RECLAMATION

Managing Water in the West

Research Scoping Project: Investigation of the Potential Use of the Unmanned Aircraft System Predator B on Reclamation Projects

Research and Development Office
Science and Technology Program
Final Report 202014-01-9059

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Research and Development Office
Bureau of Reclamation
U.S. Department of the Interior

September 2014

Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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The U.S. Customs and Border Protection (CBP), a part of the Department of Homeland Security, operates and maintains a fleet of MQ-9 Predator B unmanned aircraft systems (UAS) in support of law enforcement and homeland security missions along the United States borders. Several years ago, in what the U.S. Geological Survey (USGS) refers to as a 'good government' effort, the CBP began allowing other civilian Federal agencies to submit Predator B tasking requests for remote sensing data collection over areas along our borders that are routinely patrolled by the CBP Predator B fleet. During FY2014, the Bureau of Reclamation (Reclamation) submitted two project areas of interest for Predator B data collection, data for both areas were to be obtained using the full suite of Predator B sensors. The tasking request was to be a test of; a) the effectiveness of the overall tasking procedure, and b) to better understand and evaluate the utility of the sensor data collected by the Predator B for possible Reclamation applications.

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PEER REVIEW DOCUMENTATION

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Peer Reviewer: I have reviewed the assigned items/sections(s) noted for the above document and believe them to be in accordance with the project requirements, standards of the profession, and Reclamation policy.

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(Signature)

Executive Summary

The U.S. Customs and Border Protection (CBP), a part of the Department of Homeland Security, operates and maintains a fleet of MQ-9 Predator B unmanned aircraft systems (UAS) in support of law enforcement and homeland security missions along the United States borders. Several years ago, in what the U.S. Geological Survey (USGS) refers to as a 'good government' effort, the CBP began allowing other civilian Federal agencies to submit Predator B tasking requests for remote sensing data collection over areas along our borders that are routinely patrolled by the CBP Predator B fleet. As communicated during a pre-2011 meeting between Department of Interior (DOI) agency mapping/remote sensing personnel, and CBP in Building 810 on the Denver Federal Center, the primary considerations for Predator B tasking requests were; 1) the remote sensing data requests fit within the requesting agencies mission, 2) project areas should be within approximately 100-miles of the U.S. border, 3) DOI tasking requests do not interfere with CBP mission priorities, and 4) CBP had the final say on all tasking requests. During 2011 the USGS and Army Corps of Engineers successfully tasked Predator B data collections related to the Mississippi River flooding events, and the Bureau of Land Management (BLM) and US Forest Service (USFS) successfully acquired Predator B data for the 2011 Monument wildfire event in Arizona. In 2014, the Bureau of Reclamation (Reclamation) submitted two project areas of interest for Predator B data collection, data for both areas were to be obtained using the full suite of Predator B sensors. The tasking request was to be a test of; a) the effectiveness of the overall tasking procedure, and b) to better understand and evaluate the utility of the sensor data collected by the Predator B for possible Reclamation applications.

The CBP Predator B is typically equipped with a remote sensor package optimized for surveillance, monitoring, tracking, and targeting operations. Primary sensors utilized on the Predator B are full motion video oriented electro-optical (EO), thermal infrared (IR), and synthetic aperture radar (SAR). DOI agencies were to submit CBP Predator B tasking requests thorough the USGS National Unmanned Systems Project Office in Washington, DC. In spring 2014 Reclamation submitted a Predator B tasking request for two project areas; 1) the Yuma, AZ to Calexico, CA area, for 8 sites along the All-American canal. Canals, infrastructure, and irrigated lands were to be imaged within and adjacent to the 8 sites, and 2) the area around Grand Coulee Dam; the Dam itself, associated electrical and mechanical infrastructure, and switchyards were to be imaged. Both daytime and nighttime data acquisition missions were requested for each project area, using the full suite of available Predator B sensors, data acquisition were requested for anytime during May or June 2014.

The results of the Reclamation Predator B tasking requests were disappointing. The Yuma, AZ to Calexico, CA area request for 8 sites was denied by CBP, the reason given was that the 'airspace was too busy' during every day/night of May and June 2014. CBP offered no alternative timeframe for data acquisition; it was assumed that Predator B data collections along this section of the US-Mexico border were for CBP mission priorities only. Reclamation's request for Predator B data collection over the Grand Coulee Dam area was also denied; the reason given was that our tasking did not fit into their NASOC-GF UAS schedule. However, for the Grand Coulee Dam area request, CBP did offer the use of their Spokane Air Branch helicopter; it could be equipped with EO and FLIR (forward looking infrared) sensors for remote sensing data acquisition. The CBP alternative offer of the helicopter sensor platform was respectfully declined, because the purpose of this research scoping project was to investigate the potential use of the CBP Predator B sensors to collect remote sensing data during their routine daily overflights of the US/Canada and US/Mexico borders. Without any current sensor package Predator B collected data to review and analyze for Reclamation areas of interest, it was not possible to adequately assess the utility of Predator B sensor collected data for Reclamation use. Questions remain unanswered; including those related to the timeliness of Predator B data collection and delivery, quality and resolution of the live video imagery vs. delivered imagery resolutions, data formats available, band wavelengths, software and hardware needed for imagery data exploitation, and our assessing the overall quality and usefulness of the various sensor types of data for Reclamation projects.

Reclamation requests for remote sensing data acquisition using the Predator B platform sensors, during routine daily overflights of the US/Canada and US/Mexico borders, appeared to not align with CBP mission priorities, at least during the spring-summer of 2014. It should be noted that during 2014, the Bureau of Indian Affairs (BIA) also submitted Predator B data collection requests for several dams, irrigated land areas, and a forested area for the Blackfeet Indian Reservation in northwest Montana (see BIA maps in Appendix), and their tasking requests were also denied by CBP (reasoning not disclosed). For reasons unknown, in 2014 there appeared to be a change in CBP policy from the previous successful 2011 DOI Predator B tasking requests.

While not successful in acquiring remote sensing data using the CBP Predator B in 2014, Reclamation was able to gain some insight into CBP operations and procedures for tasking requests. This experience did help us determine that the CBP Predator B was not a suitable platform for the acquisition of remote sensing data during their daily overflight missions, and followed by the effective dissemination of that data to Reclamation for our use. If Reclamation experiences an emergency in the future; such as a natural disaster, criminal-terrorist incident, or infrastructure breakdown at one of our facilities, perhaps a request for Predator B overflights to collect remote sensing data would be approved.

In addition, the acquisition, operation, and maintenance of a large UAS such as the Predator B would be cost prohibitive for an agency like Reclamation, and likely even DOI. These types of UAS cost millions of dollars to acquire, and their annual operations and maintenance costs are significant. These large UAS were developed for surveillance, reconnaissance, monitoring, tracking, and targeting operations, which they excel at. However, their emphasis on full motion video sensors hampers their usefulness to Reclamation and other DOI agencies for the majority of the large scale mapping applications these agencies undertake. While the full motion video sensors could be useful for certain DOI law enforcement operations, animal counts, and wildfire events; full motion video imagery is not very compatible with the photogrammetric mapping, CAD, imagery interpretation/analysis, and GIS based workflows established at Reclamation and other DOI agencies.

It is recommended that for the foreseeable future, and depending on final Federal Aviation Administration (FAA) rules and Agency guidelines for use of small UAS (sUAS); that use of sUAS will potentially offer the most timely and cost effective sensor platforms for acquiring remote sensing data over small Reclamation project areas. With increasing competition, sUAS costs continue to become more reasonable, a sUAS system suitable for large-scale photogrammetric mapping applications can likely be acquired for $25,000 or less. With the continued advancement, accuracy, and miniaturization of associated components and sensors; such as global positioning systems/inertial measurement unit (GPS/IMU), thermal IR, multi/hyperspectral, and LiDAR, fixed wing and rotary type sUAS will become even better and more effective for many remote sensing applications.

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U.S. Customs and Border Protection

FACT SHEET

Guardian UAS
Maritime Variant Predator B

The U.S. Customs and Border Protection (CBP), Office of Air and Marine (OAM) MQ-9 Predator B unmanned aircraft system (UAS) is a strategic asset for homeland security operated at and beyond the nation's borders to overcome threats moving towards the United States. In partnership with the U.S. Coast Guard, OAM developed a maritime variant of its Predator B UAS, called the Guardian, to increase reconnaissance, surveillance, targeting, and acquisition capabilities in maritime operating environments.

The Guardian was modified from a standard Predator B with structural, avionics, and communications enhancements, as well as the addition of a Raytheon SeaVue Marine Search Radar and an Electro-optical/infrared sensor that is optimized for maritime operations.

OAM pilots use the Guardian to conduct long-range surveillance in support of joint counter-narcotics operations in the southeast coastal and Gulf of Mexico border regions and drug source and transit zones, where maritime radar is necessary to detect a variety of threats. Video recorders document suspect activities for evidentiary use.

CBP UAS Operations

- Six UAS are assigned to the Southwest Border Region, two are assigned to the Northern Border and two Guardian UAS are assigned to Cape Canaveral Air Force Station in Florida.

Performance and Weight:

- **Maximum Speed**
  240 knots (276 mph)
- **Service Ceiling Altitude**
  50,000 feet
- **Endurance**
  Up to 20 hours
- **Maximum Gross Weight**
  10,500 pounds

Other System Components

- Fixed and mobile ground control stations
- Electro-optical/infrared sensors, which allow for crewmembers to maintain awareness of targets in all environments.

For more information, visit the CBP.gov website
or contact the Office of Public Affairs at (202) 344-1780.

5/1/2013

Figure 1: CBP Predator B-Maritime Variant Fact Sheet.

U.S. Customs and Border Protection

Unmanned Aircraft System MQ-9 Predator B

FACT SHEET

The U.S. Customs and Border Protection (CBP), Office of Air and Marine (OAM) operates the highly capable and proven Predator B unmanned aircraft system (UAS) in support of law enforcement and homeland security missions at the nation's borders. OAM selected the Predator B, manufactured by General Atomics Aeronautical Systems, for its unique combination of operational capabilities, payload capacity, mission flexibility, potential to accommodate new sensor packages, and its safety and performance record with other federal agencies.

The UAS program focuses operations on the CBP priority mission of anti-terrorism by helping to identify and intercept potential terrorists and illegal cross-border activity. It also supports disaster relief efforts of its Department of Homeland Security partners, including the Federal Emergency Management Agency and the U.S. Coast Guard.

The remotely-piloted Predator B allows OAM personnel to safely conduct missions in areas that are difficult to access or otherwise too high-risk for manned aircraft or CBP ground personnel.

CBP first employed the Predator B in support of law enforcement operations on the Southwest Border in 2005 and along the Northern Border in 2009. OAM operates Predator Bs from Libby Army Airfield in Sierra Vista, Ariz., and Grand Forks Air Force Base in ND.

OAM also operates a maritime variant UAS called the Guardian. OAM's three Guardian aircraft fly from Cape Canaveral Air Force Station, Fla.; and Naval Air Station Corpus Christi in Texas. OAM expects to employ the Predator B throughout the border regions with command and control from a network of ground control stations across the country. The Predator B's capability to provide high-quality streaming video to first responders, and to assess critical infrastructure before and after events, makes it an ideal aircraft to support emergency preparations and recovery operations.

The UAS provided emergency support for multiple hurricanes and floods since 2008, including Hurricane Sandy in 2012.

Video recorders document suspect activities for evidentiary use.

Performance and Weight:

- **Maximum Speed**
  240 knots (276 mph)
- **Service Ceiling Altitude**
  50,000 feet
- **Endurance**
  Up to 20 hours
- **Maximum Gross Weight**
  10,500 pounds

Other System Components

- Fixed and mobile ground control stations
- Electro-optical/infrared sensors, which allow for crewmembers to maintain awareness of targets in all environments.
- Surface Search Radar/Ground Moving Target Indicator

For more information, visit the CBP.gov website
or contact the Office of Public Affairs at (202) 344-1780.

5/1/2013

Figure 2: CBP Predator B- Fact Sheet.

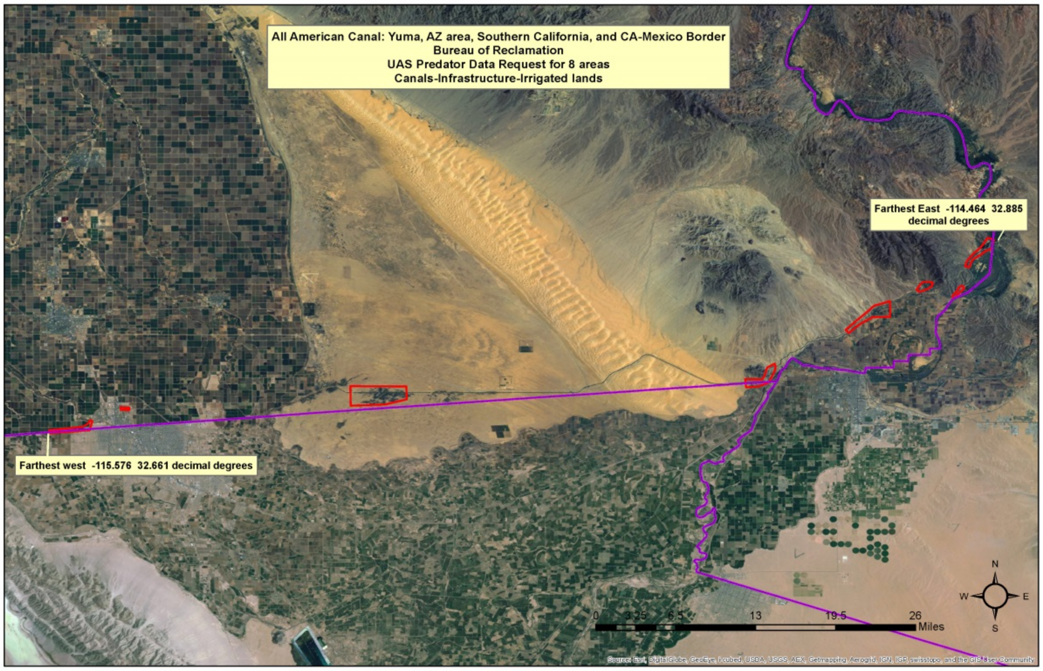

Figure 3: Reclamation All-American canal Predator B tasking request (orthoimage). The red polygons are the eight individual site requests for data collection.

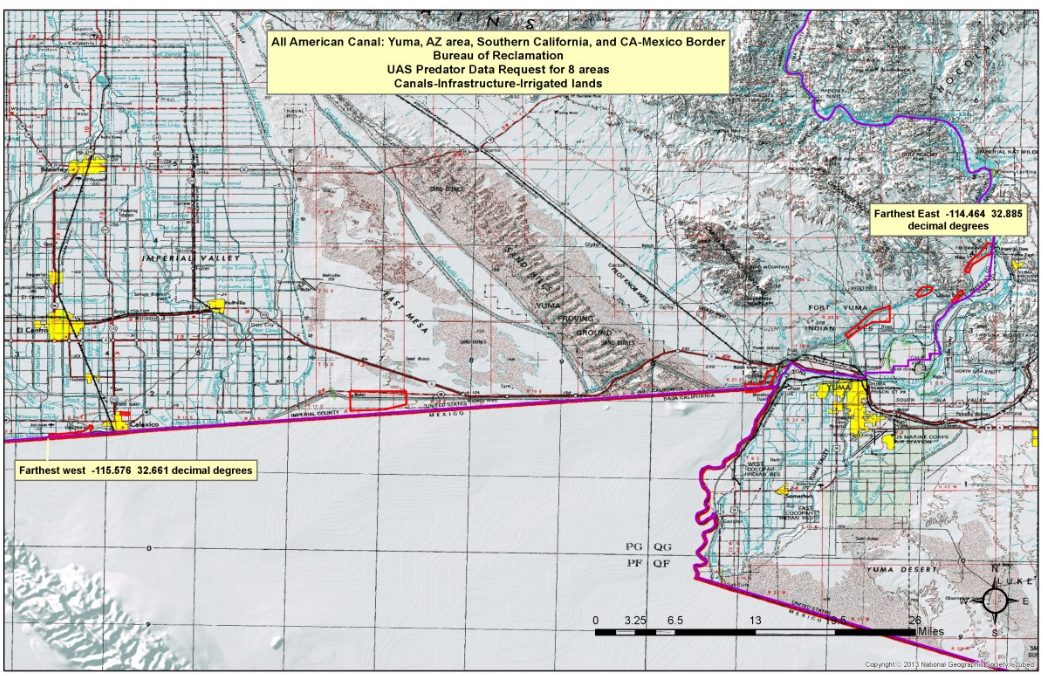

Figure 3a: Reclamation All-American canal Predator B tasking request (topo map). The red polygons are the eight individual site requests for data collection.

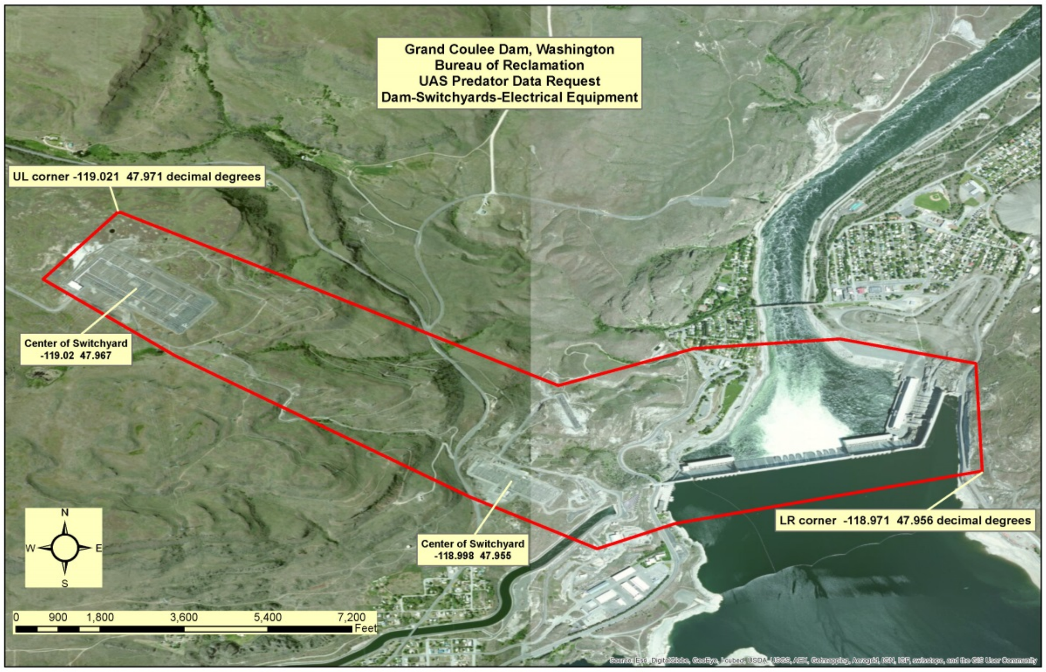

Figure 4: Reclamation Grand Coulee Dam Predator B tasking request (orthoimage). The area within the red polygon is where data was requested.

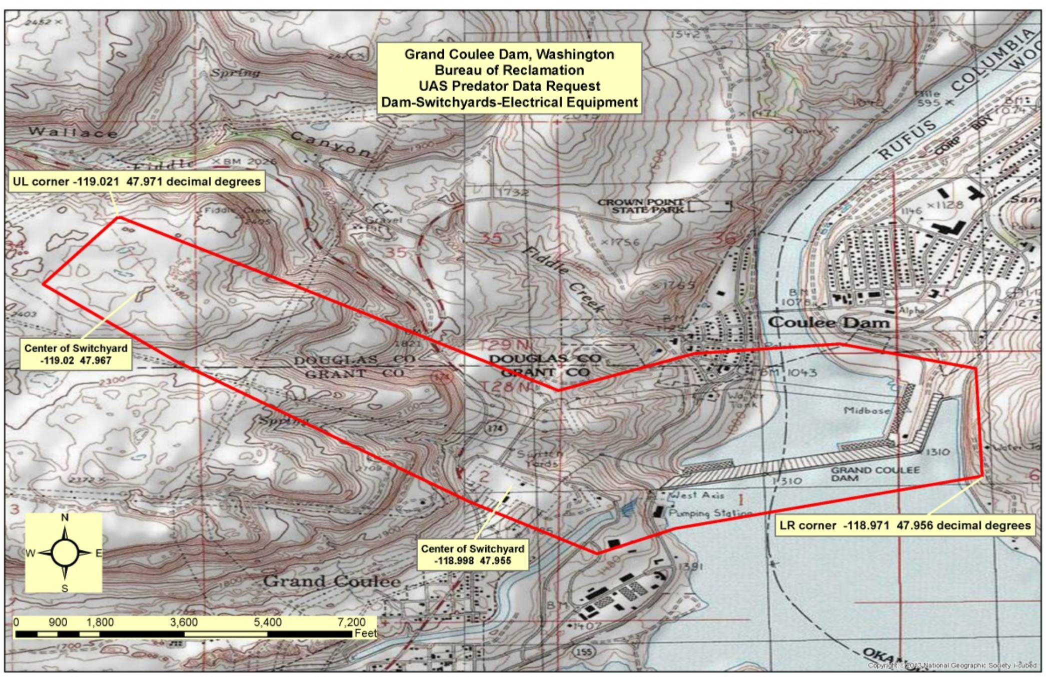

Figure 4a: Reclamation Grand Coulee Dam Predator B tasking request (topo map). The area within the red polygon is where data was requested.

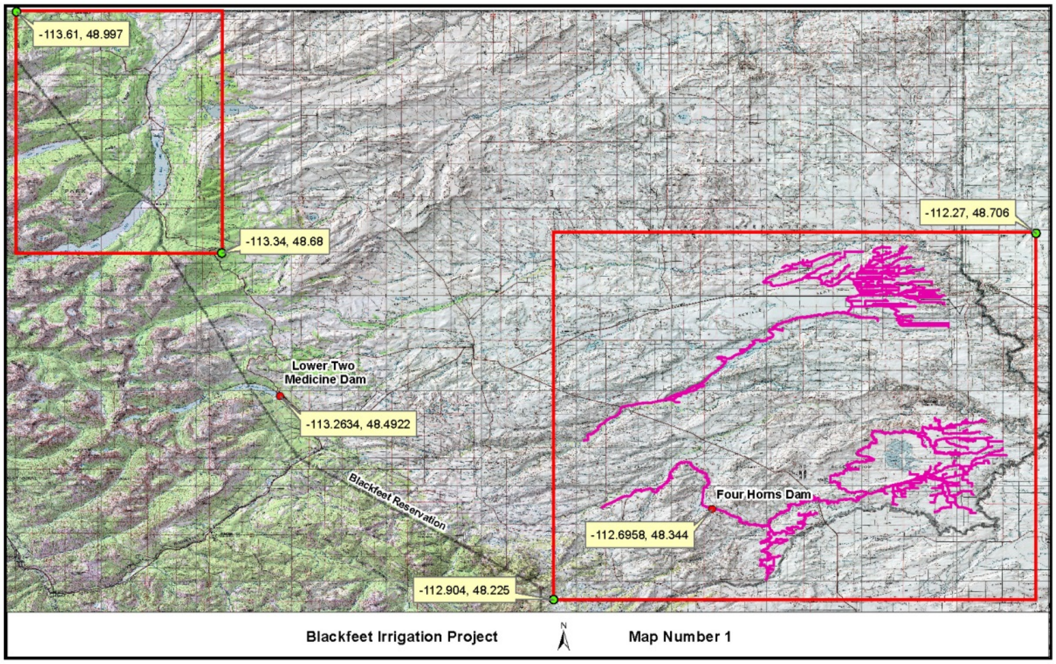

Figure 5: Overall BIA Predator B tasking request map 1, northwest Montana.

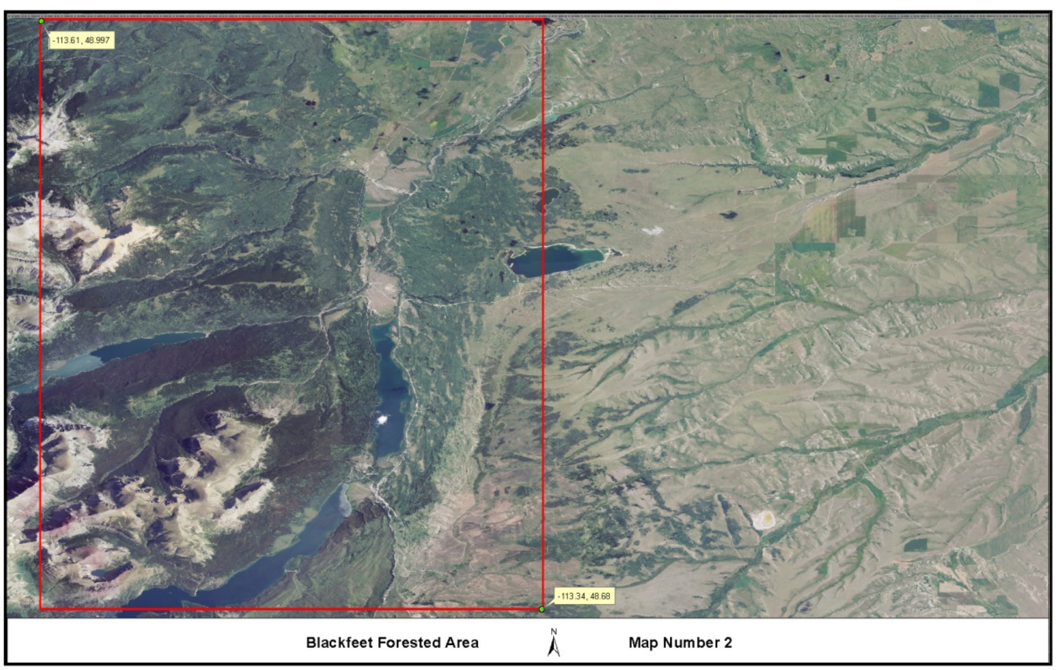

Figure 6: BIA Predator B tasking request map 2; northwest Montana.

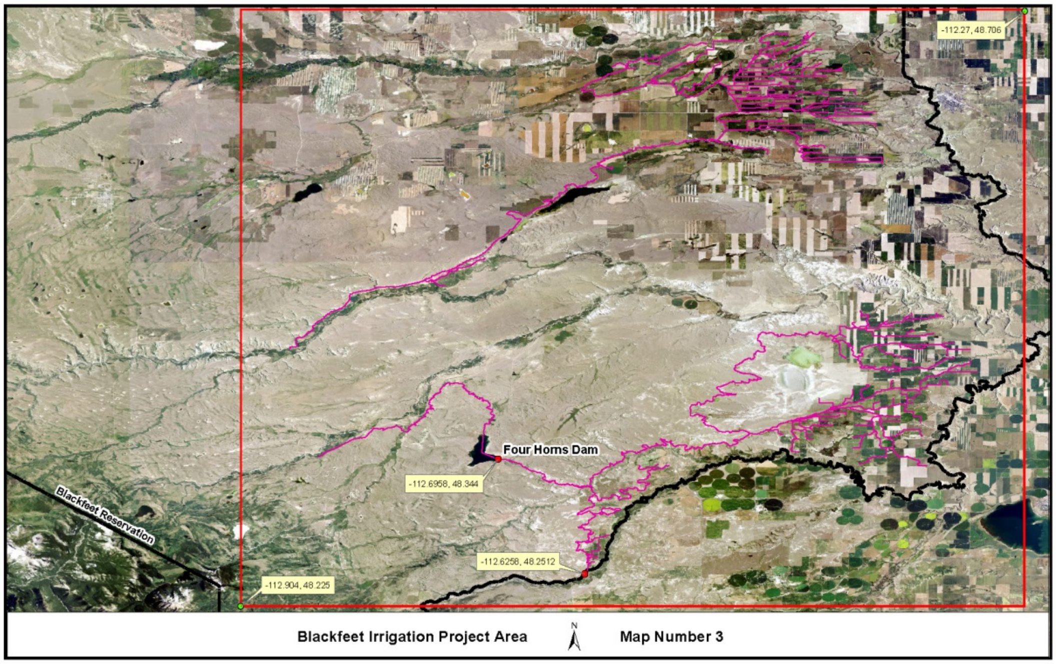

Figure 7: BIA Predator B tasking request map 3; northwest Montana.

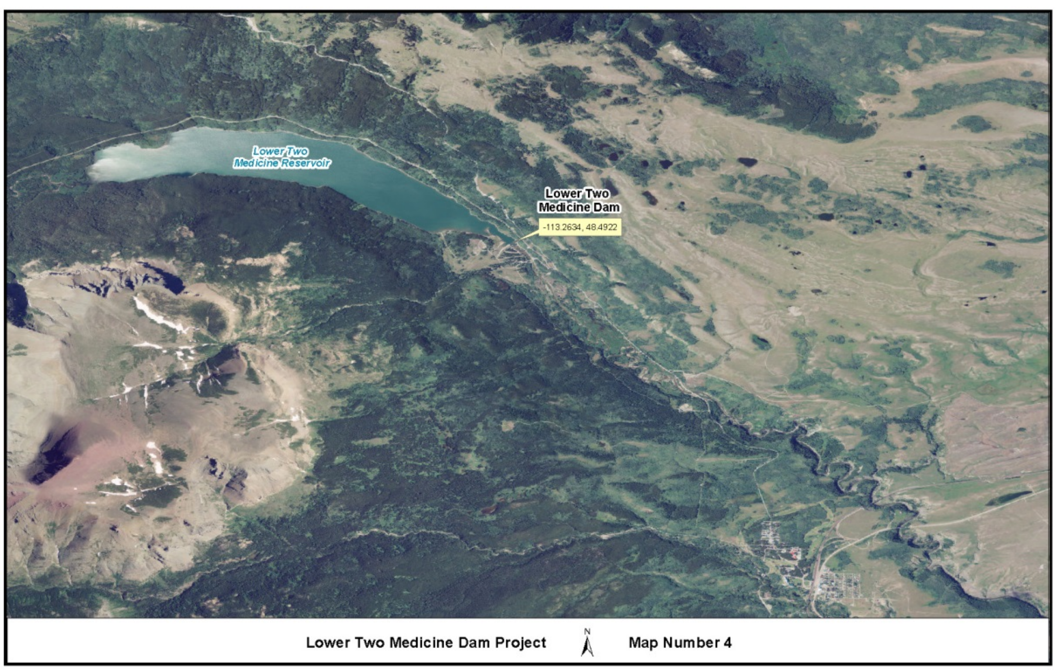

Figure 8: BIA Predator B tasking request map 4; northwest Montana.

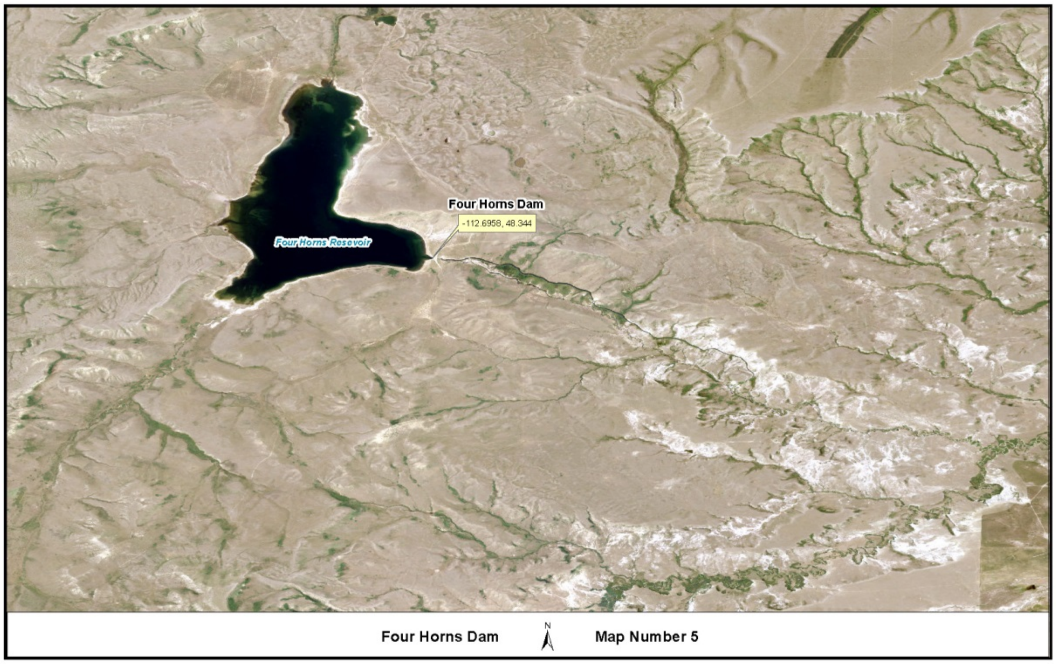

Figure 9: BIA Predator B tasking request map 5; northwest Montana.

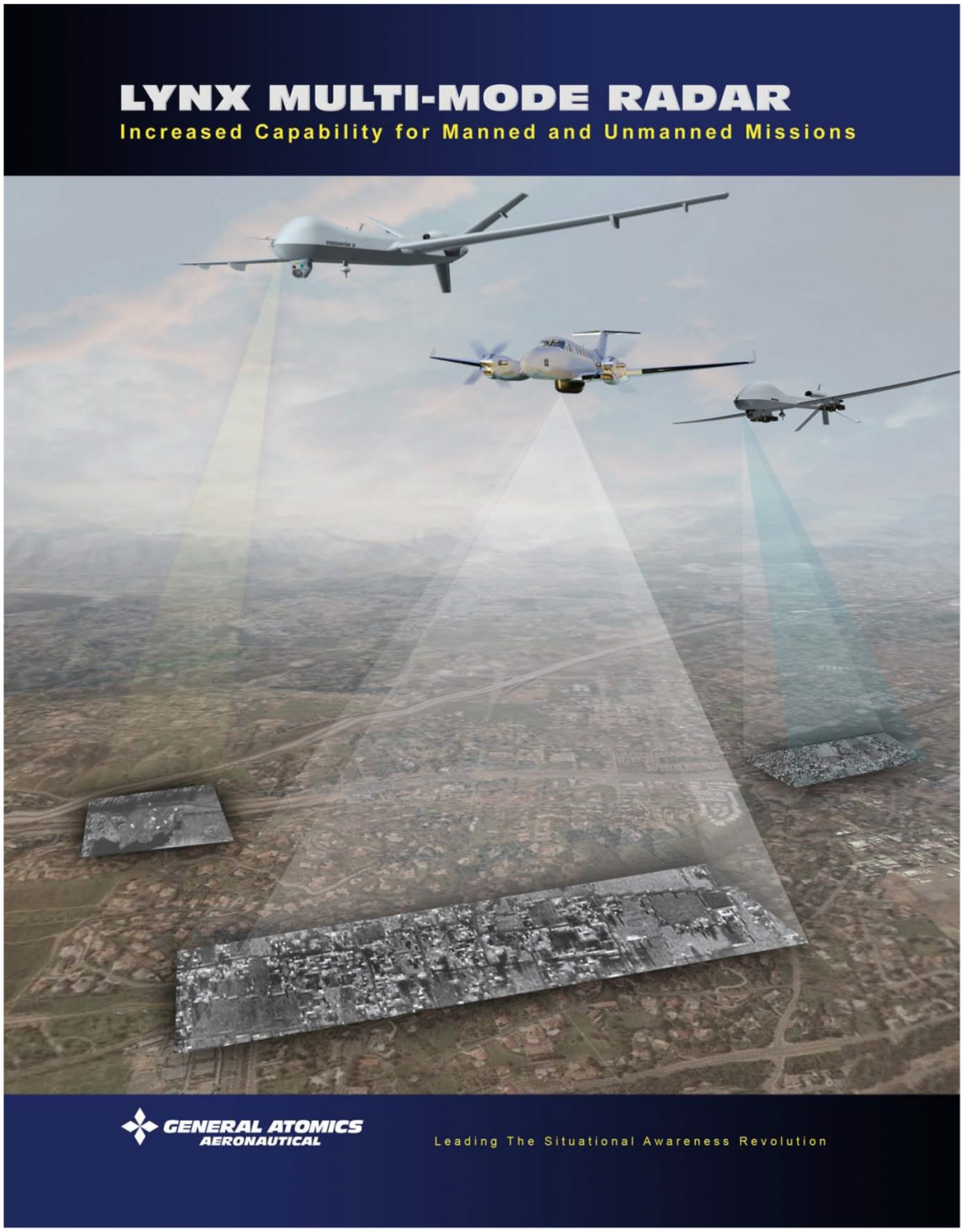

Figure 10: Page 1 of brochure for SAR system carried by the CBP Predator B. General Atomics is the manufacturer of the Predator B.

LYNX® MULTI-MODE RADAR

FEATURES/BENEFITS

- High-resolution photographic quality SAR imagery
- Selectable resolution
- All-weather, day/night performance
- Combat-proven
- Change detection capability
- Claw® payload control and exploitation ready
  Two LRU system (antenna and electronics module)
- Available modes
  - Synthetic Aperture Radar (SAR)
  - Spotlight
  - Stripmap SAR
- Ground Moving Target Indicator (GMTI)
  - Arc scan
  - Spot scan
- Maritime search mode
- Designed for use on manned and unmanned systems
- Approved for export to NATO/coalition forces

TECHNICAL SPECIFICATIONS

- Total Weight: <37 kg (83 lb)
- Input Power: 28 VDC, 1 kW peak, 300W nominal
- Transmit Power: 320W peak
- Frequency: Ku-Band
- Cooling: Sealed conduction
- SAR Resolution: Very fine to 3m
- SAR Range: >80 km (50 mi)
- GMTI Range: 23 km (14 mi)
- Antenna (reflector) Size: 44.5 cm x 16.5 cm (17.5″ x 6.5″)
- Electronic Module Size: 51.4 cm x 29.6 cm x 26.7 cm (20.2″ x 11.6″ x 10.5″)

OPERATIONAL USE WITH:

- U.S. Department of Homeland Security
- U.S. Air Force
- Royal Air Force
- Italian Air Force
- Iraq Air Force

General Atomics Aeronautical Systems, Inc. • 16761 Via Del Campo Ct., • San Diego, California 92127 USA
Phone: +1-858-762-6700 Fax: +1-858-762-6100 • www.ga-asi.com

Subject to U.S. export control regulations.

ASH0310712

Figure 10a: Page 2 of brochure for SAR system carried by the CBP Predator B. General Atomics is the manufacturer of the Predator B.

Raytheon

MTS-B Multi-Spectral Targeting System

Multimedia

Raytheon's MTS-B Multi-Spectral Targeting System provides electro-optical, infrared, laser designation, and laser illumination capabilities integrated in a single sensor package.

The MTS-B provides superior detecting, ranging, and tracking for the U.S. Air Force Predator B and for today's military forces worldwide. Using state-of-the-art digital architecture, this advanced system provides long-range surveillance, high-altitude target acquisition, tracking, rangefinding, and laser designation for the HELLFIRE missile and for all tri-service and NATO laser-guided munitions.

The MTS and variants are available to support domestic and international user missions for rotary-wing, UAV, and fixed-wing platforms.

With advanced electronics and optical design driving a clear growth path for image fusion and other performance enhancements, the MTS system will continue to be the world's most advanced EO/IR multi-use system.

SAS Communications and Public Affairs
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To order parts:
Products@raytheon.com
For supplier inquiries:
sas.supplier.diversity@raytheon.com

Figure 11: MTS-B multi-spectral targeting system (Raytheon), similar to those used on CBP Predator B.

MTS™ FAMILY OF SENSORS

MTS-A • **MTS-B** • CSP • AAS-44C(V)1

Incorporating MTS-A capabilities, the MTS-B was specially adapted for high-altitude applications. It provides superior detection, ranging and tracking for the U.S. Air Force Predator B and allied military forces worldwide. MTS-B has expanded into the maritime domain, supporting applications such as broad area surveillance, search and rescue, as well as customs and border patrol operations.

Designated the AN/DAS-1 by the U.S. military, this technology has been fielded on the U.S. Customs and Border Protection's Guardian UAV and the Broad Area Maritime Surveillance mission.

Figure 11a: Close in view of the Predator B MTS-B targeting system (Raytheon), red areas are where specific components-sensors are located.

Federal Aviation Administration

Section 333

Due to the intense public demand to expedite integration of Unmanned Aircraft Systems (UAS) into the National Airspace System (NAS), the FAA continues efforts to develop the regulatory framework for safely integrating small UAS into routine NAS operations. This will primarily be accomplished by the small UAS (sUAS) rule, which is scheduled to be released for public comment later this year.

While these efforts continue, the FAA is also working to leverage authority granted under Section 333 of the FAA Modernization and Reform Act of 2012 (FMRA) to establish an interim policy that bridges the gap between the current state and NAS operations as they will be once the small UAS rule is finalized. Section 333, Special Rules for Certain Unmanned Aircraft Systems, grants the FAA limited statutory flexibility to expedite requirements for the safe operation of certain aircraft systems in the NAS.

The interim policy provides a framework for authorizing safe civil operations in the NAS, including operations for air commerce. This framework will provide operators who wish to pursue safe and legal entry into the NAS a competitive advantage in the small UAS marketplace, thus discouraging illegal operations and improving safety. It is anticipated that this activity will result in significant economic benefits.

The FAA Administrator has identified this as a high priority project to address demand for civil operation of small UAS for commercial purposes. The interim policy established under Section 333 will be superseded by future regulations, such as the sUAS rule.

Specifically, Section 333 authorizes the FAA to determine:

1. If certain unmanned aircraft systems, if any, as a result of their size, weight, speed, operational capability, proximity to airports and populated areas, and operation within visual line of sight do not create a hazard to users of the national airspace system or the public or pose a threat to national security; and

2. Whether a certificate of waiver, certificate of authorization, or airworthiness certification under section 44704 of title 49, United States Code, is required for the operation of unmanned aircraft systems identified under paragraph (1).

The FAA is currently considering exemptions under Section 333 from several different companies. You can view the exemption requests at regulations.gov (http://www.regulations.gov/#!searchResults;rpp=25;po=0;s=%2522section%252B333%2522%252BFAA;fp=true;ns=true) .

Page last modified: July 24, 2014 10:26:33 AM EDT

This page was published at: http://www.faa.gov/uas/legislative_programs/section_333/

Figure 12: Section 333 information from the FAA website regarding release of sUAS rule for public comment by the end of 2014.

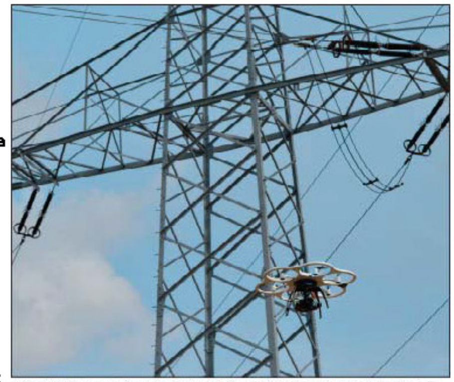
Feature: Preparing to Fly

Professional Surveyor Magazine - May 2014

An industry insider provides an overview of the advantages of using UAS for surveying as well as common misconceptions, plus preparation steps for surveyors and firms.

By Alistair Stuart

Unmanned aircraft systems (UAS) represent a culmination of advancements in miniaturization, electronics, optics, batteries, and data-processing techniques. After being widely used in military and security operations for the past 10 years, this transformative technology is now being adapted and refined to be useful for a variety of commercial applications.



Rotary UAS, such as the Aibotix Aibot X6 shown here, can maneuver close to power lines and other targets to provide high-resolution in-flight imagery.

In other western countries, UAS are already used for business purposes. Commercial development in the U.S. has lagged as the Federal Aviation Administration explores the policies, regulations, technologies and procedures that will be required for UAS operations to be integrated into the nation's airspace. However, the delay in commercial approval has done little to dampen the enthusiasm for this promising new technology—and for good reason. The future of UAS isn't a matter of if, but of when, and forward-thinking firms are already beginning to prepare for the coming changes.

Commercial Applications

One of the major benefits of UAS is the ability to carry a variety of payloads that are appropriate for different applications. Depending on the type of vehicle, it might carry instruments and sensors that collect meteorological data, air samples, video, digital imagery, lidar data, and infrared images. UAS are particularly useful in hazardous situations that could endanger human life, such as night flying and over storms, forest fires, floods, and accidents involving toxic chemicals.

A significant cost-effective application for UAS is monitoring various types of infrastructure and specific locations on a frequent basis. This may include harbor and border control, area and event security, landfills, mines, and pipelines. Safety inspections will particularly benefit when UAS become commercially available. Regular inspections of power transmission lines, pipelines, and bridges will enhance public safety without increasing risk for workers conducting visual inspections.

Agriculture is frequently cited as a growth area for UAS. The traditional methods of aerial imaging, from aircraft or helicopters, are often cost-prohibitive other than for very high-value crops. With UAS, fields can be more frequently flown, which provides more detail and indicates where water, pesticides, and fertilizer needs to be applied to increase yield. UAS are also used for crop dusting and locating livestock. After natural disasters, UAS can map the acreage of crops lost to storms so that farmers receive a fair reimbursement from insurance companies.

One of the primary applications for UAS is in mine safety inspections.

UAS can be more cost-effective for traditional topographic mapping of small projects (from just a few acres to several hundred acres), such as landfills, open-pit mines, and coal stock piles, which need frequent revisits. Compared to a large-format system, UAS take more pictures so more processing is involved, but a large-format system is more expensive to mobilize and operate for short flights.

Emergency response, search and rescue, and damage assessment are other highly useful applications for the technology. In areas of difficult terrain or during bad weather, UAS can fly without risking the lives of first responders. After natural disasters, imagery is often used to estimate the cost of rebuilding and the value of insurance claims.

Fields such as real estate, construction, the film and entertainment industry, and accident investigation are all potential markets for commercial UAS operations.

Rotary vs. Fixed-wing vs. Full-size Aircraft

The choice between multicopter/helicopter UAS technologies and traditional fixed-wing designs requires consideration. Helicopter mapping is not new, but rotary UAS, with their small size and lower costs to operate, open the door to broader applications and markets for services. Because of its ability to maintain a single position in space, a rotary UAS can collect data thoroughly and precisely. Rotary UAS can also fly in restricted or interior spaces, such as under bridges or around power lines, moving horizontally and vertically.

Additionally, a rotary UAS can maneuver close to targets to provide higher-resolution, in-flight imagery. This stability makes detailed inspection work easier to complete. Rotary UAS can also handle applications that require flexibility of movement (i.e. horizontal, vertical, hovering).

Safer, more controlled landings are another advantage of rotary UAS. They require only a small amount of surface to safely take off or land. This added control means rotary UAS can be relied upon to carry more delicate equipment.

As with every technology decision, however, the application will dictate the best approach. A common misconception is that UAS will replace all current forms of aerial data capture. The reality is that projects that are large in scope, such as planning surveys for pipeline routing, will likely continue to be more cost-effective to achieve with a full-size aircraft and a larger sensor.

Additionally, the UAS platform is only part of the package. Professional users will need to carefully examine aspects such as the durability, safety, and ease of use of the system (is it designed for professionals or hobbyists?), the related software (is it fully integrated, fast, and accurate?), and the service and support provided by the manufacturer (is it a startup from someone's garage or a company with substantial R&D capabilities?).

For the professional, the UAS is a tool that must provide a solid return on investment, and the selection should be made accordingly.

Rotary UAS can be used to assess the precise condition of rockfall protection netting.

Alistair Stuart *handles sales of aerial sensor systems for Leica Geosystems, Inc.*

Sidebar

Common UAS Misconceptions

Myth: UAS will make everyone a mapping expert. Fact: UAS are affordable, are easy to operate, and may not even require a pilot's license to use, depending on the system and the regulations that emerge. As a result, UAS will create aerial mapping opportunities for a much wider group of users than those who have traditionally been able to perform these tasks. However, this doesn't mean that just anyone will be able to go out and fly a system, come back with the imagery, press a button, and produce high-value deliverables. Because these systems don't have the same large GNSS IMU sensors that are on full-size planes, achieving good spatial accuracy will require expertise and additional survey work, such as setting ground control.

Myth: All UAS are created equal. Fact: If a system seems too good to be true, it probably is. Look for solutions that are safe, robust, and designed for professionals. Pay careful attention to software and support. An inexpensive "do-it-yourself" system can cost a substantial amount of money in downtime and lost business if it doesn't produce the required results in a timely manner. Also, make sure the manufacturer is reputable and has a history of standing behind its products long term.

Myth: It's okay to fly a UAS under 400 feet or on private property. Fact: Much of the conventional wisdom about UAS simply isn't true. In fact, the FAA recently issued a fact sheet to clarify eight of the most common UAS myths, and these two are on the list. Be sure to check the FAA website or another reputable resource to determine what activities are permitted.

Sidebar 2

Six Steps You Can Take to Prepare

1. Begin exploring capabilities and workflows. Some of the most popular professional solutions are affordable and easy to operate, but there's still a learning curve for successful adoption. Firms that have purchased a UAS are wisely focusing on internal R&D, workflows, and marketing strategies that will give them a competitive edge when the market opens for commercial use.
2. Build internal support. The successful integration of a new technology requires an internal champion who invests time in learning about the capabilities and applications and then communicates the benefits to internal stakeholders to achieve widespread buy-in. Developing realistic expectations is a key part of the process.
3. Establish relationships with universities and FAA-approved UAS test sites. Universities are actively seeking industry partners that can contribute to the general understanding of the technology and airspace integration issues. Three of the FAA-approved UAS test sites are operated by universities, and there may be opportunities to participate in the other test sites as well.
4. Take an active role in industry initiatives. Organizations such as the Association for Unmanned Vehicle Systems International (AUVSI) and MAPPS are working diligently on behalf of professionals to lobby the federal government for commercial approval of UAS. Participating in related task forces, events, and campaigns are just a few ways professionals can support these efforts.
5. Respect the regulations. Despite widespread media coverage of operators who have seemingly been able to "get away with" commercial use of UAS, the regulations exist for a reason. Safety is paramount. Continued progress in securing commercial approval requires a professional approach—and that means playing by the rules.
6. Do your homework. One of the best ways to prepare for the commercialization of UAS technology is to stay abreast of the latest developments. Make sure the information is coming from a reliable source; even well-intentioned reports in articles and blogs can be misleading. Two good resources are the FAA website and the AUVSI.

Sidebar 3

Online Resources

> For more UAS myths, see "Busting Myths about the FAA and Unmanned Aircraft": faa.gov/news/updates/?newsId=76381
> Contact information for all six FAA-aproved test sites are on the FAA website: faa.gov/about/initiatives/uas/contacts/

> Unmanned Vehicle Systems International: auvsi.org

Figure 13: Professional Surveyor magazine article, May 2014, regarding possible sUAS applications and preparation to operate them.

Issue: 09/08/2014

Survey Technology Firms Deploy Their Own Drones

09/02/2014

By Jeff Rubenstone

Text size: A A

Photo Courtesy of Leica Geosystems

Small, remote-controlled drones, such as Leica's Aibot A6, can be used for dam inspection.

Related Links:

- Construction Industry Drones Fly In Rules Vacuum
- Some Firms Are Not Waiting For Regulations On Commercial Drone Operations
- Topcon Positioning Systems Showcases Unmanned Aerial Systems at ESRI User Conference
- JAVAD Triumph F-1 Promotional Video

Consumer-level unmanned aerial vehicles (UAVs) can be purchased off the shelf and be up in the air as soon as the batteries are charged, but the data-driven world of construction surveying often demands something a bit more robust. In anticipation of up- coming regulations from the Federal Aviation Administration, surveying and mapping equipment firms are making big investments in UAVs. Many companies are already offering their own drones that are tailored to the needs of construction surveying.

"Anybody can run to a hobby shop, get a quadcopter [UAV] and throw a GoPro [camera] on it. But that's just a photo," says Bryan Baker, Leica Geo- systems' NAFTA region sales manager for unmanned-aircraft systems. "People in construction are going to want this integrated into their CAD systems, their building information modeling, their construction design tools. You're not going to get that from a hobby shop." Leica now offers two unmanned aircraft systems: the high-end Dragon 35 syncopter from original equipment manufacturer (OEM) Swissdrones, Sevelen, Switzerland, and the more compact, less pricey Aibot A6 hexacopter, made by Aibotix, a Kassel, Germany-based drone maker Leica acquired in early 2014.

In recent years, many of the biggest manufacturers of construction surveying equipment have acquired or made OEM deals with UAV manufacturers, rather than develop their own drones. "Getting [FAA special certification for a UAV] is a very expensive and time-consuming process for us," says Baker. "If the FAA ends up requiring certification for use, you're going to see about 90% of UAV companies go away."

Not looking to compete with the drone makers that target consumers and, particularly, photographers, survey technology firms are pitching their own premium-priced UAVs to the construction, mining and agriculture markets. These machines often boast more features than the standard "waypoint navigation with an onboard camera" offered by entry-level UAVs. In some cases, these higher-end machines can perform much of the work done in traditional aerial surveying.

"We're already able to use UAVs in basic surveying: photogrammetry, volumetrics for earthmoving. For the construction process, we can now provide stakeholders with updates on the project—not just photos, but measurements taken from the aircraft—to see if it's all up to spec," says Baker. Photogrammetry, the process of using aerial photography and location data to make exact measurements, requires a level of precision that most lower-cost drones can't meet, he says.

"I don't believe UAVs will replace surveying equipment, but they will certainly narrow the scope of what you'll need a total station or other ground-based equipment for," says Todd Steiner, imaging business marketing director for Trimble's geospatial division. "It is changing the workflow. In the past, you might hire a survey company to do a topographic survey of the land. Now, you can take out a UAV with some other survey technology and do the initial planning and survey in a couple of hours—versus days or weeks using traditional technology—and what you end up with is a much denser info set," he says.

Layout software already exists to incorporate ground-based survey data into the design and construction workflow. According to Steiner, proper integration into these platforms is one capability the $50,000 Trimble UX5 drone has that is lacking in, for example, the $1,299 DJI Phantom 2 Vision+.

Trimble acquired Gent, Belgium-based drone maker Gatewing in 2012 and has worked to integrate Gatewing's UAVs into its survey and construction software platforms. The UX5 is bundled with Trimble Business Center software and includes photogrammetry and UAV flight-planning modules. "It offers us a nice way to create deliverables," says Steiner. "Rather than a UAV company saying, 'Here's your UAV,' we bring the whole solution integrated into ground-based surveying and photogrammetry software."

By performing much of the work of a third-party aerial surveyor, UAVs offer gains in productivity and cost savings that more than justify the cost, says Dave Henderson, director of geospatial solutions at Topcon Positioning Systems. "In a 55-minute flight you can survey 180 acres. Ask yourself: What other method can a contractor use to get all that?" he says.

Topcon's UAV entry is the Sirius, a fixed-wing, propeller-driven drone made by MAVinci, a drone maker based in St. Leon-Rot, Germany. The basic $42,000 model works with ground reference points to tag image locations precisely. The $53,000 Sirius Pro has onboard real-time kinematics (RTK), which eliminates the need for multiple ground-reference points when obtaining highly accurate map data. "What these [UAVs] offer is another tool for contractors to get data as needed on a continuous basis, based on the demands of the project," says Henderson. "It's a different piece of technology for the same deliverable."

Some survey technology firms are getting into drones on their own terms. Javad Ashjaee's firm, JAVAD, is best known for its global navigation satellite system (GNSS) receivers and base stations. However, when eight rotors are attached on four arms and cameras are fixed to a base station, it becomes a survey UAV. "Other people just bought some toys and put a GPS on it. We added wings to our survey unit," Ashjaee says. "It is a flying GPS survey unit."

The Triumph F-1 is designed to get a GPS instruments package up to height and then take the same precise measurements as it can on the ground. "Ideally, it will be used for small-scale surveying of buildings or roofs," says Ashjaee. The drone has four 45°-mounted cameras for documentation and a single high-precision, downward-facing camera for photogrammetry. JAVAD plans to launch the Triumph F-1 in the first quarter of 2015.

While there are immediate benefits for using a lower-cost UAV to get aerial views on the cheap, survey tech firms are betting the construction industry is more interested in rich data as more elaborate sensors are added to drones, says Trimble's Steiner. "We're going to be able to provide a deeper kind of deliverable than construction uses today. Eventually, we'll be comparing a live 2D or 3D scan to 3D models in real time."

Keywords: Drone; UAV; UAS; Unmanned; Leica; Topcon; Trimble; JAVAD

Figure 14: Engineering News-Record sUAS article, September 2014, possible Reclamation applications for Dam inspections.

Feature: UAS Applied

Professional Surveyor Magazine - May 2014

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Surveyors provide a topographical survey of a harbor in Ireland with a UAS, thus avoiding significant disruption (and risk) that would have been created by a conventional survey.

By Paudie Barry and Ross Coakley

Editor's Note: Our October 2013 issue features a UAS evaluation by a surveying firm in Ireland; they conducted field tests using UAS photogrammetry and compared the results to traditional survey techniques. Now this company has put their UAS to use commercially on a first-of-its kind project. This article provides an excellent example of where a UAS survey can help overcome many project-specific challenges.

Baseline Surveys was awarded a contract to survey approximately one square km (about 247 acres) of the seaside town Dun Laoghaire in County Dublin, Ireland, specifically the town center and marine harbor area. The deliverable was to be a topographic survey for a detailed engineering redesign of the existing port; the client was the Dun Laoghaire Harbour Company.


The Dún Laoghaire promenade in Ireland would have taken a ground survey crew three to four months to survey—*image courtesy of Wikipedia.*

Project Specifics

Site conditions were such that conventional survey methods would have been labor-intensive and hazardous. Survey work next to tidal water had to include a retaining wall and all waterside features down to low water, and survey work outside the confines of the harbor on public and private roadways with live traffic was specified.

Gaining access to the private property would have been unusually complicated. The harbor area is occupied by individual stakeholders, clubs, and statutory bodies. Entry to these sites and the timing was subject to individual consent outside the Harbour Company's direct control. Although every effort would have been made by Harbour staff to facilitate the survey in advance, the final consents were a matter for liaison by the successful surveyor. Each required a minimum notice of two weeks to facilitate any entry permits.

Additionally, conventional survey methods would have required a traffic safety management system, which would have caused substantial disruption to traffic for the duration of the survey. A special track-side permit would have had to have been obtained from Irish Rail, and there would have had to have been special safety considerations in order to ensure the safety of surveyors working at sea-front locations.


Baseline Surveys tested the C-Astral Bramor UAV extensively before undertaking this project.

Additional requirements included:

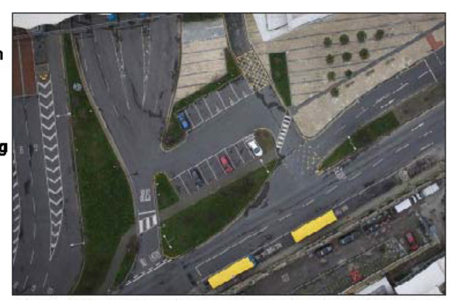
- Entry to individual buildings was not envisaged; however, spot levels to define building heights were required.
- Contour mapping of open areas at 0.1m intervals was required.
- A list of typical features in the specification to be surveyed included cover level and location of underground services, overhead services, all street furniture, curb lines, fences, road markings, buildings with heights, etc., all to be located within an accuracy of +/-25mm.
- The final output data format was to be in AutoCAD dwg format.

Typically, a project such as this would have taken a ground survey crew three to four months to complete.

Using UAS on the project eliminated all these obstacles. The data capture took less than one hour for the entire site, and the final survey was produced within 10 days while achieving all the requirements as set out in the client's survey specification.

Pre-flight Planning

Attaining a permit for this work was a challenge, as normally in Ireland UAS are not allowed to fly over congested areas and must fly within a visual line of site of 500m (.3 miles). Our unmanned aircraft required a take-off and landing area of 100m x 100m cleared land. The nearest suitable land was a soccer field, which was 1200m from our flight location, directly over a congested town center.


This 3D point cloud derived from the aerial imagery has 2cm absolute accuracy.

For the required aerial works application, we prepared a detailed operational risk assessment and mitigation matrix on hazard identification in the target and surrounding areas, including weather requirements, an outline of our crew's experience to date, and operational altitude and location information.

The Irish Aviation Authority was very helpful in assisting us in preparing the operational risk assessment and granted us the permit to execute the work.

We generated a flight plan with an 80% overlap and an 80% side-lap and an altitude of 120m to provide an expected grand sample distance (GSD) of 2cm. Flight direction was plotted at 90 degrees to the actual wind direction to maintain a constant ground speed.

Data Acquisition System

The data acquisition system we used on this project was a C-Astral Bramor UAV, the same model as described in the evaluation feature in the October 2013 issue of this magazine. As during that test, we used the RTK GPS to establish ITM (Irish Transverse Mercator) coordinates on our specifically designed ground markers to provide photo control. The GPS unit has an expected spatial accuracy when operated in the subject region of 10-25mm.

Site Conditions

The prevailing weather conditions on the day of our flight were overcast, with a wind speed at our flying altitude of 120m above ground level (AGL) at a maximum of 7m/s.

The topography of the site had a 17m variation in terrain and had buildings, church spires, and tower cranes up to 40m tall, which would all contribute to turbulence at our flying altitude.

As mentioned previously, the site is in a marine harbor for maritime recreational use, with live road traffic and vessel sailings for the duration of the survey.

Data Processing

Just as we did during our earlier evaluation, we first surveyed 10 ground markers using Network RTK GPS in Irenet95 coordinates and then downloaded the data into Geosite office 5.1 and exported it to AutoCADit 2014.

We downloaded 2,800 photographs from the Bramor UAS along with the flight log file. We imported the photos and the logfile into Agisoft photoscan, and using the software we eliminated superfluous photographs by deleting photos with high roll values. The refined 2,000 photographs were then used for the photo alignment stage.

We then imported the 10 control stations into photoscan and identified the center of each control point marker on each photo and attached it with its appropriate coordinate value.

Next we processed the data into a 3D model for subsequent orthophoto and digital surface and bare earth model output. The orthophoto was outputted at a resolution of 20mm pixel size and the DEM was outputted at 50mm pixel size.

The resulting geo-referenced orthophoto was imported into AutoCAD for the process of heads-up digitizing, which accurately defined the photographic features in CAD. The ground points were isolated in Agisoft Photoscan and exported as a bare earth surface into Global Mapper, where we generated 10cm contour file and spot levels for export to CAD.

Results

The outputs were:

- AutoCAD topographic survey in 2D or 3D
- Orthophoto for CAD/GIS underlay
- DSM & DTM geotiff
- Lidar point cloud

Ground Truth

Once the survey was complete, we returned to the site to ground truth our final survey with 20 GPS check points on already-defined features throughout the extent of the survey. The GPS Z value was compared with our readymade height model value at the same point. The mean difference between the UAS survey and RTK GPS ground truth survey results was 2cm.

This project proves that survey-grade mapping is now possible using remotely piloted aircraft systems. By using UAS to carry out topographic surveys, European government agencies (and mostly likely soon U.S. agencies) can now look forward to spending less money on better geographic information so they in turn can make better informed decisions with less risk to life and less disruption to traffic. This geographic data can be recycled for multiple geographical analyses and design uses across a range of departments.

To represent the landscape, the orthophoto can be combined with the DEM to produce very accurate photorealistic 3D models in AutoDesk, ArcGIS, and MapInfo products and can be analyzed to yield highly accurate earthmoving volumetric calculations, and viewshed and flood analysis, as well as offering a tool to aid geographical communication throughout the lifetime of any given project.

We carried out this UAS operation in a safe manner in accordance to our aerial works permit and operations manual. The flight was without any incident or occurrence, and I particularly thank the Irish Aviation Authority for their helpful and progressive attitude.

Paudie Barry *founded Baseline Surveys Ltd and is a committee member of Unmanned Vehicle Systems International.*

Ross Coakley, BE, MIEI *teamed with Baseline Surveys to develop a UAV aerial photogrammetry and GIS data-capture service.*

» Back to our May 2014 Issue

Figure 15: Professional Surveyor magazine, May 2014 sUAS article, possible Reclamation large scale mapping applications.

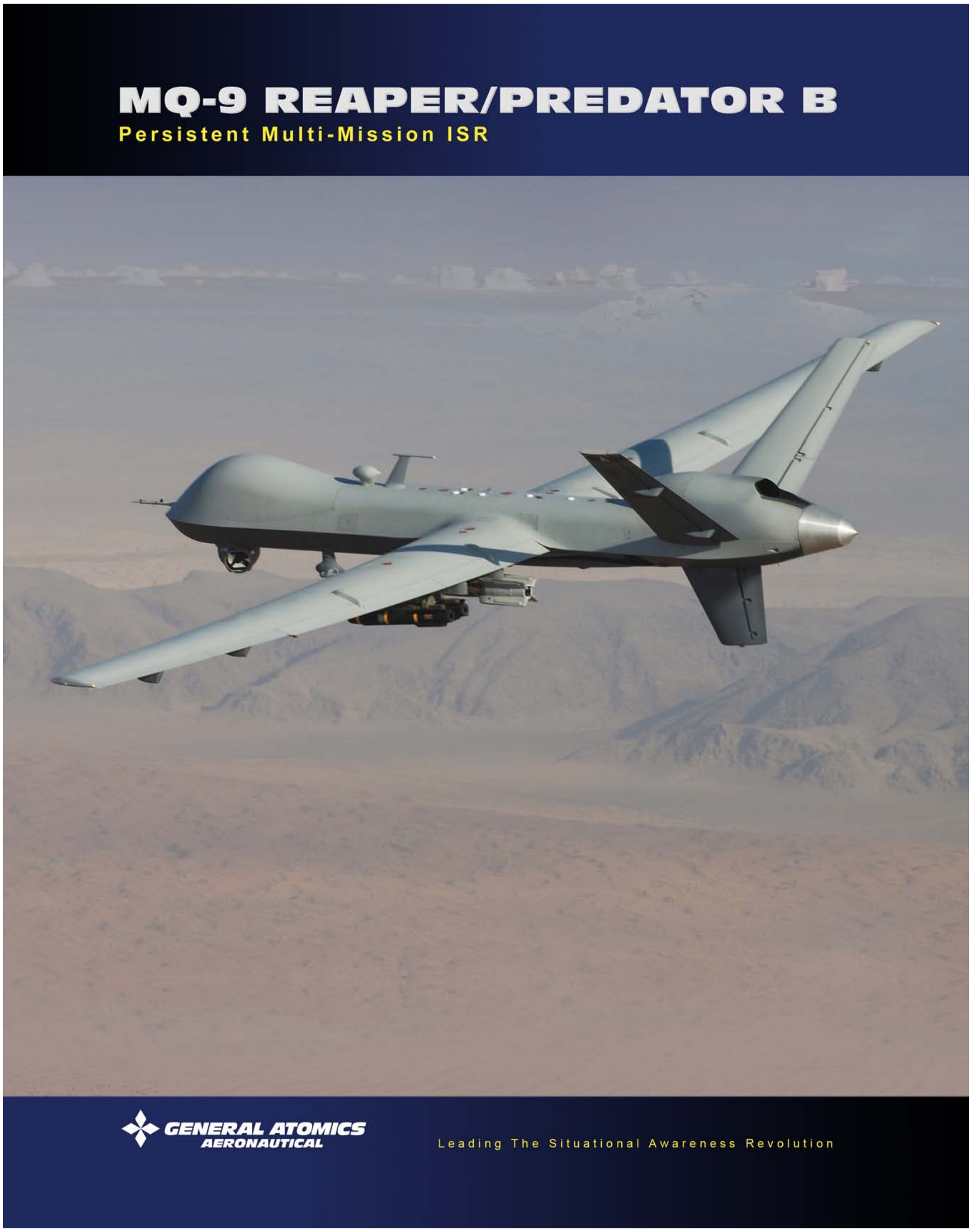


Figure 16: Page 1 of the General Atomics brochure for Predator B-Military version.

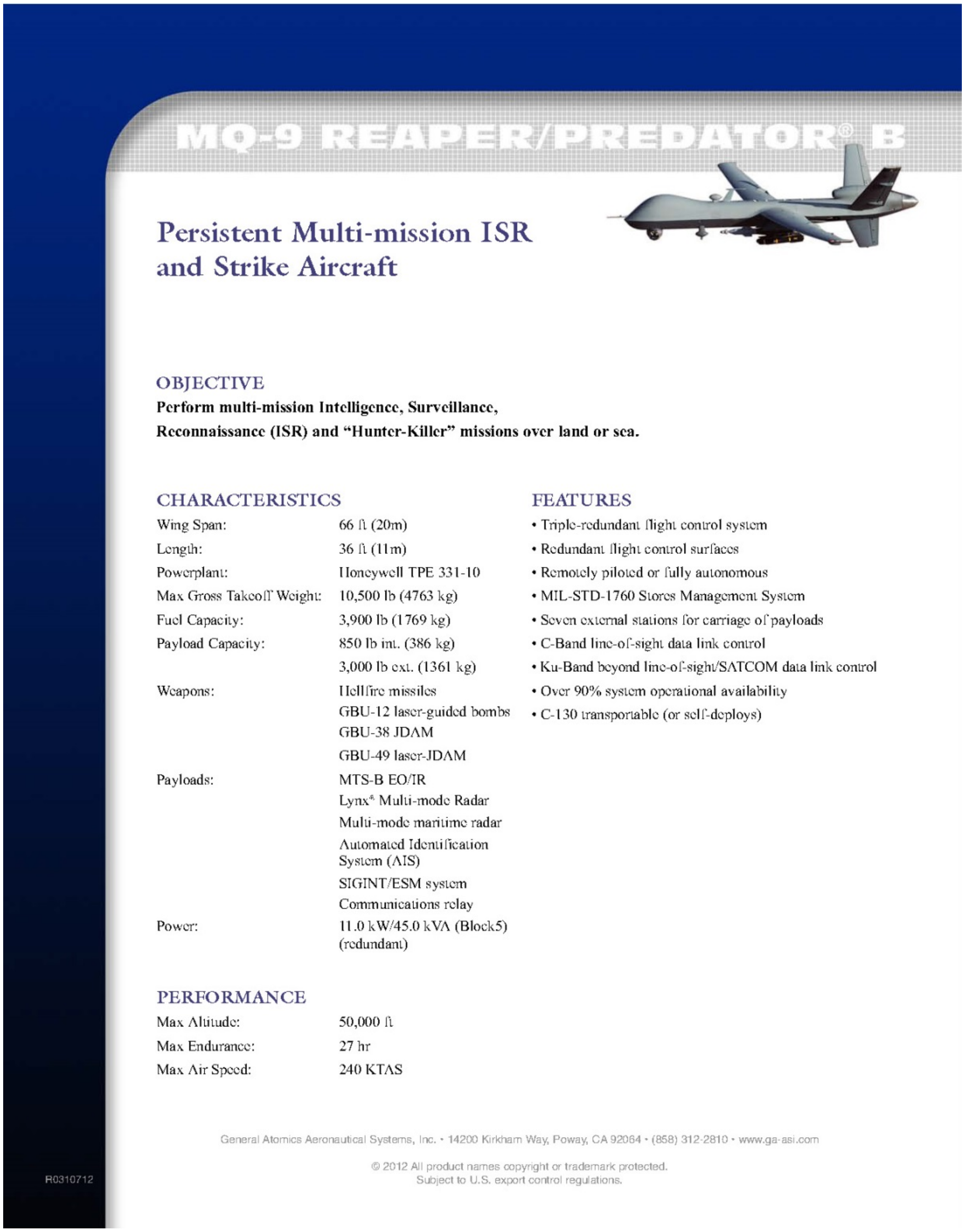


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Figure 16a: Page 2 of the General Atomics brochure for Predator B-Military version.