

# BRIDGING THE GAP

89 YEARS OLD AND TOPPED BY AN INTERSTATE HIGHWAY ACROSS THE DELAWARE RIVER, THE 3,659-FOOT TACONY-PALMYRA BRIDGE NEEDS REGULAR, CLOSE INSPECTION. A TAILOR-MADE JOB FOR A DRONE. BUT WHAT AERIAL CAMERA WOULD DELIVER THE BEST RESULTS? TO FIND OUT, KEYSTONE AERIAL SURVEYS PUT THREE CONTENDERS TO THE TEST

With its base at Northeast Philadelphia Airport, just a few blocks from the banks of the Upper Delaware River, Keystone Aerial Surveys is no stranger to bridge inspection work. It is but part of a wide range of digital, film and LiDAR surveys conducted across the nation by its 20-strong fleet of piloted aircraft, but it does have its own special challenges.

Perhaps the most obvious is the danger of flying close enough to obtain detailed imagery of what are large, complex, fracture-prone structures with numerous confined spaces such as culverts and box girders. And with FAA regulations prohibiting the flying of piloted aircraft any closer than 1,000 ft. under Visual Flight Rules, the task has traditionally fallen to engineers to make annual on-site inspections. This arduous and costly process can, as disgruntled motorists will vouch, call for partial or complete bridge closures over extended periods. For toll bridge operators, closures can also mean a loss of revenue.

## Impeccable logic

Recent years have witnessed mounting interest in applying rotary wing Unmanned Aerial Vehicles or drones to the task, and the logic is impeccable. Quickly and easily

deployed, highly manoeuvrable, and posing few risks, they offer a stable platform for a range of optical and thermal sensors. The acquired digital images can be assessed as they are captured and made available for analysis at a fraction of the cost of a manned inspection.

All good news, and back in 2016 Keystone was one of the first to sound-out the possibilities by conducting a series of pilot trials on the 11,000-foot Delaware Memorial Bridge further downstream at Wilmington, Delaware. Two different types of drone were employed to capture video and still imagery of a concrete anchorage, a concrete pier, and the suspension bridge's steel cable and superstructure. Conducted on behalf of bridge operator, the Delaware River and Bay Authority, the results were promising.

'Drone technology, it is hoped, may enable inspections to take less time, cost less, be of better quality, and allow fewer lane closures while they are occurring,' was the Authority's conclusion.

Much has changed since then, not least new FAA regulations, announced in late 2016, that eased many of the previous flying restrictions on UAVs. Indeed, Keystone – now with half a dozen fixed and rotary wing drones in its fleet – was one of the first commercial operators to obtain an FAA waiver that allows it to fly them in controlled airspace. This, coupled with rapid advances in aerial sensor technology, prompted the company to conduct a new bridge inspection trial in June of this year.

For David Day, who started at Keystone as an aerial photographer in 1995 and who, today, is its Executive Vice President, the advent of drone-mounted cameras opened-up new opportunities for the business. "We flew our first UAV missions in 2015 and are now using them increasingly on smaller mapping and survey projects, typically extending over five or ten acres. These include bridges where aerial imaging may not have previously been considered but which we calculate could save their operators 10-20 per cent in annual inspection costs that can





Keystone's  
David Day



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run into the millions. Hence our interest in a comparative evaluation of current technology.”

### Three of the best

The chosen structure was the Tacony–Palmyra Bridge that crosses the Upper Delaware River between Palmyra and Tacony (Philadelphia), Pennsylvania. Keystone already had access to the site, piggy-backing off an earlier mapping mission and took the opportunity to evaluate three advanced aerial cameras aboard its DJI Matrice 600 Pro (M600Pro) hexacopter.

Pitched head-to-head against DJI's recently-introduced Zenmuse X5 and Sony's first-generation Alpha 7R cameras was the brand new iXM 100MP metric aerial camera from Phase One Industrial. This has been purpose-engineered for UAV-based mapping,

surveying and inspection missions and is available with a range of fixed and motorised lenses (see inset). Importantly, the iXM 100 pushes the boundaries in being the first high resolution sensor to incorporate backside illumination technology to boost spectral sensitivity and extend dynamic range. An added bonus is its plug-and-play integration with a variety of aerial platforms including the M600Pro, where it snaps straight into the running gimbal.

### Showcase

For Phase One Industrial's Area Sales Manager, Ryan Boswell, also based in Philadelphia, it was an opportunity to showcase how its latest camera overcomes a particular drawback of imaging large steel structures at close range. He explains: "While we can get pretty close with UAVs, the closer you get, the greater the magnetic interference and scattering of GPS signals. Wind turbulence close to bridges can also be incredibly variable and entails a lot of very stressful manual flying."

Being able to hover at a distance from such structures - while still capturing fine detail - is clearly the answer. Bridging this gap is where the iXM 100MP, with its wirelessly-controlled variable focal length 80mm and 150mm lenses, excels.

"During flight, you simply key-in the new distance at which you want to focus and the motorised lens does the rest," says Boswell. Of course, it's still possible to predefine a focusing distance during flight planning, but this feature avoids the need to land each time a change is needed. A big time-saver.



## PUSHING THE BOUNDARIES OF AERIAL IMAGING

Pictured above: The Phase One Industrial iXM 100MP medium format camera, with its 35mm and 80mm fixed focal length and 80mm and 150mm motorised lenses (left) is a plug-and-play install for a variety of UAVs including the DJI600 Pro hexacopter (right). The brief technical specs for this new camera/lens combo include:

**Resolution:** 100MP (11664 x 8750)

**Dynamic Range:** 83dB

**Aspect ratio:** 4:3

**Pixel size:** 3.7 µm

**Effective sensor size:** 43.9 x 32.9

**Light sensitivity (ISO):** 50-6400

**Capture rate:** 3fps

**Lens mount:** Phase One RSM

**Data interfaces:** USB3, Ethernet 10G

**More information at:** <https://industrial.phaseone.com>

**I/O interfaces:** Trigger, Mid exposure, Ready, Serial

**Dimensions (including 80mm lens):**

90x90x164mm

**Weight (including 80mm lens):** 1100gr

**Approvals:** FCC Class A, CE, RoHS

**Environmental:** Temperature -10°C to 40°C;

Humidity 15% - 80% (non-condensing)



With its wirelessly-controlled motorised lens, the iXM 100MP acquired images at a distance of 130ft that were comparable in resolution to those captured by its nearest rival at a distance of 30 ft.



Examples at 1:1 scale of imagery acquired by the three cameras flown during the evaluation

### Put to the test

For the purpose of the evaluation, all three cameras were flown at two distances from and along the bridge, capturing stills at the same resolution.

"Flying time was limited, and it would have been nice to have flown a couple more lines and distances, but the iXM 100MP performed flawlessly and the quality of its images at a distance of 30 feet from the bridge was extraordinary," notes Boswell. Perhaps even more telling were the images captured at a distance of 130 feet and where he claims definition was on a par with images acquired by its nearest competitor at a distance of 30 feet (see examples overleaf).

While Keystone's David Day continues to evaluate the test results with a view to

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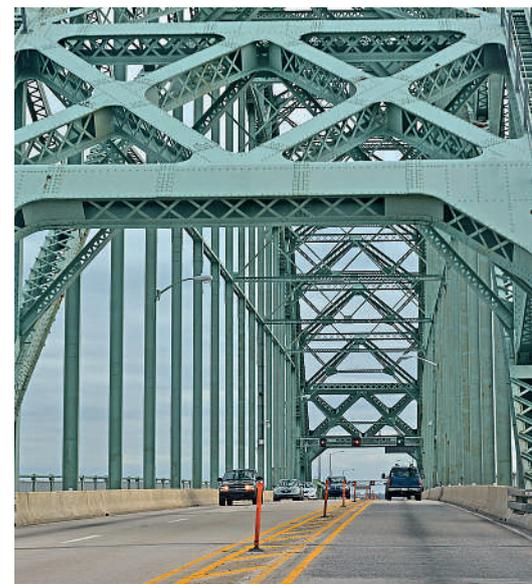
producing a White Paper quantifying the results, he agrees that the image quality of the iXM 100MP more than matched expectations.

"We're still examining some of the finer points such as edge contrast, and an autofocus lens setting is something we would welcome, but it is clearly the camera best suited to our UAV-based close inspection needs and one we're seriously considering," he says, adding that the relationship established with Phase One Industrial over the past 18 months has been a positive experience.

Looking ahead, Day intends to create a comparative 3D model based on the imagery acquired by each sensor during the evaluation. He also sees further scope for the iXM 100MP aboard Keystone's piloted fleet and where a Phase One Industrial 100MP camera with a fixed focus lens is already in use alongside an Optech Galaxy LiDAR system.



iXM 100MP image from the bridge inspection gives a clear view of the condition of fixtures and fittings with no loss of definition



### TACONY-PALMYRA BRIDGE

Opened in 1929 to replace a ferry service across the Delaware River and today operated by the Burlington County Bridge Commission, this steel hybrid structure comprises a through-tied arch at the middle of the river, a double-leaf bascule span, three-span continuous half through-truss spans, and deck girder approach viaduct spans. Vertical clearance under the centre arch span is 64 feet at high tide and clearance under the bascule span is about 54 feet. The bascule's twin leaves can be raised to permit the passage of vessels needing a greater vertical clearance. The 38-foot wide deck carries three lanes of vehicular traffic on Route 73, with a separate walkway provided for cyclists and pedestrians. Annual inspection costs amount to US\$300,000 and a US\$28 million rehabilitation programme is currently underway to paint the bridge and upgrade its mechanical and electrical infrastructure.

More information at: <https://industrial.phaseone.com>

