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## DRONES: A NEW TOOL

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# Building Envelope Technology Symposium

## ABSTRACT

Occasionally, building enclosure professionals are presented with challenges in getting to a particular wall or roof for up-close examination. Often, these are observed using boom lifts, binoculars, and an adjacent building or roof. Today, the use of unmanned aerial vehicles (UAVs, or drones) can aid in visual observations of roofing and building façades. Research into the current regulations regarding the use of drones and their operation for commercial use by architects, engineers, and consultants will be presented. This paper briefly discusses various drones and equipment used to document observations such as infrared thermography, videos, and cameras. Project examples from a drone-mounted camera are provided.

## SPEAKER

*WILLIAM WATERSTON, RRC, AIA — WISS, JANNEY, ELSTNER ASSOCIATES, INC.*

WILLIAM WATERSTON has extensive experience in roofing and waterproofing products and systems, including their investigation, evaluation, and design. He is also experienced in construction document preparation and specification writing, as well as façade assessment. As a registered architect and RRC, Waterston has broad-based experience in architecture and roofing systems that provides him with a unique perspective on problem solving for waterproofing and roofing challenges. He has authored several articles on roofing material choices and roofing practices and has presented at Build Boston, RCI, and CSI meetings and symposia.



# DRONES: A NEW TOOL

## INTRODUCTION

Occasionally, roofing and building enclosure professionals are presented with a challenge in getting to a particular wall or roof—such as a church steeple, a clock tower, or a steep-slope roof near the top of a multistory wall—for up-close observation. Often these are observed using boom lifts, binoculars, and from adjacent buildings or roofs, or by employing rope access techniques that often provide limited access, poor viewing angles, and unsafe situations. Today, the use of unmanned aerial vehicles (UAVs), commonly referred to as drones, can aid in visual observations and condition assessments of roofing and building façades. In some circumstances, documenting existing conditions with drones can be completed at a lower cost, faster than traditional methods of visual evaluation, and, most importantly, providing a safer means to complete the work.

Research into the current regulations regarding the use of drones and their operation for commercial use by architects, engineers, and consultants will be presented. We will briefly discuss drone types, along with various onboard tools used to document conditions, including infrared thermography, video, and visible cameras.

Project examples of documentation gathered from a drone-mounted camera in difficult-to-access roof areas will be provided. We will also present innovative uses of images from drones to develop existing condition maps and measured drawings.

### Assessment Challenges

At times, the buildings we assess present unusual challenges. Gaining access to a roof is generally through a roof hatch or from a ladder at its eave, drip edge, or parapet. Observation of

the façades of multiple buildings can be accomplished from the ground or neighboring structures using binoculars. Sometimes, we are required by a façade ordinance to provide an up-close observation of the materials on the building. This is often completed using a personnel lift or boom. More difficult or taller structures are often surveyed using swing stages by dropping down the face of the building on each elevation. In some cases, rope access techniques are an alternative to a swing stage, requiring highly trained professionals in both rope safety and façade assessment to complete the work. For example, this technique was used at an Art Deco-style building with many offsets and setback roof areas, proving it much easier to assess the condition of the limestone walls (*Figure 1*).

There are conditions where these techniques have their limitations; they may

be too difficult or expensive to perform. Examining the roof of a building after a fire, a church steeple, the mansard roof of a downtown building, or a brick chimney within an industrial complex are all examples of challenges where these other techniques are not effective. Drones or unmanned aircraft systems (UASs) with a mounted camera are capable of capturing images from locations that are either difficult or impossible to reach through conventional methods. This advantage in the inspection procedure will translate to a higher-quality work product, resulting in improved client satisfaction.

The list of buildings and conditions where UASs are being used is growing. A few examples and conditions will follow. Video is available for these examples and will be presented, in part, during the presentation of this paper. Prior to discussions of examples of their use, a short discussion of UASs is appropriate.

### Description of a UAS

Commonly used drones can contain one, three, four, or eight separate rotors on various bodies with a wide range of prices and capabilities. The range of uses includes real estate, event aerial photography, action sports, and building construction monitoring. Currently, the most commonly used small UAS in these types of applications is the Phantom Quadcopter series manufactured by DJI. These drones are capable of being outfitted with a variety of cameras and devices, depending on the needs of the inspection to be performed. Additionally, these drones may be equipped with many safety and user functions, including real-time relay of video or images to the operator via tablet or cell phone, image stability from environmental interference, impact-avoidance systems (from objects mobile and immobile), and a “return home” capability. “Return home” is a feature that allows



**Figure 1 – Building where rope access techniques were used in lieu of a swing stage.**

**In Marblehead, drone injures two Memorial Day spectators**



May 26, 2015 *WickedLocal*  
 No charges have been filed against a Westborough man whose miniature drone hit a Pleasant Street building and then injured two spectators watching the town's Memorial Day parade on Washington Street Monday morning, according to Police Chief Robert Picariello. When asked if the incident were the first of its kind for Marblehead, Picariello said in an email, "Yes, as far as I know." The collision occurred a little after 9 a.m. Scott Callahan was flying his ...

**Figure 2 – Article from *WickedLocal*, May 26, 2015.**

the autopilot feature to return the drone back to its origin. This can be utilized in the event of poor signal, low battery life, damage to the device, or predefined Federal Aviation Authority (FAA) boundary obstructions.

Here are some links to available drones that are popular for commercial use:

- <http://www.dji.com/product/phantom-3>
- <http://www.walkera.com/en/show-goods.php?id=2294>
- <http://www.bhphotovideo.com/bnh/controller/home?O=&sku=1106906&gclid=CMYA3OGXgcYCFdcYgQo d0R4AKQ&is=REG&Q=&A=details>
- <http://3drobotics.com/solo/>

There are local clubs where fellow recreational drone operators compete in agility competitions. These types of recreational drones are typically more difficult to maneuver, requiring heightened skill levels. Although the example drones listed in this paper for commercial use are relatively easier to operate than recreational drones, training and/or sufficient practice is necessary to ensure that the operator understands the operating functions, navigation functions, general safety features and procedures, and FAA safety requirements.

It should be understood that there are FAA safety concerns for all operators, whether recreational or commercial. Currently, the FAA requires a drone operator to have an airplane pilot's license. There has been discussion that the FAA is likely to require operator training that will include a 40-hour course for commercial use of drones. The purpose of this effort would be to ensure a safer airspace with knowledgeable pilots. Actions like this are also critical to ensure a safe sky. The challenges the FAA faces moving into a drone-operated world are obviously great for the national airspace (NAS).

**Making the News**

Drones have made the news.  
 Planes fighting a forest and brush fire

in California were grounded because a drone was too close to firefighting planes. This made the CBS Evening News on June 25, 2015. A drone flew between two planes flying within 1,000 feet of each other, and the planes were grounded for about 30 minutes.<sup>1</sup>

In Marblehead, Massachusetts, a drone hit a building and then injured two spectators watching a Memorial Day parade (Figure 2). In the article, the operator had "flown this drone numerous times without ever having a negative experience." He wanted to videotape the parade. One of the injured suggested an operator should

obtain a license before flying drones over crowds.

**Current Regulations**

Figure 3 is excerpted from the Federal Register, Volume 80, No. 35, dated Monday, February 23, 2015, and provides a summary of the proposed regulatory action:

The public comment period closed April 24, 2015. A ruling is expected in 2017.

**Exemption Request**

To receive an exemption for commercial use of a UAS, you must foremost prove that the current restrictions in Chapter 14, Section 333, present a work safety hazard that could be resolved with drone use. Such a request by a forensic or similar firm typically includes a description of reasons the

**9546 Federal Register / Vol. 80, No. 35 / Monday, February 23, 2015 / Proposed Rules**

**B. Summary of the Major Provisions of the Regulatory Action**

Specifically, the FAA is proposing to add a new part 107 to Title 14 Code of Federal Regulations (14 CFR) to allow for routine civil operation of small UAS in the NAS and to provide safety rules for those operations. Consistent with the

statutory definition, the proposed rule defines small UAS as those UAS weighing less than 55 pounds. To mitigate risk, the proposed rule would limit small UAS to daylight-only operations, confined areas of operation, and visual-line-of-sight operations. This proposed rule also addresses aircraft

registration and marking, NAS operations, operator certification, visual observer requirements, and operational limits in order to maintain the safety of the NAS and ensure that they do not pose a threat to national security. Below is a summary of the major provisions of the proposed rule.

**SUMMARY OF MAJOR PROVISIONS OF PROPOSED PART 107**

Operational Limitations .....	<ul style="list-style-type: none"> <li>• Unmanned aircraft must weigh less than 55 lbs. (25 kg).</li> <li>• Visual line-of-sight (VLOS) only; the unmanned aircraft must remain within VLOS of the operator or visual observer.</li> <li>• At all times the small unmanned aircraft must remain close enough to the operator for the operator to be capable of seeing the aircraft with vision unaided by any device other than corrective lenses.</li> <li>• Small unmanned aircraft may not operate over any persons not directly involved in the operation.</li> <li>• Daylight-only operations (official sunrise to official sunset, local time).</li> <li>• Must yield right-of-way to other aircraft, manned or unmanned.</li> <li>• May use visual observer (VO) but not required.</li> <li>• First-person view camera cannot satisfy "see-and-avoid" requirement but can be used as long as requirement is satisfied in other ways.</li> <li>• Maximum airspeed of 100 mph (87 knots).</li> <li>• Maximum altitude of 500 feet above ground level.</li> <li>• Minimum weather visibility of 3 miles from control station.</li> <li>• No operations are allowed in Class A (18,000 feet &amp; above) airspace.</li> <li>• Operations in Class B, C, D and E airspace are allowed with the required ATC permission.</li> <li>• Operations in Class G airspace are allowed without ATC permission</li> <li>• No person may act as an operator or VO for more than one unmanned aircraft operation at one time.</li> <li>• No operations from a moving vehicle or aircraft, except from a watercraft on the water.</li> <li>• No careless or reckless operations.</li> <li>• Requires preflight inspection by the operator.</li> <li>• A person may not operate a small unmanned aircraft if he or she knows or has reason to know of any physical or mental condition that would interfere with the safe operation of a small UAS.</li> </ul>
Operator Certification and Responsibilities .....	<ul style="list-style-type: none"> <li>• Pilots of a small UAS would be considered "operators".</li> <li>• Operators would be required to:                         <ul style="list-style-type: none"> <li>○ Pass an initial aeronautical knowledge test at an FAA-approved knowledge testing center.</li> <li>○ Be vetted by the Transportation Security Administration.</li> <li>○ Obtain an unmanned aircraft operator certificate with a small UAS rating (like existing pilot airman certificates, never expires).</li> <li>○ Pass a recurrent aeronautical knowledge test every 24 months.</li> <li>○ Be at least 17 years old.</li> <li>○ Make available to the FAA, upon request, the small UAS for inspection or testing, and any associated documents/records required to be kept under the proposed rule.</li> <li>○ Report an accident to the FAA within 10 days of any operation that results in injury or property damage.</li> <li>○ Conduct a preflight inspection, to include specific aircraft and control station systems checks, to ensure the small UAS is safe for operation.</li> </ul> </li> </ul>
Aircraft Requirements .....	<ul style="list-style-type: none"> <li>• FAA airworthiness certification not required. However, operator must maintain a small UAS in condition for safe operation and prior to flight must inspect the UAS to ensure that it is in a condition for safe operation. Aircraft Registration required (same requirements that apply to all other aircraft).</li> <li>• Aircraft markings required (same requirements that apply to all other aircraft). If aircraft is too small to display markings in standard size, then the aircraft simply needs to display markings in the largest practicable manner.</li> </ul>
Model Aircraft .....	<ul style="list-style-type: none"> <li>• Proposed rule would not apply to model aircraft that satisfy all of the criteria specified in section 336 of Public Law 112-95.</li> <li>• The proposed rule would codify the FAA's enforcement authority in part 101 by prohibiting model aircraft operators from endangering the safety of the NAS.</li> </ul>

**Figure 3 – From Federal Register, Volume 80, No. 35, dated February 23, 2015.**



firm is requesting relief from each section of Section 333 of Chapter 14, the specific UAS to be used, operation manual(s) of UAS(s) being used, safety manual created by the firm, flight log, maintenance record, etc.

For an example of an exemption request to operate a UAS for commercial use by a forensic engineering firm, refer to the hand-out. This provides context as to the effort necessary to satisfy the agency.

Here are some of the conditions and limitations from the exception, many of which echo the proposed rules:

- The UAS weighs less than 55 pounds.
- Operated less than 100 mph
- Altitude below 400 feet
- Operated within a visual line of site (VLOS), unaided
- Utilize a visual observer and within verbal communication of pilot in command (PIC) at all times.
- Carry the operating documents, which include the conditions and limitations, at all times.
- Conduct functional flight tests.
- Maintain aircraft.
- Conduct preflight checklists.
- PIC must hold airline transport, commercial, private, recreational, or sport pilot certificate and a valid U.S. driver's license.
- Operate it safely.
- No nighttime operations: sunrise to sunset only.
- A PIC cannot operate within five nautical miles of an airport reference point, unless a letter of agreement with that airport's management is obtained.
- No operation less than 500 feet from below a cloud or 2,000 feet horizontally from a cloud or when visibility

is less than 3 miles from the PIC.

- Conduct UAS in accordance with an Air Traffic Organization Certificate of Waiver or Authorization.
- Aircraft must be identified by serial number (or N-number) as large as practicable.
- Give way to all manned aviation operations.
- A UAS may not be operated from a moving vehicle.
- Conduct operations at least 500 feet from all nonparticipating persons, vessels, vehicles, and structures unless:
  - Barriers are available to protect in case of an accident. Must cease immediately if a person is within 500 feet of the UAS.
  - Granted permission for operating closer and PIC made a safety assessment of the risk and it doesn't present an undue hazard.
- Accidents and incidents must be reported to the FAA.

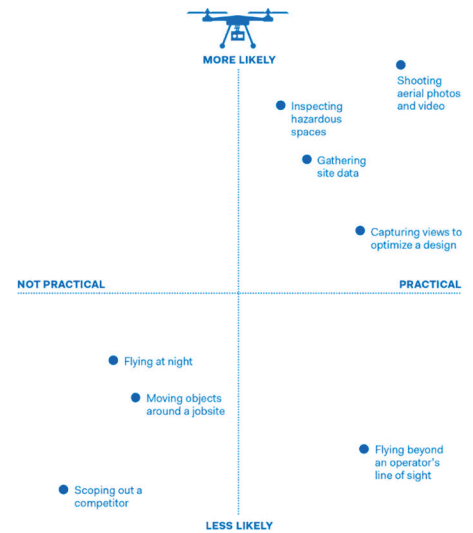
### Applications

3-D modeling on drones is quickly becoming a tool. Some computer science engineers are developing software that can detect cracks, voids, and irregularities in a bridge or façade. Other firms are using video collected from



Figure 5 – Educational building in downtown Boston with mansard steep-sloped roof areas.

Figure 6 – Low-sloped roof areas of educational building in Figure 5.



Just because you can (technically) use a drone, doesn't mean you should. We plotted potential uses of the technology in architecture and construction based on how likely each is to pass muster with the federal government compared to how practical the use is in the field.

Figure 4 – When to use a drone. From Architecture.

roofing surveys to develop 3-D models and 2-D drawings of the roof.

A recent article in *Architecture* magazine included the chart in Figure 4, outlining when to use a drone. The horizontal axis represents the practicality of the application, and the vertical axis is an estimate of the likelihood that the FAA will approve the application.

According to this chart, the use of drones to photograph building façades and roofs is classified as practical and is more likely to receive approval from the federal government.





**Figure 7 – Low-sloped roof areas of educational building in Figure 5.**



**Figure 8 – Steep-sloped mansard roof areas of educational building in Figure 5.**

**Advancements**

The FAA, NASA, and industry leaders are working on a flight database stored on the cloud that potentially would require a drone operator to enter the registered drone’s purposed preflight plan into the program for approval prior to flight. The program would review all potential ge-fence conflicts, proximity to other air traf-

fic, weather conditions, civilian hazards, etc., and then it would spit out a green or red light to fly or not. It is in the early stages of discussion, but it has the ability to solve many concerns, primarily safety-related.

Another technology advancement is in the area of “e-bumpers.” This is hardware built into or added to the device that can recognize nearby obstacles such as buildings (including glass), other drones, fences, trees, etc. This is in the demonstration mode. This would be a great tool in the structure evaluation realm. The operator could set the dis-

tance to decrease potential for impact and also make sure he or she would be able to get the view needed for proper observation.

**EXAMPLE PROJECTS**

The following are example projects where a drone has been used to photograph various building locations for assessment. (Dramatic videos during the presentation will demonstrate the level of image quality that can be collected.)

**Roofing Assessment**

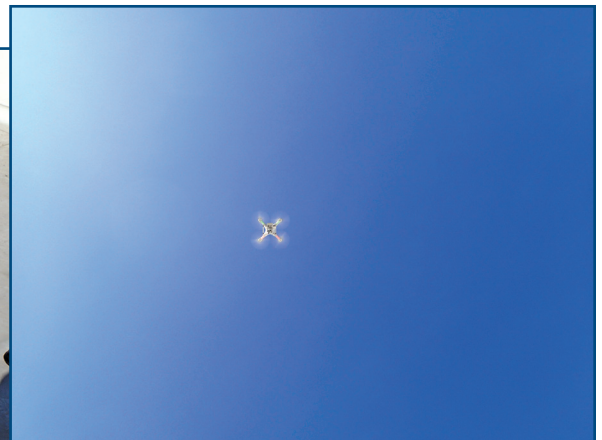
This building (Figures 5-8) is located in a congested portion of downtown Boston. It is a seven-story educational facility. The top floor contains a mansard roof covered with red slate. Regularly spaced, copper-clad



**Figure 9 – Drone and controller used to survey.**



**Figure 10 – Drone ready to take off from low-sloped roof area.**



**Figure 11 – Drone in flight.**



dormers protrude from the mansard. A survey of the façade was required to comply with the City of Boston Façade Ordinance.

There was a concern about falling slate. A single vertical sampling of the roof area that would be available from a swing-stage inspection was not adequate to determine the full extent of repair required. Maybe a big selfie stick would work, but the owner hired a contractor with a drone to photograph the areas. The contractor is a major Boston-based general contractor with staff and equipment to perform the work. The operator was experienced with the operation and control of the aircraft (Figures 9-11).

A report with images and types of deficiencies was prepared, including images from the drone (Figure 12).

### Façade, Chimney, and Silo Assessment

Wiss, Janney, Elstner Associates (WJE) performed a façade condition assessment of the Bailey Power Plant located in Winston-Salem, North Carolina. The purpose of our assessment was to develop a prioritized scope of repair work for the exterior façade of the building, the concrete train trestles that extend along the west side of the building, the chimneys, and the silos. Our scope of services included a visual assessment of the masonry and concrete components of the complex from grade and accessible roof areas, and with the aid of a drone. In addition, close-up inspections were performed from personnel lifts at selected areas of the west, south, and east façades of the building, and inspection openings were made at select locations on the masonry portions of the façade to evaluate concealed conditions.

The Bailey Power Plant was reportedly constructed in the 1930s as part of the Reynolds Tobacco manufacturing plant. Subsequent to the original construction, the building has been modified. Currently, the building consists of the original structure, a shorter masonry addition that abuts the north façade, a concrete addition that is connected to the south façade of the original building by a metal panel clad ramp, several other metal-panel-clad additions that also abut the north façade of the original building, and the north and east façades of the masonry addition.

Two brick chimneys are located along the east façade of the building. A terra cotta silo that is set on a steel frame is located adjacent to the south façade of the concrete addition, and two terra cotta silos that are set on concrete frames are located adjacent to the west façade. Regularly spaced concrete train trestles extend along the west side of the site and support train tracks that are now abandoned. An aerial view of the complex is shown in Figure 13, with the var-



Figure 14 – Image from a drone.



Figure 15 – Image from a drone.



Figure 12 – Image from drone of steep-sloped, mansard roof area of educational building in Figure 5.

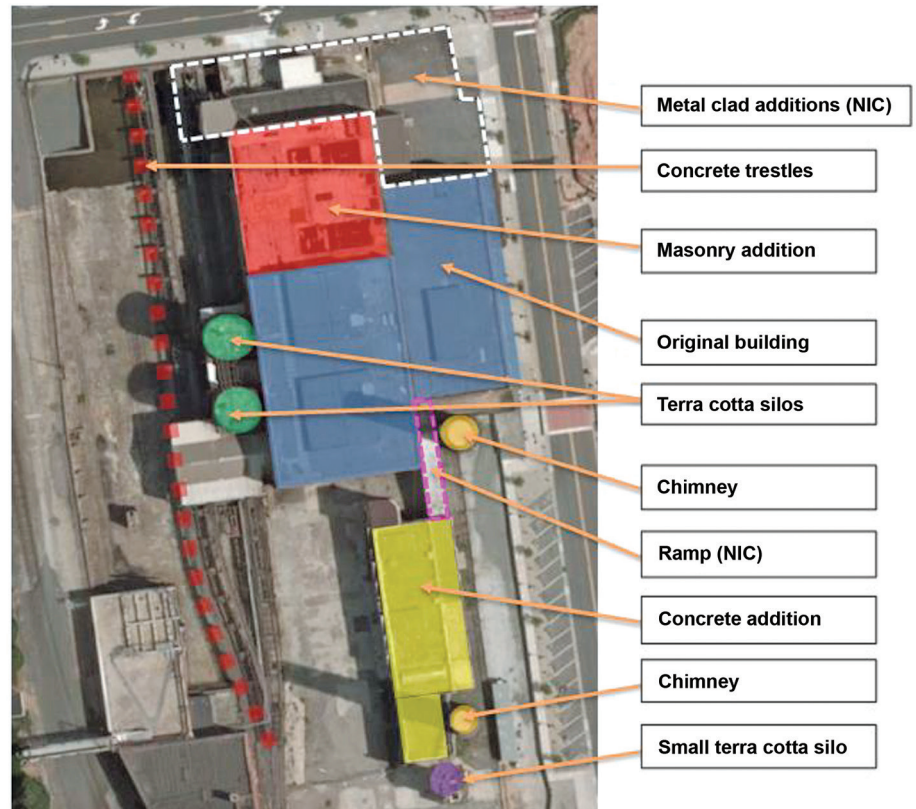


Figure 13 – Image from a drone of Bailey Power Plant.





**Figure 16 – Image from a drone, looking straight down a chimney.**



**Figure 17 – Image from a drone. Crack in brick masonry is visible.**

ious components of the complex identified. The drone was used to photograph the conditions of the chimneys and silos (Figures 14 and 15).

The terra cotta shell face has sheared at the units near the base of the right silo. (A video of the images from the drone will be shown during the presentation.)

### **Dramatic photos**

Figures 16 and 17 show some dramatic photos from other assessments using a drone.

### **Great Potential**

WJE was asked to review conditions of a slate roof that was reportedly damaged by ice damming. The roofs are on a three-building complex that is a well-known tourist destination in Boston; the location is home to offices, retail, and restaurant tenants. The buildings are linear, with north, central, and south buildings. The central building is three stories tall and contains a large dome. The north and south buildings contain five and six floors, respectively, with dormers and skylights within roof areas separated by short brick masonry firewalls

that extend above the roof surface. The insurance claim suggested that a certain percentage of slate shingles were damaged over the winter and should be replaced. Trees are planted between the buildings, which block direct views from building to building. Because of the height of each building and the distance between buildings, views of the roofs from grade is prevented. Even views from neighboring buildings are difficult except from the parking garage on the north, where the north-facing slope of the north building is clearly visible.

WJE approached two firms with experience in using drones to photograph buildings to determine if a drone could be used to record conditions at these three buildings.

The first firm returned the following response:

We are able to perform those roofing surveys for \$650-\$750 per building (depending on roof size and proximity to the city center). I look forward

to discussing this with you in further detail soon. Thank you for your interest in our services.

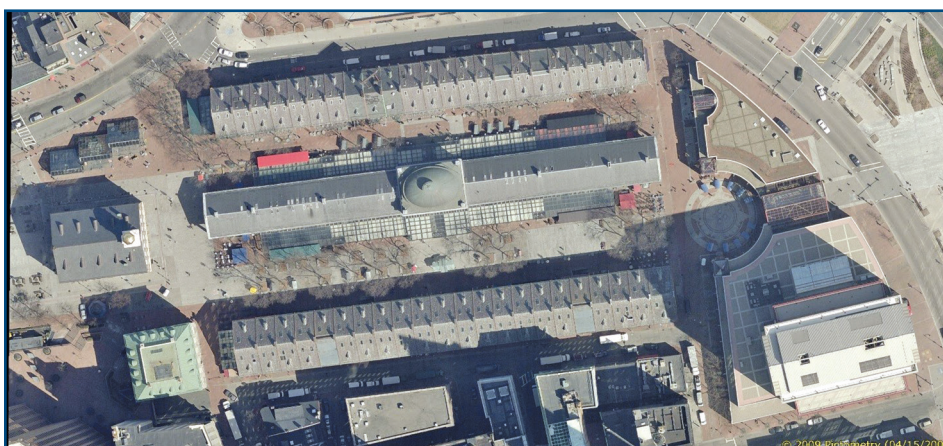
Then, we received the following e-mail from another firm:

My apologies. This is a significant project that will require several issues to be addressed. 1) The site is located within Boston's Logan Airport airspace and will require a COA from the FAA. 2) We are researching the permit process which, like New York, doesn't have it defined. 3) Crowd control due to the fact it is a major retail location.

It will most likely take approximately 3 weeks to hear from the FAA. I believe a shorter time frame from the city. I spoke to city officials this morning. Hoping to define a process soon.

Then, we heard from them with their proposal:

Our proposal is attached. We have applied for a Certificate of Authorization (COA) to operate in FAA Class D airspace (Logan Airport). We are working with the Boston DPW on a permit process as well. Not sure how long this process will take. We have been in contact with them several times since learning of this project. We will keep you informed as we move through this process.



**Figure 18 – Aerial view of the three-building complex.**



Please keep in mind, the two largest hurdles needed to overcome to accomplish this project are FAA approval and City of Boston permit.

**Request:** Video footage of slate roofs of the 3 main buildings of the marketplace.

**Proposed:**

- Provide 4K (4096x2160) UHD raw video data of slate roofs of 3 main buildings.
- Provide real-time data display or engineer review at the time of operation.
- All files provided to engineers the day of operation.
- Insurance certificate issued per WJE specifications.
- Operations crew of 3: pilot, camera, and safety observer for 3-day operation.
- Schedule for early morning operation to reduce incursion into area of operation.
- Schedule will require multiple-day operation due to retail business in downtown location.
- Scheduling requires weather to meet visual flight rules for UAS operations.
- Operations will be conducted in accordance with FFP-approved COA and FAA exemption.
- FFP is responsible for all municipal and FAA permits and notices.
- Proposal is subject to city and FAA approvals.

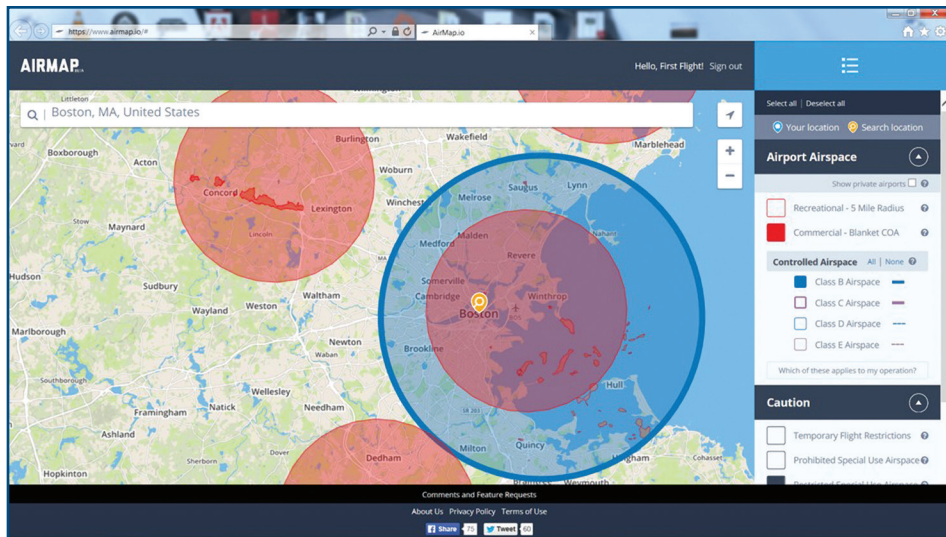
**\$5250**

There was a wide discrepancy between the two proposals in both prices and what would be completed. One contained information about safety and crew that was clearly missing from the other. Shortly thereafter, we received an e-mail including the following:

As of now, UAS operations are prohibited in Boston Logan’s airspace for the foreseeable future.

From the email received today:  
John,

Just realized the request at the market place is in Class B



**Figure 19 – Boston Logan Airport Class B airspace. The project falls within the inner circle. This is an 8-nautical-mile diameter around the center of the airport, from the surface to 7,000 feet above sea level.**

Airspace. At this time, we are not permitting operations in Class B due to airspace complexity/density and equipment requirements. Please feel free to call and discuss. Please cancel request 2015-ESA-11260-92-333E.

Kind Regards,  
Scott Sweet  
Program Analyst  
A3 Technology, Inc.  
Contracted by JMA Solutions in support of The FAA Unmanned Aircraft Systems Integration Office

The firm continued its explanation with the following information:

The map [Figure 19] depicts Logan’s airspace in red with a larger blue circle in blue. The blue identifies class B airspace. The FAA will not permit operations until such time when UAS[s] have transponder broadcast capability. (This will identify the exact location of the UAS to ATC and other aircraft.)

The area in ques-

tion is the red area within the blue circle. We can operate at lower altitudes in the blue area without requiring FAA approval. Think of it as an upside-down wedding cake.

We are working to see if any exceptions are possible. Please keep in mind that we are dealing with a government dinosaur here. I spoke to several individuals from the FAA this morning and their general position is that, “We should just be happy to have an exemption.” They clearly cannot see the forest [for] the trees.

I will keep you updated as we progress. We will still work with the



**Figure 20 – Boston Logan Airport airspace plan view.**

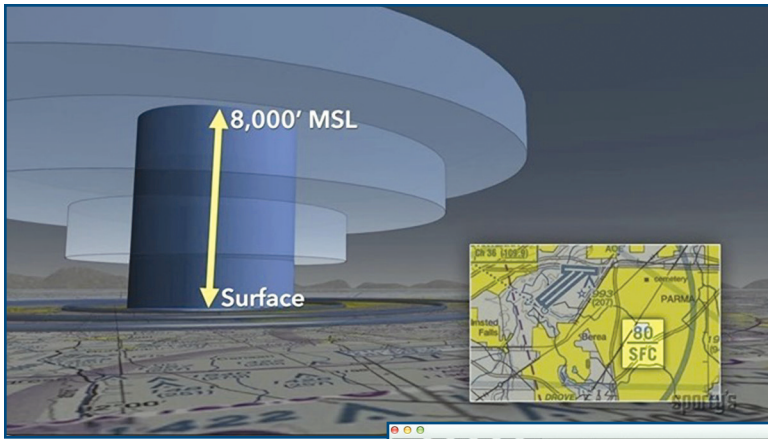


Figure 21 – Generic picture of a Class B area.

city of Boston to ensure a process is in place when the FAA catches up to itself.

Figure 20 shows a Class B area. Figure 21 is a generic picture of a Class B area with the wider rings arranged like an upside-down wedding cake.

We did our best to use the viewing angles we could find and make our own estimates of the number of slate shingles that were damaged or displaced on the roof areas.


## SUMMARY

Drones are new equipment available in many forms that many foresee as a great tool for this industry. New game-changing technologies are here and on the way that will make the skies safer and structure evaluations better. The possible applications are, at times, beyond belief. One researcher is using drones to collect whale snot. They call it their SnotBot! Check out <http://www.whale.org> (Figure 22).

The Wright brothers experimented with gliders in 1900 and took the first manned airplane flight on December 17, 1903, at Kitty Hawk, North Carolina. Also, the jetliner age is making its 60th lap around

the sun. It is amazing how far we have advanced in those years since.

UAVs are advancing at a high rate in type, capabilities, and application. There are many applications that can be used by architects, engineers, and consultants as we assess the buildings we deal with every day. And some newer applications, such as fitting the UAV with an infrared camera, are already here. The challenges of battery life, control during flight, and regulations of their use will

all be resolved and refined—some faster than others. This is a case where a toy that was just a hobby is evolving many commercial applications and is here to stay. 

## REFERENCE

1. <http://www.cnn.com/2015/07/18/us/california-freeway-fire/>

Figure 22 – Whale research is now being done via drones.

