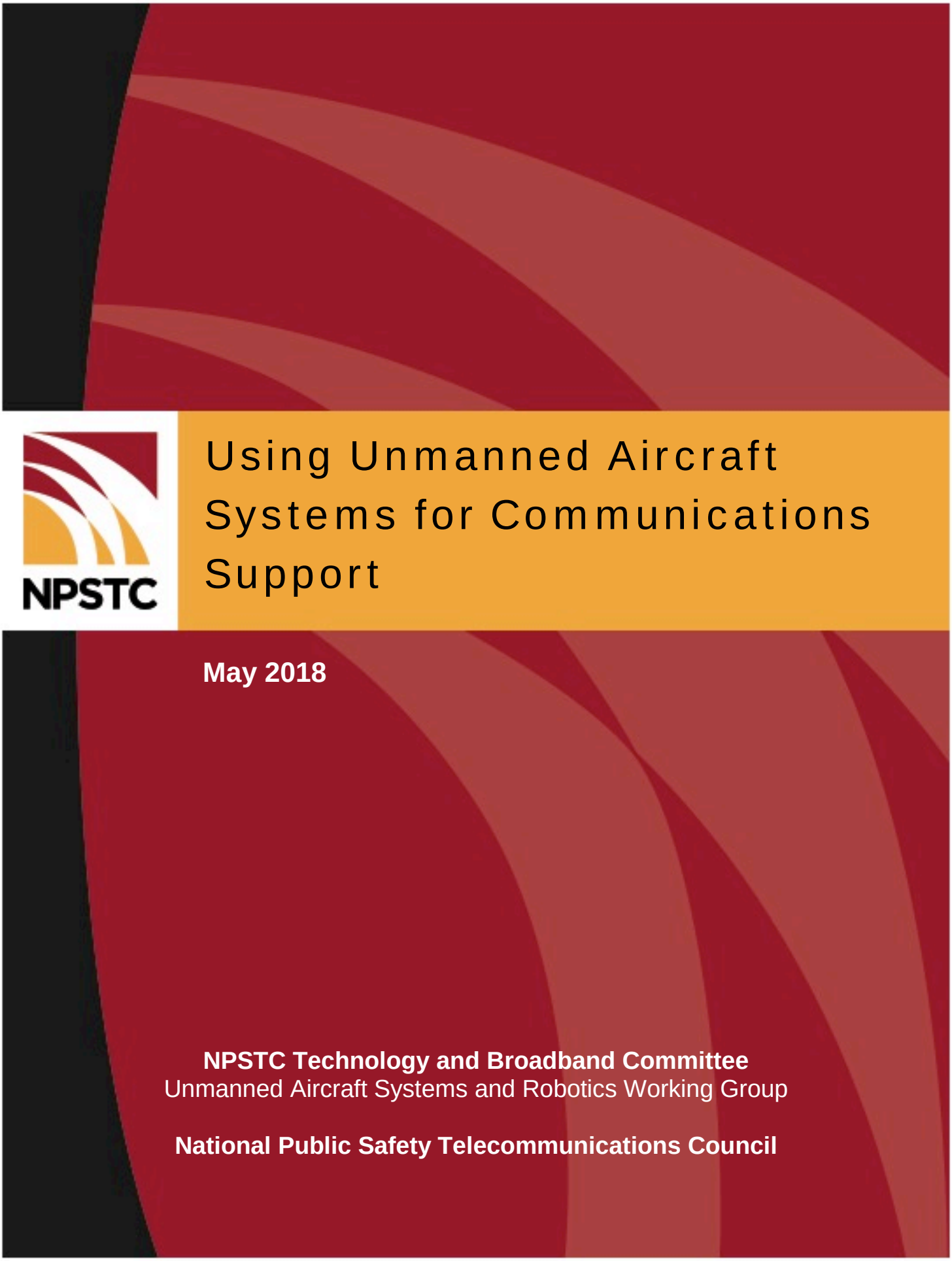

Using Unmanned Aircraft Systems for Communications Support

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Introduction

This report is provided to educate public safety agencies on the availability of emerging technology which will provide an aerial communications coverage extension for both LMR and LTE networks. It is designed as an education and outreach document to illustrate issues relevant to the public safety community and therefore does not include any detailed technical requirements. This document leverages content from the NPSTC "Guidelines for the Creating a UAS Program" report.

Unmanned Aerial Systems (UAS) are rapidly gaining popularity with public safety agencies who seek to enhance operations and provide an additional layer of safety for first responders operating in dangerous environments.

Voice and data communications, including transmission of video and telemetry, are an emerging cornerstone for public safety operations. Failure of two-way communications due to radio system coverage deficiencies and damage to network infrastructure can place first responders in danger. Most agencies continually evaluate their ability to provide communications and seek ways to improve radio system coverage, capacity, and resiliency. Industry has recognized this benefit and UAS technology is being adapted to provide both aerial Land Mobile Radio (LMR) system extension as well as Long Term Evolution (LTE) cellular capabilities. UAS vehicles are uniquely designed to augment public safety communications in a variety of settings and environments.

Credit - FCC White Paper – The Role of Deployable Aerial Communications Architecture in Emergency Communications

- Public safety operational capabilities are expanding as agencies learn more about the technology.
- The FAA continues to study rule changes that will enable UAS technology to be used in more situations.
- As agencies rush to implement UAS solutions, they must be mindful of the existing regulatory landscape.
- An emerging area for UAS is the ability for the aerial asset to support two-way communications between first responders.
- Commercial cellular carriers are currently testing the deployment of UAS technology to provide cellular service to areas following disasters and other major events.

- Public safety agencies at the federal, state, and local level are keenly interested in providing LMR service using UAS technology to reach first responders who are in areas without coverage.
- Beyond the restoration of coverage following a disaster, commercial providers and public safety agencies are seeking ways to augment coverage using UAS technology.
- UAS-aided universal coverage – where UASs are deployed to assist the existing communications infrastructure, if any, in providing seamless coverage.
- UAS-aided relaying, where UASs are deployed to provide wireless connectivity between two or more distant users or user groups without reliable direct communication links.

1. UAS Support for Public Safety Communications

Wireless communication systems that include unmanned aerial vehicles (UASs) promise to provide cost-effective wireless connectivity for devices without infrastructure coverage. Compared to terrestrial communications or those based on high-altitude platforms (HAPs), on-demand wireless systems with low-altitude UASs are in general faster to deploy, more flexibly re-configured, and are likely to have better communication channels due to the presence of short-range line-of-sight (LoS) links. However, the utilization of highly mobile and energy-constrained UASs for wireless communications also introduces many new challenges.

The use of UAS as an aerial platform to extend coverage can be an option to meet the needs of small distributed forces operating in areas where line-of-sight communications are not possible.

Drone carried on-demand WiFi prototype systems. Photo Credit Yixin Gu,

The use of multiple UAS allows for beyond line of sight (BLOS)[1] flight operations. In the mountainous or high-density urban regions, the communication between UASs and the ground control station can be easily interrupted, causing the ground control station to lose real-time data feedback from the UASs, leading to mission failure. In addition, if the mission requires long flight range, the communication might also be interrupted by the extended distance.

[1] Though the FAA is scheduled to begin testing Beyond Visual Line of Site (BVLOS) in some areas during the summer of 2018, Beyond Line of Sight (BLOS) operations are not currently authorized as it applies to a single operator. For the purposes of this document, BLOS refers to the use of additional observers to extend the line of sight of the operator or the use of multiple drones and multiple operators to daisy chain the coverage.

2. Current State of On Scene Communications

Agencies rely on their LMR system to provide coverage. A variety of factors prevent LMR systems from providing ubiquitous coverage across the agency's service area. Financial, regulatory, and spectrum propagation constraints frequently result in service areas without sufficient radio coverage.

Agencies often augment LMR coverage with vehicle repeaters and portable repeaters that can extend coverage into large buildings and remote areas.

First responders must also rely on simplex radio channels in order to maintain communications. These channels are restricted in range and typically do not allow direct communications between public safety personnel and the agency's dispatcher.

Agencies are increasingly using LTE broadband communications to share video and data with first responders. First responders may be operating in areas "at cell edge" with minimal throughput, preventing use of data communications.

3. Benefits of UAS Platforms

UAS technology is poised to provide cost effective solutions of these coverage issues, by providing "just in time" services at the scene of an emergency. A reliable communication infrastructure is crucial for an efficient and successful emergency response system. Disruption of communication infrastructure may be caused directly by damage to cables and cellular towers, or indirectly, through shutdown of power and water. The unreliability of fixed communication infrastructure in disaster situations is well documented. In such scenarios, an on-demand communication infrastructure that can quickly recover communications in the disaster area is of critical need to coordinate emergency response operations.

A balloon launches from Nevada on its way to Puerto Rico – Project Loon

UAS vehicles come in a variety of types of configurations, including tethered units which can operate indefinitely from a fixed location. Even tethered UAS systems require a remote pilot maintaining operations and a visual line of site.

An aerial communications platform can extend radio system communications over a large area, even when the UAS is operating at low altitude. However the use of multiple UAS may require policy surrounding Unmanned Traffic Management (UTM) as it relates to both the number of drones in the air and maintenance schedule as well as frequency management of the command and control

frequencies. This also extends beyond the public safety drones and may require coordination with other agencies, media, and private sector as well as recreational drones operating in the same area.

4. Spectrum and Technology

UAS currently use unprotected radio frequency spectrum and remain vulnerable to unintentional (environmental or technological) or intentional (hostile) interference. This is of paramount security concern for public safety users as interruption of radio transmissions of the command and control signal can disengage UAS control mechanism which may result in loss of a communications link or a "lost link" scenario.

The risk of interference must also be considered when deploying UAS to supplement communications. Flying a UAS high above ground, i.e., above the terrestrial infrastructure and other obstacles, is likely to create higher levels of interference than engineers expected during the design and planning of the terrestrial network. Interference is higher because, as radio waves propagate through the air, signals from the UAS do not suffer as much attenuation or variations as signals transmitted for ground operations. Although interference risks are much reduced when UASs are deployed in times of disaster, i.e., when the terrestrial infrastructure is partially down, the potential for disrupting device-to-device communications exists. As noted above, the (interference) risk is higher when multiple UASs are hovering in the same area, which may be the case if multiple agencies bring their own UAS to an incident scene.

A more detailed companion document on "Using UAS to Support Communications - Spectrum and Technology Considerations"[2] concerns is available to download from the NPSTC UAS/Robotics Working Group webpage at http://npstc.org/unmannedAircraftSys.jsp.

5. Use Cases

The following use cases describe the basic capabilities of an aerial communications platform using UAS technology. The first three use cases are all designed around LMR system coverage though LTE cellular coverage could also be provided to support broadband data. The fourth use case explains how this might be accomplished.

5.1 Use Case #1 – LMR Coverage Restoration Following a Tornado

[2] NPSTC "Using UAS to Support Communications - Spectrum and Technology Considerations" document - http://npstc.org/download.jsp?tableId=37&column=217&id=4115&file=UAS_Comm_Spectrum_&_Tech_Considerations_180530.pdf

A severe storm has struck the community of Anytown, causing widespread destruction and damage to the city's public safety communications infrastructure. Mutual aid units have responded to provide law enforcement, fire, rescue, and EMS assistance and support local first responders.

The LMR system is operating in a severely reduced capacity due to damage to several radio towers, coupled with loss of microwave backhaul to some sites and loss of power at others.

A tethered UAS is deployed in one of the hardest hit neighborhoods where multiple agencies are performing search and rescue. The UAS is equipped with an on board UHF repeater that has been programmed to mirror an existing public safety channel that is out of service.

First responders are directed to switch their radios to the designated UHF frequency and are able to communication throughout the entire area. The repeater also allows communications with the incident command post located at a school several miles away**.**

5.2 Use Case #2 – LMR Coverage Augmentation in Fringe Area

Multiple public safety units respond to a reported school bus crash on a rural highway near the county line. The bus has slid off the roadway and down into a ravine. Multiple children have been injured and two rescue helicopters are on standby to respond.

First responders arrive and find that the area around the crash scene only supports mobile radio coverage on their agency LMR network. EMS personnel need radio access to the local hospital to coordinate patient care.

A UAS is deployed at the scene of the crash to create an aerial communications platform. The UAS is programmed to operate as a vehicle repeater on a number of existing LMR frequencies. The UAS radio is switched to operate on a channel designated for EMS operations.

EMS personnel are directed to switch their portable radios to the designated Vehicle Repeater access channel and are able to communicate through the agency's trunked radio system. Contact is made with the local hospital and a base station physician confirms treatment and patient destination decisions.

5.3 Use Case #3 – LMR Coverage Solution in Remote Area

A group of firefighters are battling a wildfire in a national park that has no LMR radio coverage. The fire has extended into an area with steep hills and rough terrain. As the firefighters move to the south end of the fire, they cross over high terrain and into the adjoining valley.

The only method of communication is using a VHF simplex radio channel which has limited range and requires a "human relay" where messages are passed from one group of firefighters to another group of firefighters, who pass the message further back to the command post.

As the firefighters descend into the valley, they lose contact with their nearby "relay group." The firefighters return up to the top of the ridge in order to restore communications and report their situation.

A UAS is deployed from the command post to fly to the area above the ridgeline. A portable repeater frequency has been activated which will provide coverage to the entire area.

The firefighters in the target area are notified to switch their radios to the designated frequency and are able to communicate through the UAS to reach other firefighter groups and the command post.

If firefighting operations become extended beyond the available flight time of the UAS, the command post will direct that the aerial unit land on the ridge line. The firefighters in the area will go to the UAS landing site and set the portable repeater up for stand-alone operation.

5.4 Use Case #4 – Drones for LTE Coverage[3]

A tornado struck AnyTown, USA, and caused widespread damage, including the destruction of several commercial carrier LTE towers disrupting public safety LTE broadband communications.

UASs are deployed to restore coverage in areas where LTE services are down or to create LTE service where service did not previously exist.

The UAS flying in an orbit temporarily restores LTE service and also provides for new service where needed. This also includes the enhancement and extension of the existing LTE data service.

First responders do not need to take any special action in order to access the restored LTE coverage. First responder LTE devices will reactivate once the UAS is in orbit.

The amount of operational time is dependent on how long a drone can hover or orbit over a specific area. The incident commander or COML will manage the continuation of LTE coverage based on battery life, flight time capacity, weather conditions, etc.

7. UAV Types

The most common types of Unmanned Aerial Vehicles (UAVs) to be considered for use as an aerial platform for communications are Rotary Wing and Tethered. Tethered UAV aircraft are those that

[3] The aerial platform assumes support for a full airborne LTE communications suite which includes network functions, and one or more applications (e.g., mission critical voice communications), it may be expanded.

come equipped to be tethered to the ground and should be considered in those aerial operations where it is desired for the UAV to be in a single stationary fixed position at a particular altitude. The tether can also be used to send power to the drone itself, the communications payload, and/or other active sensor technologies resident as payload on the tethered UAV. Data can also be sent up and down the tether in a point-to-point fashion should that be desirable for the mission requirements. These types of UASs are limited to line of sight (LOS) operations and limited altitudes due to the weight of the tether. Rotary wing have the advantages of hovering capability, high maneuverability, and medium range for use in an incident such as a natural disaster or wildfire which covers a large geographical area.

Fixed Wing or unmanned airplanes generally have longer endurance but these systems must keep moving forward and require a larger take off, landing, and flight area. Their inability to hover over a location or object makes this solution more challenging for incidents with a smaller geographical footprint.

Determination of the best UAS solution is based on the mission, the geography, weather, and flight time requirements.

More information on the various types of UAV and information on creating a UAS program can be found in the NPSTC Guidelines For Creating a UAS Program Report.[4]

8. Recommendations for Public Safety Agencies

Public safety agencies are encouraged to study the emerging role of UAS including the ability to provide LMR and LTE coverage solutions. The following steps are recommended for agencies pursuing this issue:

- Monitor industry developments to learn of new features and capabilities being offered to support LMR aerial communications services.
- Make inquiries to your commercial cellular provider to determine what aerial communications services are available now and which may be available in the future.
- Monitor the changing FAA[5] regulatory landscape to determine when a UAS communications aerial platform may be an option.
- Evaluate areas where a UAS communications platform could benefit your agency.
- Discuss UAS capabilities with regional partners to develop a shared vision.

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[4] NPSTC Guidelines for Creating a UAS Program
http://www.npstc.org/download.jsp?tableId=37&column=217&id=3901&file=Guidelines_for_Creating_UAS_Program_vs2_170418.pdf

[5] https://www.faa.gov/UAS/

- If planning to implement a UAS program, determine if the desired UAS vehicle may be capable of supporting a future communications payload. Remember that UAS technology may also be procured as a service which does not require a public safety agency to own and operate the equipment.
- Monitor the rule making processes, including the FAA, regarding remote ID identification and consider supporting the need for requirements.

9. Contributors

NPSTC wishes to thank the over 130 registered members of the Unmanned Aircraft Systems (UAS) and Robotics Working Group representing public safety, commercial, academia, and industry for their participation in the group.

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