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A View for Security: Thermal Imagers

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A VIEW FOR SECURITY: THERMAL IMAGERS

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ABSTRACT

The use of thermal imagers in everyday security applications has been, until recently, very limited. The last several years have seen an increased use of existing military inventory and commercial imagers to satisfy a variety of security and surveillance needs. This paper discusses the recent history of applying today's available thermal imagers to security-related problems. It discusses the problems, the deficiencies of existing imagers to solve those problems, and summarizes the current status of imagers applied to security and suggests imager features which would make them more useful to security applications.

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TABLE OF CONTENTS

1.0 INTRODUCTION

Each of the military services has some component responsible for providing security of its property, facilities, and other mission-related assets. These components also typically have responsibilities for enforcement of law on the military base and protection of on-base housing, stores, and banks. These security functions have historically been implemented with large investments in, and use of, manpower. Electronic systems have been used as sensors to provide detection, and standard black and white video cameras (and associated lighting) to provide surveillance and assessment. In general, systems used incorporate mature, low-risk technology which can operate for long periods of time with little maintenance and low cost.

In contrast, mission-oriented systems have used more state-of-the-art technology which by its very nature has higher risk and is costlier to initially procure and operate. In many cases, its operating lifetime between repairs is relatively short. A typical example of a mission-oriented system is the FLIR available today in the military inventory, and which can be readily procured from commercial vendors.

Until recently, the use of FLIRs has been concentrated to the mission areas for which it was originally designed; i.e., weapon and missile sights, aircraft viewing aids, and other high-performance passive imaging needs. In the last several years, the use of FLIRs has filtered down into the security community. This has caused some operational problems because the mission and operational requirements of the security community differ, drastically in some areas, from that for which the FLIR was originally designed. This has not prevented some security users from investing major sums of money to procure systems which were immediately available. However, FLIRs designed specifically for security use could greatly increase the applicability of these devices in the future.

2.0 SECURITY APPLICATIONS

Applications of FLIRs to security missions generally fall into two major areas, fixed and mobile. Fixed applications require the FLIR to be mounted in a specific location

and not to be moved. Mobile applications relate to any mission which requires the ability to move the FLIR to the area of concern.

2.1 Fixed

Fixed applications can be applied in two major uses. The first is for a wide area surveillance and/or detection. In this case, the FLIR would be mounted on a prominent building or tower which would provide a vantage point such that large areas could be viewed. Inherent in this application is the need to display the video output from the FLIR at a remote location and to control the FLIR functions (gain, focus, FOV, etc.), remotely. This application would also require some method of panning/tilting the imager to view selected features. At its most advanced stage, this type of system would incorporate the functionality of Automatic Target Recognition (ATR) hardware/software to improve the effectiveness of the operators.

Several prototype systems of this type have been installed for surveillance applications using available piece parts (Ref 1). No manufacturer currently offers, as a standard product, an integrated system supportable through military logistics channels; nor is there a coordinated user operational concept to guide the developers. The net result has been limited deployment of these systems; however, their future appears promising.

The second use for a fixed system would be as a replacement for existing Closed-Circuit-TV assessment cameras. Typical uses for these cameras today are in a fixed-mount, fixed FOV to view areas which are monitored by electronic sensors. It is not uncommon to have a camera positioned every 100 meters around a perimeter and at strategic internal site locations. For night operation, these cameras require high illumination levels which present a recognizable signature. FLIRs offer the future promise of being used instead of the visible system, with the inherent advantage of eliminating the need for lights and reducing the signatures of sensitive facilities.

2.2 Mobile

Mobile systems can be categorized into those needed for truly hand-held operations and those which can be vehicle-mounted.

Hand-held applications could range from covert patrols to the surveillance of temporary high threat areas. The location of these areas could change on a frequent basis depending upon the nature and progress of the mission. Critical to the usefulness of a FLIR for these applications is the need for a truly lightweight system. These systems will probably not have a remote viewing capability, and ideally, would approach the size of today's smallest single hand-held video cameras.

Vehicle-mounted systems would typically incorporate high quality FLIRs, too heavy for manual transport, which could be mounted on a vehicle and moved quickly to different threat areas. They would provide remote viewing, most likely within the vehicle's personnel area, but possibly at a remote site through the use of RF communications. At their most sophisticated, they would incorporate many of the features of the advanced fixed-site systems.

2.3 Continuous Operation

Independent of which of the above applications is being considered, there is one requirement for use in a security environment which remains constant. This is the need for protracted long-term operation without major maintenance requirements. In other words, security forces must operate twenty-four hours a day, seven days a week, fifty-two weeks a year, regardless of the weather. In essence, this is the same as saying any security system must operate continuously.

Of course, there will be some periodic maintenance, but it must be simple to perform and not required very often. Experience has shown that even a simple yearly maintenance focusing of standard video cameras is often beyond the resources of many security organizations.

A FLIR which, for example, has a compressor MTBF of less than 2000 hours presents severe operational constraints which, unless solved, will limit the widespread application of FLIRs to security problems.

3.0 EXISTING FLIRs and SECURITY

A review of the FLIRs available today, either from the military inventory or as an "off-the-shelf" commercial item, will show that they were designed for non-security applications. Among the features which limit their usefulness to security are (Ref 2):

1. **Operating time between maintenance.** Most of today's FLIRs were designed for relatively short missions, at least by security standards. The importance of the missions assigned to the current FLIRs has justified a large and expensive on-site maintenance facility and procedure. Security missions have not historically had the benefit of such intensive maintenance efforts, nor are they likely to have such luxuries in the future.

   The short lifetime of coolers integral to the FLIR units can be consumed in as little as three to six months. This further aggravates the already high initial cost of the FLIRs.

2. **Logistics of supply items.** Again, because of the importance of the missions, no effort has been spared to organize and stock a supply chain to keep the FLIRs operational. Of particular note is the significant effort required to supply FLIRs which use compressed gas bottles. These FLIRs usually are sold with a separate compressor to recharge the gas bottles. This has proven to be a burden to the security community.

3. **Operator intensive.** None of the existing FLIRs are very user-friendly, from a security standpoint. Either they require an operator to view the image through an eyepiece, or they require connection to a video monitor through a converter, which appears to have been added as an afterthought. Furthermore, the FLIRs are bulky and require too much support equipment. This is even true of the so called hand-held systems.

   Despite these problems, the military security community has invested substantial sums to procure existing FLIRs. A majority of the FLIRs have been "hand-held" devices allegedly intended for the mobile remote applications discussed above, but

some have also been transportable systems for more permanent mounting. It is interesting to note that most of the units procured have been from a manufacturer in the United Kingdom. The FLIR manufacturers in the United States have not aggressively pursued this market and also do not generally have a product which readily meets the users' needs.

4.0 SECURITY-ORIENTED FLIRs

If FLIRs are to gain more widespread acceptance and use within the security community, their design and features will need to be modified from those available today. The following features are most likely to increase the application of FLIRs to security applications.

1. **Continuous operation.** Future designs must eliminate the high maintenance portions of the FLIR. Specifically, a future system must not have mechanical coolers or gas bottles. Cooling, if required at all, must be performed with solid-state devices. The step to solid-state cooling should eliminate the expensive and cumbersome logistics trail of gas bottles, compressors, etc.

   Of secondary importance is the need for eliminating scanning devices in favor of focal-plane array technology. Certainly, high-speed devices which must operate in a vacuum are not conducive for continuous operation.

2. **Operator friendly.** This can take on several forms, depending upon the application. For mobile remote applications, this implies a small unit which can be held in one hand and can operate for hours without replacement of batteries.

   For advanced fixed-mount or vehicle-mounted systems, this implies a FLIR which can be integrated into an ATR System so that the operator is not required to continuously observe the imager's output. Such a FLIR must provide for remote video output, remote control of imager functions, and a stable image so as to ease the job of the ATR processing.

3. **Quality images.** Although some difference in image quality between a small hand-held and a large fixed-mount system can be tolerated, any future FLIR(s) must produce a quality image. This quality must be in spatial, thermal, and temporal resolution. Spatial resolutions on the order of 256 x 256 are a minimum, thermal resolutions below .2° C, and temporal frame rates of standard video (30 frames/second) are also required.

4. **Cost.** Unit costs must be drastically decreased from today's prices. A unit, used to replace existing video cameras every 100 meters around perimeters, cannot be orders of magnitude more expensive than today's small CCD video cameras. Hopefully, the cost would be under $5K per FLIR. Even costs for the higher performance fixed surveillance systems must be drastically reduced from today's prices. Costs in excess of $10-20K will surely limit the number of applications.

5.0 SUMMARY

A new application exists for FLIRs. For widespread use, this application requires new FLIR designs which maintain image quality but reduce both initial and recurring maintenance costs and improve operator effectiveness. If achieved, this new class of FLIRs may find applications in areas not envisaged today, resulting in large quantities for production.

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