Spynel: a solution for the southern US border

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1. SOUTHERN BORDER SURVEILLANCE CHALLENGES

The 2000 miles of border between the US and Mexico present a disparity of security measures, from large cities such as San Diego or El Paso which benefit from high fences and large deployment of patrols to rural or mountainous areas in Texas and Arizona.

Pushed to less traveled routes between the 330 ports of entry on the southern border, illegal immigrants, drug smugglers and human traffickers are more prevalent in certain rural areas such as the Rio Grande Valley. While statistics accurately describe a sharp decrease of illegals crossing at the southern border overall, a sharp increase in the number of armed drug and immigrant smugglers in areas such as Southern Texas require heightened levels of surveillance.

Actionable intelligence needs to be provided to patrols in the field. But technologies providing information to the Border Patrol personnel need to address a very specific set of challenges:

- Surveillance equipment are pushed to their limit as they are required to operate on a continuous basis in a harsh environment where temperatures can reach 115 degree Fahrenheit on a daily basis, in remote locations.

- Detection and Tracking technologies have to face a highly cluttered environment, at times filled with tumbleweeds and a wide range of animals. On top of the usual wildlife, including rabbits, raccoons, coyotes, deers and up to 400 species of birds, the region is known to host a large number of wild hogs. Now numbering in the millions, these wild boars wreak havoc across the southern United States.

- The geography itself can present its own intricacies: the border follows two major rivers, the Colorado and Rio Grande, that low profile groups of smugglers cross at night in makeshift rafts or by swimming. Line of sight is not always available as rugged hills are part of the landscape's fabric. The arid Arizona border differs from the shrubby Rio Grande valley, where sugar hackberries, honey mesquite trees and black willows can become a hiding ground for walkers.

- Last but not least, smugglers' creativity has found multiple ways to bring drugs in the US:
  - Drop bags of drugs with UAVs
  - Carry drugs in homemade semi-submersible
  - Use speedboats during night time
  - Cross rivers where no fence can be built
  - Catapult bags of drugs over the border

Smugglers also continue to cross the border using tunnels or simply walking or driving through the desert. This variety of CONOPS forces the border patrols to continuously adapt their working methods and integrate new technologies to counter the traffickers.

In this complex environment, CBP's goal when deploying new technologies is both tactical and strategic. As described by Mr. Mark Borkowski, Assistant Commissioner, CBP OTIA[1] :

- Technologies need to provide actionable intelligence in real time to allow for immediate action.
- Technologies also need to keep an eye on the "big picture", thanks to persistent surveillance. Through forensics and observation of changes over time, CBP will gain the intelligence to design adequate long term strategies.

HGH Infrared Systems' Spynel systems address both requirements in an innovative, cost effective and operationally efficient manner while tackling the southern border environmental challenges through a proven, widely deployed, mature technology.

[1] Interview of M. Mark Borkowski in Border and CBRNE Defense, March 2013, pp.16-19

2. SPYNEL: A UNIQUE VALUE PROPOSITION FOR THE BORDER PATROL

Spynel sensors were initially developed in 2006 and have been deployed in the harshest environment since their inception: Afghanistan for the US Army, in the Middle East desert to protect critical infrastructure or at sea in hot, humid and corrosive environments for the French Navy.

The MIL-SPEC Spynel is uniquely designed to provide full 360 degree situational awareness in near real time with automatic intrusion detection and tracking. Spynel is often described as a “thermal radar”: it provides the benefits of a thermal camera, visualizing threats day and night, including in total darkness, coupled to the benefits of a radar, as it allows to automatically detect and track an unlimited number of threats in all directions at once.

Spynel is a high resolution, spinning, thermal camera with full panoramic imaging enhanced by an advanced proprietary software developed over the course of 7 years. The complex algorithms perform continuous scene analysis over land or water, and can automatically detect and display small asymmetric threats such as UAVs, people walking slowly or crawling, and vehicles.

Spynel is particularly effective in wide unobstructed areas. But demonstrations showed that in dense vegetation, where radars and long range cameras alike have a hard time tracking humans, Spynel can detect and follow walkers along a tree line: intermittent tracks do not result in lost targets since the high thermal resolution sensor picks up the heat signal emitted by walkers wherever they are, over 360 degrees, and provides immediate visual cues to the operator. Predictive algorithms are also used while targets are hidden by vegetation to determine where the walkers will show up next.

Figure 1 shows a group of 3 walkers consistently tracked in a woody area during an Army demonstration in May 2013.

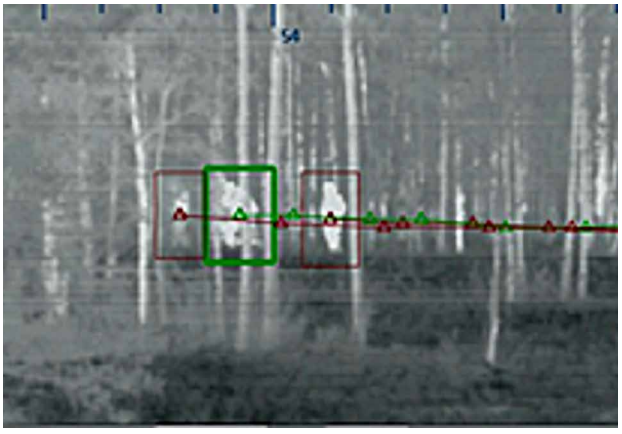

Figure 1 - Screenshots of three men detected and tracked in a woody environment

As Spynel provides immediate visualization over 360 degree, an operator can easily determine if detected “threats” are real or not. In a highly cluttered environment, filled with “moving” wild life, which will be picked up by any radar, an operator can quickly become overwhelmed by data or get fatigued. Spynel relieves the operator from the taxing operation of cueing a PTZ camera to each threat pinpointed by the radar to “check” what’s out there. The identification is fast and efficient.

Spynel, as opposed to radars, is completely passive: it cannot be detected nor jammed and does not interfere with other equipment. Its design features a continuously rotating head, which does not allow observers to determine where the camera is looking at any moment to avoid it and prevents incidents where camera lenses get shot.

Current detection ranges for the Spynel range from 1km to 6km for a regular sized person, depending on the model. Upcoming models will bring the detection range to 8 km. Spynel can be deployed on fixed towers or vehicles. One model is not fit for all fixed towers: the choice depends on the location of the towers (the distance between towers vary from one site to the other) and geography (line of sight) but it is a best fit for those towers less far apart from each other and in high risk areas where time to action and intelligence are critical.

Spynel can detect all types of targets, on ground, water or airborne. Spynel systems have been tested and operated at the border and extensively evaluated at Yuma Proving Ground. On ground, a common observation made at the border, in dusty environment, is the false alarm rate introduced by dust clouds behind vehicles. HGH developed a specific algorithmic filter to eliminate this random perturbation.

Table 1 shows a sample of detection range for the Spynel-S 6000 model.

TYPE OF TARGET	DETECTION RANGE
Human	Up to 6km
Vehicle	Up to 12km

Table 1 - Detection range for Spynel-S 6000.

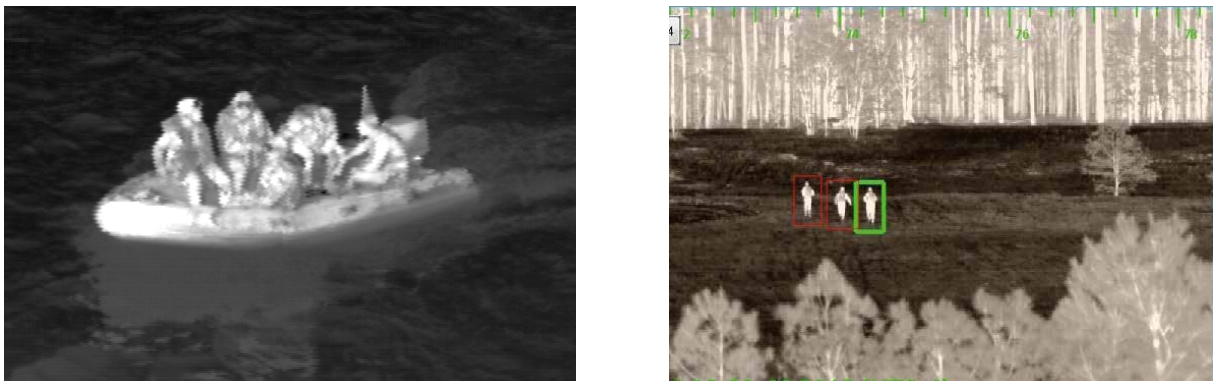

Figure 2 - Screenshots of a speedboat (left) and from running men (right) taken with the Spynel-C 3000.

The Spynel operator receives location information on all the detections: precise azimuth (direction) to dispatch a patrol or point a PTZ camera, and estimated distance. As a passive sensor, the Spynel doesn't use a laser range finder, illuminator or radar waves to give distance information; it calculates targets positions using topographic data. The level of precision achieved with this method of calculation allows for effective patrol dispatching while not revealing to the intruder the position of the sensor.

3. FIXED TOWERS APPLICATION

Historically, sophisticated sensors were deployed by CBP, often times the same used by the Department of Defense in harsh war zones such as Iraq and Afghanistan. But the scenarios are different at the border: systems mounted on strategically placed fixed site have to detect and track targets going away from them, whereas FOB protection is focused on incoming, convergent threats. This basic difference, combinedwith the fact that smugglers learn about systems' location and capabilities, make for singular challenges:

- Track walkers, ultralights, vehicles and rafts (used by smugglers on the Colorado and Rio Grande rivers) over long distances – up to 7.5 miles
- Provide coordinates of walkers in near real time for interdiction purposes
- Track multiple divergent targets at once: when escaping, a group of backpackers can separate and run different ways.
- Record activities and imagery on a persistent basis over 360 degrees to get a full understanding of modus operandi.

These challenges call for new ways of approaching situational awareness and intelligence, and overall managing risk.

Traditionally, a combination of medium-range radar and long range PTZ will provide detection over 360 degree with a slow refresh rate and imagery over a narrow field of view.

In surveillance mode, the numerous blips brought up by the radar, due to the aforementioned cluttered environment at the border, force the operators to go back and forth from target to target with the PTZ to identify and prioritize the threats: he is constrained by the well-known soda straw effect induced by the long range camera. While the detection range meets the CBP requirements, the solution does not operationally provide near real time 360 degree coverage over long distances: the latency of medium range radars over 360 degree is just too slow. As a consequence, events are detected later. Diverging threats end up getting lost in an overwhelming amount of false alarms, as tracking can often be intermittent in these environments.

Figure 3 illustrates a situation with multiple diverging targets of interest with and without the Spynel.

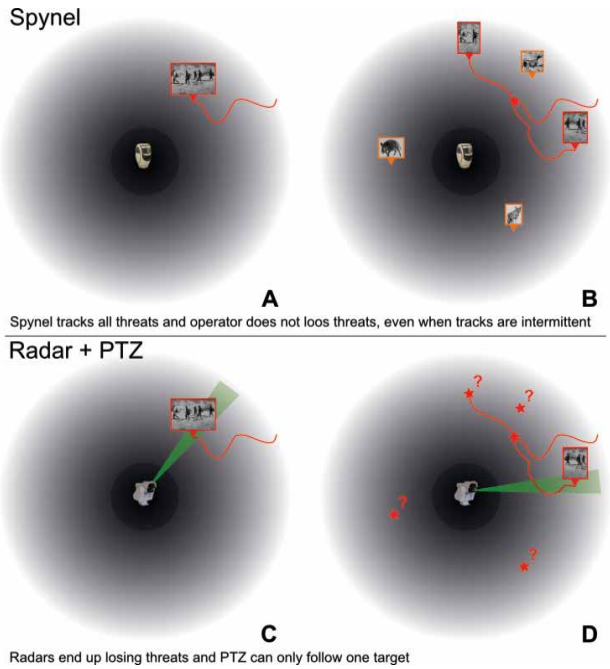

Figure 3 - comparison of a multiple targets' scenario with Spynel-S and a PTZ. (A) represents a group a people detected and tracked within the covered area of Spynel-S. In (B) the intruders divide into two groups. Spynel-S keeps tracking both groups

In tracking mode, the PTZ will auto-track and image a single target - assuming the track is not lost – while the radar will keep tracking other targets up to the point when these targets merge into the regular “noise” induced by animals and other false alarms. The system is simply not effective.

With Spynel, panoramic detection and near-real time imagery come in pair: the operator directly has available images of the all the targets at once and are able to discriminate quickly and without effort the targets that are of interest from the ones generated by wild or domesticated animals, moving vegetation or regular activities. There is no such thing as a “lost track” because the operator keeps an eye at all times on the threats.

The Spynel display unburdens the operator: intuitively, watching panoramic images is less taxing than following a high number of dots and tracks on a map. Operators can get desensitized over time when faced with too much data.

The Spynel interface is user-friendly and very intuitive.

A 3 hours test conducted by independent DOD personnel in May 2013 demonstrated how easily soldiers with no technical background could apprehend the Spynel technology. 4 participants were asked to perform 6 mission-based tasks while being timed by evaluators:

- Participant 1: HGH expert
- Participant 2: a soldier trained by HGH for 15 minutes
- Participant 3: a soldier trained by participant 2 for 15 minutes
- Participant 4: a soldier with no training

The evaluation showed that participant 2 and 3 could perform 90% of sensor operation with effective results. Participant 4 still had a 70% success rate and could operate the sensor basic features with effective results.

With more than 100 Spynel units deployed and extensive feedback from theater, HGH’s engineering team automated all the Spynel settings, including the most complex ones, to make sure untrained operators or operators dealing with a large number of complex technologies, could successfully use the system. As a result, the Spynel doesn’t require a dedicated operator: it can run on a dedicated screen, as part of a layered border control and management system: it provides a precious help in early detection of real threats but also as a mechanism to collect ongoing intelligence for analysis and prosecution purposes.

Spynel forensics advanced capabilities allow for the replay of a sequence over 360 degrees as if it were live: all settings (color palette, zoom resolution, contrast, detection sensitivity, etc.) can be changed which allows to pinpoint elements that were possibly missed previously. Additionally, smart tags provide an easy way for the operator to mark and describe an event or a particular component in the scene. When looking back at the timeline (Figure 4), the analyst has a quick overview of all alarms and bookmarks. “Intelligence synthesis” can be achieved by keeping an eye on the “big picture”, patterns of operations or unusual behaviors.

Figure 4 - Spynel’s software timeline with color coded smart bookmarks.

4. SPYNEL FOR MOBILE SURVEILLANCE

Given the dynamic nature of cross border threats and avoidance strategy developed by smugglers, the border patrol has developed a mobile strategy surveillance. Vehicles equipped with surveillance solutions can be dispatched between fixed surveillance sites or in remote areas where fixed assets are not a good fit. CBP tends to operate these surveillance vehicles in a stationary mode, but quick relocation via off roads is frequent. As such, resistance to shocks, vibrations and dust, is paramount. Spynel has been mounted on armored vehicles for the Army and used on dirt roads and off roads. It provides quality high resolution situational awareness on the move and automated panoramic intrusion detection when stationary.
Benefits previously observed for fixed sites apply to mobile strategy. The advantages of a full panoramic near real time thermal sensor are made more prevalent as the patrol vehicles venture at night in areas with no external light or in treacherous terrain where full awareness on one's surroundings become highly valuable.

The Spynel system can be quickly operational; it is easy to integrate on a concealed deployable mast at the back of a vehicle or with a hardware kit that can be dismounted relatively easily. Spynel only requires an Ethernet cable connected to a ruggedized laptop and a power cable linked to a 24DC power source. A hardware kit developed by SRI Sarnoff for the REF for the Spynel sensor provides a convenient solution for fast deployment on any vehicle, including non-armored vehicles or trucks with a hard top.

Figure 5 shows the Spynel camera mounted on a mast integrated on a Ford F-350 (CBP vehicle model). As Spynel can work as a compact standalone system, it provides detection and tracking as well as imagery day and night, while minimizing installation and integration costs. If needed, it can be easily coupled with a PTZ camera which can be slewed to cue from the Spynel interface or from a third party mapping software.

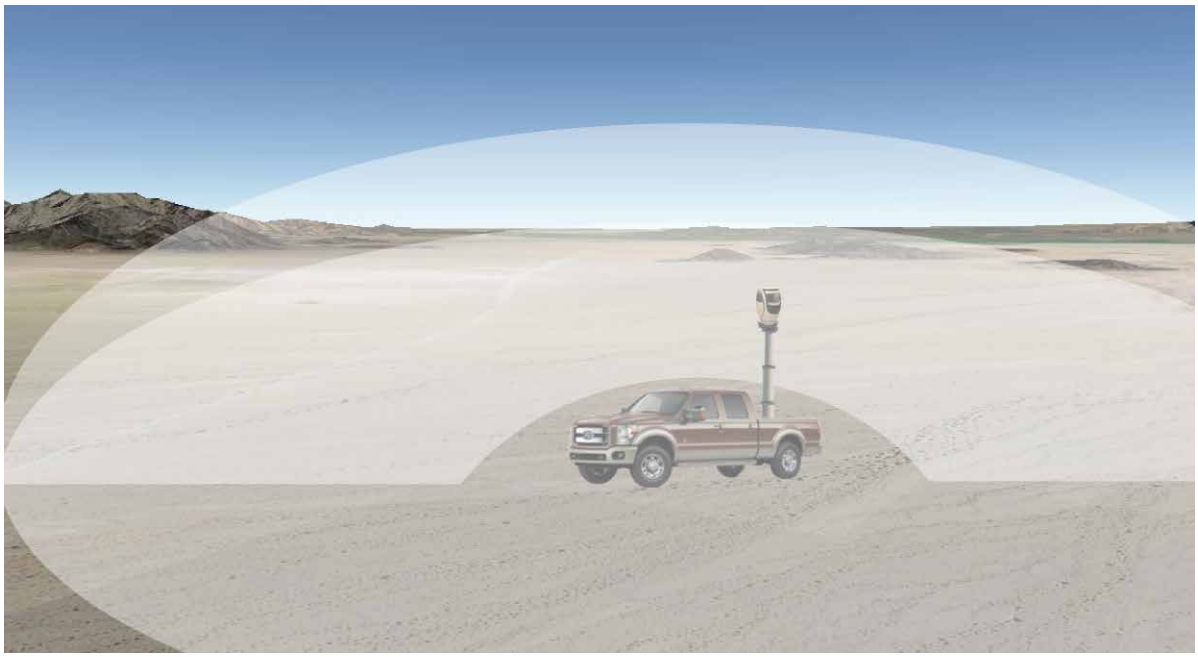

Figure 5 - Concept of surveillance with the Spynel on a Ford F-350.

5. SPYNEL FOR COASTAL SURVEILLANCE

Smuggling by sea has surged. In 2010, 867 illegal immigrants and smugglers were arrested at sea or along the California coast, more than double from 2009.

Figure 6 shows sample routes taken by smugglers. Examples of incidents include smugglers zipping across the border on wave runners and jet skis to make attempts to drop off immigrants and drugs, or illegal immigrants hiding along the cliffs of San Onofre State Beach after disembarking from a small fishing boat.

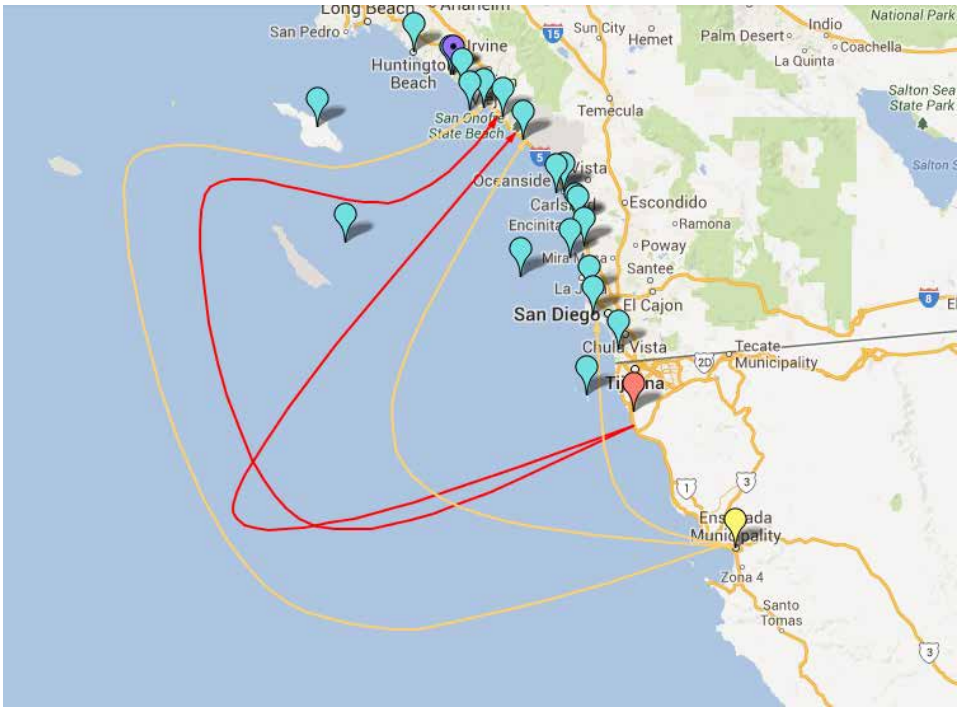

Figure 6 - sample routes taken by smugglers.

Smugglers have also been known to use speedboats (up to 40 miles) at night or even semi-submersibles that can contain up to 12 tons of drugs. Such methods require installing advanced surveillance systems near the coast.

Spynel is especially effective at detecting asymmetric maritime threats such as RHIBs, speedboats or submersibles as they emerge from the ocean.

Strategically placed, a couple of Spynel sensors can monitor several miles of coast line as well as suspect activities on shore.

6. CONCLUSION

The Spynel system is a mature, COTS technology readily available for deployment. It is easy to set up and integrate with Common Operating Pictures software and other sensors such as radar or long ranges cameras. Information can be sent back to the station headquarters through wireless or fiber in real time, displayed in a central command Room and stored digitally in a database for further analysis. Maintenance data is well documented and proactive maintenance plans allow for 95% system availability.

Spynel is the only reliable, proven 360 degree "thermal radar" with more than 100 units deployed to date. Spynel can automatically detect, track and visualize an unlimited number of asymmetric and unconventional air, ground and maritime targets thanks to advanced detection algorithms developed over the course of 7 years.
The harsh environmental conditions found on the southern border are comparable to those found in southern Afghanistan, where Spynel protects Forward Operating Bases against lethal dangers on a continuous basis.

It is an ideal fit for the specific conditions of operations observed at the southern border. Its unique 360 degree imaging and detection capabilities make for a powerful, innovative and cost effective way to tackle the complex challenges presented by smugglers and illegal immigrants crossing the border.

About HGH Infrared Systems: Founded in 1982, HGH designs, develops, assembles and sells high end optronics systems for security, industrial and civil applications. HGH's team of highly qualified engineering team is comprised of experts in optics, software, mechanics and electronics and operates in France, at Igny (near Paris). HGH strives to provide advanced and innovative infrared equipment to protect their clients all around the world, while keeping the agility and dedication of a small and passionate team. Speed, flexibility, technical excellence and innovation constitute their core values. HGH has established itself as an international reference for infrared technology innovation through the development of multiple advanced thermal sensors, among which its award-winning real-time 360-degree thermal camera, the SpynelC 2008 Product of the Year from Photonics Tech Briefs, 2010 Innovation Prize from the EuroNaval Committee, 2011 Kummerman Award from the French Academy of Marine, 2012 GovSec Platinum Award.

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