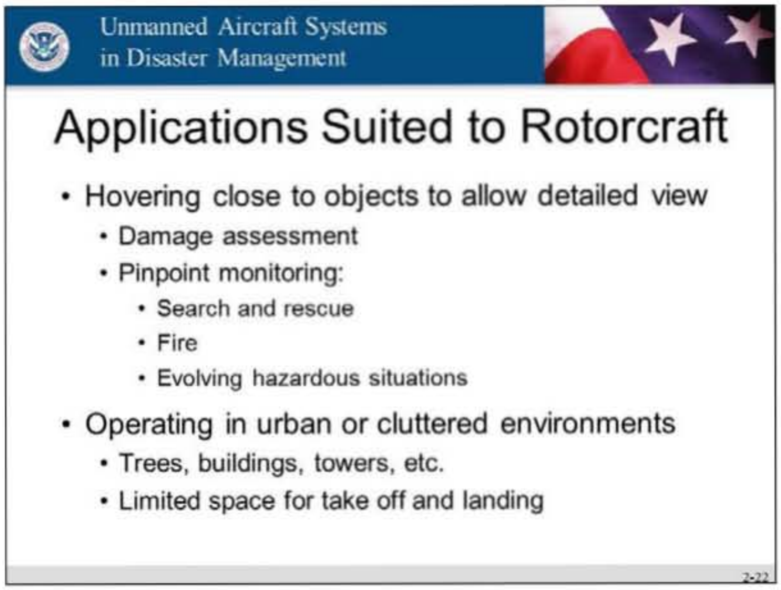
Example: Deep stall. Some UAS land by deep stall, compared to traditional skid or runway landings. Some of the advantages of deep stall landing are:

1. Ability to land in a smaller area
2. Ability to lessen impact on landing through the use of.
   - Catching techniques with a net or other means
   - Parachutes
   - Airbags
   - Bumpers at point of impact of the UAV

Example: Skyhook and water landing. Offer operational flexibility.

The skyhook and water landing UAVs shown above also provide operational flexibility and maritime operations. These methods of recovery also minimize damage risk on landing and recovery by lessening or eliminating traumatic impact to the aircraft.

Participant Notes:



Slide 2-22. Applications Suited to Rotorcraft

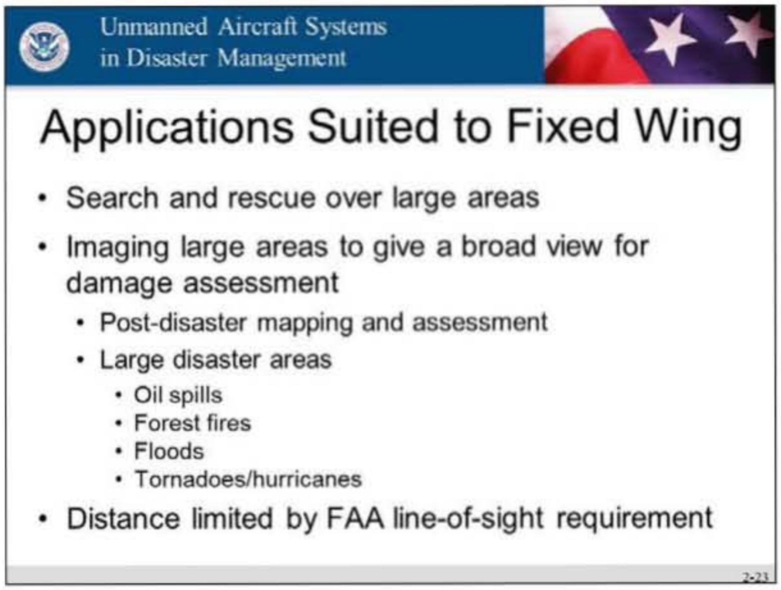
Key Point: Hovering

- Rotorcraft can hover, allowing a focus on a fixed target or small area.
- "Perch and Stare" ability allows much more detailed data collection due to proximity to target and time on target.

Key Point: VTOL (Vertical Takeoff and Landing)

- Allows operations in urban and cluttered environments where a fixed wing would not be able to operate at close range and where there is little space for a takeoff and landing area.

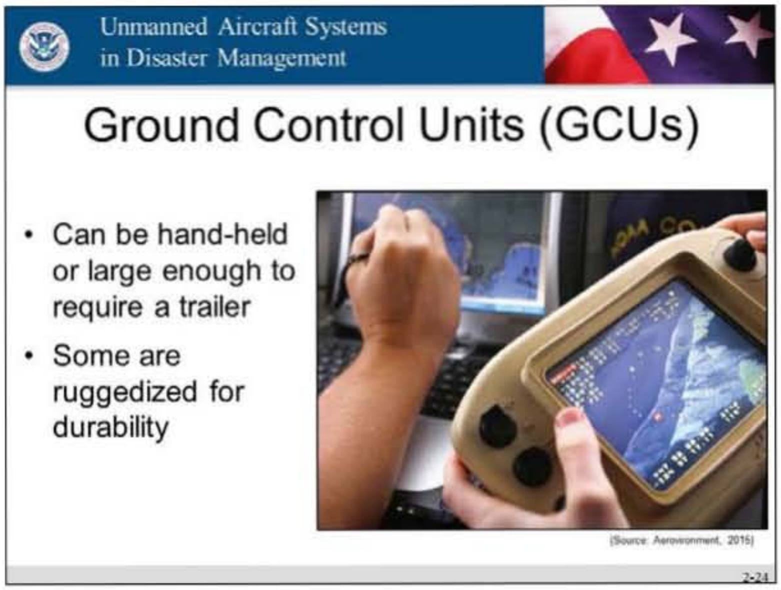
Participant Notes:



Slide 2-23. Applications Suited to Fixed Wing

Key Point: Longer flight times and speed allow fixed-wing UAS to cover larger areas.

Participant Notes:



Slide 2-24. Ground Control Units (GCUs)

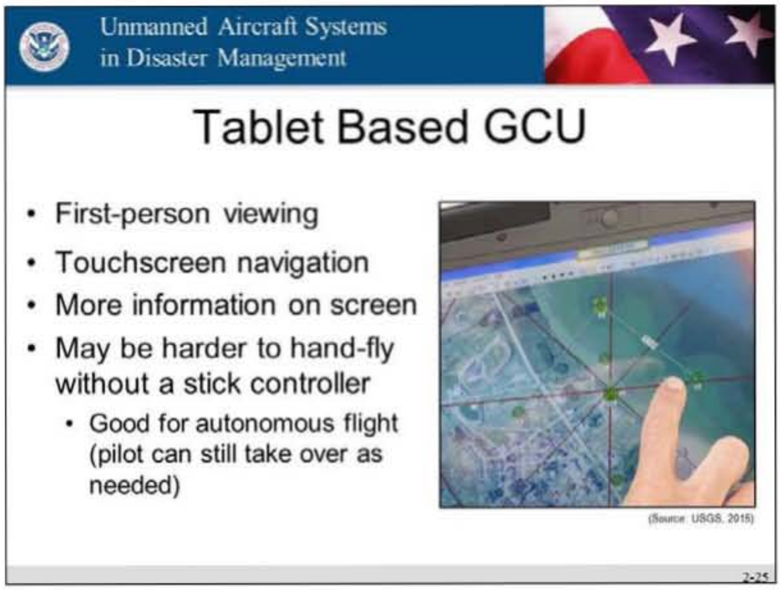
Pictured are controllers for Aerovironment's sUAS systems. This is a good example of a pilot and navigator set up. The pilot is able to concentrate on the flying while the navigator is on the computer assisting by monitoring the flight, changing waypoints, monitoring data, etc.

Some controllers are ruggedized for durability and use in the field. These types of units often are found in systems built for the military and may be more expensive. There are several commercially available ruggedized tablets and laptops that may be good alternatives.

e.g. **Example:** Two types of controllers are pictured.

- Laptop/Tablet
- Handheld

Participant Notes:



Slide 2-25. Tablet Based GCU

Key Point: Tablets can be used as the only controller or as an additional controller in the same manner as laptops are used. Some configurations mount tablets on the primary controller. With the larger touch screen available, tablets make it much easier to designate waypoints and control autonomous flight. Tablets generally provide more flight information to the UAS operator than a UAS controller with a joystick and a small screen, but can have less precise control of aircraft than one with a joystick.

Participant Notes:

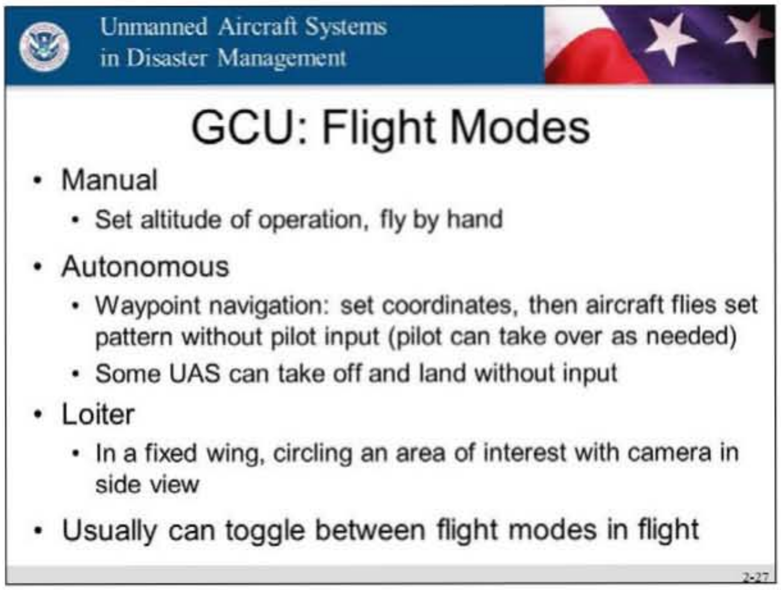
Slide 2-26. Combination Navigator and Pilot GCU

If a pilot handles the primary control of the aircraft while the navigator uses a laptop or tablet, this allows pilots to focus on flying and the navigator to focus on data collection.

Using the laptop/tablet, the navigator will be able to relay information that may not be on the pilot's interface.

Remind participants that when an agency sets up a UAS program, it needs not only staff to fly the UAS but also staff to serve as an observer, which is needed for every flight to have eyes always observing the aircraft. In addition, an agency may need specialists to analyze the data and to take the raw data and turn it into useful and actionable data and imagery for first responders and emergency management to use.

Participant Notes:

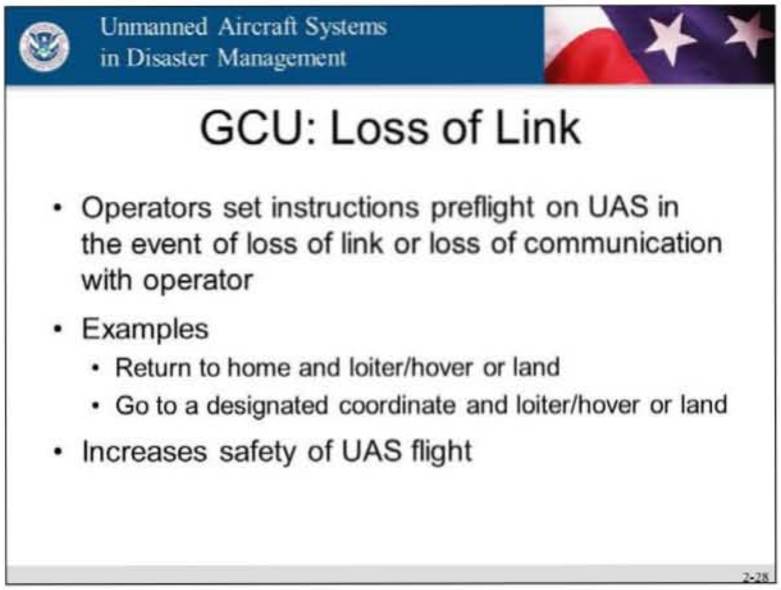


Slide 2-27. GCU: Flight Modes

There are several basic flight modes for UAS.

e.g. **Example:** Autonomous mode is generally used to gather information over a set area of interest, such as mapping for damage assessment or inspecting power lines. Autonomous flight allows an operator to focus on the sensor data and when something of interest is identified, the operator can toggle to Loiter mode to circle (fixed wing) or Hover (rotorcraft) to gather more data or get a closer look. Once sufficient information is gathered, the operator may toggle back to Autonomous mode to resume data gathering over intended area.

Participant Notes:



Slide 2-28. GCU: Loss of Link

Key Point: Loss of link is a very important function to understand, as it details what will happen to the aircraft if there is a loss of communication between the aircraft and the controller. The application for a Certificate of Authorization (COA) or Waiver, which allows operation of UAS for civil or public use, asks for a description of the lost link procedures for your operation.

Participant Notes:

Slide 2-29. GCU: Flight Planning Software

Key Point: Flight planning software generally makes it easier for an operator to plan and make changes to flight plans within an operation. Creating a flight through a software program and modifying the flight to fly to areas of interest is easier than having an operator flying by visual line of sight or by landmarks seen through the video feeds from the aircraft.

Participant Notes:

Slide 2-30. UAS Payloads. Sensors for Every Need

UAS can carry a variety of sensors depending on the need. Many large sensors have now become miniaturized to fit on UAS, as manufacturers are cutting back on the size and weight of sensors. Sensors include a variety of still frame cameras and video cameras, spectral analysis and lidar sensors, electromagnetic and thermal infrared sensors, sirens, and sensors that can be used for atmospheric science.

Key Point: Use of some or most of these sensors will likely raise privacy, civil rights, and civil liberties issues. The Alaska UAS Legislative Task Force created a useful document titled "Drone/UAS Operator Safety Guidelines and FAQs about Privacy," with examples of how UAS flights might violate someone's right to privacy, or at least be an annoyance. It presents situations in which UAS operators should be sensitive, such as flying over other people's property or where people might expect privacy, flying in a way that disturbs other's space or disturbs animals, posting imagery online, etc. Ask participants to give examples that they think might cause issues.

www.commerce.alaska.gov/web/Portals/6/pub/UAS%20Operator%20Guidelines%2010-1-15.pdf

Remember that law enforcement, fire services, EMS providers, emergency management, etc. must operate within their authorities: an Office of Emergency Management in a county has different authorities and different guidelines to follow in a disaster than law enforcement or the Department of Health.

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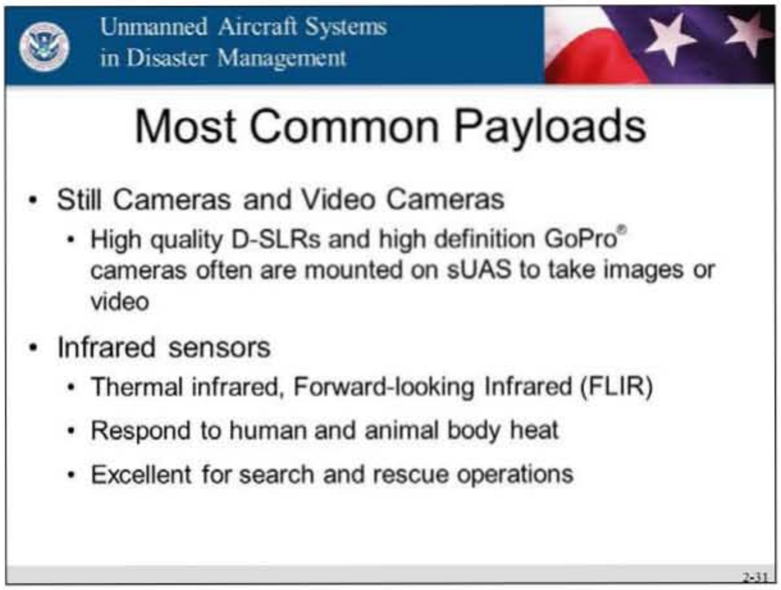

Slide 2-31. Most Common Payloads

When deciding on which UAS system to choose, sensors and payloads are another key consideration in addition to the aircraft itself. The next module will detail some of these sensors and payloads and how they each can be used in different disaster situations.

Key Point: The most common payload for UAS is a still camera or video camera (or more likely one camera that can do both). High quality digital D-SLR cameras and high definition GoPro® cameras are the main payload mounted on sUAS to take images or video, and they may be gimbaled or fixed, depending on the system. A gimbaled payload is mounted on a pivoted support to allow rotation and to stabilize image during flight, while a fixed payload is set in one position.

Key Point: Another payload that is mounted fairly often on UAS is an infrared sensor—thermal infrared or forward-looking Infrared (FLIR). Infrared sensors respond to human and animal body heat and are excellent for search and rescue operations. UAS mounted with infrared sensors can detect survivors buried under debris after a disaster, or can search for people lost in a forest.

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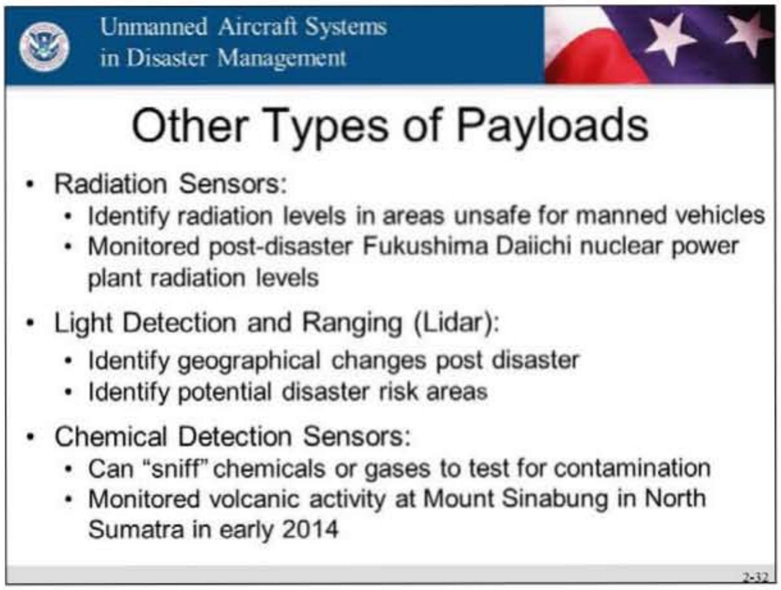


Slide 2-32. Other Types of Payloads

Many other types of payloads can be mounted on UAS that allow payloads to be switched out. Radiation Sensors can be mounted on UAS to identify radiation levels in areas unsafe for manned vehicles, such as during the post-disaster Fukushima Daiichi nuclear power plant meltdown, when UAS were used to monitor radiation levels.

Another type of sensor is lidar (Light Detection and Ranging, also known as light radar), which measures distance by illuminating a target with a laser and analyzing the reflected light and can be used for high-resolution maps. Lidar can help identify geographical changes after a disaster and identify potential disaster risk areas.

UAS also can carry chemical detection sensors, which can "sniff" chemicals or gases to test for contamination and was used in 2014 to help monitor volcanic activity at Mount Sinabung in North Sumatra in Indonesia.

Participant Notes:

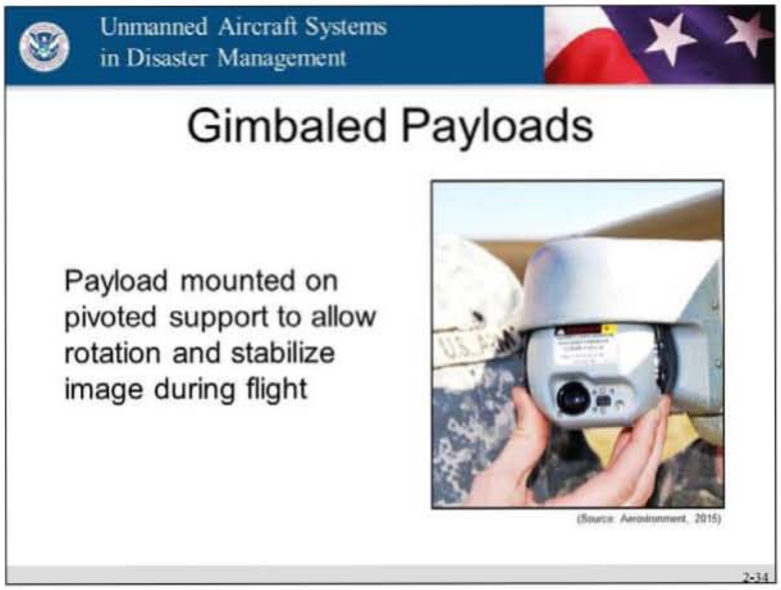
Slide 2-33. Fixed Payloads

Key Point: Fixed payloads are generally lower priced than gimbaled payloads.

Key Point: Advantages of fixed payloads:

- Generally, more rugged and reliable with little or no moving parts
- Easier operation by a single pilot, while gimbaled payloads may require another operator to operate just the payload

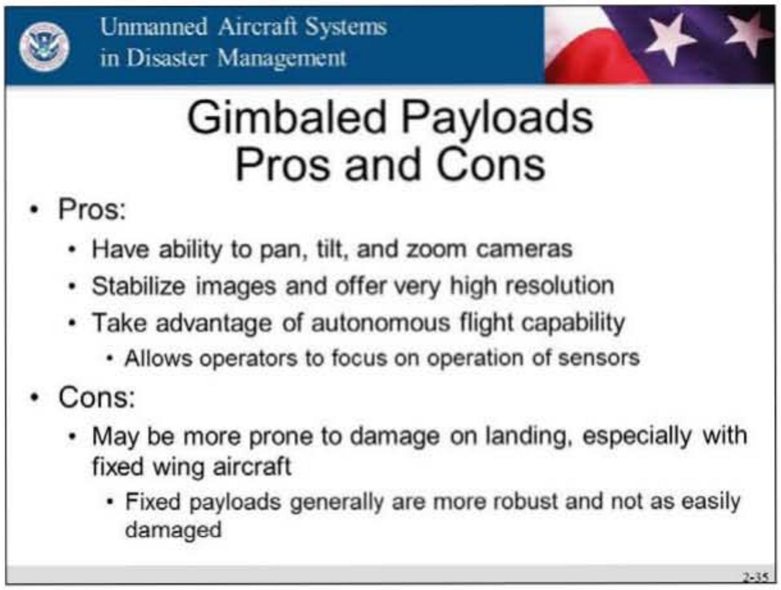
Participant Notes:



Slide 2-34. Gimbaled Payloads

Pictured is a gimbaled payload on the Aerovironment Raven UAS.

Participant Notes:

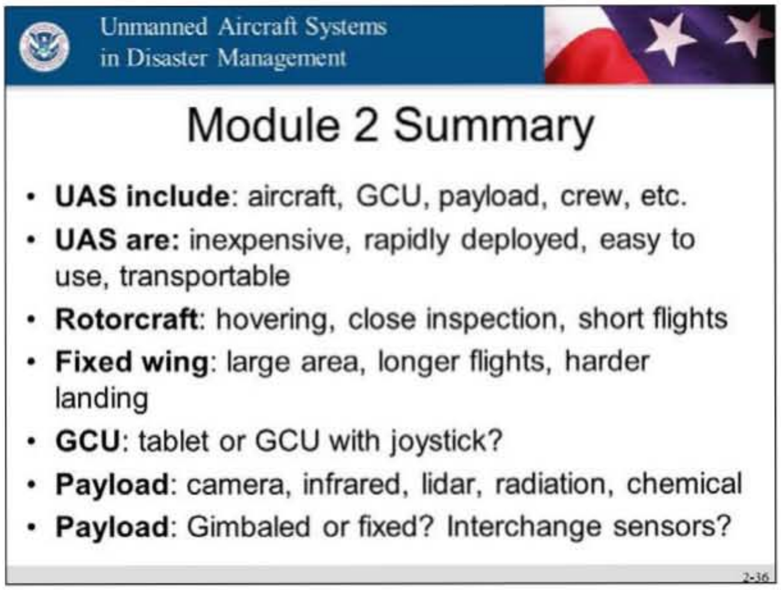


Slide 2-35. Gimbaled Payloads Pros and Cons

A gimbal allows the operator to pan and tilt a payload, eliminating the need for multiple cameras (such as fixed cameras that are set to point frontward, sideways, or downward). The precision of a gimbaled payload makes it easier to lock onto areas or targets of interest to the operator.

Gimbaled payloads may require an additional operator for the payload if the aircraft is not flying in autonomous flight mode.

Participant Notes:



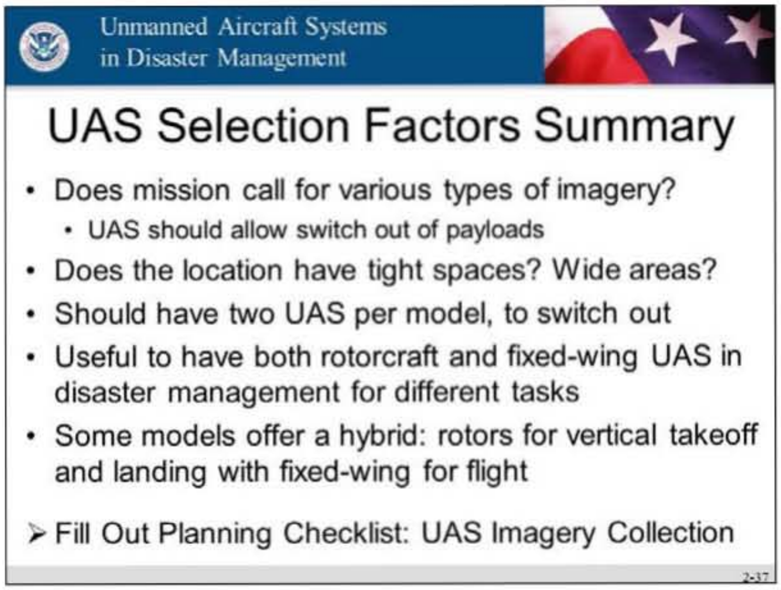
Slide 2-36. Module 2 Summary

This slide summarizes Module 2, to remind participants what was covered and briefly refresh their memory of the main points.

Briefly review.

- The parts of a UAS (aircraft, GCU, payload, crew, etc.)
- Why UAS are a good option (inexpensive, rapidly deployed, easy to use, transportable)
- The difference between rotorcraft (hovering, close inspection, short flights) and fixed wing (large area, longer flights, harder landing)
- The other components of UAS, including the GCU and payload, and payload options

Participant Notes:



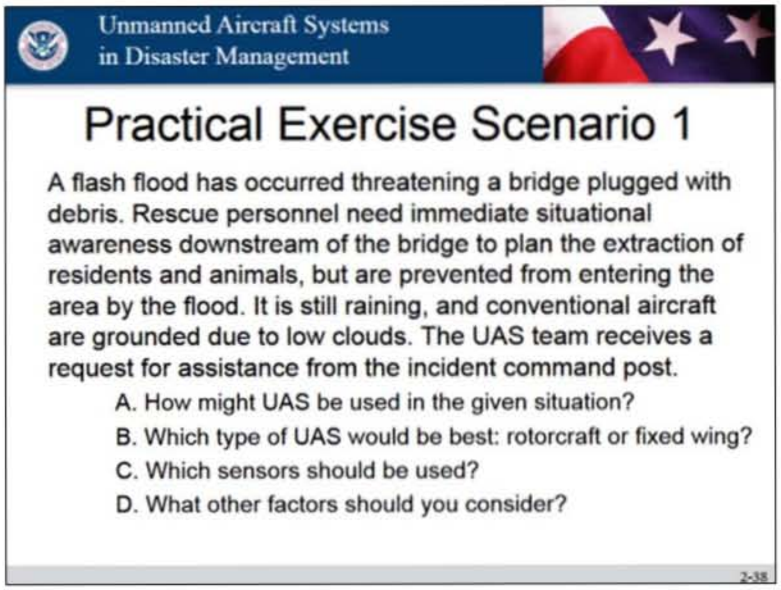
Slide 2-37. UAS Selection Factors Summary

Key Point: Several types of UAS only allow the sensors that are built into the aircraft. If an agency requires several types of sensors, make sure that the aircraft can carry those sensors or has them built in.

Key Point: It is important to have more than one unit of a given type of UAS, because if a UAS gets damaged, and the operator has only one, then the operations are on hold until it is fixed (which at times is a quick repair, but could be more extensive). If the operator has a backup aircraft, then operations can be resumed immediately.

Key Point: Not included in the slide is that fixed-wing UAS require more training and expertise to operate. Fixed-wing UAS also sustain greater damage in general due to more traumatic landings. When deciding on a system, if a fixed-wing UAS is selected, it is more important to have spare parts and spare aircraft to ensure maximum utility. These considerations could translate to higher costs in spares, replacement aircraft, and possible downtime.

Participant Notes:



Slide 2-38. Practical Exercise Scenario 1

This exercise at the end of Module 2 presents a possible scenario in which UAS could be used. Participants will apply information learned in the module to help answer the questions.

The instructor will ask participants either to break into groups to discuss the scenario here and then discuss the possible answers together as a class, or not break into groups and discuss the questions together, at the discretion of the instructor.

Unmanned Aircraft Systems in Disaster Management

Module 3: UAS Options in the Disaster Management Cycle

Version 1.0

FEMA

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Module 3: UAS Options in the Disaster Management Cycle – Administration Page

Slide 3-1. UAS Options in the Disaster Management Cycle

Duration

80 minutes

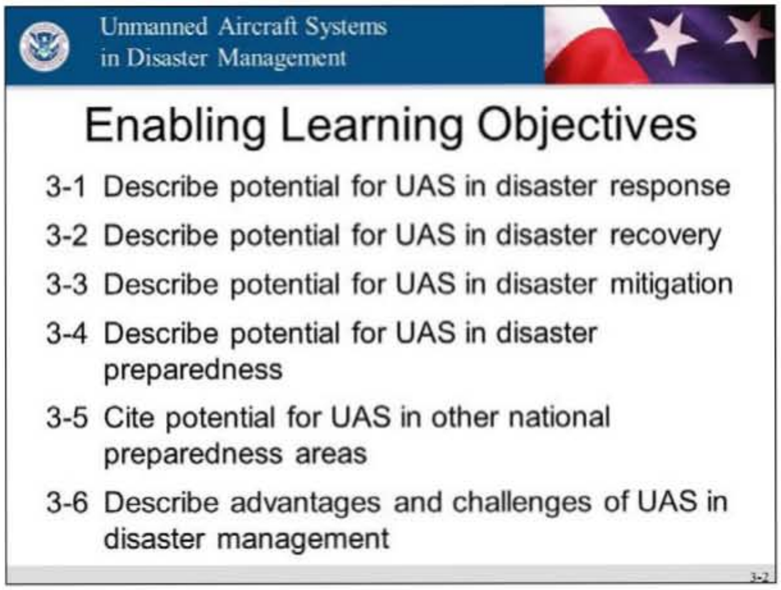
Scope Statement

Participants will learn the various ways that UAS have been used in disaster management and potential ways they could be used in future disaster situations. Specifically, this module will discuss UAS uses in disaster response, damage assessment, disaster recovery, disaster mitigation, disaster preparedness, and in national preparedness, in a format focused on engaging participants in the thought process of how to best integrate UAS operations to fit their specific needs in the future.

Terminal Learning Objective (TLO)

The participant will be able to explain several ways that UAS can support disaster management.

Enabling Learning Objectives (ELO)



Slide 3-2. Enabling Learning Objectives

At the conclusion of this module, participants will be able to.

- 3-1 Describe potential for UAS in disaster response
- 3-2 Describe potential for UAS in disaster recovery
- 3-3 Describe potential for UAS in disaster mitigation
- 3-4 Describe potential for UAS in disaster preparedness
- 3-5 Cite potential for UAS in other national preparedness areas
- 3-6 Describe advantages and challenges of UAS in disaster management

Resources

- Instructor Guide (IG)
- Module 3 presentation slides
- Laptop with presentation software installed and CD-ROM capability
- Audio-visual (A/V projection unit)
- Projector screen
- Chalkboard (and chalk), whiteboard (and dry erase markers), or easel and easel paper (and permanent markers)
- One of each of the following items per participant:
  - Participant Guide (PG) available for download from http://ndptc.hawaii.edu/
  - Participant Handout

Instructor-to-Participant Ratio

2:40

Reference List

Akl, Aida. "Aid Groups Turn to Unmanned Aircraft for Disaster Support." Voice of America, May 9, 2014. http://blogs.voanews.com/techtonics/2014/05/09/aid-group-tests-unmanned-aircraft-for-disaster-support/

Carey, Bill. "U.S. Security Agency Begins Small UAS Testing." Aviation International News AINOnline, Oct. 5, 2012.

Chiu, Imes, Chuck Devaney, and Ted Ralston. "Flying High. The Use of Expendable Civil Drones after Typhoon Haiyan." Liaison, Volume VI, Winter 2013-2014, pp. 49-53.

Debusk, Wesley M. "Unmanned Aerial Vehicle Systems for Disaster Relief. Tornado Alley." AIAA Unmanned Unlimited Conference and Exhibit; Seattle, Apr. 6-9, 2009.

"Drones Used for Good - Relief Organisation Uses Drones to Map Typhoon Haiyan Recovery Efforts." Reliefweb, Apr. 2, 2014.

"Global Hawk Aids in Philippine Relief Efforts." PRNewswire, Jan. 6, 2014. http://www.prnewswire.com/news-releases/global-hawk-aids-in-philippine-relief-efforts-238865571.html

Hickey, Shane. "Humanitarian Drones to Deliver Medical Supplies to Roadless Areas." The Guardian, Mar. 30, 2014. http://www.theguardian.com/world/2014/mar/30/humanitarian-drones-medical-supplies-no-roads-technology

Li, Kevin. "Fukushima Radiation Disaster News. Japan Uses Drone to Check Rad Levels at Nuclear Site." Latin Post, Jan. 27, 2014. http://www.latinpost.com/articles/6442/20140127/fukushima-radiation-disaster-news-japan-uses-drone-check-rad-levels.htm

McCormack, Edward, and John Stimberis. "Small Unmanned Aircraft Evaluated for Avalanche Control." Transportation Research Record. Journal of the Transportation Research Board, No. 2169, Transportation Research Board of the National Academies, Washington, D.C., 2010, pp. 168–173.

Meier, Patrick. "An Introduction to Humanitarian UAVs and Their Many Uses." iRevolution, May 1, 2014.

National Unmanned Aircraft Systems (UAS) Project Office. U.S. Geological Survey website. http://rmgsc.cr.usgs.gov/UAS/. Accessed June 2015

Santos, Lean Alfred. "In the Philippines, Drones Provide Humanitarian Relief." Devex, Dec. 16, 2013. https://www.devex.com/news/in-the-philippines-drones-provide-humanitarian-relief-82512

Skoloff, Brian. "Progress Made as Drone Helps Fight Yosemite Fire." MSN News. Aug. 29, 2013.

sUAS News. "Drones Provide Humanitarian Aid in Haiti." May 29, 2013. http://www.suasnews.com/2013/05/23106/drones-provide-humanitarian-aid-in-haiti/

Subbaraman, Nidhi. "Swarms of Drones Could Be the Next Frontier in Emergency Response." MSN News, Jan. 25, 2014.

Practical Exercise Statement

There is a practical exercise at the end of Module 3 that presents two possible scenarios in which UAS could be used. Participants will apply information learned in the course to help answer the questions. The instructor will ask participants either to break into groups to discuss the two scenarios and then discuss the possible answers together as a class, or not break into groups and discuss the questions together, at the discretion of the instructor.

Assessment Strategy

- Instructor observation of participant involvement in the classroom exercise and discussion.
- Instructor-led discussion to ensure that participants understand the material.

Unmanned Aircraft Systems in Disaster Management

Icon Map

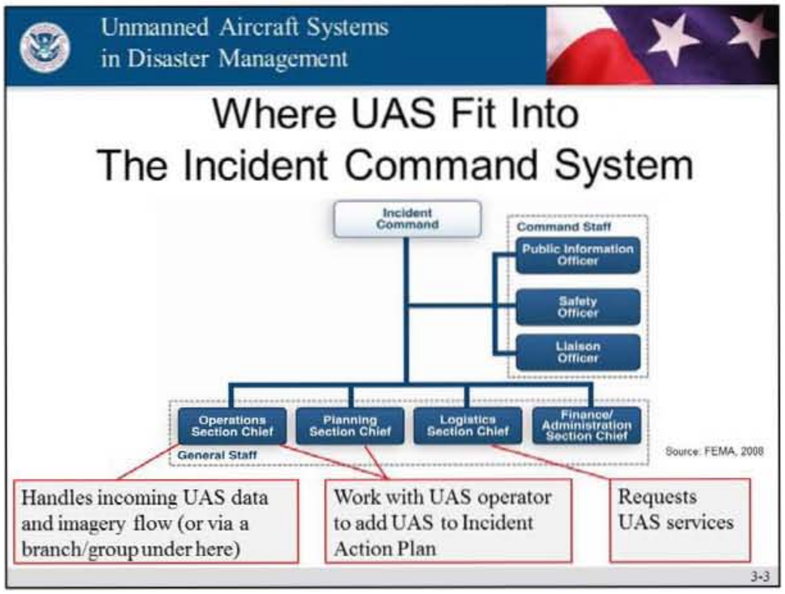
Knowledge Check: Used when it is time to assess participant understanding.

Example: Used when there is a descriptive illustration to show or explain.

Key Points: Used to convey essential learning concepts, discussions, and introduction of supplemental material.

Participant Note: Used to indicate text that has been included as additional information for the participant. The text may not be directly addressed in the slide presentation or during class discussion.

Participant Notes:



Slide 3-3. Where UAS Fit Into The Incident Command System

When a request comes from the Incident Command Post (ICP) for UAS services, it will usually come to the UAS service provider from the Logistics Section Chief. This person provides services to the ICP for obtaining resources.

The Planning Section Chief works with other General and Command Staff within the ICP to present the Incident Action Plan (IAP). If the IAP needs to be modified to accommodate UAS services, the UAS service provider will work with the Planning Section Chief and the Operations Section Chief.

Once the UAS missions are being flown, the information, data, and imagery will flow from the UAS service provider into the Operations Section. That information, data, and imagery may go directly to the Operations Section Chief, or to a specific Branch or Group under the Operations Section Chief.

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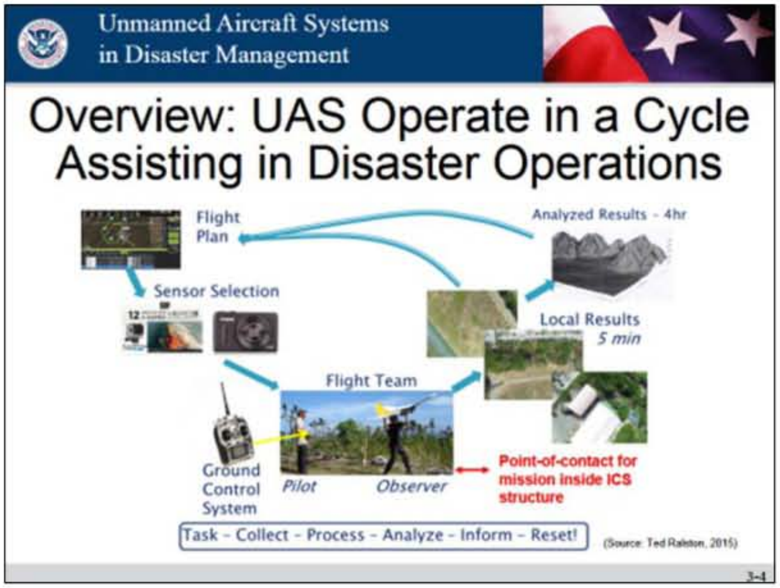


Slide 3-4. Overview: UAS Operate in a Cycle Assisting in Disaster Operations

Key Point: The most important information that we deliver in this course is the broad view illustrated here, where UAS operations are seen as a cycle, feeding critical information to the point-of-contact for the mission inside of the ICS structure, which is the Operations Section Chief or the Planning Section Chief, depending on the need. Whereas a lot of attention is focused on the unmanned vehicle and its operators, it is really the information collected, analyzed, and delivered at the end of a flight cycle that defines the value of UAS in disaster operations.

e.g.

Example: The cycle starts with the point-of-contact for the mission inside of the ICS structure, which would be the Logistics Section Chief (from whom the request for UAS would originate), or the Planning Section Chief (if UAS missions are being planned), or the Operations Section Chief (who may use information from a UAS for tactical decisions). That information need may require a broad, overall perspective for evaluation of access or major damage; a detailed, close-up inspection of a structure or roadway; a landform topography map for landslide threat prediction; a simple single-frame photograph of a structure; an electronic spectrum cellphone network assessment; or the delivery of a message.

The illustration shows two specialists hand-launching a fixed-wing UAS for broad area surveillance. Implicitly, launch and recovery clearways and a landing zone have been verified; wind vector and potential flight path obstacles have been

Participant Notes:

accounted for; the UAS communication system is unaffected by local electromagnetic spectrum; the flight vehicle equipment is airworthy and the operator and observer are qualified; and any/all permissions for overflying the operational area are in place. The UAS flight team has to coordinate with other air and ground teams to ensure safe, smooth operations. In particular, coordination of the UAS team with other air services is essential, which is accomplished at the discretion of the point-of-contact for the mission inside of the ICS structure, who would be primarily the Planning Section Chief, although the Operations Section Chief also likely would be involved. Further, it is also implied that software tools are in place for extracting and processing the collected information, forwarding it for supporting analysis, and for sharing, storing, and protecting the information developed. Finally, it is implied that a UAS operations reporting system is in place that will meet FAA, and other agency, requirements.

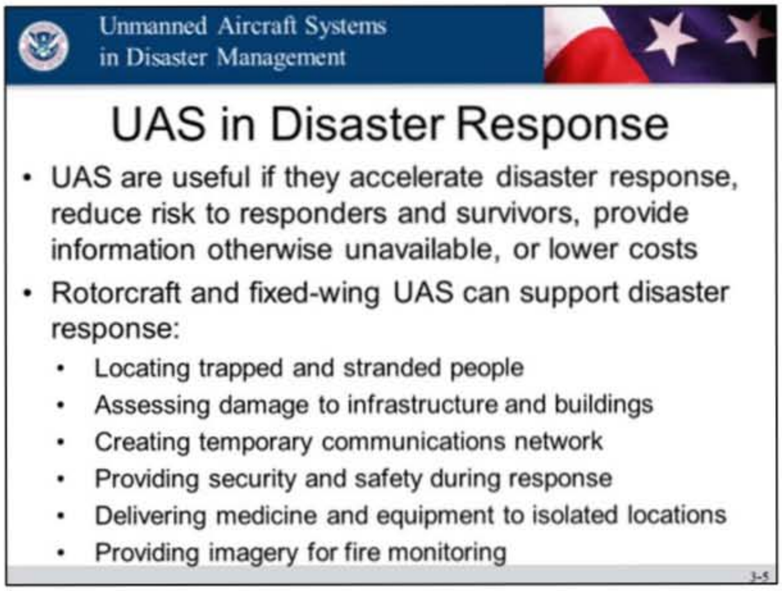
e.g.

Example: The fixed-wing specialists in the picture become part of the forward cadre that must be provided with food, water, domicile, and protection. With simple rotorcraft systems that do not require the level of operator specialization as fixed wing, it may be possible for the mission to be performed without such specialists. In either case, accommodating the UAS operation and its people into the event scenario must be considered.

This depiction shows a number of considerations underlying UAS in disaster management. While UAS is a simple concept, implementation is not simple, as there is no model to follow and the challenges that must be met include principles as fundamental as protecting basic civil rights.

Key Point: The use of UAS in the disaster management cycle must start with an idea of the end analytic or expressive product in mind, based on an agreement with the point-of-contact for the mission inside of the ICS structure as to what information, in what form, is most useful at this point in his/her mission.

Participant Notes:



Slide 3-5. UAS in Disaster Response

The range of utility for UAS in disaster response is potentially quite broad. No specific mission or use stands out as the most useful. All are performed by the same basic flow cycle. However, the several phases of disaster require different formats of information collection and analysis, at different tempos, pointing to a set of different sensors and UAS flight vehicles to accomplish the mission. The most beneficial value of UAS may be as much in time saved as the imagery result recorded. For example, being able to examine a damaged building up close immediately, without having to call the utility company to locate and shut of the electric or gas service, may be in itself a game-changing value.

UAS are not in common use in disaster operations today, as the technology is just emerging at a scale, price, capability, and legality that can become useful. UAS can be a good option under certain disaster conditions but not under all. Operations and command personnel should consider introducing UAS into their disaster management efforts when the use of a UAS would improve the overall disaster operation effort and reduce risk to responders or survivors.

e.g. **Example:** The listed uses are suggestions for potential use of UAS with the types of system currently available at the ‘entry level’ of UAS into disaster operations. This is the capitalization on existing technology and systems at reasonably low cost and low risk with potential high returns. By no means are disaster operations uses limited by this list.

Participant Notes:

Key Point: In this very formative time when the utility of UAS is being developed, an important takeaway from this course is to have potential operators think about how they might most effectively put this technology to work and communicate with each other and with UAS manufacturers to further develop ideas. User ideas and feedback are essential to getting the most out of UAS technology as we collectively improve the future of disaster management. As UAS technology continues to evolve, it will take a partnership between users and system developers to evolve the right systems for the disaster management task, leading to purpose-designed systems optimized for disaster operations. At this point in UAS evolution, that specialization has not happened yet. UAS we may consider using today are inherited from other aspects of aerial surveillance.

Key Point: Participation of UAS operators with first responders during drills, exercises, tabletops, and real-world missions will be an essential factor in determining the best uses in any particular emergency. Searching for the 'path of least resistance' forward, together, will be an important aspect in the necessary step of socialization of UAS operations in disaster operations.

Participant Notes:

Slide 3-6. Example: UAS Imagery of Napa, California Earthquake 2014

Example: This is an example of informal UAS usage in the Napa earthquake of 2014. Here, a consumer-grade multi-rotor carrying a video camera has been called upon to gather some imagery of an affected building for on-scene assessment of structural damage. Clearly this level of acuity in imagery, this close up and this quickly collected, would be useful to an emergency manager.

Key Point: This image also points out the issues that need to be addressed as UAS capability is built up for disaster operation, from privacy, personal rights, and information protection to safety and reliability, operating procedures, and regulations.

Participant Notes:

Slide 3-7. Disaster Response: Locating Trapped People with Infrared Sensing

Infrared (IR) imagery captures the near-infrared information otherwise filtered out of light collected in photography, allowing information about source temperatures, rather than reflective colors, to be collected. Temperature differences between elements in the image and the background can indicate presence of human or animal life, if the operator understands how to interpret the imagery. Thermal infrared (TIR)/Forward-looking Infrared (FLIR) imagery responds to human and animal body heat; and sees through smoke, tree canopy, and fog.

Infrared sensors have been extremely expensive in the past, due to the technology of the energy-receiving rare earth elements, and are not in the usual kit for disaster operations. As prices come down and infrared systems are miniaturized to a size that can fit onto UAS, the utility of this technology warrants being explored, evaluated, demonstrated, and capitalized in UAS-based disaster operations.

When using infrared sensors on UAS to find trapped people, the operator must consider a number of factors, including the background thermal basis, the interpretation of the on-screen video display, and post-flight imagery reprocessing.

Infrared works best at dawn when the background temperatures are a stabilized overnight coolness, while human and animal figures show up brightly. At higher sun angle conditions, the background surface temperature will respond to integrated solar input, changing the discrimination of body heat.

Participant Notes:

Using infrared sensors for locating trapped people makes sense if the sensor can be brought into the proximity of the people, to generate a thermal response with adequate discrimination from the background. Typical sensor acuity suggests 400 feet as a maximum working altitude; if large crowds of people closely spaced are anticipated, higher altitudes will work. The nature of infrared collection suggests a rotorcraft UAS so that the sensor can be carefully positioned and remain in place while hovering. Experience and training are necessary to get the most out of infrared for finding trapped people.

Typical infrared observation is by real-time video display on a downlinked monitor. Recorded video may be of lower quality than the original, a consequence of the DVR process.

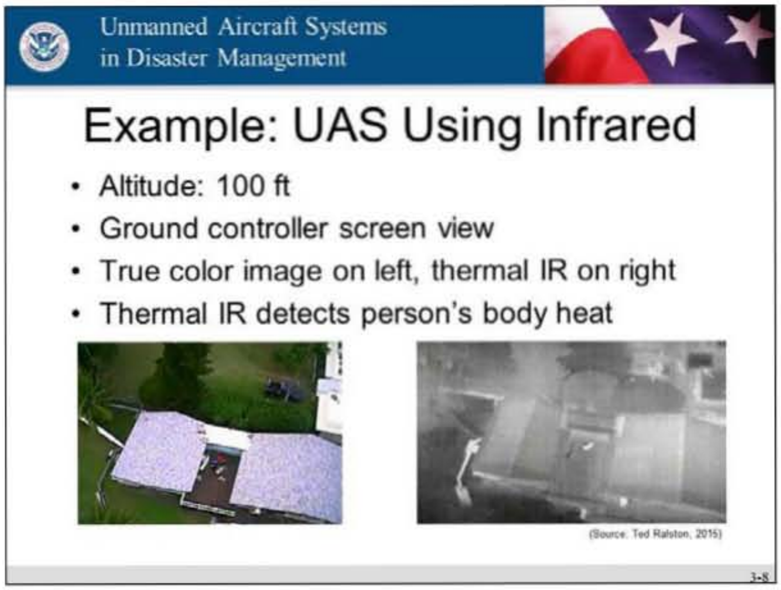
Still-image analysis is becoming available, leading to computational assistance to the analyst, through software that operates at the pixel-temperature level. However, still-imagery analysis implies post-flight processing, with a necessary time delay and transmission of collected information to an area for analysis. This extra processing time would not be possible when searching for trapped people.

Learning how to use infrared sensors with UAS in disaster operations is important, as well as training with the equipment, including any transmission of information for analysis, or as the decision process of the point-of-contact for the mission inside of the ICS structure.

Key Point: Key here is for the operator/analyst to understand the heat signature of the background against which the trapped people may be highlighted.

Key Point: Training in a range of sun angles and weather conditions, background materials, and placement of target people is necessary to capitalize on UAS infrared technology in disaster operations.

Participant Notes:



Slide 3-8. Example: UAS Using Infrared

Example: These are screenshots from a ground control unit of a typical tactical, first-level infrared camera compared to the same scene in true color installed on a rotorcraft UAS.

Clearly, different aspects of the scene are highlighted by the two methods. Debris buildup is evident in the color frame, but heat sources are not. The two people in the image disappear against background debris in the color picture.

In the heat-based infrared image, the reverse is true. The human figures show up brightly, but so do the concrete retaining wall and stair landing—heated as they are by the sun. The internal structure of the house even shows up—a consequence of heat accumulation variability in thick structure (beams) versus thin sheathing. This information itself might be useful to breaching teams who must enter the building. Hot spots indicating fire would show up in infrared and would be useful to fire teams.

Employing infrared technology requires training to be sensitive to background heat sources and the factors that drive background temperatures. Time of day is an important consideration—dawn or early morning is very useful, by taking advantage of overnight cooling, when the thermal emitters (people and animals) stand out more clearly.

Participant Notes:

Slide 3-9. Example: Using All Image Sources to Understand Situation

Training and practice are essential in determining the presence of trapped people through UAS collected imagery. Each type of sensor says something about the scene. The responder must be good at extracting the essential information, triaging the present situation, and moving on to the next situation, being cognizant of battery life of the UAS.

Example: The injured person has moved into the corner of the roofless building for protection and is under a chair. The chair shows up in the true color image but the person does not. In all of the sample infrared images—black hot, white hot, and orange hot—the reverse is true, as the heat generated by the person is evident. Most infrared sensors are designed to be reset from black, to white, to orange-hot easily; the latter setting is often preferred.

Key Point: In disaster management, all sources need to be considered, especially when needing to find trapped people. Color, infrared, and other sources—as much as can be collected—will paint the most comprehensive picture.

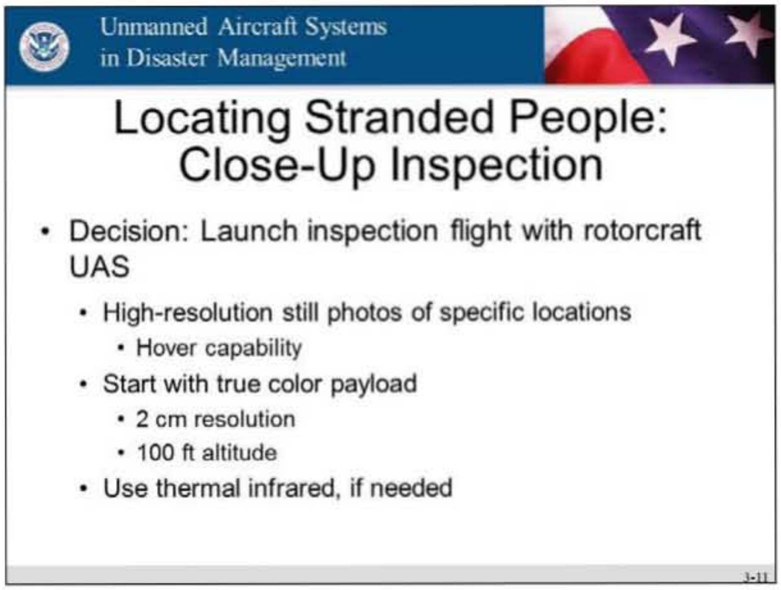
Participant Notes:

Slide 3-10. Locating Stranded People: Wide Scan

Getting the widest area surveyed quickly, at a larger resolution such as 6 cm, is likely to be the first step in finding stranded people.

e.g. **Example:** A mapping UAS system, composed of conventional true-color DSLR installed on a fixed-wing UAS, will do a great job of collecting multiple acres of overlapped imaging on one battery charge. The resulting imagery can be processed rather quickly in the field into a conventional ‘photo-mosaic,’ sufficient for identifying the patterns and markers that indicate stranded people. Back-up support analysts can make deeper analytic assessments from the same information and relay them forward.

Participant Notes:

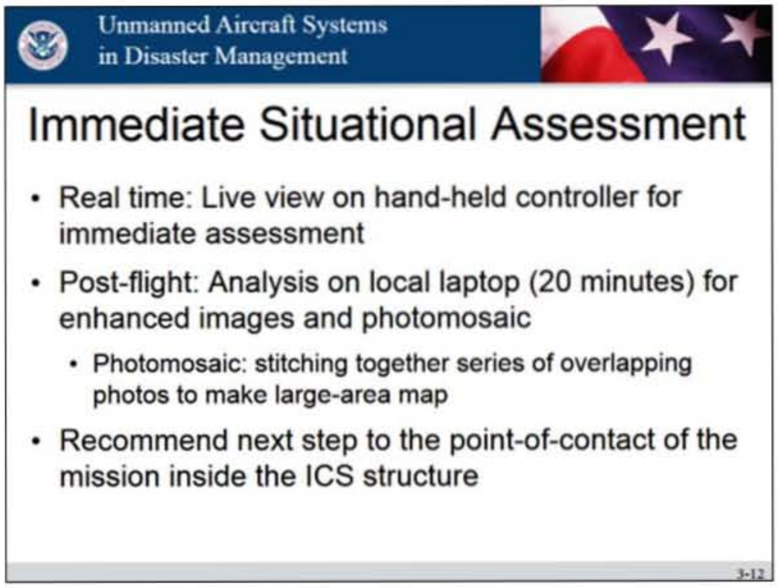


Slide 3-11. Locating Stranded People: Close-Up Inspection

A rotorcraft would help one of the task teams triaging the area. Being a simple system, the rotorcraft needs no specialist to operate and the necessary imagery can be collected in phase with the team's operating tempo, minimizing disruption. The team is directed by the point-of-contact for the mission inside of the ICS structure to collect imagery at the geolocation specified by the fixed-wing team.

Note that we are using both metric and English units of measure to describe resolution and altitude, respectively. In practice, individuals working in disaster management will encounter such situations and care should be taken to ensure that units are properly understood as they relate to UAS missions.

Participant Notes:



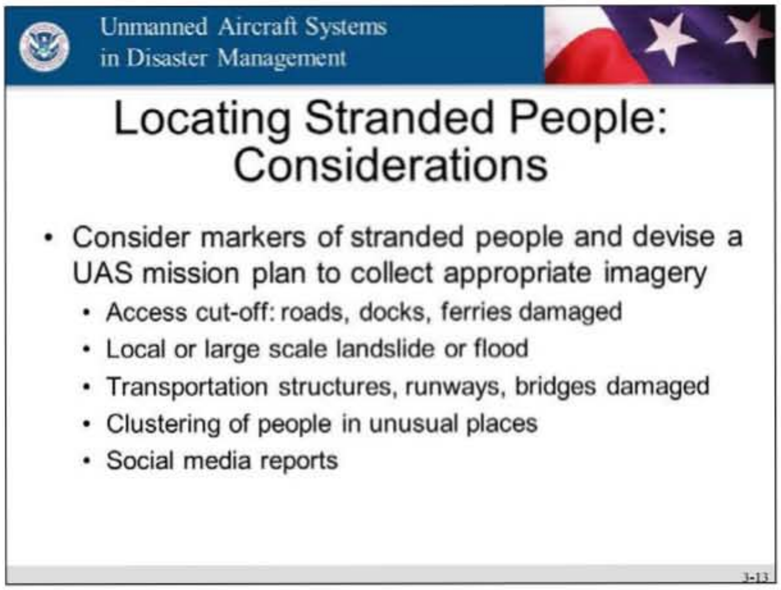
Slide 3-12. Immediate Situational Assessment

Example: The imagery from the UAS can be seen in real time on most flight controllers. Further analysis and cleaning up of the imagery would take roughly 20 minutes for more detailed, useful images.

Key Point: Photomosaics can be created quickly, in which a series of overlapping photos are stitched together to make one large area map.

The fixed-wing imagery may lead to a decision to send in a UAS rotorcraft with a color camera payload to get specific imagery. The mission plan would be to hover over the area long enough to understand the emerging picture relative to stranded people, quickly.

Participant Notes:



Slide 3-13. Locating Stranded People: Considerations

Key Point: In order to use UAS to help find stranded people, it is necessary to first understand the direct and indirect markers of human behavior that indicate stranding, then devise a plan of collection that will reveal these markers, fast, efficiently, and accurately. The combination of UAS sensors, analytics, and mission planning that address other disaster management needs will also support the task of finding stranded people. However, for this task, the nature and scope of the search, and the resolution required in the resulting imagery, are introduced into the picture.

Certain markers can be deduced at low resolution, suggesting wide-area, high-altitude, fast scan imagery collection using fixed-wing UAS. Fixed-wing will get the broadest view of the terrain in which markers might exist. Fixed-wing UAS may imply a level of specialization in equipment and capability in the operator/observer that may exceed that of a task team. The intense study of imagery necessary to uncover all markers may require additional local or remote support, connected via a reliable communications channel, to perform the analysis.

Information other than the imagery alone likely will be necessary to reach a conclusion. This extended operation then introduces the additional task of combining inputs to inform the solution and managing the information analysis workflow. UAS becomes a contributor to the solution but is likely not to be the sole element.

Participant Notes:

Slide 3-14. Example: Wide-Area Scan in Philippines

This photomosaic of a flooded river basin was composited from numerous overlapping still images taken by the hand-launched, fixed-wing UAS shown. Detailed examination by people familiar with the area can reveal markers that may indicate stranded people.

Example: In this example, smoke can be seen rising from the flooded area in a way that suggests human activity, perhaps stranded in an isolated area cut off by the flood, which should be investigated.

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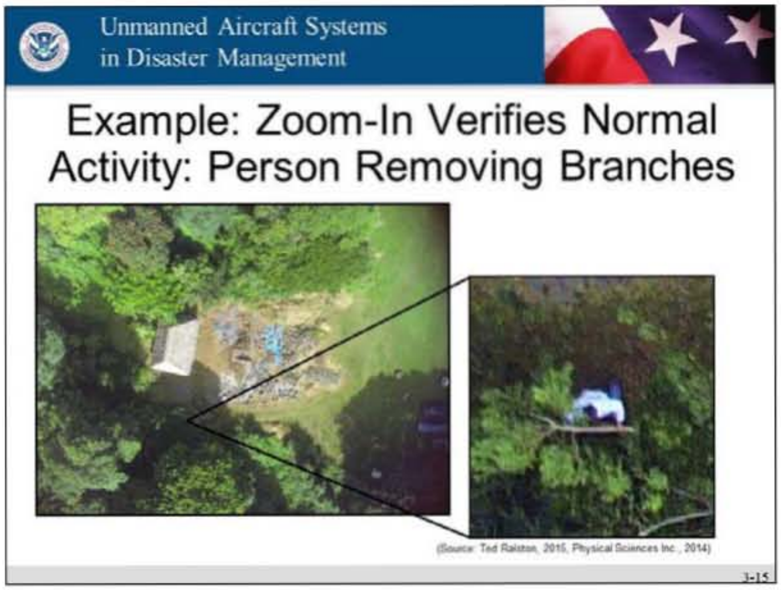

Slide 3-15. Example: Zoom-In Verifies Normal Activity: Person Removing Branches

Example: The resulting detailed still imagery may be played back locally by the task team, and in this image, they could observe that there is a person removing and stacking downed brush and tree limbs, cleaning up post-flood. The person is dressed, working in an orderly fashion, and is clearly not displaying the behavior or markers of someone that signifies any immediate threat of being stranded.

Key Point: In complex situations such as finding stranded people, it will take the creative use of multiple information systems, including UAS, to reach the most successful conclusions. UAS can certainly accelerate the process and increase the accuracy of the result, as well as provide the capability where it has not typically been available and at lower cost. Fixed-wing and rotorcraft working together are most likely the best combination of assets.

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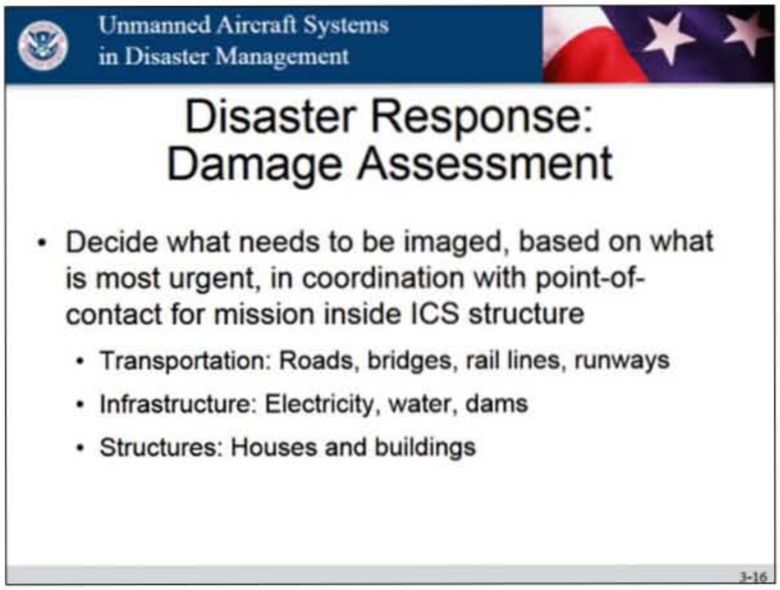

Slide 3-16. Disaster Response: Damage Assessment

Damage assessment via UAS follows the same flow and process as the prior examples. Most important is to decide what has to be measured or imaged, at what resolution, and at what priority or urgency, in conjunction with engineers and the point-of-contact for the mission inside of the ICS structure. From that point, the method of collection must be determined. It is likely to be a combination of fixed-wing and rotorcraft.

UAS could be an invaluable tool to help with damage assessment of transportation assets such as roads, bridges, rail lines, and runways; of a community's infrastructure, including electricity, water, dams, etc.; and of the area's structures, including houses and the buildings in a town or city.

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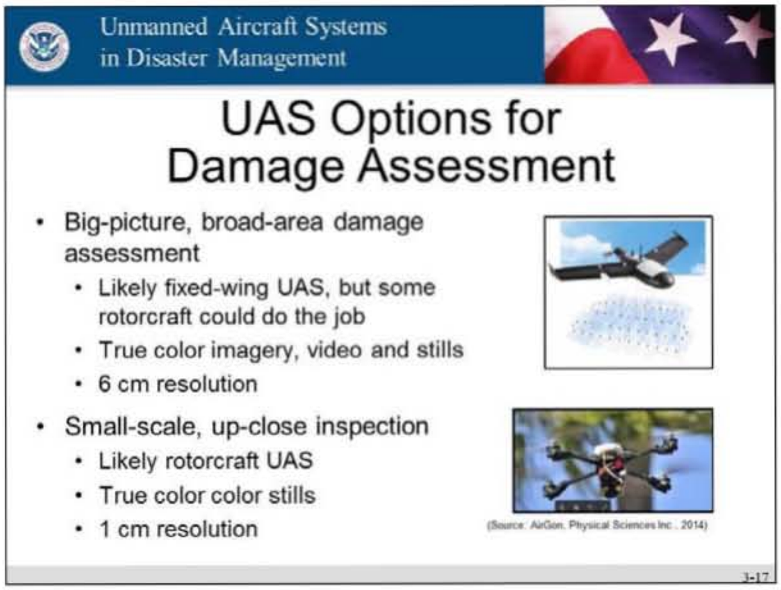

Slide 3-17. UAS Options for Damage Assessment

This approach is similar to what was discussed in the previous section. It is important to note that imagery collected can always be used for multiple purposes. Agencies should think through all the possible uses for UAS to help with their work, and new UAS uses always will continue to emerge.

Broad-area damage assessment would often be conducted with a fixed-wing UAS, because they tend to have a longer battery life because of more efficient flight. Small-scale and up-close damage assessment would tend to be conducted with a rotorcraft UAS, because of its hovering ability and ability to fit into tighter spaces. However, this is not set in stone and various platforms can be used for different missions.

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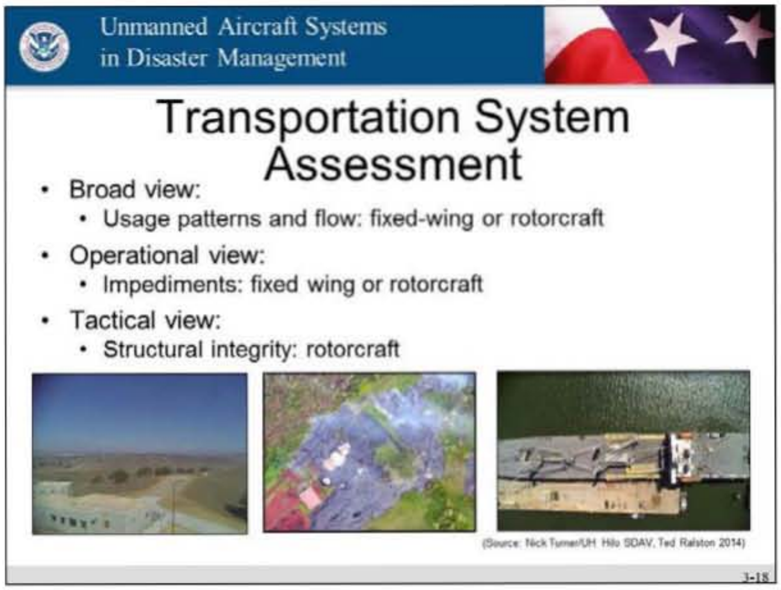
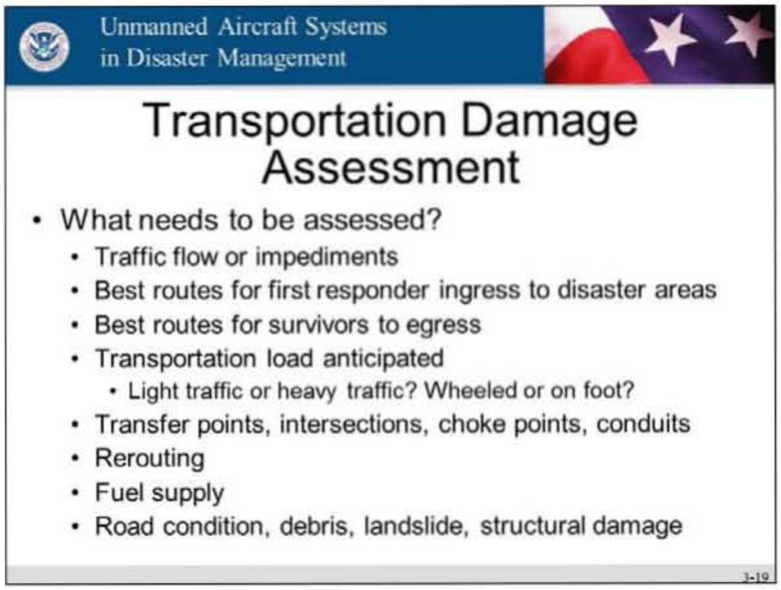


Slide 3-18. Transportation System Assessment

Transportation and access are often the first conditions that must be assessed post-disaster. UAS can assist by providing clear, detailed imagery of specific nodes in the transportation network quickly.

Key Point: Whether a broad view of a large area, an immediate operational view of an event underway, or a tactical view in support of an impending action, a UAS system can assist in assessing transportation system viability.

Participant Notes:

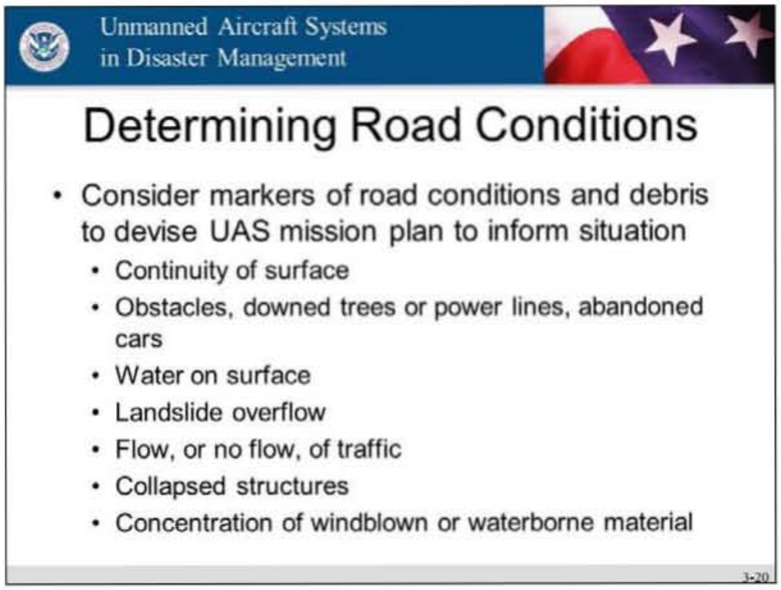


Slide 3-19. Transportation Damage Assessment

Key Point: The starting point is to understand what needs to be assessed, at what accuracy or resolution, at what frequency, as needed by the point-of-contact for the mission inside the ICS structure and his or her engineers to understand the transportation system viability or damage. Once that has been decided, the sensor, UAS, and mission plan can be created.

Be aware that UAS use for transportation damage assessment could create opportunities for image collection that could violate individuals' privacy, particularly at low altitude, so carefully consider data retention and data security rules when using UAS for this type of mission. Collecting personal identifiable information (PII), such as addresses, license plate numbers, faces, etc., could violate someone's privacy. Participants should consult with their agencies to understand their guidelines on gathering information and whether new policies and procedures need to be developed to address the collection of data and imagery, including PII, while using a UAS.

Participant Notes:



Slide 3-20. Determining Road Conditions

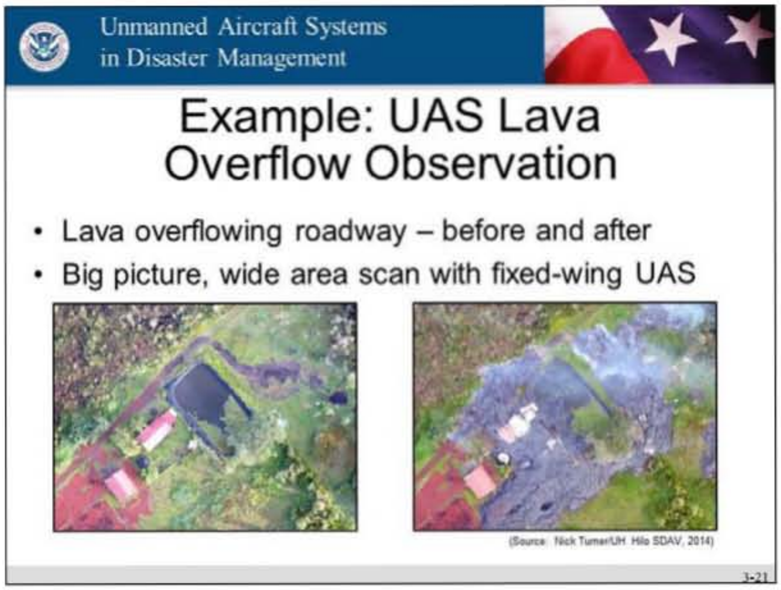
Road conditions are an important subset of the transportation system.

The process for determining best use of UAS to assist commanders in gaining an understanding of road conditions follows the same flow as transportation systems in general.

Key Point: It may be important to engage engineers early on to gain knowledge of specific measurements that need to be made such as surface slope, cracks in roadway or structure, or 3D mass assessment of accumulated debris in order to calculate road bearing strength and threats to roadway structures such as causeways, bridges, and retaining walls.

Sensors, software, and the UAS system that will do the job can then be chosen.

Participant Notes:



Slide 3-21. Example: UAS Lava Overflow Observation

e.g. **Example:** This example of UAS use in road condition assessment comes from the "June 27, 2014, lava flow" in Pahoa, Hawaii, a small town on the eastern flank of Kilauea Volcano.

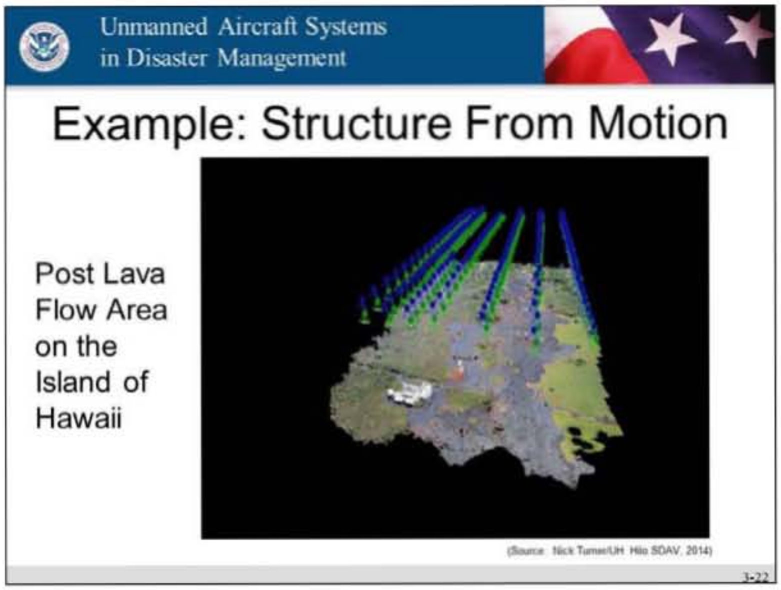
In November 2014, the general need was to identify areas of isolation created by lava flowing over roads. Because a large area was of interest and the measurement was straightforward—is there lava over the road, approaching the road, or being halted and will not threaten the road—the choice was made to use a fixed-wing UAS with a consumer-level camera.

The work was done in total coordination with the point-of-contact for the mission inside of the ICS structure, and with other airspace users and ground operations.

The photomosaic on the left shows lava approaching a farm road and, three days later, overflowing that road.

This information was included in developing a work-around solution for this section of the community.

Participant Notes:

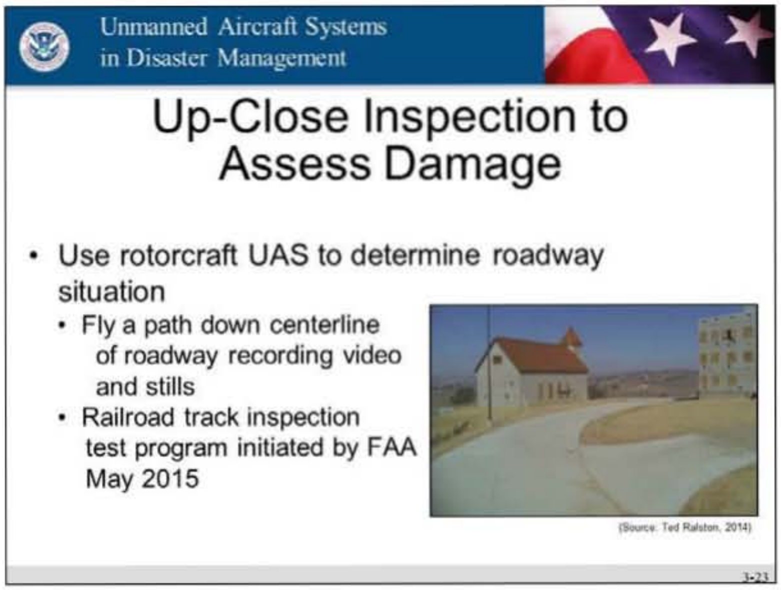


Slide 3-22. Example: Structure from Motion

e.g. **Example:** Depiction of a more complicated terrain situation is illustrated here, where a structured collection flight was conducted by a fixed-wing UAS over the recent Kilauea lava flow. The blue and green symbols represent camera position and orientation along the collection path, producing the 3D surface depiction of the hardened lava surface.

Key Point: Photogrammetry is the process by which an individual can create 3-D models by taking a series of 2-D images with a camera attached to a UAS and using software to convert them into a model such as in this slide, which looks similar to a video. A UAS-generated surface model is a new capability not widely available previously, but useful now for more precise disaster analysis in support of the decision process of the point-of-contact for the mission inside of the ICS structure. Periodic reassessment can be used to observe progressive distortion in the surface, useful for geologists in predicting potential lava outbreak.

Participant Notes:



Slide 3-23. Up-Close Inspection to Assess Damage

A unique capability that UAS possess is that of maneuvering in small and tight areas, supporting deployed task teams, where aircraft-based support imagery has not been possible. One example is that of detailed, up close roadway inspections, as may be required to determine remaining bearing strength.

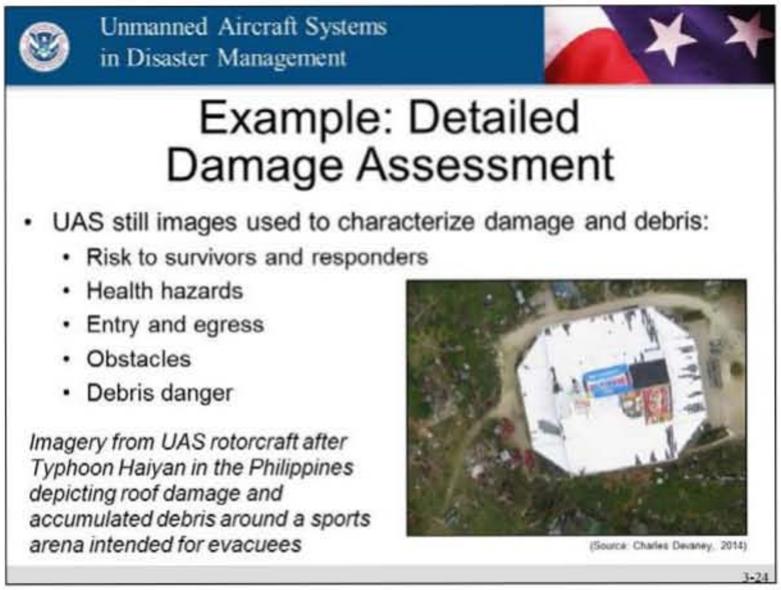
e.g.

Example: The example shows an experiment wherein a small UAS is tracking down the centerline of a roadway in a simulated examination of a roadway post-disaster. With the UAS flight navigation capability tied to geospatial reference data, this kind of inspection is feasible even for remote areas where inspectors or engineers lack access.

Recently a program was launched with the FAA to develop UAS-based inspection capability for railroad tracks as much as 200 miles from launch origin.

Key Point: It will take additional system development in reliability and safety to put this capability into common use. An important part of that development is getting disaster operations users in on the projects early.

Participant Notes:



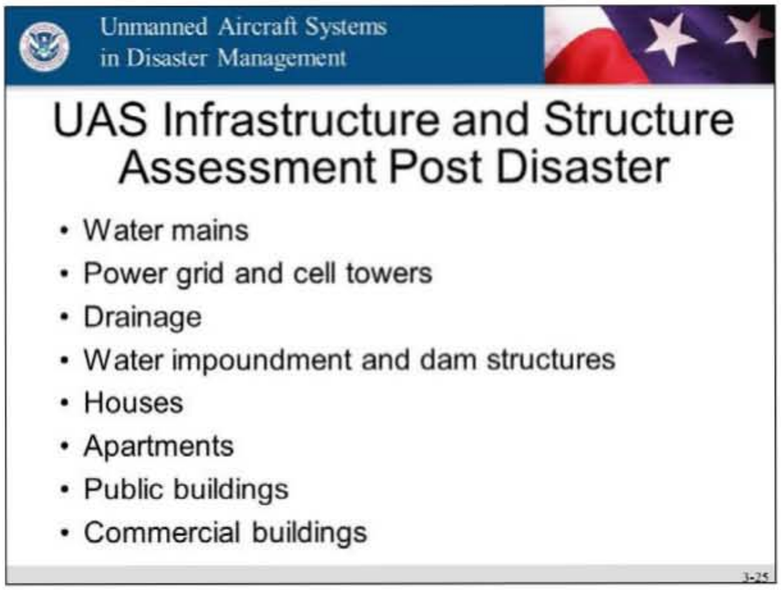
Slide 3-24. Example: Detailed Damage Assessment

Example: In the case shown here, a sports arena intended for use as a shelter for refugees post-disaster was itself damaged by the typhoon. Quickly determining the overall damage and debris accumulation picture was an important part of the decision process of whether to use this structure.

A small, consumer-grade rotorcraft was flown overhead to collect simple still pictures, one frame of which is illustrated here. This allowed local authorities to make an accurate decision quickly without having to make a manual survey.

Key Point: In this case, the response team itself was able to make its own decisions without having to call out for overhead inspection by a supporting air group, as would normally be the case. Secondarily, the use of simple, consumer-level systems was effective in winning approval from the local community.

Participant Notes:



Slide 3-25. UAS Infrastructure and Structure Assessment Post Disaster

Key Point: As assessments are expanded to the broader infrastructure, different sensors and sensor orientation may come into the picture. Whereas a pure vertical orientation of the camera on the UAS is appropriate for mapping and big-picture awareness, an oblique orientation of camera may be needed to produce the 3-D graphic representations of buildings, power grid, and landforms.

Participant Notes:

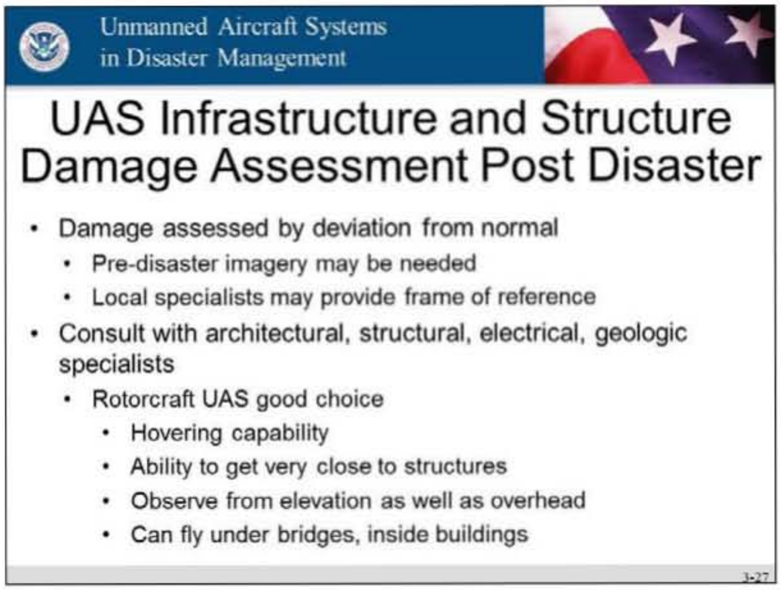
Slide 3-26. Example: Damage Assessment Napa Earthquake 2014

e.g. **Example:** Here a consumer-level rotorcraft was able to collect imagery illustrating the close-up details of damage from a position not available from the usual ground perspective. Engineers can use this imagery to help make decisions on the stability of structures.

Harnessing the capability of UAS into a reliable, dependable, accurate information collection system is the challenge, so that information of the quality illustrated can become the standard.

At the same time, the collected information must be protected from unauthorized access, must be configured to feed into the reporting and analysis flow up to the point-of-contact for the mission inside of the ICS structure, and must be archived and saved, in a responsible and legal manner. An agency must include in the development of its UAS program how it will protect the data gathered by UAS at the time of collection and once stored. Some agencies may use as a guideline protocols that they already have in place on protecting data that was gathered using other tools such as helicopters and body camera. If data and imagery gathering is new to an agency, or the protection protocols need to be improved or expanded for UAS, the agencies should seek guidance from their internal legal and privacy departments and reference documents such as the Department of Homeland Security's *Best Practices for Protecting Privacy, Civil Rights & Civil Liberties In Unmanned Aircraft Systems Programs*, released on December 18, 2015.

Participant Notes:



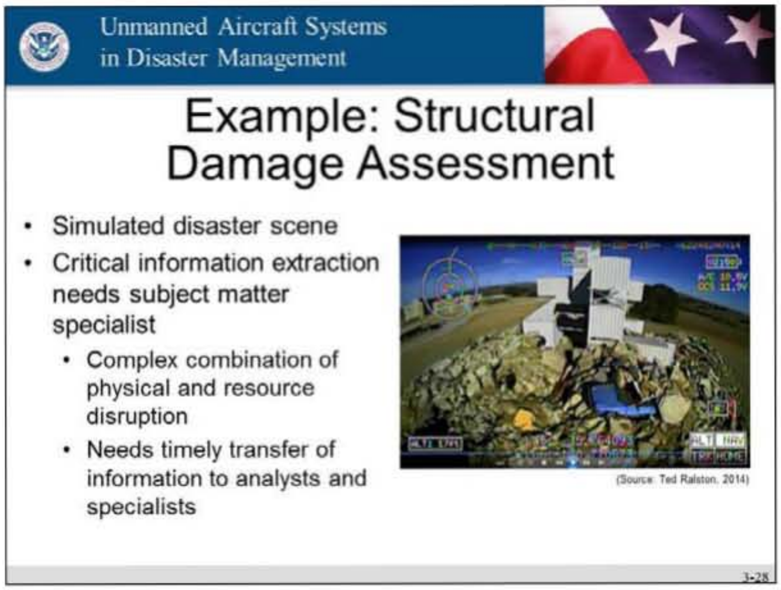
Slide 3-27. UAS Infrastructure and Structure Damage Assessment Post Disaster

With the infrastructure imagery collected post-disaster, the analysis of that imagery may require local experts, engineers, and structural specialists as part of the review team to support the decision process of the point-of-contact for the mission inside of the ICS structure. Post-flight processing by feature-extraction software may be indicated.

Key Point: This implies a level of analysis beyond the training for forward-deployed response teams, suggesting that a communication method for getting the imagery quickly sent to a back area for analysis may be necessary.

Rotorcraft UAS are the likely choice for these operations, given their hovering ability and ability to fly close to structures for an up-close view of damage. In addition, rotorcraft can fly under bridges to assess their level of damage and assess their stability, and some rotorcraft can fly inside buildings, though maneuvering through corridors may be challenging.

Participant Notes:



Slide 3-28. Example: Structural Damage Assessment

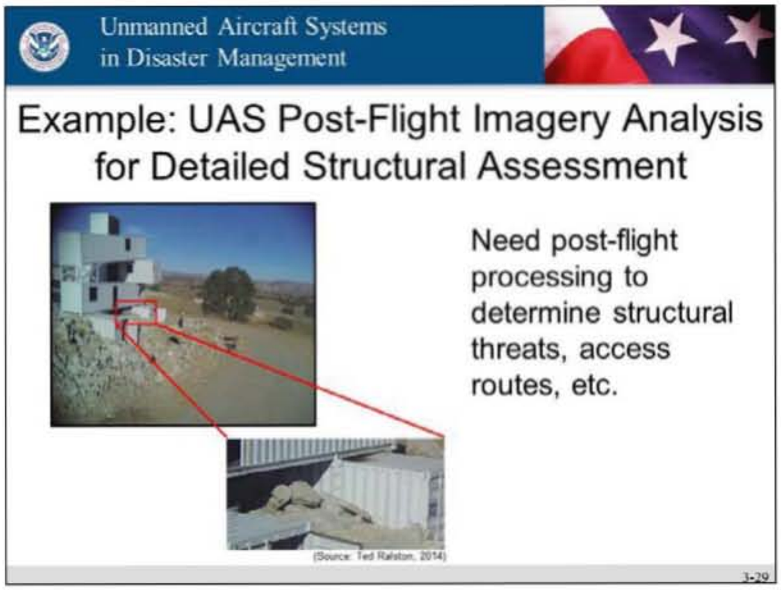
Example: This is an example of a 'rubble pile' training area, where the UAS is being used to complement the observations that can be made from the ground.

An important distinction is that UAS could perform this information collection far away from the nearest access for responders, well before the responders arrive on scene.

The imagery shown is a typical screen on a ground controller, or FPV screen (first person view), as it is sometimes called. To use this information effectively, the operator needs to understand what is important to observe and report, and needs to be conscious of sun angle, shadow, and other photography impedances such as rain, fog, or dust in the air. Deducing the key observables from the screen takes training. Furthermore, the downlinked video may be at a lower resolution than the HD recordable on board.

Key Point: It is almost assured that more analysis of the imagery will be required to extract the greatest value in damage assessment. This implies a communication capability in place between the UAS team that is forward deployed and the analysis team in a back area, functioning via a pre-defined analytic workflow.

Participant Notes:



Slide 3-29. Example: UAS Post-Flight Imagery Analysis for Detailed Structural Assessment

Key Point: UAS can get in close, well forward of the responder team, providing timely imagery with orientation and resolution very capable of supporting damage assessment and assisting the responder decision process.

Participant Notes:

Slide 3-30. Example: UAS Imagery Helped 2014 Napa Earthquake Damage Assessment

Key Point: Up close inspection supplements traditional ground-based assessments, leading to more accurate results, better decisions, and faster overall triage.

In this case, images from a rotorcraft UAS helped engineers determine that a historic church was not too heavily damaged and could be saved. A ground-based damage assessment team previously had red-tagged it, but could not see the damage from above since they did not have a UAS.

Participant Notes:

Slide 3-31. Example: Post-Processing for Damage Assessment in Philippines

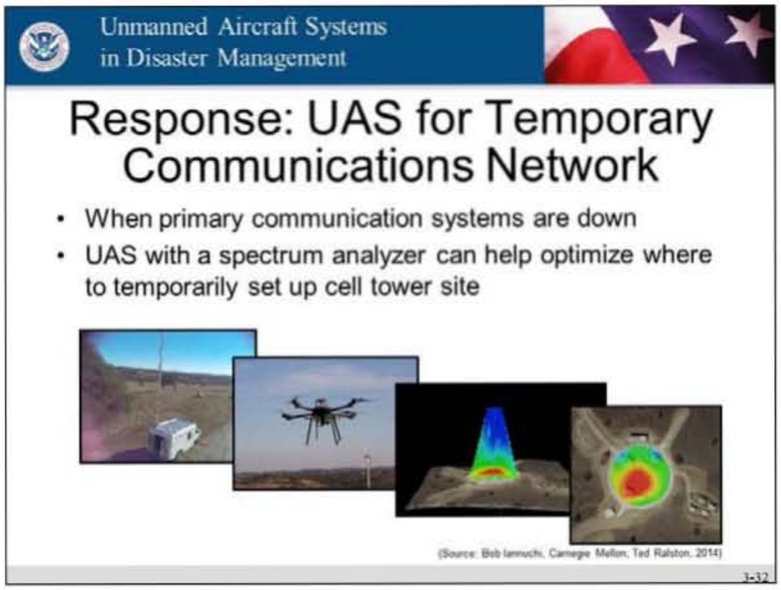
Imagery collection and processing capability are expanding rapidly, increasing the capability of the forward team, as well as the back area support analysts to produce useful information faster. The traditional 'photograph' is giving way to 'structure from motion,' one form of feature-extraction and superposition modeling, resulting in superior 3-D depictions of complex infrastructure from simple cameras on UAS.

e.g.

Example: In the example shown, a five-minute quick flight just above treetop height along one side of this burned-out structure in the Philippines, while taking still photographs on a random flight path, enabled 'structure from motion' software to construct this 'point cloud 3D solid' depiction on the laptop. A second pass at a lower altitude would have given the software enough information to remove the canopy effect, depicting the tree trunks properly.

Key Point: UAS, sensors, and software are becoming very powerful generators of insight that is useful in disaster management.

Participant Notes:

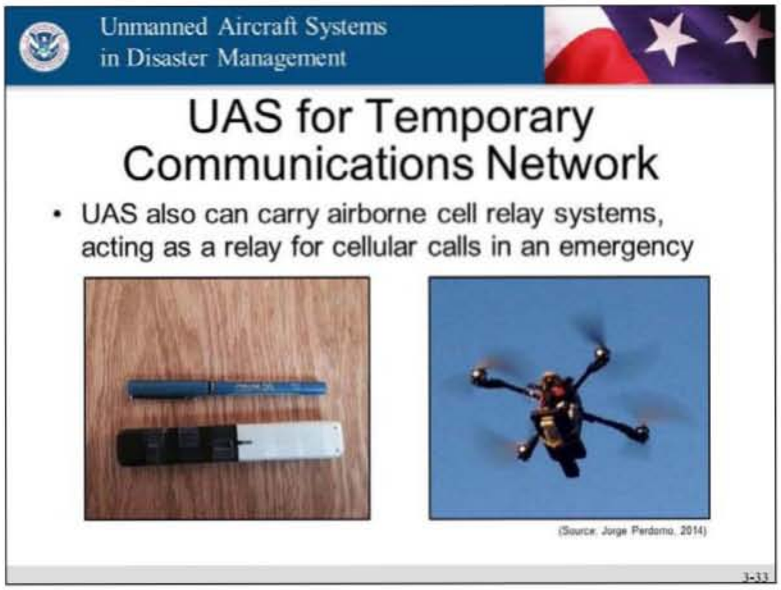


Slide 3-32. Response: UAS for Temporary Communications Network

Example: In this example, a temporary cell tower is being placed in service and a small rotorcraft UAS carrying a test emitter is flown through the community airspace to test the electromagnetic strength pattern of the tower.

Based on the spectrum strength results, tower position can be optimized, while decisions can be made regarding 'quiet zones' where signal shielding occurs.

Participant Notes:

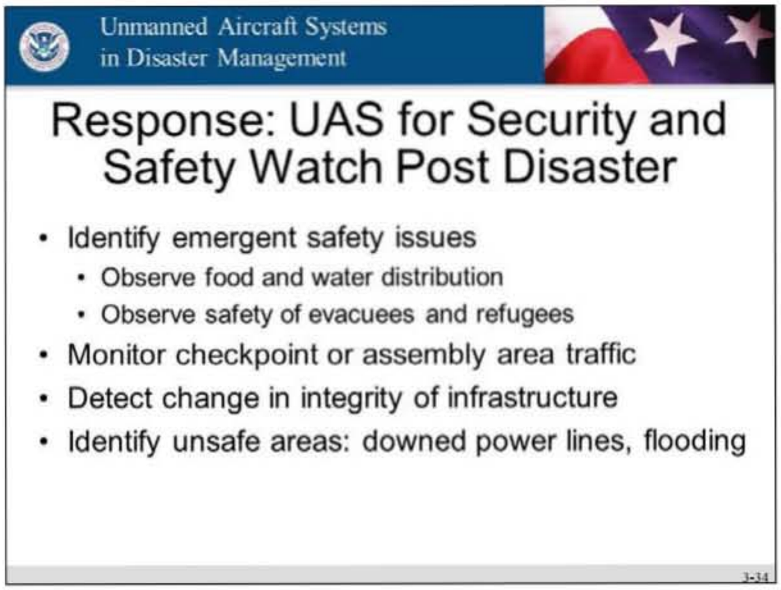


Slide 3-33. UAS for Temporary Communications Network

Example: Where no cell spectrum is available, a small relay payload can be carried by a hovering rotorcraft or orbiting fixed-wing UAS, bringing at least temporary communications back to an area affected by disaster.

For continuous operation, a cyclic flight sequence would be needed, changing batteries and recycling the flight, whether rotorcraft or fixed-wing.

Participant Notes:



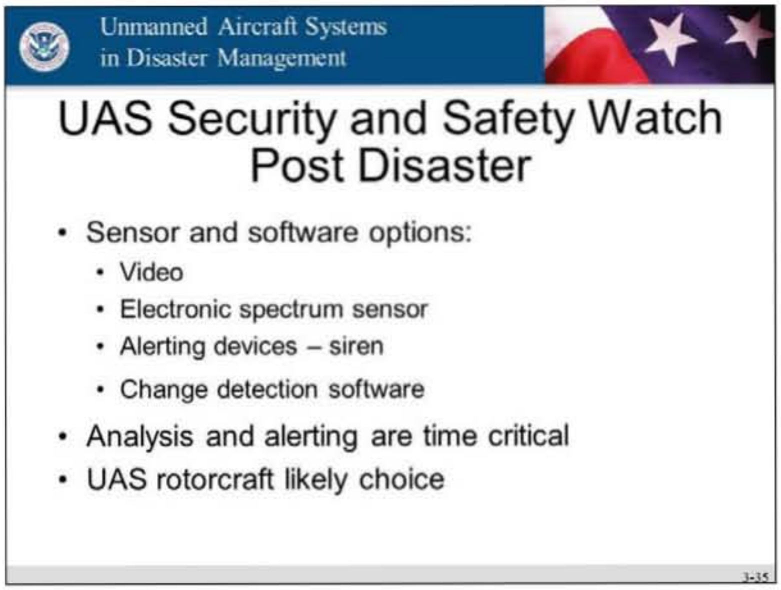
Slide 3-34. Response: UAS for Security and Safety Watch Post Disaster

UAS can be put to many tasks in the post-disaster time frame when security and safety watch become important. At these times, orderly recovery, requiring periodic overview observation, imagery, and mapping is in order.

Key Point: UAS can be employed by local units under the direction of the point-of-contact for the mission inside of the ICS structure to collect periodic imagery and process it rapidly for local review and decision-making regarding orderly progress of recovery. Both fixed wing for wide area coverage and rotorcraft for detail inspection are logical choices.

Key Point: Any use of UAS for safety and security monitoring must take into full consideration the rights and privacy of the people below.

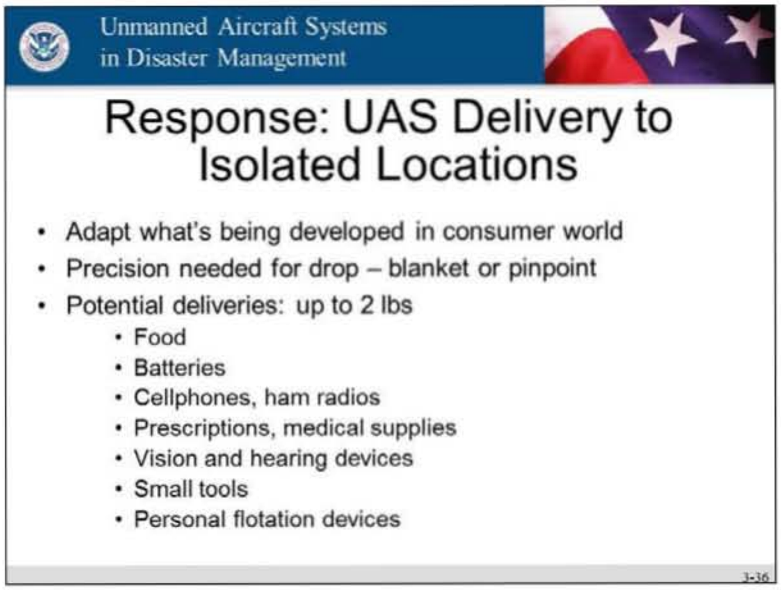
Participant Notes:



Slide 3-35. UAS Security and Safety Watch Post Disaster

For next-level inspection or other local flight mission within the domain of security watch, UAS can be an advantage. Video imaging or periodic photographic coverage may be in order, as well as collecting electromagnetic spectrum data, atmospheric quality data, water quality data, refugee public health data, or providing remote alerting via siren or other attractor device. Rotorcraft are a likely choice for these missions.

Participant Notes:

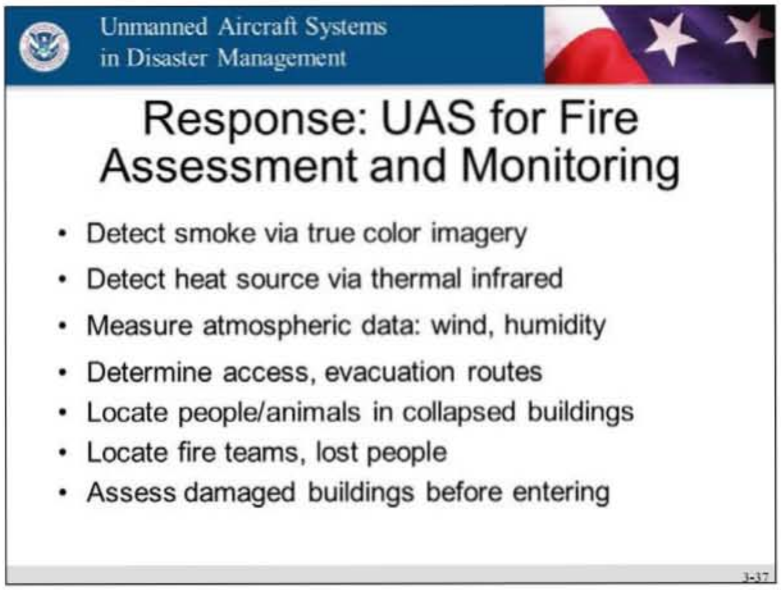


Slide 3-36. Response: UAS Delivery to Isolated Locations

Delivery of small parcels by UAS is a clear future mission, extremely useful in situations where access is limited. Commercial businesses are developing this capability, which can transition to disaster management operations when perfected.

The UAS design and development community would welcome feedback from people in disaster response about the commercial delivery systems under development.

Participant Notes:



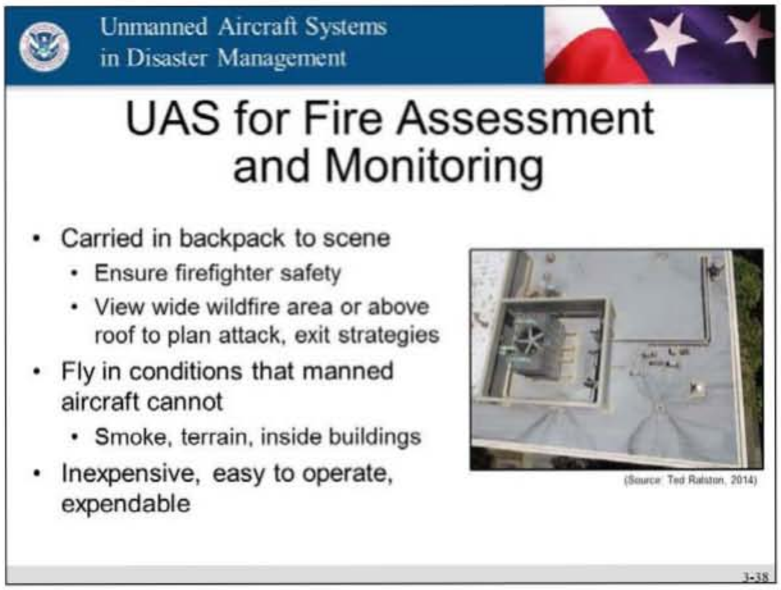
Slide 3-37. Response: UAS for Fire Assessment and Monitoring

UAS can become effective in partnership with manned fire attack teams if properly coordinated. UAS have the additional capability of being easily carried forward with the attack team and being able to measure atmospheric properties and wind to feed the fire-propagation model at macro level.

Beyond the direct fire measurement or imagery, UAS can assist in monitoring the evacuation and ingress routes, providing alerts, and delivering small parcels.

Key Point: Manned air assets are a well-ingrained function of wildland fire fighting; it is important for UAS to be integrated with that function, supplementing manned operations, rather than be separate from it.

Participant Notes:



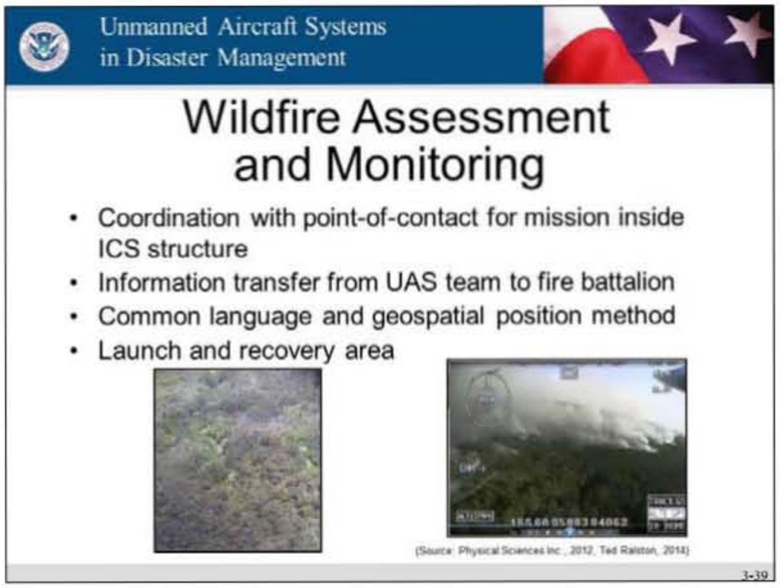
Slide 3-38. UAS for Fire Assessment and Monitoring

Key Point: Fire response teams can use simple, or possibly expendable, UAS for fire assessment and monitoring. UAS in firefighting would primarily be rotorcraft, though fixed-wing UAS would be effective for large-scale wildfires. Getting a top-down roof view is extremely useful in fire attack planning.

Some UAS can be folded and carried to the scene in a backpack by firefighters, who can use UAS imagery immediately to view a wide wildfire area or to see above roof to plan how to approach a fire and determine exit strategies, all of which supports firefighter safety.

UAS often can fly in conditions that manned aircraft cannot, allowing them to fly in some smoky conditions, near uneven terrain, and inside buildings.

Participant Notes:

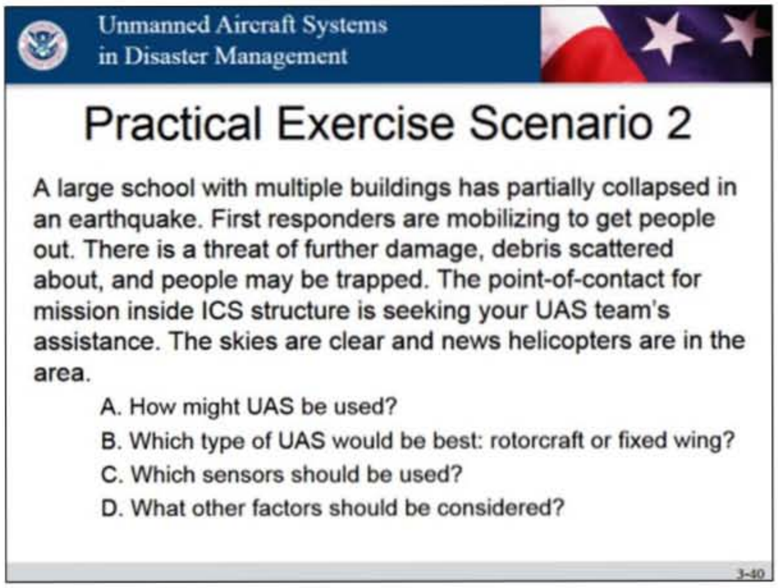


Slide 3-39. Wildfire Assessment and Monitoring

Example: Integration of UAS into wildfire operations will require the same attention and training as introducing any other new technology to the current fire fighting system, through tabletop and field exercises, development of operating protocols, and system/operator certification.

Currently there is a sense of concern over growing 'hobbyist' UAS penetrating wildfire situations in a rogue and unwanted way, without coordination or alignment with existing manned air operations. This situation is another factor that must be resolved to enable fully-trusted use of UAS in wildfire situations.

Participant Notes:



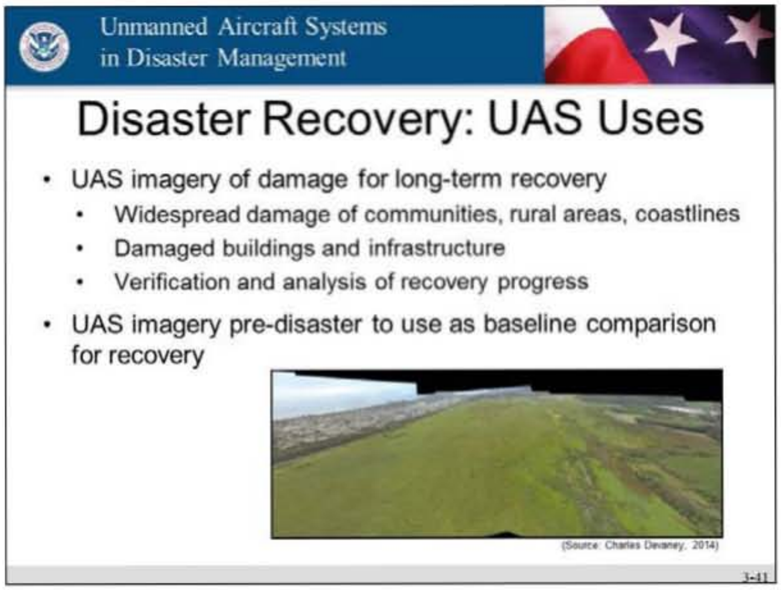
Slide 3-40. Practical Exercise Scenario 2

The exercise presents a possible scenario in which UAS could be used. Participants will apply information learned in the modules to help answer the questions.

The instructor will ask participants either to break into groups to discuss the scenario and then discuss the possible answers together as a class, or not break into groups and discuss the questions together, at the discretion of the instructor.

You can ask the participants if they would like to take a 5-minute break after this exercise.

Participant Notes:

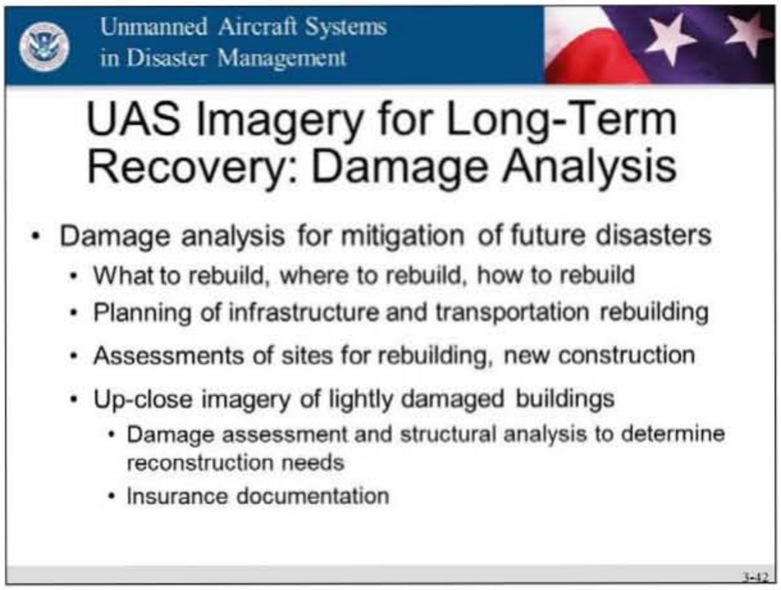


Slide 3-41. Disaster Recovery: UAS Uses

Long-term recovery from disasters requires a determination of what must be done to prevent re-occurrence. UAS can contribute to this understanding by enabling damage measurement in topographic and other forms to assist in recovery decisions.

To aid the long-term process, it is possible to use UAS to collect specific site data in areas likely to be impacted, such as coastal or watershed flood control areas, river basins, dams, embayments, waterfront infrastructure, etc. in advance of a disaster occurring. These data, part of a periodic surveillance and site review, can serve as a basis for making decisions for long-term recovery.

Participant Notes:

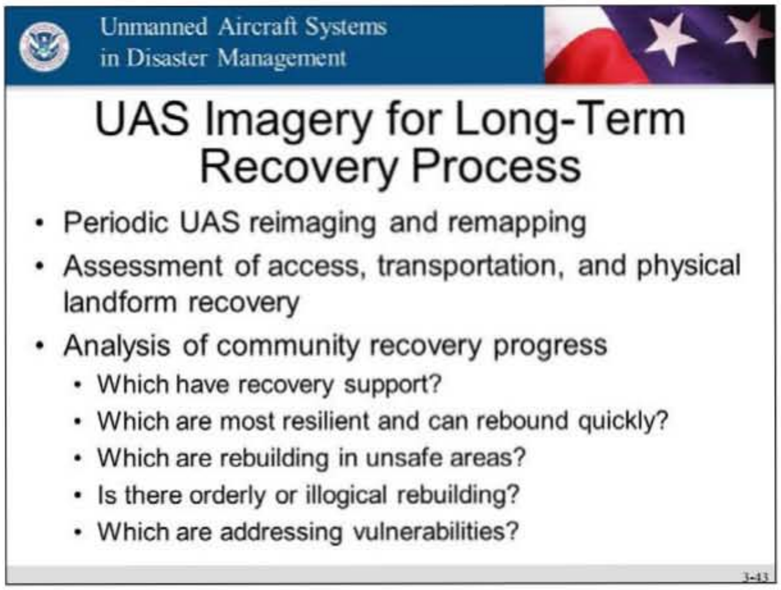


Slide 3-42. UAS Imagery for Long-Term Recovery: Damage Analysis

Long-term recovery decisions must be informed with as much specific information as possible of the current condition. UAS can perform much of that collection.

UAS are a useful tool to help analyze the damage from a disaster, which is key for the mitigation of future disasters. Post-disaster imagery can help with the decision of where to rebuild, with assessments of sites for rebuilding and new construction, and for the rebuilding planning of infrastructure and transportation that was damaged in the disaster. Furthermore, UAS can provide up-close imagery of lightly damaged buildings to help with damage assessment and structural analysis to determine what reconstruction is needed. This imagery also could greatly assist with insurance documentation.

Participant Notes:



Slide 3-43. UAS Imagery for Long-Term Recovery Process

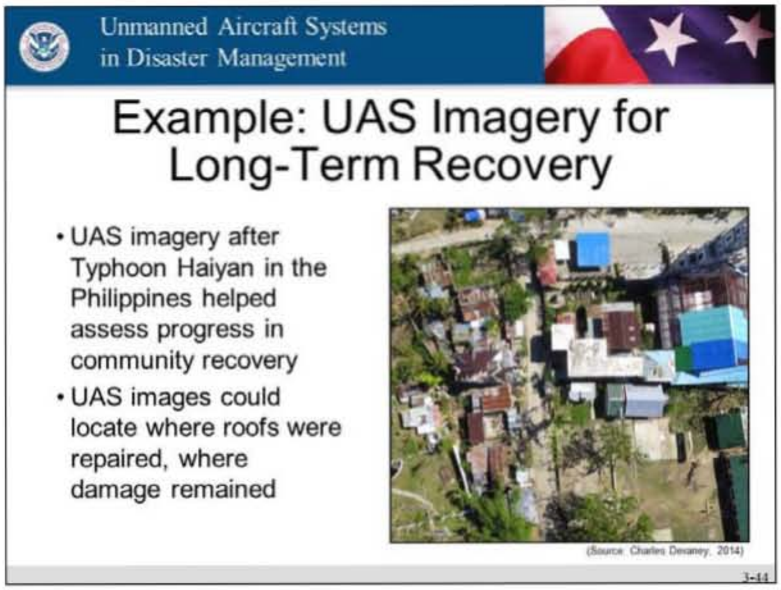
Key Point: UAS can help the disaster recovery effort by periodically reimaging and remapping the area to assess any improvements in access and transportation, as well as changes in physical landform recovery.

Furthermore, UAS imagery can help with an analysis of the community recovery progress to determine which communities are recovering quickly, where unsafe rebuilding is occurring, and where vulnerabilities remain that need to be addressed.

This use of UAS can help socialize the UAS concept and assist in developing system operational strategies in a less-stressed environment, since it is not occurring in the fast-paced emergency phase of disaster response, but rather during the long-term recovery process.

Any capture and storage of images raises potential privacy and civil liberties considerations that will need to be addressed in an agency's UAS plan and potentially in a Privacy/Civil Liberties Assessment. Long-term recovery may imply long-term retention of UAS imagery, so as part of a UAS plan an agency must determine how long it should allow data and imagery to be retained. A Privacy/Civil Liberties Assessment is a tool an agency can use to address the P/CL issues as it develops its plan and policies. Module 5 will provide some examples.

Participant Notes:

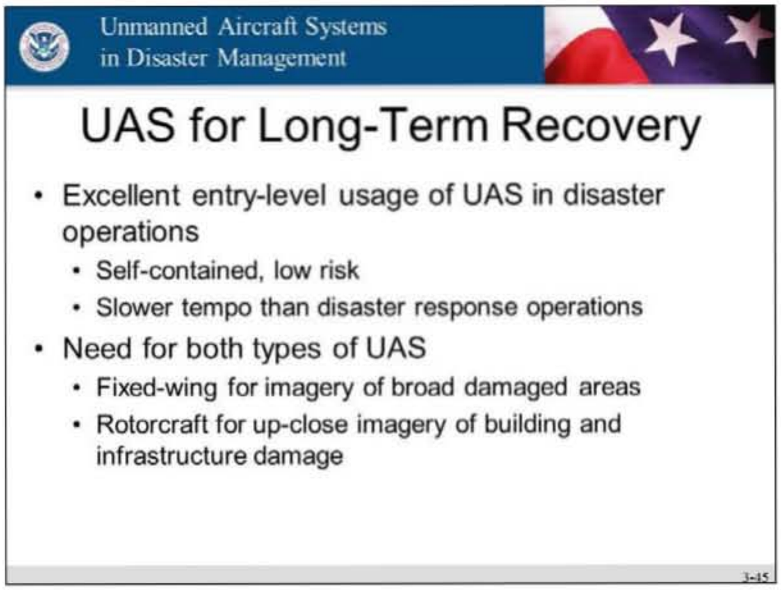


Slide 3-44. Example: UAS Imagery for Long-Term Recovery

e.g.

Example: UAS imagery during the recovery phase after Typhoon Haiyan in the Philippines helped disaster management at the local leadership level, as local officials were able to evaluate the overall damage situation in order to plan out the recovery process. Periodic re-flights were planned to check on progress.

Participant Notes:

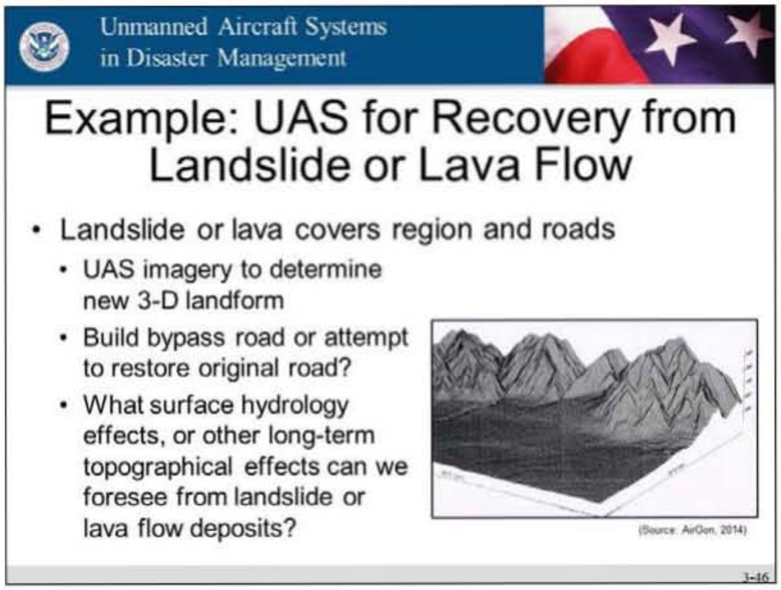


Slide 3-45. UAS for Long-Term Recovery

Key Point: UAS use during situations that are not immediate emergencies, such as disaster recovery and disaster mitigation, are a great way to help socialize the UAS concept and assist in developing system operational strategies in a less-stressed environment.

Both fixed-wing and rotorcraft UAS may be needed, depending on the disaster recovery operation.

Participant Notes:



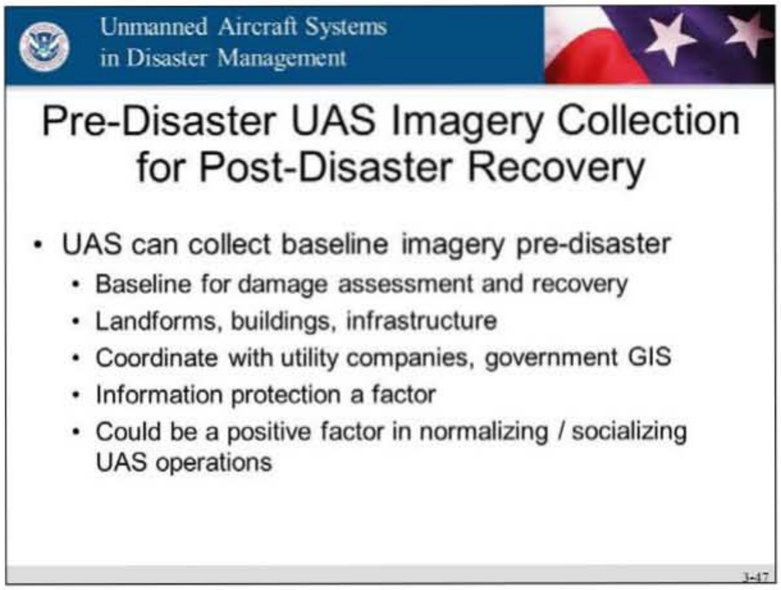
Slide 3-46. Example: UAS for Recovery From Landslide or Lava Flow

Example: Highly accurate local area 3-D topographical surface and volume models can be produced from locally flown UAS surveillance flights to inform decision-makers on risks associated with landform change. Periodic, focused re-flights can be conducted where high risk is indicated.

Key Point: Well beyond 'pictures,' analytic extraction capability will continue to grow, making UAS more useful as the analytic systems advance, sensors and analysis software become tuned to each other, and flight/mission planning becomes simpler.

Disaster recovery user feedback into the UAS design domain is extremely important.

Participant Notes:



Slide 3-47. Pre-Disaster UAS Imagery Collection for Post-Disaster Recovery

Pre-disaster imagery can be extremely important as a reference and coordinating function for decisions in time of disaster, for recovery planning, and for insurance reasons. UAS can contribute markedly to this collection process.

This use of UAS can tie in with normal environmental and infrastructure management, adding value to normal infrastructure management while building UAS capability for the higher-paced disaster time frame.

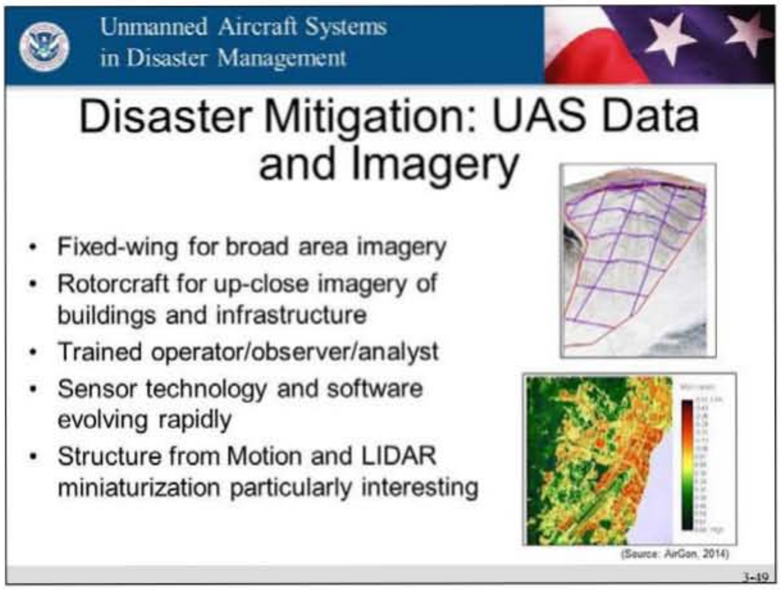
Participant Notes:

Slide 3-48. Disaster Mitigation: UAS for Inspections

Example: The two photos on the left are examples of UAS images of earthen dams, which are subject to condition change based on vegetative growth or removal, as well as water level. The photo on the right is of a power grid system. In both cases, UAS offer insights not easily achieved with normal ground-based inspection.

Key Point: Disaster mitigation requires actions taken in advance that reduce the risk of adverse consequences when disaster conditions arise. Understanding of weak points or points of vulnerability can be enhanced and localized using imagery collected from the altitude and lateral offset perspective of the UAS.

Participant Notes:



Slide 3-49. Disaster Mitigation: UAS Data and Imagery

Sensor and software technology are continually being developed to extract more useful information from UAS flight data, extremely useful in disaster mitigation decision-making.

e.g. **Example:** Simple imagery from consumer-level cameras can be readily converted into three-dimensional land topographical maps for landmass predictive assessment. Relatively simple modification of cameras into near-infrared sensors can result in calculating vegetation stress. Both factors are useful in forecasting for disaster mitigation.

This work can be done at local level in support of local authorities, quickly, and at low cost via UAS.

Participant Notes:

Slide 3-50. UAS Imagery for Disaster Mitigation

e.g.

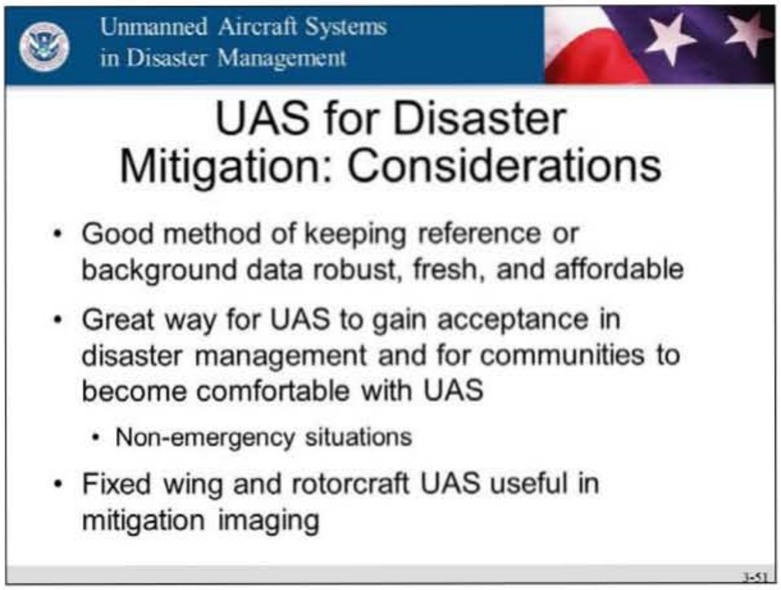
Example: Two examples shown here of useful mitigation information collected by UAS include a refugee assembly site on a military base and a housing development with substantial alteration in the topography.

The growth of vegetation over time around the refugee site may turn into debris during a typhoon and must be kept clear to enable the site to perform its intended function.

The progress in vegetation growth around the housing site will be a factor in retaining ground slopes and preventing landslides.

Monitoring both situations via UAS is important in planning mitigation steps in advance of a storm season.

Participant Notes:

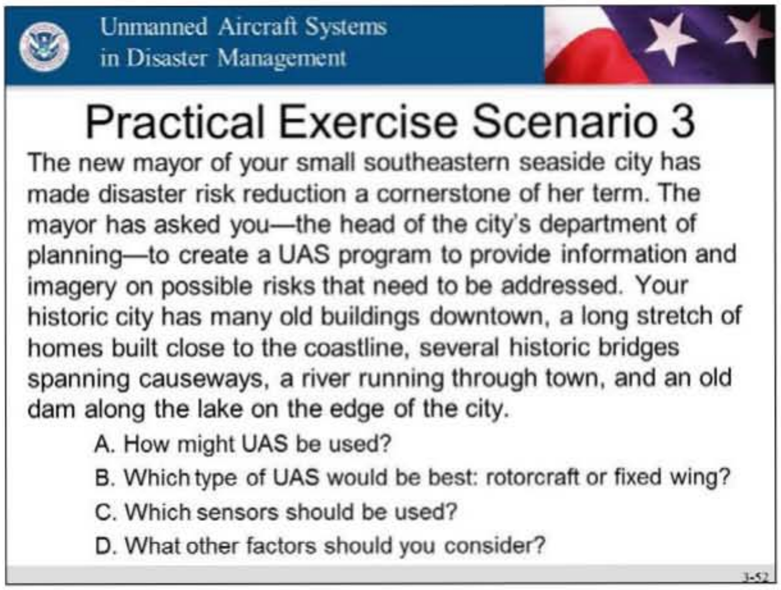


Slide 3-51. UAS for Disaster Mitigation: Considerations

Key Point: UAS are a good partner with urban planners and disaster managers in the continuous mitigation analysis that needs to accompany the spread of urbanization and the interdependence on infrastructure. UAS can be a good method of keeping reference or background data and imagery robust, fresh, and affordable.

UAS use in disaster mitigation also is a great way for communities to become comfortable with UAS.

Participant Notes:

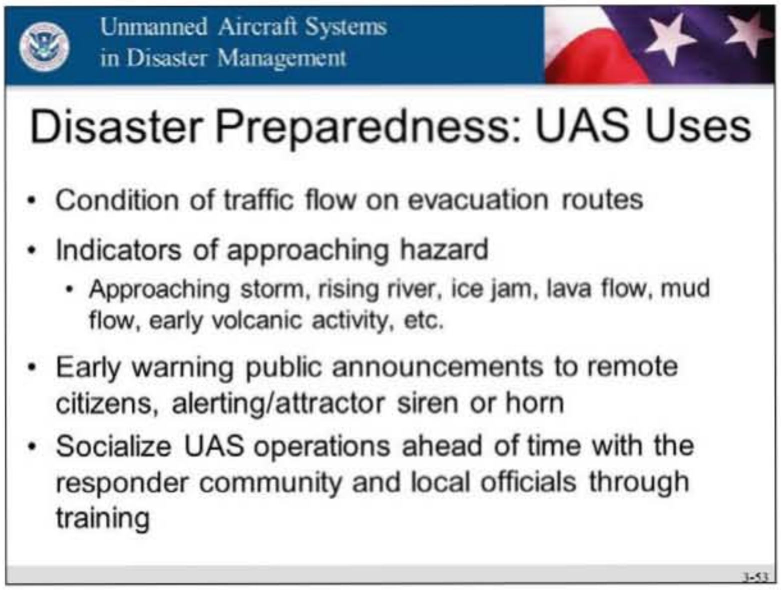


Slide 3-52. Practical Exercise Scenario 3

The exercise presents a possible scenario in which UAS could be used. Participants will apply information learned in the modules to help answer the questions.

The instructor will ask participants either to break into groups to discuss the scenario and then discuss the possible answers together as a class, or not break into groups and discuss the questions together, at the discretion of the instructor.

Participant Notes:



Slide 3-53. Disaster Preparedness: UAS Uses

Whether well in advance of an impending disaster or in the immediate preceding time interval, UAS can be very effective in providing local, specific information useful for disaster preparedness. Information collection to indicate evacuation route status, for example, before landfall of a storm or volumetric measurement of ice jam accumulation upstream of a bridge are two examples of measurements that can be made by UAS that would be helpful to authorities.

UAS also can carry a siren or horn as payload, which can provide early warning public announcements to people in remote locations that are hard to reach by other means.

The same process and considerations apply to UAS employment in disaster preparedness as in the other phases, all starting with the need to define what it is that should be measured, by what means, and at what time interval.

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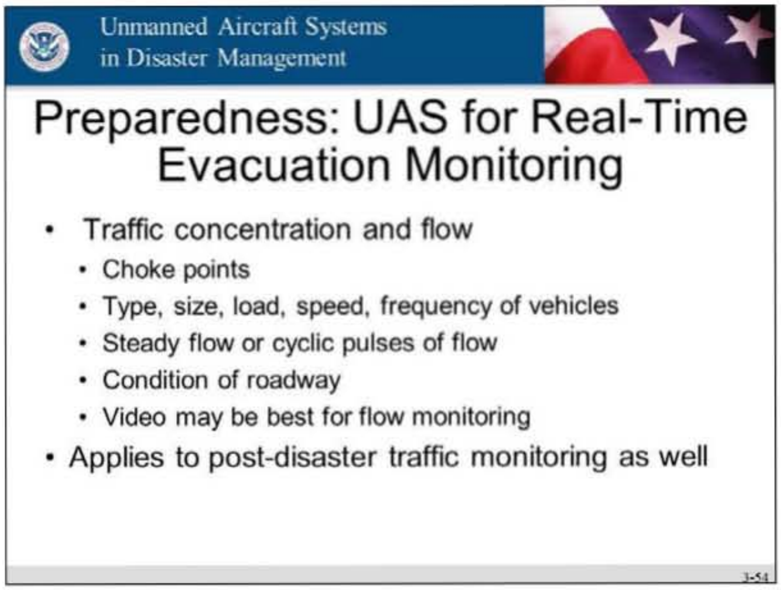
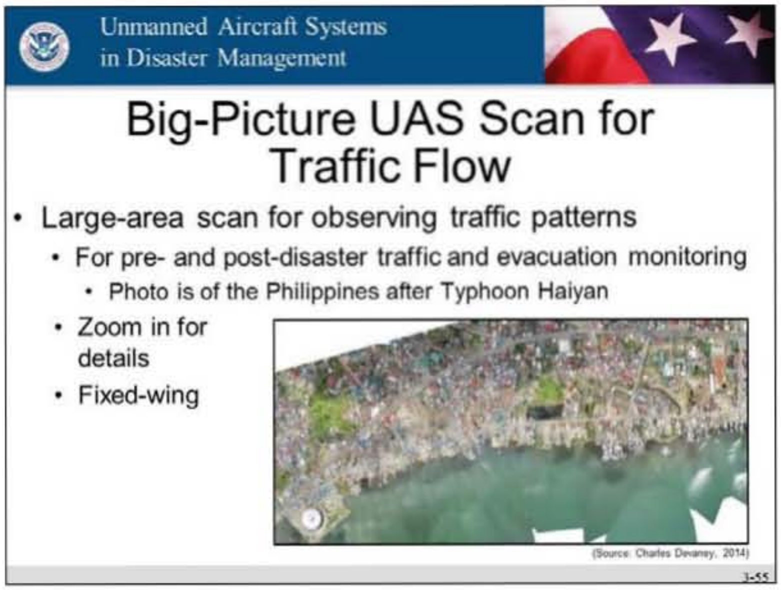


Slide 3-54. Preparedness: UAS for Real-Time Evacuation Monitoring

The operational flow and pattern here is much the same as in the previous examples, with the addition of the dynamic nature of evacuation (or any mass movement of people).

Key Point: Motion assessment implies video coverage for observing dynamic factors, rate patterns, and other flow features less evident in stills.

Participant Notes:



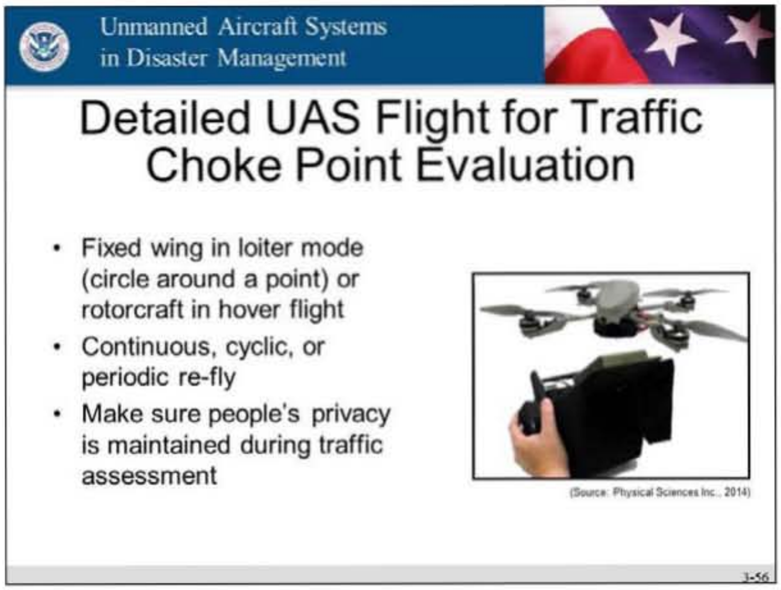
Slide 3-55. Big-Picture UAS Scan for Traffic Flow

Wide scale, big-picture imaging can provide situational awareness of traffic flow for pre-disaster evacuation monitoring to identify areas of traffic congestion and best routes. With these results, local officials are able to observe traffic patterns in relation to occupant density and structural state, to quickly identify choked points or traffic incidents to improve evacuation efficiency.

Example: This image happens to be taken after a disaster, but the concept is the same for pre- or post-disaster evacuation monitoring. The image, a photomosaic derived from stitched together UAS images to create one large image, is of a waterfront area in the Philippines that was hit by Typhoon Haiyan. The state of the overall traffic patterns—of the evacuation of survivors as well as the ingress of responders—needs to be understood quickly by the point-of-contact for the mission inside of the ICS structure.

A fixed-wing UAS with a consumer-grade color camera was flown with an overlapping flight path to collect imagery in sufficient detail to map the entire waterfront area, for quick field generation of high-resolution photomosaics.

Participant Notes:

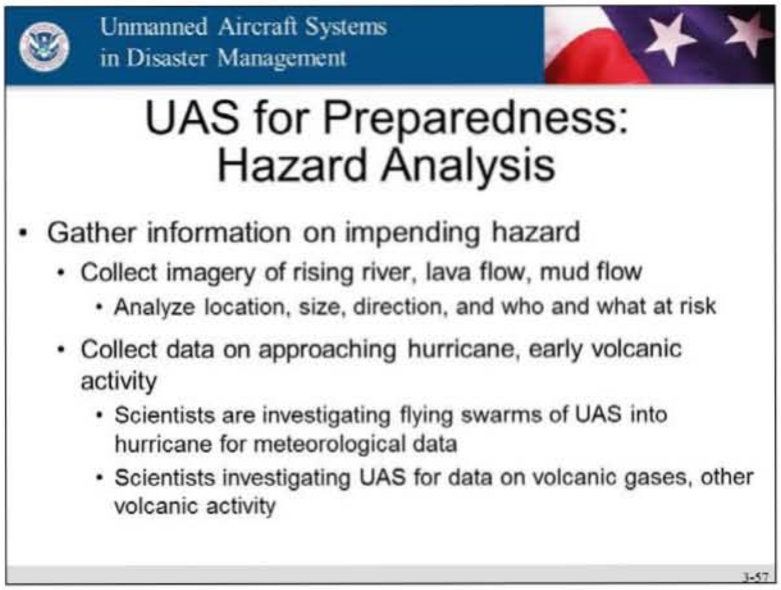


Slide 3-56. Detailed UAS Flight for Traffic Choke Point Evaluation

If a big-picture mosaic revealed a location with a particular choke point that was hindering traffic, it might be appropriate to launch a small rotorcraft UAS (or series of such UAS) to hover over the critical point. This would provide dynamic information over a set time period to assess the problems with the delays, while ensuring that this traffic assessment did not affect people's privacy. Collecting personal identifiable information (PII), such as imagery of license plate numbers and faces, could violate someone's privacy. Participants should consult with their agencies to understand their guidelines on gathering information and whether new policies and procedures need to be developed to address the collection of data and imagery, including PII, while using a UAS.

Key Point: In most cases of UAS support for disaster management, it will be necessary to employ both fixed-wing and rotorcraft systems, as in this case. Rotorcraft can be simple enough to operate that responder teams can use these systems as they would their other tactical equipment. Fixed-wing systems usually are more complicated in mission planning and operation, requiring at least one specialist to be on the team.

Participant Notes:



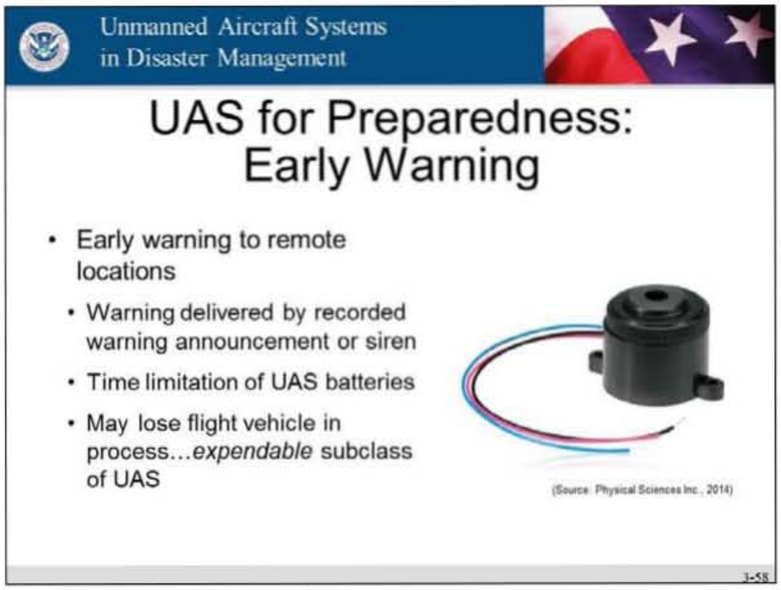
Slide 3-57. UAS for Preparedness: Hazard Analysis

Hazard analysis is the process of looking at an impending disaster situation from a systems perspective, including the collection of atmospheric, oceanic, or public health data that can inform the systems analysis. UAS have the ability to collect that information closely and rapidly, leading to a highly accurate, predictive data stream that has not heretofore been available.

As UAS functionality and sensor capability continue to develop, valid data at the local scale can be collected quickly by UAS for local threat assessment and for feed upward into the overall disaster predictive model.

Scientists at several universities in the United States are testing UAS by flying swarms of very small UAS into hurricane for meteorological data. Scientists around the world also are investigating UAS for data on volcanic gases and other volcanic activity.

Participant Notes:

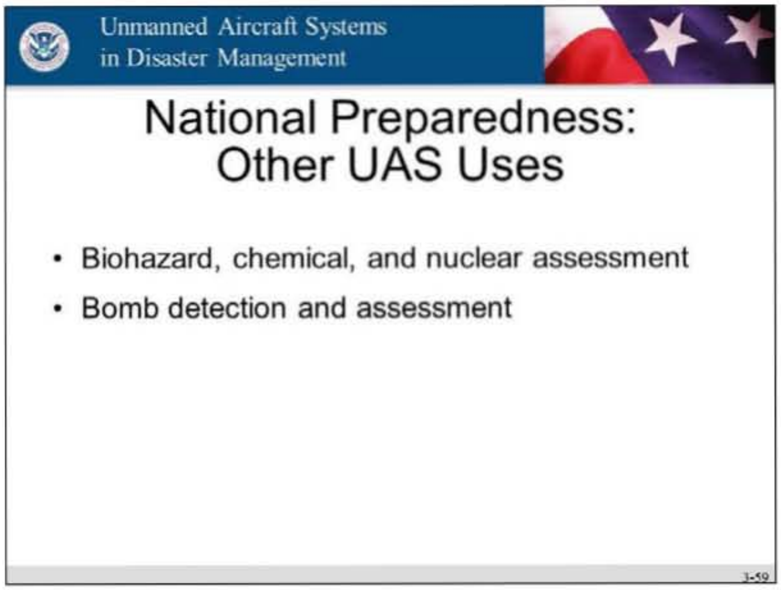


Slide 3-58. UAS for Preparedness: Early Warning

Early warning is a function that UAS can provide by delivering audible messages via siren or other attractor attached to the UAS or by delivering message material. Commercial business interests are working on several possibilities for the delivery of items by UAS, which will be usable in disaster operations.

Message delivery is quite different from imagery collection, to the point that one-way trips may be necessary with expendable UAS, if there is no reliable way to re-launch the UAS post-delivery for a return to base.

Participant Notes:

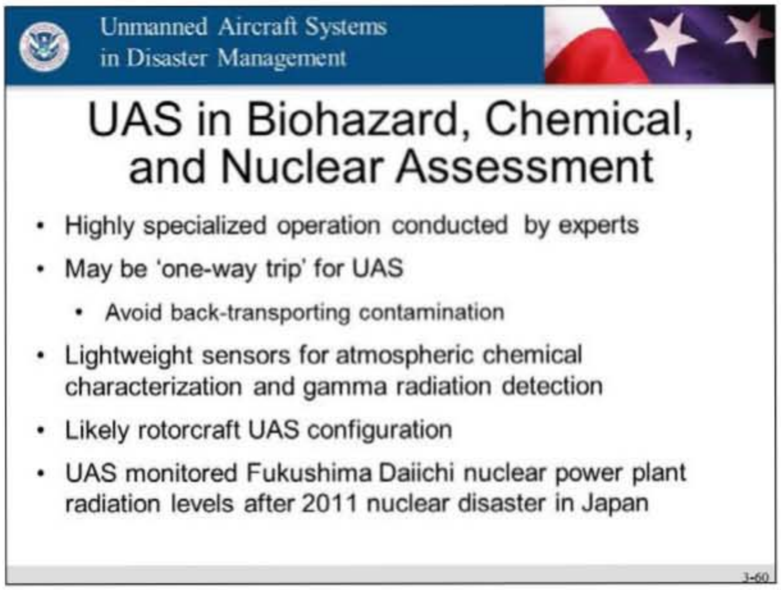


Slide 3-59. National Preparedness: Other UAS Uses

Key Point: Virtually any preparedness function currently performed by manual inspection can be performed by UAS--it merely requires the intelligent and creative use of sensors, analytic software, and the UAS itself.

Especially interesting are inspections or data collection where penetration into the zone itself is hazardous. In these cases, an expendable UAS may be employed to collect the necessary information and the UAS purposefully scuttled to avoid returning with contamination.

Participant Notes:



Slide 3-60. UAS in Biohazard, Chemical, and Nuclear Assessment

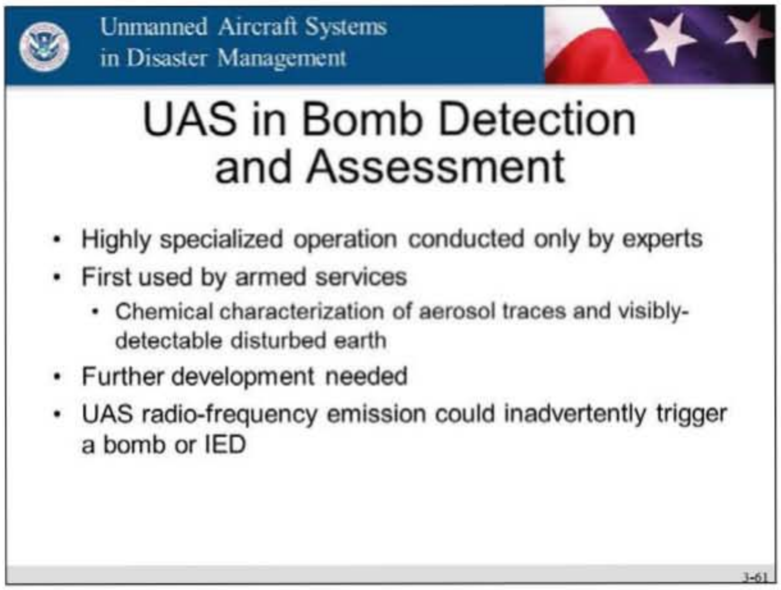
Key Point: Using UAS as one-way sensor carriers into contaminated environments is an important use, even though in some cases the UAS may not be recovered. In such cases, it is important that trained specialists be involved so that the UAS, its electrical system, and its communication system do not become event triggers or otherwise involved in an extension of the disaster.

UAS can carry lightweight sensors for atmospheric chemical characterization and gamma radiation detection, keeping personnel further away from the contaminated site.

e.g.

Example: UAS were flown with radiation sensors to monitor the Fukushima Daiichi nuclear power plant radiation levels after the 2011 nuclear disaster in Japan.

Participant Notes:

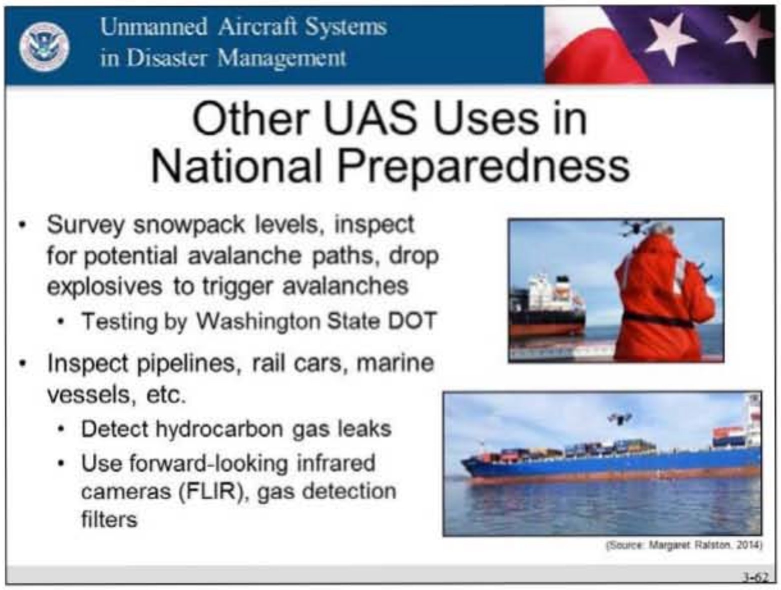


Slide 3-61. UAS in Bomb Detection and Assessment

Key Point: Using UAS as one-way sensor carriers into bomb threat environments is another important use, even though the UAS may not be recovered.

In such cases, it is important that trained specialists be involved so that the UAS, its electrical system, and its communication system do not become event triggers or otherwise involved in an extension of the disaster.

Participant Notes:



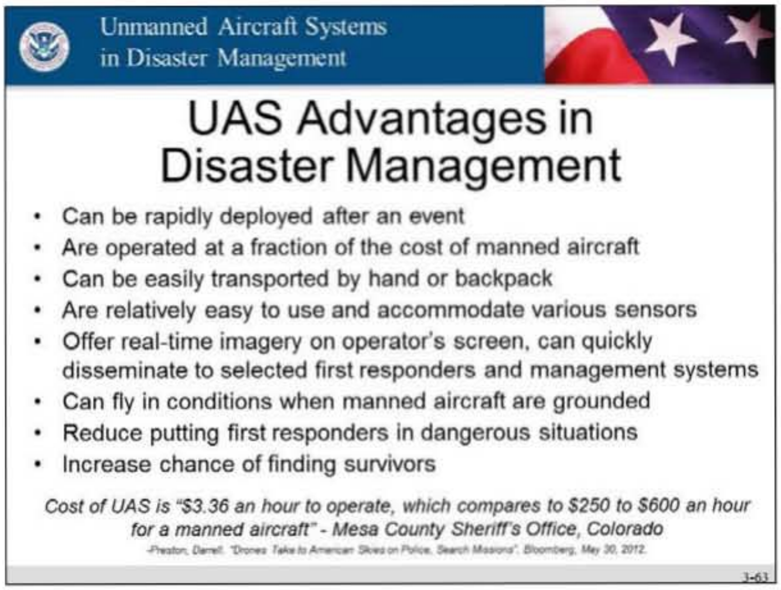
Slide 3-62. Other UAS Uses in National Preparedness

The future is wide open for progressive miniaturization of sensors, increasing sensor capability, increasing UAS capability, more comprehensive software analytics, and cost reduction. At the same time, operations of UAS will continue to get simpler with more assurance of mission completion.

Key Point: Washington State DOT has been testing UAS to survey snowpack levels, inspect for potential avalanche paths, and drop explosives to trigger avalanches.

UAS also can be used to inspect pipelines, rail cars, marine vessels, etc., and detect hydrocarbon gas leaks.

Participant Notes:



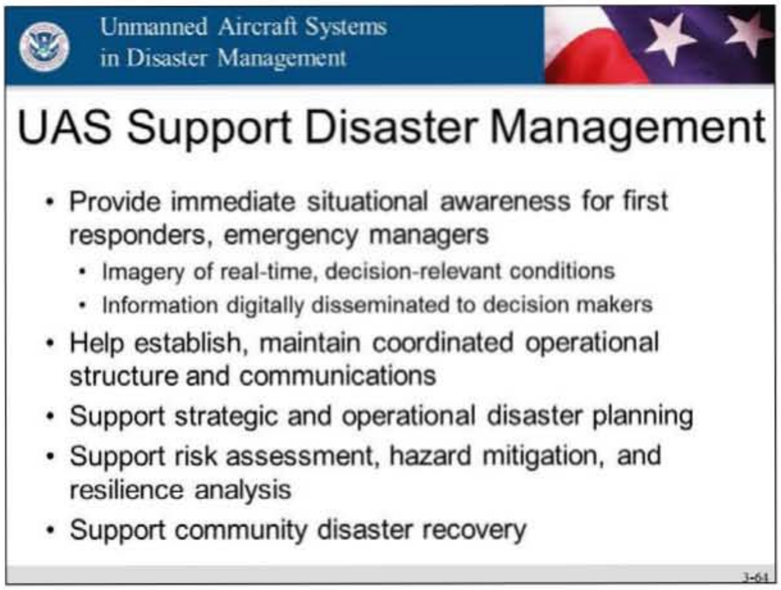
Slide 3-63. UAS Advantages in Disaster Management

Experience in disaster operations with UAS is just beginning in the United States, following actions taken by Congress and the FAA to make UAS available to responders.

The advantages of UAS, measured by lower cost, more rapid results, new and useful sensors, most advantageous placement of sensors, ubiquitous operations, and higher level of information provided to ICs, are expanding rapidly as the UAS industry grows at a significant pace.

a. Small and portable
b. Low cost
c. Many accommodate multiple sensor payloads
d. All of the above

Participant Notes:

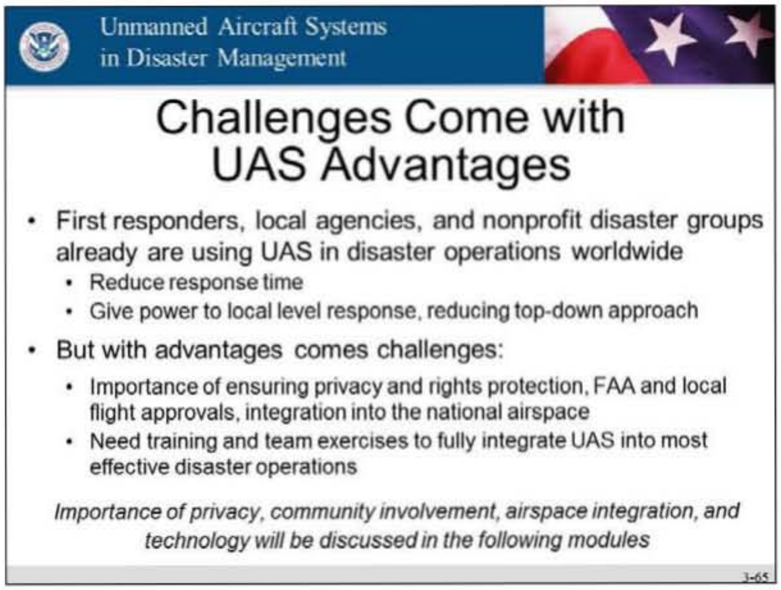


Slide 3-64. UAS Support Disaster Management

Key Point: UAS can be a critical component in disaster management, by providing immediate situational awareness for first responders and emergency managers through imagery of real-time, decision-relevant conditions. This UAS imagery and information can be digitally disseminated quickly to decision-makers, to help establish and maintain coordinated operational structure and communications. UAS also can be a valuable tool for risk assessment, hazard mitigation, and resilience analysis.

Understanding the optimum way forward for incorporating or adapting UAS technology into disaster operations is the next step. Observing the issues of community awareness, privacy, and citizen rights need to be addressed as the technology is incorporated. Module 5 in this course will explore this in greater depth.

Participant Notes:



Slide 3-65. Challenges Come with UAS Advantages

Key Point: First adopters always face new hurdles on the way to achieving the benefits of new technology, and UAS are no exception.

Privacy and protection of personal rights are key considerations that surveillance systems confront. A Privacy Impact Assessment (PIA) and a Civil Liberties Impact Assessment (CLIA) are tools that can be used to involve the community both at the outset when they are developed and later on when the document is posted for the public on a website.

In Module 5, privacy, civil rights, and civil liberties are discussed in more detail.

Participant Notes:

Unmanned Aircraft Systems
in Disaster Management

Sample of UAS Use in Actual Disasters

YEAR	DISASTER	UAS USE
2015	Nepal earthquake	Damage assessment
2015	Typhoon Pam, Vanuatu	Damage assessment
2014	Mt. Sinabung volcano, Indonesia	Volcano monitoring
2013	Typhoon Haiyan, Philippines	Infrastructure and damage assessment, humanitarian assistance logistics, recovery mapping
2013	Sichuan earthquake, China	Damage assessment, power line inspection
2012	Hurricane Sandy, New York	Detect power line failures using infrared and ultraviolet filters
2011	Earthquake, tsunami, nuclear meltdown, Japan	Monitor radiation levels, damage mapping and imagery
2010	Earthquake, Haiti	Map camp site, survey rebuilding, flood analysis (used in 2012 and 2013)
2009	Typhoon Morakot, Taiwan	Post-disaster reconnaissance and damage assessment, recovery reconstruction

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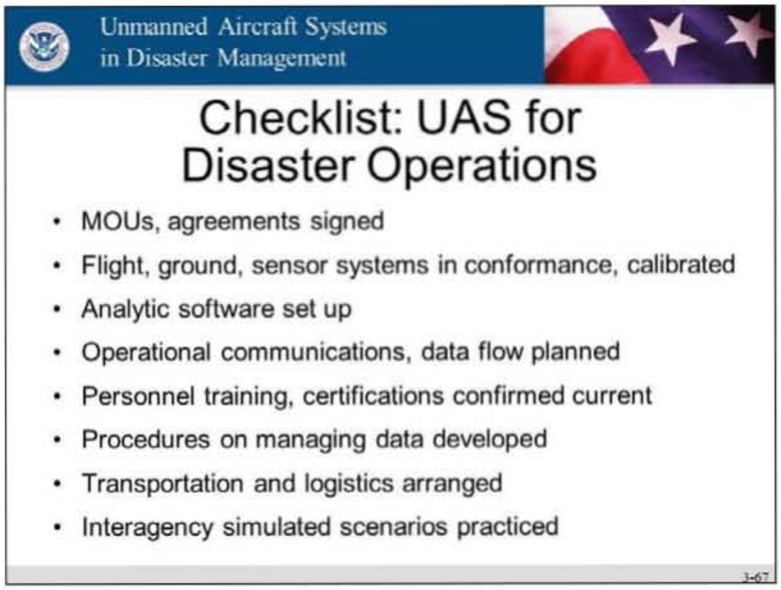
Slide 3-66. Sample of UAS Use in Actual Disasters

Key Point: Most documented uses of UAS in disaster operations have come from international experiences. Now that the FAA is moving quickly in opening the doors in the United States, we can expect accelerated development of capability and use in disaster operations.

Participant Notes:



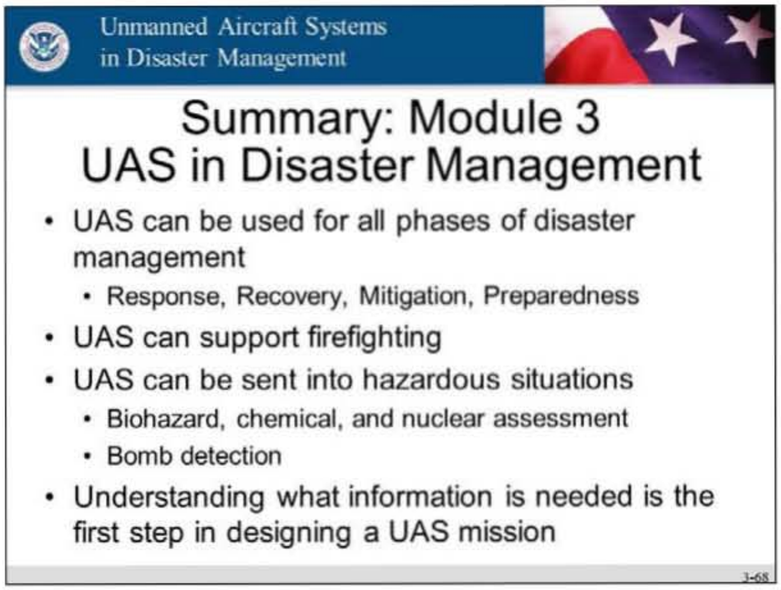
Slide 3-67. Checklist: UAS for Disaster Operations

Moving forward with a UAS program for disaster management requires an organized approach to ensure integration into the current operational workflow and address the certification and legal responsibilities. Agencies that want to establish a UAS program need to think through the needed agreements, equipment, software, personnel training, and data flow management, including who will have access and how the information will be protected, among other things.

Key Point: Now that Congress and the FAA have opened the door to more widespread UAS operations, standards need to be established quickly by first adopters, generally commercial users. This standardization will benefit disaster organizations, in that a degree of socialization will have occurred, giving disaster managers a place to start.

As these standards develop and the UAS industry becomes more defined, it is imperative that the disaster management community provides guidance to the UAS designers. Participating in training is one way to help inform the design community and can help to assure that all factors are considered as a UAS program is built.

Participant Notes:

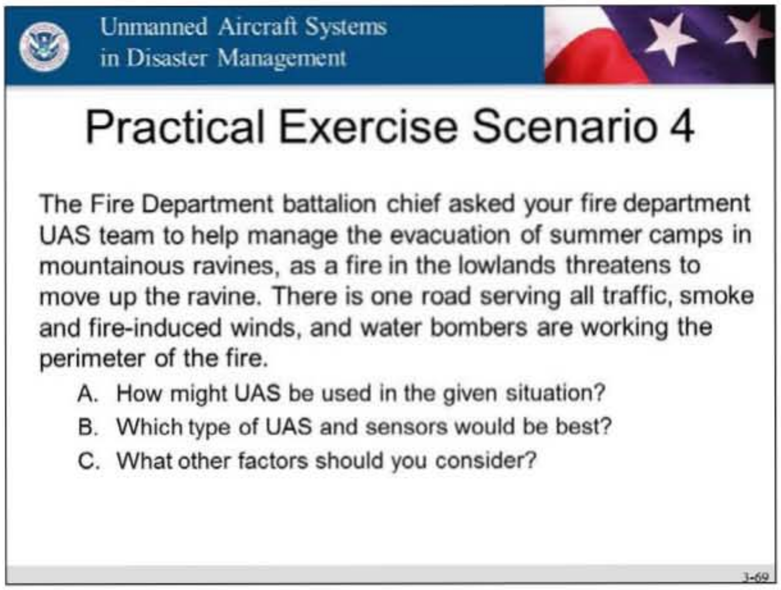


Slide 3-68. Summary: Module 3 UAS in Disaster Management

UAS can be used for all phases of disaster management, including response, recovery, mitigation, and preparedness. UAS can play an important role in firefighting; bomb detection; and biohazard, chemical, and nuclear assessment.

It is the users that will best define the utility of UAS in disaster operations that are most beneficial. Together, the users, developers, and 'clearinghouse' functions performed through training can contribute greatly to the value of this technology in disaster operations.

Participant Notes:



Slide 3-69. Practical Exercise Scenario 4

The exercise at the end of Module 3 presents possible scenarios in which UAS could be used. Participants will apply information learned in the modules to help answer the questions.

The instructor will ask participants either to break into groups to discuss the scenario here and then discuss the possible answers together as a class, or not break into groups and discuss the questions together, at the discretion of the instructor.

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