AESS MEETINGS & CONFERENCES

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DATE | MEETING | PLACE | CONTACT
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17-19 September 2007 | 2007 International SpaceWire Conference | Dusseldorf, Germany | N. Pecenpe - +44 1382 380730
4-11 October 2007 | 2007 IEEE International Consumer Conference on Security Technology (ICUST) | Ottawa, ON, Canada | L. Senkov (815) 384-2502
10-12 October 2007 | 2007 European Radar Conference (EuRAD) | Munich, Germany | W. Heinrich, +49 30 6192 2630
15-18 October 2007 | Radar 2007 The International Conference on Radar Systems | Edinburgh, UK | E. Wöhrle, +49 (0) 341 76 76 699
15-18 October 2007 | AESS Boston Meeting | Edinburgh, UK | T. Swanson, (301) 386-4149
21-23 October 2007 | 2007 IEEE AESS 26th Digital Avionics Systems Conference (DASC) | Dallas, TX | J. Good - (703) 932-2772
1-8 March 2008 | 2008 IEEE Aerospace Conference | Big Sky, MT | D. Wiczek, (418) 726-422
26-29 May 2008 | 2008 IEEE Radar Conference | Torino, Italy | P. Cordonaro, (39) 02 877577
8-11 September 2008 | Amsterdam2008 | Salt Lake City, UT | B. Auer, (334) 64 8280
29-31 October 2008 | 2008 European Radar Conference (EuRAD) | Amsterdam, Netherlands | A. Vanev, +31 15 278 2046

OTHER SOCIETY MEETINGS OF AESS INTEREST

11-13 September 2007 | Biometrics Symposium 2007 | Baltimore, MD | latex@emwi.org

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Satellite-Aided Search and Rescue (SAR) System
To carry out search and rescue of people in distress on the distressed aircrafts/vessels on land, at sea, or in a remote mountainous region, there are a number of different search and rescue systems and methods that are being used by the different national search and rescue organizations worldwide. Herein, the main terrestrial search and rescue (SAR) systems that are in use are discussed in brief and a satellite-aided Search and Rescue (SAR) System – COSPAS - SARSAT is discussed in detail highlighting its benefits over other SAR Systems.

A System for the Measurement of the Amazon
The System for the Vigilance of the Amazon (SIVAM) is a $1.4 billion dollar project of Brazil aimed at the development and deployment of a high-technology system-of-systems to perform monitoring, protection, and control of the land, air, and water resources of the Brazilian Amazon region. The primary challenge of the SIVAM project is to perform remote sensing and communications over a vast and undeveloped land area. The SIVAM network meets this challenge through an extensive network of Air Traffic Control/Surveillance Radars, Environmental Sensors, Communications Systems, Airborne Sensor Systems, and Coordination Centers. Now fully operational, the SIVAM system is the world’s largest fully integrated remote monitoring system of the environment and provides critical information on a timely basis to the Brazilian government, law enforcement agencies, and to commercial, educational, and research groups.

Adaptive Rectification Filter for Detecting Small IR Targets
Clutter suppression is one of the most important subjects in the field of small target detection under infrared (IR) strong clutter background. While removing the clutter background, however, such methods may reverse the relative energy distribution of target and noise in the clutter suppressed image, and disturb the subsequent target segmentation and detection. This paper analyzes the causation of such problems, does research on the relationship between target energy characteristics and detection probability, and presents a novel filter of energy distribution adaptive rectification (EDARF). Based on the EDARF, an improved framework of dim small target detection is proposed to rectify the energy distribution in the clutter-suppressed images by conventional adaptive filters. The proposed EDARF’s performance is estimated by experimental comparisons of three linear/nonlinear filters before and after using EDARF. Extensive experimental results show that the proposed EDARF improves efficiently the performance of detecting dim small targets against strong undulant cloud-cluttered backgrounds.

Intelligent Transportation Systems in Transitional and Developing Countries
Intelligent Transportation Systems (ITS) are state-of-the-art approaches based on information, communication and satellite technologies in mitigating traffic congestion, enhancing safety, and improving quality of environment. ITS are being used in many industrialized and emerging economies for the last two decades to facilitate traffic managers in tackling surface mobility problems. In the case of many developing countries, policy makers and practitioners have neglected this “non-conventional” approach on the pretext inter alia, “technological sophistication,” cost and institutional ill-preparedness. This aims to underscore the importance and relevance of ITS for developing countries as a complementary tool in the 21st century. In so doing, the intention is to bestow some fresh thinking into the transport debate that will serve as a catalyst for resolving mobility problems in developing countries still dwelling on conventional options.

Internetworking and Resource Management in Satellite Systems
A series of articles
PEPsal: A Performance Enhancing Proxy for TCP Satellite Connections
Internet communications with paths that include satellite link face some peculiar challenges, due to the presence of a long propagation wireless channel. Herein, we propose a Performance Enhancing Proxy (PEP) solution, called PEPsal, which is, to the best of the authors’ knowledge, the first open source Transmission Control Protocol (TCP) splitting solution for the GNU/Linux operating systems. PEPsal improves the performance of a TCP connection over a satellite channel making use of the TCP Hybla, a TCP enhancement for satellite networks developed by the authors. The objective of the paper is to present and evaluate the PEPsal architecture by comparing it with end-to-end TCP variants (NewReno, SACK, Hybla), considering both performance and reliability issues. Performance is evaluated by making use of a testbed set up at the University of Bologna, to study advanced transport protocols and architectures for internet satellite communications. At present, PEPsal is adopted, with success, by a satellite Internet provider.
Satellite-Aided Search and Rescue (SAR) System

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ABSTRACT

To carry out search and rescue of people in distress on the distressed aircrafts/vessels on land, at sea, or in a remote mountainous region, there are a number of different search and rescue systems and methods that are being used by the different national search and rescue organizations worldwide. Herein, the main terrestrial search and rescue (SAR) systems that are in use are discussed in brief and a satellite-aided Search and Rescue (SAR) System – COSPAS - SARSAT is discussed in detail highlighting its benefits over other SAR Systems.

INTRODUCTION

Search and Rescue (SAR) is an operation carried out by the personnel of emergency organizations, well-trained in search and rescue skills to find and rescue the person(s) in distress either in a remote or difficult area, such as in the mountains, deserts, forests, or at sea. At present, there are different methods, such as visual, audible, and electronic, those are used by the person(s) in distress on aircrafts, vessels and on land. Visual methods include items such as mirrors, flares, and international signal flags. Audible methods include whistles and horns. The electronics methods include communication via terrestrial radio as well as through emergency beacons of a dedicated search and rescue satellite system. The different terrestrial and the satellite-based search and rescue systems which are used by different SAR organizations worldwide for search and rescue operations are as follows:

Pre-GMDSS Search and Rescue System

The first marine radio was installed on ships around the turn of the 19th century. In those days, it was used primarily for transmission and reception of passenger telegrams. However, in April 1912, a major incident of the sinking of the RMS Titanic occurred which sank after its collision with an iceberg. In this incident, some 1500 people were killed and only 700 people could be saved, mainly because of the efforts of the Titanic’s two Radio Officers who managed to summon help from the nearby vessels. This disaster brought fundamental changes in the Marine Radio for search and rescue and through the International Convention for the Safety of Life At Sea (the SOLAS Convention). Radio watch keeping hours and message priorities were standardized in which distress and safety traffic always had priority over commercial traffic and distress frequencies were also standardized. Through this Pre-GMDSS system, vessels were capable of sending and receiving messages over a minimum specified range of 150 nautical miles. This was based on the assumption that ships usually travel well-used routes and that there were sufficient ships at sea and shore stations dispersed about the world to receive distress calls.

Fig. 1. Sea areas A1, A2, and A3 in GMDSS Systems

Global Maritime Distress and Safety System (GMDSS) for Maritime

The Global Maritime Distress and Safety System (GMDSS) is an international system for the search and rescue of the person(s) in distress at sea. It uses both terrestrial as well as satellite communication technology, and is a combination of various individual terrestrial radio systems (VHF-, MF-, and HF-Coastal Radio), and a satellite system (INMARSAT). The system alerts Search and Rescue (SAR) authorities ashore as well as on ships, in the immediate vicinity of the vessels or persons in distress for assistance. It moves the emphasis from ship-to-ship alerting (which was
the case with the pre-GMDSS system) to ship-to-shore alerting. Ships which are equipped with the GMDSS equipment can perform all the communication functions which could be essential for the search and rescue of the person(s) on distressed ships/vessels – irrespective of the area through which they sail. The major difference between the GMDSS and its predecessor systems is that the radio communications equipment to be fitted to a GMDSS ship is determined by the ship’s area of operation, rather than by its size. GMDSS compliance is mandatory for commercial vessels of 300 Gross Registered Tons (GRT) and above, engaged on international voyages. The various terrestrial radio systems that are part of the GMDSS Systems work up to a certain range and on the basis of that world’s oceans are divided into 4 areas of operation that are: 1) Sea Area A1 – within range of shore-based VHF Coast Stations, typically 20 nautical miles (NM) from shore; 2) Sea Area A2 – within range of shore-based MF Coast Stations, typically 100 NM from shore, excluding Sea Area A1; 3) Sea Area A3 – within INMARSAT Satellite coverage, between 70° N and 70° S, excluding Sea Area A1 and A2; and 4) Sea Area A4 – The Polar Regions excluding Sea Area A1, A2, and A3. The sea areas A1, A2, and A3 are illustrated in Figure 1.

All of the countries that contract to the SOLAS Convention are required to enforce the equipping of vessels sailing under their flag with GMDSS and also provide suitable GMDSS shore-based infrastructure.

Emergency Locating Beacon – Aviation (ELBA) for Aviation

The Search and Rescue (SAR) operation performed by the Civil Aviation Authority is based on the concept that most of the aircrafts have filed their flight plans. Their origin, destination, and path of the flight are known beforehand. The aircraft is in constant contact with the control tower and would inform in case of any disaster. As the path of the flight, called intentions of the pilot is known, any aircraft flying on that path would find the crashed aircraft. If there is any diversion in the path, the Emergency Location Beacon – Aviation (ELBA) located in the aircraft would be detected by the over-flying aircraft through its receiving cone with the width of 100 nm or less. For the aircrafts whose flight plan has not been filed, the pilot would inform the control tower, through communication link, if there is some problem in the aircraft or if the aircraft has crashed then some individual who has seen the incident may inform the local authorities as to the whereabouts of the crashed aircraft. If the pilot is conscious, he would inform the control tower about his location.

Civil Aviation Authority implements its search and rescue operation in three phases: the uncertainty phase, alert phase, and distress phase. Search and rescue operation is started when a distress phase is declared, and conventional terrestrial VHF/HF communications equipment and the ELBA are used for searching of the crashed aircraft. The pilot normally communicates on VHF when not far away, and on HF when in remote areas. When the plane is down, ELBA is used to assist other over-flying aircrafts in locating the crashed aircraft.

Flaws of the GMDSS and the ELBA Systems

The GMDSS is a system dedicated for the safety of life at sea only and does not covers land. It was introduced on February 1, 1999, but the GMDSS-compliant Coastal Radio Stations have not been set-up as yet in many areas of the world, including many South Pacific nations. In addition, the majority of the vessels operating through many areas of the world’s oceans are not equipped with the GMDSS equipment because the carriage of the GMDSS-compliant equipment is mandatory for the vessel of 300 Gross Registered Tons (GRT) or over, engaged in international voyages only, and the vessel not falling under this category may choose not to install GMDSS equipment. On the other hand, the vessels equipped with the GMDSS-compliant equipment may not be able to use it in areas where GMDSS Coastal Radio Stations have not been installed/commissioned. The INMARSAT satellite system also does not provide coverage beyond 70° N and 70° S. As a result, any ship that is in distress may not get assistance for its search and rescue on a global basis through the GMDSS System.

The Civil Aviation Authority search and rescue system – ELBA is used to locate the crashed aircraft. When ELBA is activated in a crashed aircraft, it transmits a signal to the over-flying aircraft which could only be detected if it is in the receiving cone of the over-flying aircraft. If an ELBA is out of the reception cone of an over-flying aircraft, then it would go unreported. If the aircrafts whose flight plan has not been filed crashes or comes under some other kind of disaster, the chances of finding its exact location in a short time are very rare. If the pilot is conscious and the communication medium is also working even then the shock associated with the accident may prevent the pilot from giving vital information such as the location of the aircraft. Moreover, if the aircraft crashes in a remote area such as hills or desert, the chances of any person seeing the aircraft are very low and the pilot would have no means of knowing its exact location.

SATELLITE-BASED SEARCH AND RESCUE SYSTEM

At present, there are two main satellite-based search and rescue systems: the INMARSAT System and the COSPAS-SARSAT System.

INMARSAT System

INMARSAT is dedicated for maritime search and rescue only, and is part of the GMDSS System. It is a global network of four geosynchronous satellites that provide alerts and location data of the person(s) in a maritime distress through Emergency Position Indicating Radio Beacons (EPIRB) between 70° N and 70° S only. Beyond it, up toward the poles it does not have coverage due to geosynchronous orbit technical limitations.
COSPAS-SARSAT System

COSPAS-SARSAT is an international programme to assist in search and rescue operations using satellite-aided tracking technology. It is comprised of a constellation of satellites (six low earth orbit (LEO) and five geostationary (GEO) satellites), a number of ground stations (46 LEOLUTs, 18 GEOLUTs and 27 MCCs). The COSPAS-SARSAT satellites receive and transmit signals received from the emergency beacons. These beacons are activated in emergency situations, and operate on three different frequencies: 121.5 MHz, 243 MHz, and 406 MHz. The 406 MHz beacons are capable of transmitting a digital data stream containing the beacon serial number and other information, including GPS location.

The COSPAS-SARSAT satellites carry transponders capable of receiving and re-transmitting the emergency beacon signals to earth stations called Local User Terminals (LUTs). The Local User Terminals process the beacon signals, determining the location by Doppler frequency processing for signals from LEO satellites. The signals from GEO satellites generally contain beacon digital data stream that include the beacon serial number and location data (for the beacons with built-in GPS receivers or beacons interfaced with the aircraft navigation system). Using beacon serial numbers and a beacon registration database, rescue forces can determine the flight plan or shipping route of the aircraft or vessel carrying the beacon, as well as other information that may be useful for search and rescue operations. Doppler processing can be used to estimate the location of the beacon signals from LEO satellites. 406 MHz beacons with built-in GPS are capable of transmitting GPS location on the digital data stream. LUTs designed to process these signal protocols can report the GPS location, which is much more accurate (up to 100 meters) than locations computed by Doppler processing.

When an emergency beacon is activated, the signal is received by any of the COSPAS-SARSAT satellites and is relayed to the nearest available ground station. The Local User Terminal processes the signal and calculates the position from which it originated. This position is transmitted to a Mission Control Center where it is joined with identification data and other information on that beacon. The Mission Control Center then transmits an alert message to the appropriate rescue coordination center (in Pakistan to C.A.A. and MSA) based on the geographic location of the beacon. If the location of the beacon is in another country’s service area, then the alert is transmitted to that country’s MCC. The COSPAS-SARSAT system provides a tremendous resource for protecting the lives of aviators and mariners that was unthinkable prior to the Space Age. With a 406 MHz beacon, a distress message can be sent to the appropriate authorities from anywhere on earth 24 hours a day, 365 days a year in minutes.

Brief History of COSPAS-SARSAT Systems

The beginnings of COSPAS-SARSAT date back to 1970 when a plane carrying two US Congressmen crashed in a remote region of Alaska. A massive search and rescue effort was mounted, but no trace of them or their aircraft had ever been found. In reaction to this tragedy, the US Congress mandated that all aircraft in the United States carry an Emergency Locator Transmitter (ELT). This device was designed to automatically activate after a crash and transmit a homing signal. Since satellite technology was still in its infancy, the frequency selected for ELT transmissions was 121.5 MHz, the international aircraft distress frequency. This system worked but had many limitations. The frequency was cluttered, there was no way to verify from where the signal was originating, and most importantly, another aircraft had to be within range to receive the signal.

After several years, the limitations of ELTs began to outweigh their benefits. At that time, a satellite-based system was conceived. It would operate on a frequency reserved only for emergency beacons (406 MHz), it would have a digital signal that uniquely identified each beacon, and it would provide global coverage. Thus began the COSPAS-SARSAT.

The SARSAT system was developed in a joint effort by the United States, Canada, and France. The COSPAS system was developed by the Soviet Union. These four nations banded together in 1979 to form COSPAS-SARSAT. In 1982, the first satellite was launched, and by 1984 the system was declared fully operational.

Although COSPAS-SARSAT satellites were primarily designed to function on the much-improved 406 MHz frequency, they still had to make provision for the thousands of 121.5 MHz beacons that were already in use. For this reason, the satellites were designed to receive signals from 121.5 MHz as well as 406 MHz beacons, and shall support dissemination of the alerts data received from 121.5 MHz beacons until February 1, 2009. Beyond this date although some of the COSPAS-SARSAT satellites still shall have SAR transponders but they shall stop providing alerts data on this frequency due to it being very cluttered and false alarms generated by other devices operating at the same frequency such as ATMs etc., than the actual beacons.

In the United States, the SARSAT system was developed by NASA. Once the system was functional, its operation was turned over to NOAA where it remains today.

As the system began to take hold, more and more emergency beacons found their way onto the market. ELTs continued to operate exclusively on 121.5 MHz, but maritime
beacons (EPIRBs) were being built that operated on 406 MHz. The US Coast Guard, in their role as maritime search and rescue specialists, immediately began to see the benefits of 406 MHz, and in 1990, took proactive steps to bring it into widespread usage.

The COSPAS-SARSAT organization also continued to grow. The four original member nations have now been joined by 37 other nations, which operate more than 64 ground stations and 27 Mission Control Centers worldwide, or serve as Search and Rescue Points of Contact (SPOCs).

Mission Objective of COSPAS-SARSAT

The COSPAS-SARSAT mission is to assist search and rescue (SAR) activities on a worldwide basis by providing accurate, timely, and reliable distress alert and location data to the international community on a non-discriminatory basis. Its objective is to reduce, as far as possible, delays in the provision of distress alerts to SAR agencies, and the time required locating a distress and providing assistance, which have a direct impact on the probability of survival of the person in distress at sea or on land.

Participants

There are now a number of countries and organizations participating in the operation of the system. These include the 4 Parties to the COSPAS-SARSAT International Programme Agreement (Canada, France, Russia, and the USA), 24 Ground Segment Providers, 9 User States, and 2 Participating Organizations. The map (Figure 1) shows the COSPAS-SARSAT participants (shown as shaded).

System Concept

The basic COSPAS-SARSAT concept is illustrated in Figure 2. The system is composed of emergency radio beacons, LEO/GEO satellites, and LEOLUTs/GEOLUTs ground stations. The emergency beacons transmit signals during distress situations. The instruments on-board satellites in geostationary and low earth orbits detect the signals transmitted by distress radio beacons. The ground receiving stations referred to as Local Users Terminals (LUTs), receive and process the satellite downlink signal to generate distress alerts.

The Mission Control Centers (MCCs) receive alerts produced by LUTs and forward them to Rescue Coordination Centers (RCCs) — “CAA and MSA in Pakistan,” and to other countries MCCs. The Rescue Coordination Center (RCC) start search and rescue operation upon receipt of this alert data. All this process takes a few minutes to complete and the SAR operation is started.

The Low Earth Orbit Search and Rescue System (LEOSAR)

COSPAS-SARSAT has demonstrated that the detection and location of 406 MHz and 121.5 MHz distress beacon signals can be greatly facilitated by global monitoring based on low-altitude spacecraft in near-polar orbits. Complete, yet non-continuous coverage of the earth is achieved using simple emergency beacons operating on 406 MHz to signal a distress. The non-continuous aspect of the coverage occurs because the polar orbiting satellites can only view a portion of the earth at any given time. Consequently, the System cannot produce distress alerts until the satellite is in a position where it can “see” the distress beacon. However, since the satellite on-board 406 MHz processor includes a memory module, the satellite is able to store distress beacon information and rebroadcast it when the satellite comes within view of a LUT, thereby providing global coverage.

As described above, a single satellite, circling the earth around the poles, eventually views the entire earth surface. The orbital plane of the satellite remains fixed, while the earth rotates underneath it. At most, it takes only one-half rotation of the earth (i.e., 12 hours) for any location to pass under the orbital plane. With a second satellite, having an orbital plane at right angles to the first, only one quarter of a rotation is required, or 6 hours maximum. Similarly, as more satellites orbit the earth in different planes, the waiting time is further reduced.

The COSPAS-SARSAT system design constellation is four satellites which provide a typical waiting time of less than one hour at mid-latitudes with LEO satellites. At present, there are 6 LEO satellites in its constellation. The LEOSAR system calculates the location of distress events using doppler processing techniques.

Fig. 3. COSPAS-SARSAT System Overview

The Geostationary Search and Rescue System (GEOSAR)

COSPAS-SARSAT has also demonstrated that the current generation of COSPAS-SARSAT-type approved beacons which operate at 406 MHz can be detected by monitoring search and rescue instruments on-board geostationary satellites. The GEOSAR system consists of 406 MHz repeaters carried on-board five geostationary satellites: GOES-9, GOES-10, GOES-12, INSAT-3A and MSG-1, and the associated ground facilities called GEOLUTs that process the satellite signal. As a GEOSAR satellite remains fixed relative to the Earth, there is no doppler effect on the received frequency and doppler radio location positioning techniques cannot be used to locate distress beacons. To provide rescuers with beacon position information, the beacon acquires position data through its built-in GPS receiver or from the aircraft navigation system, or it may derive it from the LEOSAR system.
COSPAS-SARSAT has demonstrated that the GEOSAR and LEOSAR system capabilities are complementary. For example, the GEOSAR system can provide almost immediate alerting in the footprint of the GEOSAR satellite between 70° N and 70° S, whereas the LEOSAR system provides coverage of the polar regions (which are beyond the coverage of geostationary satellites), and can calculate the location of distress events using doppler processing techniques; and as the satellite is continuously moving with respect to the beacon, the LEOSAR system is less susceptible to obstructions which may block a beacon signal in a given direction.

RADIO BEACONS

There are three types of beacons called ELTs, EPIRBs, and PLBs working on three different types of frequencies; i.e. 121.5, 243, and 406 MHz which are being used in the COSPAS-SARSAT system. These beacons can be activated by different means. ELT is activated by impact and EPIRB by contact with saline water. All three types of beacons can also be activated manually. A brief description of these beacons is given below.

21.5 MHz Beacons

It is estimated that there are over 6,15000 – 121.5 MHz beacons in use worldwide. Most of these units are used aboard aircraft. The location accuracy of these 121.5 MHz beacons is around 15 Kms. 121.5 MHz beacons carried aboard aircraft can usually be activated both manually as well as automatically by shock (using a crash sensor or G switch).

243 MHz Beacons

Same as 121.5 MHz beacons.

406 MHz Beacons

The 406 MHz beacon repeatedly transmits a specific message when it is turned on. The repetition rate is 50 seconds. The message contains information about the country to which the beacon belongs, the type of the beacon (whether it is an ELT, EPIRB, or a PLB), beacon serial number, protocol of the beacon (whether it is a test beacon or real distress beacon) and beacon position from beacons with built-in GPS receivers. The location accuracy in the case of 406 MHz beacons is within 1 Km. For beacons with built-in GPS receivers, the accuracy is up to 100 meters.

LOCAL USER TERMINALS (LUTs)

There are two types of LUTs in the COSPAS-SARSAT system. Those which are designed to operate with the LEOSAR satellite constellation are referred to as LEOLUTs, and those which operate with the GEOSAR satellite constellation are referred to as GEOLUTs.

LEOLUT and GEOLUT operators are expected to provide the SAR community a reliable alert and location data, without restriction on use and distribution. The COSPAS-SARSAT parties providing and operating the space segment supply LEOLUT and GEOLUT operators, the system data required to operate their LUTs. To ensure that data provided by LUTs are reliable and can be used by the SAR community on an operational basis, COSPAS-SARSAT has developed LUT performance specifications and procedures.

In order to improve location accuracy, a correction of the satellite ephemeris is produced each time the LUT receives a satellite signal. The downlink carrier is monitored to provide a doppler signal using the LUT location as a reference, or highly stable 406 MHz calibration beacons at accurately known locations are used to update the ephemeris data.

MISSION CONTROL CENTERS (MCC)

MCCs have been set up in most countries operating at least one LUT. Their main function is to collect, store, and sort the data from LUTs and other MCCs, provide data exchange within the COSPAS-SARSAT System, and distribute alert and location data to the associated RCCs or SPOCs. Most of the data fall into two general categories: alert data and system information.

Alert data is the generic term for COSPAS-SARSAT 406 MHz and 121.5 MHz data derived from distress beacons. For 406 MHz beacons, alert data comprise the beacon location, coded information, and GPS location in case of beacons that have built-in GPS receivers, or those that are interfaced with the aircraft navigation system.

System information is used primarily to keep the COSPAS-SARSAT System operating at its peak effectiveness and to provide users with accurate and timely alert data. It consists of satellite ephemeris and time calibration data used to determine beacon locations, the current status of the space and ground segments, and coordination messages required to operate the COSPAS-SARSAT System.

All MCCs in the system are interconnected through appropriate networks for the distribution of system information and alert data. The communication media used by MCCs to disseminate the information are the Telephone, Fax, X.25, Automatic Fixed Telecommunication Network (AFTN) and secure FTP over VPN communication links. Worldwide exercises are performed from time-to-time to check the operational status and performance of all LUTs and MCCs, and data exchange procedures.

COSPAS-SARSAT BENEFITS TO-DATE

The COSPAS-SARSAT System has been very useful in saving persons in distress situations. It has helped in rescuing 18,865 persons in 5,317 SAR events since its inception in September 1982 to December 2004. In 2004 alone, the COSPAS-SARSAT System provided assistance in rescuing 1,748 persons in 466 SAR events, and these were comprised of 39 SAR events of aviation distress in which 68 persons were rescued, 321 SAR events of maritime distress in which
1,505 persons were rescued, and 106 SAR events of land distress in which 175 persons were rescued.

PALUT/PAMCC – PAKISTAN’S COSPAS-SARSAT SEARCH AND RESCUE SYSTEM

Pakistan installed the Local User Terminal – PALUT and Mission Control Centre – PAMCC at its Satellite Research and Development Center (SRDC), Lahore in 1990. This PALUT/PAMCC station is a part of the COSPAS-SARSAT System. It can locate any beacon which is activated anywhere on land or at sea area of Pakistan, around the clock. At present, the PALUT tracks six COSPAS-SARSAT LEO satellites. It cannot receive and process signals from the GEO satellites. It calculates the position of the beacons from the signal received from the LEO satellites and transmits this signal to PAMCC.

Alert and location data received at the PAMCC is provided to the appropriate SAR agencies/RCCs through fast and reliable communications means such as telephone and fax, FTP over VPN communication link. This information is also routed to SAR agencies outside Pakistan as and when required. Alerts which are generated on the land area inside Pakistan are communicated to the Civil Aviation Authority (CAA) and those that are in the sea area, to the Maritime Security Agency (MSA). The PALUT/PAMCC on average receives about 700-800 alerts a year and passes them to CAA, MSA, and other MCCs outside Pakistan.

As discussed above, the current PALUT cannot receive and process the beacons signal from the GEOSAR satellites. However it is being upgraded in the near future and after the upgrade, the PALUT Station shall have a capability to receive and process the distress signals from the GEOSAR satellite also.

CONCLUSION

COSPAS-SARSAT is a satellite-based search and rescue system which covers the whole earth. It has proved very successful in assisting the search and rescue organizations worldwide by providing reliable and timely alerts and location data of the person(s) in distress. The 406 MHz beacons which have built-in GPS receivers, or interfaced with the aircraft navigation system can provide alerts, location, and a beacon serial number in about 2 minutes from the GEOSAR satellite with location accuracy of up to 100 meters. This almost eliminates the search function from the search and rescue operation. A person who is in distress at sea and has a survival 406 MHz EPIRB with built-in GPS receiver could be located even in a severe drift at sea, as the beacon transmits its position data every twenty minutes. Similarly alert, location and identification information of any person in distress on land could be provided reliably and timely to the relevant rescue coordination center (RCC) in minutes of occurrence of distress in most cases.

REFERENCES

[1] COSPAS-SARSAT at:

[2] DG CAA-Pakistan,


gmdss_systems.htm.
A System for the Measurement of the Amazon

Paul B. Ferraro, Mark Bauersachs, John Burns & Gary Bataller
Raytheon Integrated Defense Systems

ABSTRACT

The System for the Vigilance of the Amazon (SIVAM) is a $1.4 billion dollar project of Brazil aimed at the development and deployment of a high-technology system-of-systems to perform monitoring, protection, and control of the land, air, and water resources of the Brazilian Amazon region. The primary challenge of the SIVAM project is to perform remote sensing and communications over a vast and undeveloped land area. The SIVAM network meets this challenge through an extensive network of Air Traffic Control/Surveillance Radars, Environmental Sensors, Communications Systems, Airborne Sensor Systems, and Coordination Centers. Now fully operational, the SIVAM system is the world's largest fully integrated remote monitoring system of the environment and provides critical information on a timely basis to the Brazilian government, law enforcement agencies, and to commercial, educational, and research groups.

INTRODUCTION

The Brazilian government has given significant attention to the Amazon in an effort to solve long-standing and complex social, environmental, and economic issues, intensified by mobility and communication difficulties, as well as by the limited human presence in the vast region. As a result, the Brazilian government has adopted measures to control environmentally harmful activities and to promote sustainable development in the region. The System for Protection of the Amazon (SIPAM) was conceived to facilitate coordination and integration among governmental agencies for these purposes. To provide the resources necessary to support the mission of SIPAM, the System for the Vigilance of the Amazon (SIVAM) was born.

SIVAM is the largest fully integrated remote monitoring system in the world supporting environment controls and law enforcement over land, air, and water resources. The system-of-systems is comprised of an expansive network of air traffic control and surveillance radars, environmental sensors, communications systems, and airborne sensor systems. Initial operational capability was achieved on July 24, 2002. The system has been fully operational since July 22, 2005. The primary objectives of the SIVAM system are:

- Sustainable development planning;
- Environmental protection;
- Ecological and economic zoning program;
- Social services including disease control;
- Protection of Indian reserves;
- Civil defense;
- Border surveillance and control;

Fig. 1. The Amazon Region of Brazil (red), Superimposed with a United States outline to indicate relative size
• Combating illegal activities;
• Surveillance and control of air traffic; and
• Monitoring of fluvial navigation.

SIVAM ground facilities are comprised of a large number of remote sensor and user stations, connected by an integrated telecommunications network to regional centers: three Regional Surveillance Centers (CRVs) located in the cities of Manaus, Porto Velho, and Belém; the Air Surveillance Center (CVA) also located in Manaus; and the General Coordination Center (CCG) located in Brasília.

In addition to ground stations, two distinct types of sensor aircraft are integrated into the SIVAM system: the Aerial Surveillance (SA) aircraft, equipped with an Airborne Early Warning (AEW) radar; and the Remote Sensing (RS) aircraft, equipped with a Synthetic Aperture Radar (SAR) together with spectral and infrared imaging systems. Additionally, SIVAM leverages existing sensor systems from imaging and weather satellites. All remote sensor data is transmitted through an integrated telecommunications network to the regional centers for processing and distribution.

The overall SIVAM architecture can best be described in terms of three primary system segments: the Air Traffic Control (ATC) segment, the Regional Monitoring (RM) segment, and the Telecommunications (TEL) segment. The primary system segments are, in turn, decomposed into major subsystems, each of which is comprised of numerous sensors and processing capabilities integrated both within the confines of the SIVAM network and with numerous external agencies.

Geographically disbursed throughout the 5.2 million square kilometer Amazon region, the SIVAM network is configured as 5 primary centers, 37 secondary sites (UV/UT/UVT), and over 1,200 user organization (OU) and other sensor sites interconnected through a satellite and ground-based telecommunications infrastructure.

The types of SIVAM sites are described as follows:

• **CCG – General Coordination Center**, consisting of a Coordination Subcenter (SCC);

• **CVA – Air Surveillance Center**, consisting of three operations Subcenters (SCO);

• **CRV – Regional Surveillance Center**, consisting of an Operations Subcenter (SCO), and a Coordination Subcenter (SCC) including a Users Center;

• **UV – Surveillance Unit**, consisting of fixed ATC Radar, Weather Radar, Ground-to-Air voice and data communication systems, and environmental measurement equipment.

**Fig. 2. SIVAM Interconnectivity Overview**

**Fig. 3. ATC Radar and Ground-to-Air Communications Coverage**

• **UT – Telecommunications Unit**, similar to UV sites without radars. These may be unmanned sites;

• **UVT – Transportable Surveillance Unit**, consisting of a three-dimensional (3D) Transportable Radar;

• **OU – User Organization**, consisting of user data processing stations and satellite
telecommunications (VSAT) technology for system access from remote regions.

AIR TRAFFIC CONTROL SEGMENT

The SIVAM Air Traffic Control (ATC) segment provides surveillance and data processing equipment for the detection, tracking, and control of aircraft within the Amazon region. Over 60 fixed-site, mobile and airborne radars are integrated into combined operations within a newly created Center for Air Traffic Control and Air Defense, titled CINDACTA IV.¹ CINDACTA IV augments existing CINDACTA I, II, and III operations in other regions of Brazil.

Within CINDACTA IV are over 25 ground stations in or near major cities and also remote population centers in the Amazon interior. In general, the radars are sited next to existing airport operations and serve in both en-route and low altitude, local air control functions. For en-route air space coverage above 20,000 feet, the SIVAM radar systems provide nearly 100% coverage throughout the region. This coverage is achieved by employing advanced, state-of-the-art radar technology in a challenging environment.

![Fig. 4. ATC Segment Radars and Sensor Aircraft](image)

Primary Surveillance Radars (PSR) are installed at seven ground stations and are optimized to provide both en-route air traffic coverage above 20,000 feet altitude, as well as low altitude, local area coverage generally above 1,000 feet. The Amazon basin is relatively flat, approximately 50 meters above sea level and dominated by high vegetation exceeding 20 meters. For approximately half of each year, challenging atmospheric conditions are present, leading to extremely high levels of clutter returns and false alarms prior to filtering.

The SIVAM PSR is a second-generation design employing a high-power solid-state transmitter. A high dynamic range receiver, combined with frequency diversity, 4-pulse digital moving target detection (MTD), adaptive Doppler filtering, and adaptive thresholding functions significantly reduce false alarm rates. Additional post-detection filtering techniques are also employed such that the average rate of false target reports are, on average, less than 3 per scan even in the extreme clutter environment observed at SIVAM sites. In addition to target tracking, weather processing is performed via dedicated weather channels and reported to the SIVAM centers together with target tracking data.

The PSR antenna is a dual feed design which provides high and low beam patterns for false alarm control. The high-gain, double curvature antenna is used with both circular and linear polarization for all-weather performance.

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¹Centro Integrado de Defesa Aérea e Controle do Tráfego Aéreo, or Integrated Air Defense and Air Traffic Control Center.
### Table 1. Radar Types & Locations

<table>
<thead>
<tr>
<th>Radar / Co-Mount</th>
<th>Sites</th>
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<tbody>
<tr>
<td>PSR / MSSR</td>
<td>Rio Branco</td>
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<td></td>
<td>Porto Velho</td>
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<td>Vilhena</td>
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<td>Belem</td>
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<td>Santarem</td>
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<td>Conceicao do Araguaia</td>
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<td>Sao Gabriel do Cachoeira</td>
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<td>Stand-alone MSSR</td>
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<td>Cachimbo</td>
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<tr>
<td>3D / MSSR</td>
<td>Sao Felix do Xingu</td>
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<td>Sao Felix do Araguaia</td>
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<td></td>
<td>Porto Esperido</td>
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<td></td>
<td>Guajara-Mirim</td>
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<td></td>
<td>Crizeiro do Sul</td>
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<tr>
<td></td>
<td>(5) SA Aircraft</td>
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<tr>
<td>ERIEYE AEW</td>
<td>(3) RS Aircraft</td>
</tr>
<tr>
<td>Remote Sensing</td>
<td>(10) Sites</td>
</tr>
<tr>
<td>Weather Radar</td>
<td></td>
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</table>

Standalone Monopulse Secondary Surveillance Radars (MSSR) are located at seven ground stations. Similar to the PSR sites, towers exceeding 20 meters in height are used to achieve full coverage performance in the presence of tall vegetation: typically 256 nmi is achieved for targets above 20,000 feet. Secondary radars are used with cooperative targets which employ transponders to provide range and altitude information among other parameters. Angle information is achieved through monopulse processing of transponder returns.

A challenge for secondary radars is achieving low sidelobe performance to eliminate false replies and avoid coverage gaps. The SIVAM MSSR employs a Large Vertical Aperture (LVA) array, each element of which contains 12 dipole antennas for optimum sidelobe suppression. The same LVA antenna is employed in the MSSR co-mount configuration at each PSR site. The LVA antenna forms three beams for monopulse processing. An auxiliary antenna is employed on each MSSR LVA antenna for blanking returns outside of the main beam.

The SIVAM MSSR utilizes advanced processing techniques to eliminate returns caused by reflections off buildings, towers, and long reflecting structures such as fences, all of which are common at the SIVAM sites. The key element in this processing is the development of a map of local reflecting structures, typically developed over time by observing reflection events. However, air traffic in the Amazon is characterized by heavy traffic in well-defined air routes and very limited traffic off the air routes and at low altitudes. As a result, optimization of reflection maps at each
SIVAM site was accelerated by using test aircraft to orbit the sites prior to commissioning.

The SIVAM system employs six tactical transportable radars stationed near airfields for rapid deployment using C130 aircraft. These radars use transportable satellite communications integrated with the SIVAM TEL segment, and include mobile VHF/UHF ground-to-air voice communication capabilities. While not under deployment, these radars are operated at fixed ground sites which augment the overall SIVAM air space coverage. The ground sites provide an elevated roll-on/roll-off platform together with power and services for 24 hour operation.

The transportable radars provide 3D air space coverage (range, angle, altitude) using a narrow pencil beam, scanned electronically in elevation while the antenna rotates at 6 or 12 RPM. The advanced solid-state design employs MTI and Doppler processing techniques to reduce clutter and false alarms. Each 3D transportable radar incorporates an MSSR co-mount system, identical to the stand-alone MSSR with the exception of a flat-plate antenna co-located on the 3D antenna.

While SIVAM air space coverage approaches 100% at high altitudes, coverage gaps exist between the sites at low altitudes. To fill these gaps, SIVAM employs five Surveillance Aircraft (SA), each with an Airborne Early Warning (AEW) radar titled ERIEYE. The ERIEYE AEW is mounted on an Embraer aircraft, and together with embedded Command and Control becomes the EMB 145 SA. ERIEYE provides a long-range, look-down capability.

The EMB 145 SA employs an active, phased-array pulse Doppler system. A lightweight, dual-sided antenna allows the high-performance system to be mounted on an airframe based on the Embraer ERJ 145 regional aircraft. In addition to supporting coverage gaps between fixed radar sites, the long loiter capability allows for multiple roles including: border surveillance and control; support to search and rescue operations; and surveillance of moving surface vessels.

Real-time target tracking data is provided to the Manaus CVA using a unique Air-Ground Data Link capability distributed throughout the Amazon region (described below). The Data Link provides operators with the capability to downlink target tracks to air traffic controllers located at the Manaus CVA and also to law enforcement operations located at the CRVs or CCG. The aircraft is capable of integrating with other airborne platforms in real-time for combined operations.

In addition to the five SA aircraft, SIVAM also incorporates a total of three airborne Remote Sensing (RS) versions of the SA aircraft. An Embraer ERJ 145 airframe is equipped with multiple sensors including a Synthetic Aperture Radar (SAR). Data Link support allows for near real-time downlink of multispectrum imagery and radar data to the Manaus center. In 2004, the capability of the integrated SIVAM technology was demonstrated when an RS aircraft was employed to map rapidly spreading fires not visible through smoke and which threatened indigenous populations.
### Table 2. Radar Characteristics

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<thead>
<tr>
<th>Raytheon ASR 23SS/16 Primary Surveillance Radar PSR</th>
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<tr>
<td><strong>Frequency Band</strong></td>
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<tr>
<td><strong>Antenna Turning Rate</strong></td>
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<td><strong>Antenna Polarization</strong></td>
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<td><strong>Antenna Gain</strong></td>
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<td><strong>Range Performance</strong></td>
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<td><strong>Target Capacity</strong></td>
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<td><strong>Final RF Power (solid-state)</strong></td>
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<td><strong>Tower Height</strong></td>
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<tr>
<th>Raytheon Condor MK-II Monopulse Secondary Surveillance Radar MSSR</th>
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<tr>
<td><strong>Antenna Turning Rate</strong></td>
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<tr>
<td><strong>Transmitter Power</strong></td>
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<tr>
<td><strong>Antenna Gain</strong></td>
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<tr>
<td><strong>Range Performance</strong></td>
</tr>
<tr>
<td><strong>Peak Target Processing Rate</strong></td>
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<tr>
<td><strong>Target detection efficiency</strong></td>
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<tr>
<td><strong>Tower Height</strong></td>
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<tr>
<th>Lockheed Martin TPS-B34 Mobile Radar 3D Transportable</th>
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<tr>
<td><strong>Frequency Band</strong></td>
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<tr>
<td><strong>Antenna Turning Rate</strong></td>
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<tr>
<td><strong>Range Performance</strong></td>
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<tr>
<td><strong>Co-Mount MSSR Antenna</strong></td>
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<tr>
<td><strong>Antenna Height</strong></td>
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<tr>
<td><strong>Power (deployed)</strong></td>
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<tr>
<td><strong>Transport</strong></td>
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Lastly, SIVAM aircraft equipment includes four Automatic Flight Inspection Subsystem (AFIS) aircraft. The Laboratory Aircraft is a Hawker 800XP twin turbofan aircraft which provides the capability to inspect typical navigational aids, visual approach aids, landing systems, ground-to-air communications equipment, and ATC Radars.
**Fig. 11. VHF Ground-to-Air Remote Station**

**VHF GROUND-TO-AIR VOICE COMMUNICATIONS**

In parallel with SIVAM radar coverage is an extensive VHF Ground-to-Air Radio system located at the fixed radar sites and also unmanned sites. The high reliability, redundant communications network consists of a VHF Central Station located at the Manaus CVA together with 32 VHF Remote Stations that are linked to the Central Station through the SIVAM TEL Segment. In the air routes above 20,000 feet, the system provides a high level of voice communications coverage between pilots flying within the Amazon region and air traffic controllers located at the Manaus CVA.

Each VHF Ground-to-Air Remote Station supports five fixed ATC frequencies: three primary channels; and two on-demand spare channels which may be used as independent channels. The VHF frequency range for ATC operations is 118.000 MHz to 136.975 MHz, with fixed channels spaced 25 kHz apart and tuned using high selectivity cavity filters. With 32 remote VHF stations, and up to five channels per site, the system has a capacity for 160 unique ground-to-air channels with both frequency and spatial diversity across the region.

VHF Transmit and receive antenna arrays are mounted on towers with heights of up to 70 meters, providing typical coverage exceeding 250 nmi in the air routes. Three antenna arrays are mounted on each tower: two rows of four log periodic antennas dedicated to VHF transmit, an identical 2 × 4 configuration for VHF receive, and a dual-band V/UHF mast at the top of the tower supporting the Air-Ground Data Link function (described below).

The VHF Central Station, located at the Manaus CVA, implements an extensive inter-site voting function to create single-channel frequency sectors which extend across the airspace of the region. An example of one frequency sector is a single emergency channel extending across the Amazon and supported by 10 VHF Remote Stations simultaneously. As an aircraft crosses through the region, the voter function will automatically connect an air traffic controller with a pilot via the VHF Remote Station which exhibits the highest signal-to-noise ratio (SNR) with the aircraft at any one time. Up to 42 frequency-sectors may be programmed into the system.

**Air-Ground Data Link System**

The SIVAM Air-Ground Data Link is a unique and critical subsystem providing for the exchange of data between the SA/RS Aircraft and ground elements of the ATC and Regional Monitoring segments. The data link function also supports the exchange of data between two aircraft. The system is comprised of 32 V/UHF Ground-to-Air Remote Stations – colocated with the VHF ATC sites – and the Air-Ground Data Link Interface Controller (AGDLIC) located in the Manaus CVA.

The AGDLIC handles up to 80 data link connections with the V/UHF radio sites and multiple aircraft in operation. A data link is defined as one or two, half duplex paths between an aircraft and various ground destinations. Once established, message traffic between that aircraft and any destination within the ATC and Regional Monitoring segments may be routed transparently by the AGDLIC based on message type, aircraft location, or as addressed by the aircraft. In the absence of V/UHF coverage to an aircraft, a data link can be maintained with an aircraft using alternate HF radio coverage, effectively providing 100% data link coverage throughout the Amazon.

A data link is established using a client-server model, with the aircraft in the role of the client and the AGDLIC in the role of the server. A data link is established when a Data Link Reference Point (DLRP) is transmitted from an SA/RS aircraft and then is acknowledged by the AGDLIC. The information in the DLRP is used as the reference point for target track reports. The reference point position is updated periodically – at least once every 25 minutes – as the aircraft flies through the coverage area of a Remote Station.

As an aircraft transitions between overlapping coverage areas, the AGDLIC automatically manages a data link handover between the sites. The AGDLIC first detects duplicate frames on the “new” path, discards the duplicates and develops a “Quality of Service (QOS)” based on missed frames from either site: It continues to use the primary path for the data link until the QOS indicates the new site is better than the current site; the AGDLIC then switches the data link to the new site automatically. The transition is seamless to ongoing operations, and aircraft may cross the entire Amazon region while maintaining a continuous data link function to the ATC and Remote Monitoring destinations on the ground.

Once a data link is established by an aircraft, messages may be grouped into three types: Air Surveillance; Sensor Imaging; and text messaging for coordination. Messages which originate from the airborne surveillance radars (SA aircraft) are transparently routed to air traffic controllers in the CVA. The AGDLIC combines the information from the DLRP and Track Reports to create a “standard” message which is identical to target track messages received from the fixed ground-based radars. The AGDLIC can establish simultaneous data links with up to three ERIEYE airborne
<table>
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<tr>
<th>VHF Ground-to-Air Remote Station</th>
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<tbody>
<tr>
<td><strong>Total Remote Stations</strong></td>
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<tr>
<td></td>
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<tr>
<td><strong>VHF Transmitters / Station</strong></td>
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<tr>
<td><strong>VHF Receivers / Station</strong></td>
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<td></td>
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<tr>
<td><strong>VHF Transmitter</strong></td>
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<tr>
<td><strong>VHF Receiver</strong></td>
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<tr>
<td><strong>Redundancy</strong></td>
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<tr>
<td><strong>CVA Communication</strong></td>
</tr>
<tr>
<td><strong>Transmit Antenna Type</strong></td>
</tr>
<tr>
<td><strong>Receive Antenna Type</strong></td>
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<tr>
<td><strong>Antenna Gain</strong></td>
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<tr>
<td><strong>Tower Heights</strong></td>
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<tr>
<td><strong>Co-Mounted Antenna</strong></td>
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<th>VHF Central Station at the CVA, Manaus</th>
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<tr>
<td><strong>Voter Capacity</strong></td>
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<td><strong>Example</strong></td>
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<td><strong>Frequency</strong></td>
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<td><strong>Remote Stations</strong></td>
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<td>Tefe-F3</td>
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early warning (AEW) radars. The result is to dynamically add three radars over the SIVAM region with low altitude, look-down capabilities.

**REGIONAL MONITORING SEGMENT**

The SIVAM Regional Monitoring (RM) segment provides sensor data and processing capabilities for environmental monitoring applications. The RM segment sensors include Environmental Data Collection Platform (PCD) sensors, Altitude Weather Stations, Surface Weather Stations, TIROS Satellite Ground Station, GOES Satellite Ground Station, SCD-1 Ground Station, the Radio Determination Subsystem (RDSS), and an extensive Lightning Detection Network.

The RM segment processing is performed at four Coordination Subcenters (SCCs). An SCC is located at each
of the three CRVs – Manaus, Belem, and Porto Velho – and at the general coordination center (CCG) in Brasília. The capability to process and distribute airborne sensor data, including Synthetic Aperture Radar (SAR) and Multispectral Sensor (MSS) data is located at the Manaus SCC. The SCCs are the data repositories, processing nodes, and the product and service providers for SIVAM. They are inter-linked with each other by high-bandwidth data and voice communications, and provide system access to local and remote users.

Each SCC includes specialized computers, software, and a network of integrated databases to support data preprocessing and detailed analysis of collected sensor data. The SCCs provide capabilities for the retrieval, integration, presentation, and analysis of information. In addition to SIVAM sensor data, they provide the means to access and maintain extensive data sets including historical data, library data, map data, and other pieces of reference information critical to the user community.

Meteorological, hydrological, and both ground- and satellite-based environmental data are transmitted to the Coordination Subcenters (SCC) for processing, cataloging, analysis, and visualization. The SCCs exchange information to combine and share data with other regions. Each SCC provides powerful data relationship tools, allowing different types of sensor data and imagery to be analyzed in user-defined combinations. The unique analysis products which result from these tools provide insight into the evolving characteristics of the environment and the human activity within it, facilitate the correlation of information, and provide decision aids for operational planning, coordination, and monitoring.

The RM segment is supported by the Remote Sensing (RS) aircraft system. This system and associated equipment suite provides synthetic aperture radar (SAR), multispectral, infrared, and visible light imagery via the Air-Ground Data Link, and on magnetic tapes. The RS data provides imagery data from both aerial mapping and surveillance functions. Additional imagery data is obtained from real-time satellite passes: GOES, TIROS, among others. Weather data from pulse-Doppler weather radars located throughout the region is transmitted to the RM segment in real-time.

Environment data is collected continuously and used to build and update detailed knowledge of the Amazon region. On-going classification and monitoring functions include:

- Deforestation, Forest Fires;
- Soil, crop, and agricultural land usage;
- Forest cover and changes;
- Flooding;
- Water pollution;
<table>
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<th>RM Segment</th>
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<tr>
<td><strong>Surface Weather Stations</strong></td>
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<tr>
<td>&gt; 70 sites</td>
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<tr>
<td>Temperature / RH / Pressure</td>
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<tr>
<td>Wind Speed / Direction</td>
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<tr>
<td>Ozone / CO2 Measurement</td>
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<tr>
<td>Solar / UV Radiation</td>
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<tr>
<td><strong>Altitude Weather Stations</strong></td>
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<tr>
<td>11 sites</td>
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<td>Radiosondes include ozone meas.</td>
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<tr>
<td><strong>Satellite Data / Imagery</strong></td>
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<tr>
<td>Manaus CRV Tracking systems:</td>
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<tr>
<td>GEOS, TIROS</td>
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<tr>
<td>SCD-1, SPOT, among others</td>
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<tr>
<td><strong>Weather Radar Data</strong></td>
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<tr>
<td>10 sites</td>
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<tr>
<td><strong>Environmental Data Collection Platforms (PCD)</strong></td>
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<tr>
<td>100's, unmanned sites</td>
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<tr>
<td>w/satellite comm. via SCD-1</td>
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<tr>
<td><strong>Airborne Remote Sensing Aircraft</strong></td>
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<tr>
<td>Dual Band SAR: X &amp; L-Bands</td>
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<tr>
<td>All-weather, day &amp; night</td>
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<tr>
<td>High resolution terrain mapping</td>
</tr>
<tr>
<td>Optical &amp; Infra-Red sensor</td>
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<tr>
<td>Multi-Spectral Scanner</td>
</tr>
<tr>
<td><strong>Lightning Detection Systems</strong></td>
</tr>
<tr>
<td>14 sites, uses triangulation</td>
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<tr>
<th>TEL Segment</th>
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<tbody>
<tr>
<td><strong>Remote Satcom Trunking Stations</strong></td>
</tr>
<tr>
<td>27+ sites, typical site channels:</td>
</tr>
<tr>
<td>PSR Radar Data (redundant)</td>
</tr>
<tr>
<td>MSSR Radar Data (redundant)</td>
</tr>
<tr>
<td>Weather Radar Data (redundant)</td>
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<tr>
<td>VHF G-A Voice (5 channels)</td>
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<tr>
<td>UHF G-A Voice (SA/RS Aircraft)</td>
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<tr>
<td>V/UHF Data Link Channels</td>
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<tr>
<td><strong>PABX Tie Trunks</strong></td>
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<tr>
<td><strong>Remote Monitoring &amp; Controls</strong></td>
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<td><strong>Wide Area Network (WAN)</strong></td>
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<td><strong>Surface Weather Station Data</strong></td>
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<td><strong>Lightning Detection Data</strong></td>
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<tr>
<td><strong>Operations &amp; Maintenance Data</strong></td>
</tr>
<tr>
<td>Manaus CVA Satcom Hub</td>
</tr>
<tr>
<td>1 site</td>
</tr>
<tr>
<td>CRV Satcom Hubs</td>
</tr>
<tr>
<td>4 sites</td>
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<tr>
<td><strong>PABX Voice Systems (Remote)</strong></td>
</tr>
<tr>
<td>&gt; 27 sites</td>
</tr>
<tr>
<td><strong>PABX Primary Systems</strong></td>
</tr>
<tr>
<td>5 sites</td>
</tr>
<tr>
<td><strong>Remote User Sites</strong></td>
</tr>
<tr>
<td>&gt; 900 sites with satellite VSATs</td>
</tr>
</tbody>
</table>
Fig. 14. TEL Segment Overview

- Air pollution and greenhouse gases;
- Regional flora and fauna habitats; and
- Human intervention in the environment.

In addition to direct support to operations and the scientific community, hundreds of remote users have access to the SIVAM database information and services through the Telecommunications (TEL) segment. A system of VSAT terminals provides secure satellite communications to many remote cities where land-based telecommunications are not available. The remote users have computer, telephone, and fax connectivity with the system. An example of the use of the user network is in dissemination of health and safety alerts, weather alerts, and coordination of regional activities.

TELECOMMUNICATIONS SEGMENT

The SIVAM Telecommunications & Transmission Support (TEL) segment is comprised of a highly reliable, redundant network of communications equipment using Government and commercial services to provide secure voice and data connectivity between SIVAM sites. The communications architecture is comprised of two major subnetworks; one network servicing connectivity between the CVA and 27 associated second tier surveillance and telecommunications installations, and a second network providing high speed, multi-redundant connectivity between the CRVs (including SCCs) and the CCG. Primary connectivity uses Government satellite services; secondary connectivity is supported via commercial telecommunications infrastructure and regional service providers.

Connectivity between the CVA and second tier installations is configured in a point-to-point or “star” topology. This sub-network employs a highly efficient dynamic assignment of satellite resources to support connectivity. Connectivity amongst the primary regional surveillance centers and with the CCG is supported via both satellite and ground-based infrastructure. Configured in a fully redundant mesh topology, this sub-network provides a highly reliable wideband data and voice communications infrastructure.

CONCLUSION

This high level description of the three major segments of the SIVAM architecture – Air Traffic Control, Remote Monitoring, and Telecommunications – provides an overview of the SIVAM system-of-systems. Remote sensor data and measurements, collected over a large and diverse area using advanced telecommunications, are integrated and processed at SIVAM coordination centers to support environmental monitoring and control over the land, air, and water resources of the Amazon.

ACKNOWLEDGMENT

Partners in the development of SIVAM are Raytheon Company, the Brazilian Integrating Company ATECH, and Embraer S.A., working under the direction of the Coordinating Commission of the Project for the Amazon Surveillance System (CCSIVAM) and the Brazilian Air Force, Forca Aerea Brasileira.
Adaptive Rectification Filter
for Detecting Small IR Targets

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ABSTRACT

Clutter suppression is one of the most important subjects in the field of small target detection under infrared (IR) strong clutter background. While removing the clutter background, however, such methods may reverse the relative energy distribution of target and noise in the clutter suppressed image, and disturb the subsequent target segmentation and detection. This paper analyzes the causation of such problems, does research on the relationship between target energy characteristics and detection probability, and presents a novel filter of energy distribution adaptive rectification (EDARF). Based on the EDARF, an improved framework of dim small target detection is proposed to rectify the energy distribution in the clutter-suppressed images by conventional adaptive filters. The proposed EDARF's performance is estimated by experimental comparisons of three linear/nonlinear filters before and after using EDARF. Extensive experimental results show that the proposed EDARF improves efficiently the performance of detecting dim small targets against strong undulant cloud-cluttered backgrounds.

INTRODUCTION

A crucial problem in space-borne and infrared (IR) surveillance systems today is the detection and recognition of moving dim small targets at low signal-to-noise ratio (SNR). Because of the affection of atmospheric radiation, sunlight, bright clouds, earth's surface background, and imaging distance, the target often appears as one or several pixels in a strong abundant clutter background IR image. The target is characterized with weak intensity, low SNR, and not enough structure information is available [1], which makes it very difficult to detect and identify targets. So how to efficiently reject clutter's influence on target detection is the critical issue to enhance detection probability [2, 3].

A popular approach to this problem is using a filter to predict background and suppress background clutter to enhance target detectability. Therefore, the clutter suppression operation becomes the most important stage in the target detection and tracking under complex backgrounds [3]. Many methods have been used to detect small targets, including Matched Filtering [4, 5], Dynamic Programming Algorithm [6], Multistage Hypothesis Testing [1, 7, 8], Bayesian method [9-12]. Leung and Young implemented a recursive nonlinear predictor to estimate the background and to improve the predictive detection scheme [13]. Moon and Zhang adapted a Multi-level filter (MLF) to smooth background, used Bayesian methods to segment and detect sea surface small targets [14]. Based on the analysis of various target detection methods, Hilliard pointed out that a low pass IR filter has a better comprehensive performance for clutter prediction [15]. Tom et al. proposed the morphologic operators (MorF) for small target detection according to the prior knowledge of targets [16]. A local mean removal (LMR) filter was used to tack nonstationary mean in images by Reed et al. [17].

The clutter suppression procedure assumes that the operation does well in suppressing the background structures without reducing the target signal levels, and the target signal is still stronger than the clutter’s in the residual target plus noise images. However, the assumption is not always satisfied in the real images. Rickard and Zeidler indicated the error channel from a one dimensional adaptive filter which contained components from the signal of interest and the input noise, and also contained the misadjustment components of the clutter [18]. Then, Soni and Zeidler [19] analyzed the misadjustment's effect on the filter performance. This misadjustment may cause a hindrance to detect small targets under complex clutter. All this motivated us to present a novel filter to improve the clutter removal operation for better performance.

In the next section, the signal model is introduced briefly; then the general clutter suppression procedure and its
drawback are analyzed. The section entitled Energy Distribution Adaptive Rectification Filtering and Its Analysis analyzes the target/background energy distribution feature of infrared small target images and presents a hybrid Energy Distribution Adaptive Rectification Filter (EDARF) to tune clutter removal processing. Following, the target segmentation and tracking are described. The performance metrics and experiments are given in the Performance Metrics and Experimental Work section. Finally, the work is concluded in last section.

**SIGNAL MODEL AND PROBLEM STATEMENT**

**Imaging Model and Clutter Removal Procedure**

Signal modeling is of primary importance when a new detection approach is proposed. In real world infrared image sequences, images are usually modeled as containing target signal, background signal and noise signal.

Because the areas of the target and noise regions are too small to get enough information, many filters were presented to suppress background signals. The clutter removal procedure consists of two basis steps: The background is estimated before target detection, and then the image of target only plus noise is estimated by the original image minus the estimated background image. That is shown in Figure 1, where the original image is, the background estimation is obtained via a background prediction filter, and the residual image is the clutter suppressed image containing target and noise. Since the clutter removal procedure is used to reduce the effects of non-stationary background on detection performance, it must satisfy two requirements: 1) it must remove the background structures in the image in order to reduce the number of false alarms in the detection step; and 2) it must maintain the local SNR to avoid detection probability reduction.

**The Problem of Clutter Suppression Procedure**

The ideal clutter suppression procedure would be capable of transforming an arbitrary inhomogeneous and non-stationary background into an approximately stationary, homogeneous background without reducing the effective target signal power. In fact, keeping the target signal energy detectable is the critical consideration for weak targets.

**Fig. 2A. The target and noise in undulant clutter background which is one frame of the original image sequence, where □ is the actual target in high bright region; Δ is the noise in the dark region. When the clutter suppression operation is carried on, the Relative Energy Distribution reversion phenomenon will arise as shown in the following figures**

**Fig. 2B. The phenomenon of REDR**
Nevertheless, because both the original background and its estimates are undulant, dynamic, and statistically non-stationary, generally the subtraction operation of Figure 1 may reverse the relative energy distribution of the signal to noise.

In clutter suppressed image \( f_w \), the target’s energy in an original high bright region will become relatively lower than the noise in the dark region; because the target’s energy in the original image \( f \) is more closed to its adjacent bright clutter energy than the noise energy in the dark region, that is, the target’s energy is more closed to the optimal estimation of its adjacent bright clutter. Especially in strong undulant clutter background, this phenomenon arises more frequently (as shown in Figure 2A).

Therefore, background suppression methods will change the signal’s relative energy distribution, which is useless to the subsequent target segmentation and detection. A case of the phenomenon can be observed in Figure 2. Soni et al. described an analogous phenomenon and addressed that the misadjustment of signal of interest and the input noise in the adaptive filter weights is another factor contributing to the performance drop [19]. Here, the phenomenon is defined as:

**Relative Energy Distribution Reversion (REDR)**

It is the phenomenon that the relative energy of target and clutter/noise is disordered or inverted after clutter removal procedure. One fundamental cause of this phenomenon is the natural undulation of background clutter and the position randomness of target’s appearance in the background, and another is caused by filtering algorithms.

Just as shown in Figure 2, the clutter removal operation may lead to intensify the noise’s energy in a weak background region and, at the same time, reduce relatively the target’s energy in a bright background region; in some conditions, it even causes the clutter removal operation’s capability of enhancing the signal of interest, and brings an obstacle to choose a proper threshold for the segment, and also increases the risk of target leaks and false alarms (shown in Figure 2C). Obviously, this keeps away from the clutter removal operation’s objective.

So something should be supplied to improve the clutter suppression procedure to enhance target detectability. We present a novel improved framework based on clutter suppression for small target detection, in which the EDARF operation is added (shown in Figure 3). The following vast comparative experimental results also verify the necessity and efficiency of the energy adjustment.

**ENERGY DISTRIBUTION ADAPTIVE RECTIFICATION FILTER (EDARF) AND ITS THEORY ANALYSIS**

To solve the REDR problem, an EDARF model is proposed to enhance targets. In the model, three rules are considered: 1) The larger the energy of signal of interest, the more the probability of the signal regarded as a candidate for the targets, in the pre-detection stage; that is, the detection probability is in direct proportion to the target’s energy; 2) The adjacent information is an important factor affecting the target’s new feature in the residual image \( f_w \); 3) After the clutter suppression procedure, the relocated relative energy distribution of signal and noise in \( f_w \) should be preserved to avoid reversing their relative distribution. As we know, the first rule emphasizes the target energy itself; the second indicated the important relation between target and its adjacent; and the last guarantees target detectability and at the same time, reduces false alarms.

To satisfy these principles, both the target’s relative energy and its absolute energy should be considered to estimate background and suppress clutter. Because the whole background is variable and the target is dim small, the local statistical features of targets and their neighbors are critical to build up the model.

Let (in short) be the \( i \)-th image of an image sequence, every pixel \( P(x, y) \) in its neighbor \( r^c \), the EDARF filter is shown in Figure 4, where the rectification value is the local mean.

From Figure 4, it can be seen that the rectification extends the signal on purpose to highlight the signal of interest, and
this operation depends mainly on the signal’s character and the local feature: The larger the signal’s energy and the less its local mean (that indicates the more the signal is likely to be a potential target), therefore, the more signal is enhanced by the EDARF ($f_n$), in order to enhance the potential target; On the contrary, the signal of energy value closed to the local mean is enhanced not so much, that is, it is likely to be the clutter and is enhanced little to avoid false alarms. Moreover, as signal’s energy decreases and its local mean increases, the rectification value of the signal in the middle level decreases nonlinearly. That is, the filter ($f_n$) takes into account both the signal self characteristic and its local energy feature to adaptively adjust energy distribution at different probability levels to reject the REDR phenomenon for enhancing target detectability.

Generally speaking, the filter does well in satisfying the three regulations and is competent for the main task of suppressing clutter (to reduce false alarms) and enhancing

![Image](image1.jpg)

(a) The right-bottom portion of the 20th frame of the original image in sequence 6

![Image](image2.jpg)

(b) result of LMR algorithm

![Image](image3.jpg)

(c) result of E-LMR improved by EDARF

Fig. 5. The result of the right-bottom of the 20th frame of the Sequence 6

Table 1. SCR-Gains of Different Algorithms

<table>
<thead>
<tr>
<th>Filter Name</th>
<th>LMR</th>
<th>E-LMR</th>
<th>MorF</th>
<th>E-MorF</th>
<th>MLF</th>
<th>E-MLF</th>
</tr>
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</table>

IEEE A&E SYSTEMS MAGAZINE, AUGUST 2007
targets (to prevent missing targets). The following experiment results also validate the efficiency of energy distribution rectification.

With respect to the use of EDARF, just as the framework shown in Figure 3, the EDARF should be appended to a proper clutter suppression filter to improve clutter rejection and further enhance signal of interest. This paper appends the hybrid EDARF ($f_h$) to the filters LMR, MLF (linear filter), and MorF (nonlinear filter) to gain their improved filters in order to estimate the hybrid EDARF’s performance. We abbreviate these improved filters to E-LMR, E-MLF, and E-MorF, respectively.

DETECTION AND TRACKING

After eliminating background clutter, the potential targets are extracted in the residual image ($f_w$), segmentation and tracking are performed. Herein, the process is divided into two parts: the first, called pre-detection, is to find candidates for targets in every frame of difference image by temporal recursive filtering; and the second, is to identify target and track target trajectory in multiple frames of images in which a pipeline filter is used.

In the first step, some thresholding methods are proposed [13, 19-21]. Assuming the residual image ($f_w$) as white noise with Gaussian distribution, Hu et al. [20], Li et al. [3] adapted threshold operations with constant false alarm ratio (CFAR). However, under strong undulant clutter conditions, the background is often so undulant that the assumption of Gaussian distribution on which a threshold with CFAR is used is not always correct for some clutter suppression filters or in many real conditions. In addition, Cao et al. [21] chose the threshold of likelihood according to the amount of pixels of which gray values are larger than a threshold value, and kept the amount constant. Different from above, a threshold for perfect detection defined as the highest threshold at which the weakest signal of interest is detected is proposed for performance evaluation of adaptive prediction filters [19]. Moreover, Leung and Young indicated that an optimal threshold could be chosen by different criteria, depending on whether the objective is minimizing the probability of false alarm and/or the probability of missing [13].

To detect targets and mainly evaluate the performance of the hybrid EDARF ($f_h$), the pre-detection approach based on Point of interest Over-Threshold Ratio ($R_{opt}$) is used to detect targets in a single frame of the difference image obtained by a temporal recursive low-pass filtering [2, 22]. The approach is similar to the thinking of the threshold of likelihood [21], and it can also be applied by different criteria of minimizing the probability of false alarm and/or the probability of missing the target [13].

In fact, the amount of most possible candidates and the capacity of tracking multiple targets in the infrared search and track (IRST) systems are often limited, and a constant bound of processable targets can be obtained, which is called a benchmark herein. So the priori-knowledge is very helpful to choose a proper $R_{opt}$. Furthermore, the $R_{opt}$ can be transformed into the amount Ratio ($R_{opt}$) of points of interest to the benchmark. Thus, difference $R_{opt}$ fluctuating around the benchmark ratio (1.0) can be chosen for segmentation. When $R_{opt}$ varies from the small to the large, different performances as a function of $R_{opt}$ will emerge, which meet the objectives of evaluating the EDARF ($f_h$) in the next section. It is also the reason we chose this method.

In the second part, the temporal and spatial consistency characteristics of moving target trajectory, and the noise’s random fluctuations are used to track targets in multiple frames of images. When the candidates for targets are labeled, we use the pipeline filter [23] to identify targets from the candidates in temporal and spatial domain.

PERFORMANCE METRICS AND EXPERIMENTAL WORK

Performance Metrics

The main concern herein is how the hybrid EDARF filter affects the target detection and tracking. We assessed the performance in detail in the whole process. In the pre-detection stage, the Signal-to-Clutter Ratio Gain (SCR-Gain) and Probability of Pre-detection ($P_{pre}$) in a single frame of image are adapted to evaluate the clutter suppression ability and the target detectability, respectively; in the detection and tracking of the trajectory stage, the Probability of Detection ($P_d$) and Ratio of False Alarm ($P_{fa}$) in multiple frames of the images are used to estimate their affects on target trajectory detection. They are all as the function of $R_{opt}$.

Experimental Work

To test the proposed EDARF’s reliability and stability, we have employed the Monte Carlo techniques and implemented extensive experiments. The 12 synthetic data sets from real IR background images are used, every data set includes 25 image sequences, every sequence contains 39 frames and 0-8 target trajectories, and the target points of every trajectory appear or disappear in different frames with a changeable interval. Among them, multiple factors are simulated, such as the camera SNR, the target intensity and size variance, the target or background’s random shift and drift, the target’s appearance/disappearance time, the trajectory length, and so on. In our detection, the hybrid EDARF’s parameters and the subsequent processing work of target detection and tracking is the same.

Experimental results are shown in Figures 5-6 and Table 1. For instance, Figure 5A depicts the right-bottom portion of the 20th frame of an original image sequence in which the image size is $512 \times 512 \times 16$. Figure 5B depicts the processed image using LMR algorithm. Figure 5C depicts the processed image using E-LMR algorithm enhanced by the hybrid EDARF. From Figure 5, it is seen that E-LMR filter suppresses the background clutter and highlights the signal of interest better than LMR, especially in the area of bright
Internetworking and Resource Management in Satellite Systems

A series of articles in the

*IEEE Aerospace and Electronics Systems Magazine*
Discourse

"From letters one makes syllables,
From syllables, words, and
From words discourse.
Do your duty by them." **

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— Evelyn Hirt
Editor-in-Chief

**From Champ Fleury (1529) by Geofray Tory
Translation by George B. Ives**
Internetworking and Resource Management in Satellite Systems

A series of articles in the
IEEE Aerospace and Electronics Systems Magazine

appeared in this magazine’s July 2007 issue
Volume 22, Number 7, pages A-1 to A-16.

PEPsal: A Performance Enhancing Proxy for TCP Satellite Connections
C. Caini, R. Firrincieli & D. Lacamera
appears in this magazine’s current issue.

Advanced Channel Coding for Hap-Based Broadcast Services
A. Boch, F. Darneshgaran, M. Laddomada & M. Mondin
will appear in a future issue.
Internetworking and Resource Management in Satellite Systems

Mario DeSanctis
Guest Editor

Introduction

The emerging next generation networking environment presents an Internet Protocol-based (IP-based) core interconnecting different Radio Access Networks (RANs), which provides broadband multimedia communication to fixed or mobile end users. In this framework, a satellite communication system is distinguished by: global coverage even in remote areas; broadcast capability; bandwidth-on-demand flexibility; Earth disaster tolerance; last mile connection availability; and terrestrial network congestion avoidance.

The exploitation of satellite systems for packet switching transmissions began in 1973 with the experimental satellite network called SATNET of the Atlantic Packet Satellite Experiment. Since then, a large effort has been devoted to the performance improvement of the Internet protocol suite over satellite networks by exploiting new satellite system architectures and by designing novel protocols. From the system architecture point of view, the simple bent-pipe GEO architecture has been expanded including On Board Processing (OBP) capabilities, LEO/MEO satellite constellations, High Altitude Platforms (HAPs), intra-orbit and inter-orbit Inter Satellite Links (ISLs). On the other hand, the typical features of satellite communication systems such as large propagation delay, time varying channel, and the asymmetric and dynamic topology of some architectures generally affect the system performance at different protocol layers (access, network, transport, and application layer). Several solutions have been proposed to overcome these issues, also accounting for cross layer interactions and effectively exploiting the precious capacity of satellite links.

The purpose of this series of articles is two-fold: 1) to overview some of the current solutions and trends for the improvement of the exploitation of satellites for the provision of Internet services; and 2) to present to a technical audience novel results on the above mentioned areas following the tutorial style typical of the IEEE Aerospace and Electronic Systems Magazine.

Three papers have been selected for this series. The first, Network Architecture and Radio Resource Management for Satellite Digital Multimedia Broadcast System by L. Liang et al., presents the Satellite Digital Multimedia Broadcast (SDMB) system in terms of network architecture and access layer optimization. The second, PEPsal: a Performance Enhancing Proxy for TCP Satellite Connections by C. Cainen et al., proposes and evaluates a Performance Enhancing Proxy (PEP) solution which improves the performance of Transmission Control Protocol (TCP) connections over a satellite channel. The third, Advanced Channel Coding Solutions for the Provision of Broadband Services from Stratospheric Platforms by A. Boch et al., presents a framework for the design of variable-length prunable interleavers needed for the design of both bit-interleaved coded modulations and for code concatenation suitable for HAP-based communication systems.

Enjoy the reading! Your comments are invited.
PEPsal: A Performance Enhancing Proxy for TCP Satellite Connections

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ABSTRACT

Internet communications with paths that include satellite link face some peculiar challenges, due to the presence of a long propagation wireless channel. Herein, we propose a Performance Enhancing Proxy (PEP) solution, called PEPsal, which is, to the best of the authors' knowledge, the first open source Transmission Control Protocol (TCP) splitting solution for the GNU/Linux operating systems. PEPsal improves the performance of a TCP connection over a satellite channel making use of the TCP Hybla, a TCP enhancement for satellite networks developed by the authors. The objective of the paper is to present and evaluate the PEPsal architecture by comparing it with end-to-end TCP variants (NewReno, SACK, Hybla), considering both performance and reliability issues. Performance is evaluated by using of a testbed set up at the University of Bologna, to study advanced transport protocols and architectures for internet satellite communications. At present, PEPsal is adopted, with success, by a satellite Internet provider.

INTRODUCTION

Internet communications with paths that include satellite link face some peculiar challenges, due to the presence of a long propagation wireless channel. First, the presence of losses not originated by congestion cannot be considered negligible. Second, the Round Trip Time (RTT) is greatly increased by the long propagation time on the satellite radio channel (a GEO, Geostationary Earth Orbit, bi-directional RTT can exceed 600 ms). Both of these aspects pose severe challenges to the transport layer performance when an application requires reliable service [1,2]. To cope with these issues, several Transmission Control Protocol (TCP) enhancements have been proposed in past years. They could be generally classified in two main categories: TCP enhancements that involve only the end hosts [3,4], and TCP enhancements that envisage intermediate agents on the path usually called Performance Enhancing Proxies (PEPs) [5]. Among the PEP proposals, the most promising solution is represented by the splitting approach. The rationale of the splitting concept is to separate the satellite portion from the rest of the network. To this end, two alternative architectures can be adopted, namely integrated and distributed PEP [5]. In the first case, the TCP connection established among the end hosts is split in two separated connections, with a sole PEP agent in the middle. The first connection makes use of the TCP standard and is terminated on the PEP. The second connection, between PEP and the final user, can exploit an enhanced TCP version compatible with a standard TCP receiver. By contrast, the distributed architecture splits the connection in three sections, by isolating the satellite link between two PEP agents. In this case, it is possible to adopt a proper transport protocol on the satellite link, such as Space Communications Protocol Specification-Transport Protocol (SCPS-TP) [6], while the end hosts continue to adopt the TCP standard protocol. In a backbone application, the distributed approach can be preferable. However, when the satellite link represents the last hop for Internet access, the integrated approach presents the advantage of not requiring at the end user any non-standard (i.e., provider dependent), additional hardware or software modification to the receiver box. For this reason, attention is focused on the integrated architectures. As will be shown herein, integrated PEPs based on TCP splitting offer higher performance because they are able to confine the satellite impairments (long RTTs and random losses) on the second component of the split
connection, where they can be counteracted by specific optimized TCPS.

Despite the good performance provided, there are some important issues related to the splitting approach. First, splitting violates the basic end-to-end TCP semantics. The sender receives acknowledgments (ACKs) from an intermediate agent instead of the final receiver. Second, the intermediate agent needs to access the TCP header of the packets in order to send ACKs back to the sender and perform all its optimization procedures. This prevents the use of IPSec (Internet Protocol secure) technique which encrypts the IP payload making the TCP header not available. Thus, an IPSec flow cannot be managed by splitting PEP and performance can be improved only by a non-splitting PEP or an end-to-end TCP enhancement.

Although many proposals based on the splitting approach (either integrated or distributed) have been presented in the literature, some lack any operating system (OS) implementation and consequently it is not possible to evaluate their performance on a testbed [7, 8]. Other proposals are not available for the GNU/Linux operating systems, [9, 10, 11], or, being commercial implementations [12, 13, 14], are proprietary solutions and neither implementation details, nor the source software, are available. An open source distributed PEP based on the SCPS suite has been released by JPL [6]. This will not be considered here, having focused our attention on the integrated approach.

We propose a new PEP solution, called PEPsal, which is, to the best of the authors’ knowledge, the first integrated splitting solution available for Linux OS under GNU General Public License (GPL). PEPsal improves the performance of a TCP connection over a satellite channel making use of the TCP Hybla, a TCP enhancement for the satellite network developed by the authors. After describing the PEPsal architecture, the paper focuses on the performance comparison either with end-to-end TCP variants (namely, NewReno, SACK, and Hybla), and a “pure” splitting architecture, which does not exploit any advanced TCP protocol on the satellite segment. Performance is evaluated by making use of a testbed set up at the University of Bologna, in the framework of the European SatNEx II project [16].

THE PEPsal ARCHITECTURE

PEPsal Classification

The term Performance Enhancing Proxy is used in the literature to indicate a wide set of quite different solutions. Before examining in detail the PEPsal architecture it is therefore useful to anticipate its classification according to [5], which takes into account the following characteristics: layering, distribution, symmetry, and transparency. As far as layering is concerned, PEPsal can be considered as a multi-layer proxy, because in order to implement the TCP splitting, which is, of course, a transport mechanism, it must also operate at IP and Application layers. Considering distribution, PEPsal can be classified as an integrated PEP, since it runs only on a single box on the forward link satellite gateway. PEPsal can be either asymmetric or symmetric, depending on its network layer configuration: i.e., it can act in the forward direction (usual configuration), but also in the return (in this case, with proper modifications on the receiver side). Finally, PEPsal is transparent in the customary asymmetric configuration. Since modifications are not required in both the connection endpoints, TCP users are unaware of the connection splitting performed at the satellite gateway.

PEPsal Description

The TCP integrated splitting architecture that derives from the application of the PEPsal software on the satellite gateway is reported in Figure 1. PEPsal operates at three different layers (IP, TCP, and Application); hence it can be well described by analyzing the working scheme of each layer. At the network layer, PEPsal uses “netfilter” [17] to intercept the connections that involve the satellite link (it “steals” the TCP SYN packet in the three-way handshake phase of a TCP connection). Then, it works at transport layer, pretending to be the opposite side of the TCP connection for each of the two endpoints involved. It acts as the TCP receiver with the source, by acknowledging the incoming packets, while at the same time, it sets up a new TCP connection toward the real endpoint receiver. It is important to stress that on this second connection, an enhanced TCP variant can be used. Finally, to exchange data between the two connections, it is necessary to make use of an application that directly copies data between the two sockets.

After describing basic PEPsal architecture, it is convenient to move the attention on the mechanisms that allows a real performance improvement. First, we would like to highlight the fact, not well recognized in the literature, that an important improvement is achieved by simply splitting the connection. In this way, the impairments introduced by the satellite leg (long RTTs and random losses) are removed from the first connection, which becomes short-RTT and basically error-free. A path with short RTT and no errors makes the connection speed grow fast, for two reasons [4]. First, because the TCP congestion control algorithm is fundamentally driven by the ACK flow, a short RTT is a requisite for a fast opening of the congestion window (cwnd), i.e., for a fast increase of the transmission rate. A fast opening of the cwnd is also a requisite to not be penalized in the share of bandwidth resources, whenever different connections have to compete for a bottleneck bandwidth. Second, the spurious reductions of the transmission rates caused by random losses are avoided. To understand this point, it may be useful for the unfamiliar reader, remember that as TCP standard ascribes any loss to congestion, it reacts to any loss with a halving of the cwnd, i.e., with a halving of the transmission rate. In presence of random losses (i.e., losses due to a bad channel) this results in a severe interference of the recovery mechanisms on the congestion control, with which TCP standard is unable to cope.
Although useful, the splitting technique itself is not able to counteract random losses and long delay on the satellite segment. To cope with them, it is necessary to make use of a transport protocol designed to deal with these problems. While distributed architectures can make use of transport protocols different from TCP (at the expense of the introduction of an additional PEP element on the receiver side), integrated architectures, as PEPsal, must still rely on TCP. Instead of making use of TCP standard (NewReno, SACK), they can benefit from the advantages provided by advanced TCP versions, provided that they are fully compatible with a standard TCP receiver. This is the case, for instance, of TCP Westwood, TCP Hybla, and others. In particular, TCP Hybla, which is the TCP variant adopted by the PEPsal architecture, was conceived by the authors with the primary aim of counteracting the performance deterioration caused by the long RTTs typical of satellite connections. It consists of a set of procedures, which includes an enhancement of the standard congestion control algorithms, the mandatory adoption of the SACK policy, the use of timestamps, the adoption of Hoe’s channel bandwidth estimate and the implementation of packet spacing techniques. For a complete description of this TCP variant the interested reader is referred to [4].

**PEPsal Implementation**

All of the software components used to implement the PEPsal architecture are reported in Figure 2, which also outlines its functioning. The bottom area (“Linux”) represents the Linux kernel, which is accessed to set up the netfilter targets and to make use of a modified protocol for all TCP connections. Incoming TCP segments are mangled, so the TCP SYN segment is passed to the PEPsal user application via the ipqueue library, while the rest of the
Fig. 3. Layout of the testbed used for performance evaluation

Packets containing segments for that connection are redirected to local TCP port 5000. The small area on the right side ("Libs") shows which system libraries have been used to implement PEPsal. Shared memory is a fast and powerful Inter-Process Communication (IPC) method, used by the PEPsal processes to share information about incoming and outgoing connections, their state and their original endpoints. A bitmap array index is used by the application to give faster access to this memory zone. Iqueue library is commonly used to pass a whole IP packet, including network and transport headers, to user space applications. PEPsal uses it to read information from incoming TCP SYN packets, which contain no useful data except for the headers themselves, and would be normally forwarded by the gateway to their destinations to initiate new connections.

The top area ("PEPsal") represents the user space application, which is completely written in C using the two libraries described above. One process, the "queue," waits for data coming from netfilter, by blocking on the iqueue read routine. When Linux netfilter reads incoming TCP SYN segments and copies them into a queue, the queue annotates the information (IP addresses and TCP ports) on the two endpoints in a known zone of the shared memory. Then, the SYN packet is released and continues its path through the netfilter chain. Just after that, the SYN packet, as well as every subsequent packet containing a segment of that connection, is redirected by netfilter to TCP port 5000, where a TCP daemon, the "connection manager," is listening for it. Another process, the "proxy server," accepts the connection and searches in the shared memory for the instance matching the source address and the TCP port of the host that has started the connection. Once the destination IP address and port have been found in the connection array, a new TCP connection is attempted toward the real destination. After establishing the two connections, the proxy starts reading from one TCP socket and writing all the data in the other. When one of the two connections ends, its twin socket is closed and its memory zone is released.

TESTBED DESCRIPTION

The topology of testbed used for performance evaluation is shown in Figure 3. It consists of several PCs running the Linux operating system fully controlled through a web interface specifically designed by the authors in order to speed up the execution of the tests and to enable a fast collection of execution logs [18]. Sources and sinks, as well as the router R2, where the PEPsal software is mounted, have been patched with the Multi-TCP package [19], which allows the user to easily select at run-time the TCP variant to be used, as well as a fine tuning of a wide variety of TCP parameters. As the testbed aims at reproducing a heterogeneous network, both satellite and terrestrial TCP connections are present. Satellite connections are composed of both wired legs and a satellite link (emulated by dedicated PC running NistNet software [20]), while TCP background traffic is present only in the entirely wired paths. All the connections share the R1-R2 bottleneck link, whose bandwidth has been deliberately limited to 10 Mbps in order to study the congestion effects. All other links are set to 100 Mbps, but the satellite channel that is set to 10 Mbps. The router R1, where all the congestion events are confined, follows a Random Early Detection (RED) policy (qlen = 50 sec., maxth = 15 sec., and minth = 5 sec.); all the other hosts follow a Drop Tail (DT) policy. The RTT is set up to 25 ms on the wired network segment, while the two-way propagation delay of the satellite link varies in such a way that the RTT of the satellite connections ranges from 50 ms (mainly considered for comparison purposes) to 600 ms (corresponding to the case of a forward and return GEO satellite link). The wired links are supposed to be error-free, while uniformly distributed random errors can be introduced on the satellite link, with a variable Packet Error Rate (PER). The Maximum Segment Size (MSS) is 1448 bytes and the senders access the 10 Mbps bottleneck through 100 Mbps access links. For every TCP connection, a persistent File Transfer Protocol (FTP) process is considered. The
Fig. 4. Performance comparison in the presence of congestion on the R1-R2 bottleneck:
- goodput of a satellite connection vs. its RTT;
- 5 background wired connections (RTT = 25 ms) active.
- PER = 0% on the satellite channel

performance is evaluated in terms of goodput, i.e., the amount of packets correctly received divided by the transfer process time. In order to prevent the transmission bit rate from being limited by the advertised window instead of the cwnd, the advertised window of the satellite receiver has been appropriately increased. This is necessary to grant fair conditions to the different TCP flavors. Finally, in TCP Hybla, the parameter $RTT_o$ [4] is chosen equal to the RTT of the wired connections for comparison purposes.

PERFORMANCE EVALUATION

This section presents a numerical evaluation of the proposed architecture considering a variety of different environments. PEPsal performance is compared with end-to-end NewReno, SACK, and Hybla. Moreover, in addition to the preliminary results presented in [21], we expanded this numerical evaluation to a “pure” TCP splitting architecture, by adopting TCP SACK, instead of TCP Hybla, on the satellite segment. In this way, it is possible to independently evaluate the different contributions of TCP splitting and of TCP Hybla.

Performance in the Presence of Congestion

Standard TCP congestion control is fair in the allocation of bandwidth resources as long as competing connections have comparable RTTs. This is not the case of heterogeneous networks, where satellite connections are severely penalized by the presence of competing wired connections. Figure 4 shows the performance of a satellite connection, supposed error-free (PER = 0%), in presence of 5 wired connections on the R1-R2 bottleneck. As expected, standard TCP performance (e.g., NewReno, SACK) shows a fast a severe degradation with increasing RTT, with totally unsatisfactory performance for the RTTs typical of GEO satellite (600 ms). For clarity, the goodput of background connections is not reported but it is always close to the maximum fair share (i.e., the bottleneck bandwidth divided by the number of competing connections). PEPsal, by splitting the end-to-end satellite connection, removes the causes of this penalization achieving a goodput always very close to the maximum fair share. This is because the first connection (from the satellite sender to R2), being fully wired, has the same RTTs of competing background traffic. As a result, any penalization in the bottleneck bandwidth share is removed. As the satellite segment is supposed error-free (PER = 0%), the adoption of TCP Hybla on the second connection (from R2 which acts as a satellite gateway to the satellite receiver) does not provide any additional advantage with respect to the use of SACK, when dealing with persistent file transfers (PEPsal and splitting SACK show the same performance). However, note that if we have dealt with small data transfers, TCP Hybla would have further improved performance thanks to its fast opening of the cwnd at start-up. Being TCP Hybla-compatible with a TCP standard receiver (it is only required to enlarge the advertised window) the TCP end-points can continue to adopt standard TCP versions. For comparison, in the figure is reported also the performance achievable by an end-to-end TCP Hybla connection. Although results are very close, it is worth pointing out that TCP Hybla, used as end-to-end protocol, would require installation on all of the Internet Service Providers (ISP) servers which the satellite users want to reach (virtually all the ISPs). On the contrary, PEPsal requests the modification of just the satellite gateway which is usual under the satellite operator control.
**Fig. 5.** Performance comparison in the presence of random losses on the satellite channel (PER = 1%):
goodput of a satellite connection vs. its RTT; no background wired connections

**Fig. 6.** Performance comparison in the presence of random losses on the satellite channel (PER = 5%):
goodput of a satellite connection vs. its RTT; no background wired connections

**Performance in the Presence of Link Losses**

As the standard TCP does not distinguish the origin of packet losses, link errors cause spurious interference on the congestion control mechanism, causing even in this case a fast degradation of performance with increasing RTTs. This behavior is apparent by examining the performance of NewReno and SACK reported in Figure 5, which refers to the case of a single satellite connection without background traffic. Having eliminated any form of congestion, all the losses are due to the non-ideal satellite channel (PER = 1%). By contrast to the previous case, here the benefit provided by PEPsal is entirely to be ascribed to the adoption of TCP Hybla on the satellite segment, which is much more efficient of TCP standard in re-opening the cwnd after the spurious reductions caused by random losses. This is proved by the unsatisfactory performance of the splitting SACK, which provides roughly the same result of NewReno and SACK. Performance advantage of both PEPsal and TCP Hybla, whose performance is equivalent, is impressive. In Figure 6, the same scenario is considered with a PER = 5%; comments related to the previous case still hold although the higher PER induces a general performance worsening for all of the protocols.

**Performance in the Presence of Congestion and Link Losses**

The simultaneous presence of both congestion on a link shared with wired connections and random losses on the
satellite channel represents the most challenging environment. Related results, obtained by setting PER = 1% in the congestion only scenario previously considered, are reported in Figure 7. A limited performance worsening with respect to congestion only data reported in Figure 4 can be observed, however, the qualitative terms of comparison between the different possible solutions are left substantially unchanged by the addition of random losses. The only exception is represented by the splitting SACK, whose performance is basically ruled by the amount of PER, being totally unable to counteract random losses.

**Fairness and Friendliness**

Fairness and friendliness are two important features for any version of TCP protocol. Fairness refers to the capacity to assure a fair band subdivision among competing connections that use the same version of the protocol, while friendliness indicates the same ability with reference to different protocol variants. To study fairness and friendliness in a heterogeneous environment, in Figure 8 is reported the R1-R2 bandwidth share of three satellite connections (RTT = 600 ms) and three wired connections (RTT = 25 ms), all simultaneously active and error-free. TCP SACK confirms its full inability at providing a fair share in the presence of different RTTs. By contrast, PEPsal removes any penalization against satellite connections, presenting very good properties of both fairness and friendliness.

**CONCLUSION**

To the best of the authors’ knowledge, PEPsal represents the first free software implementation of an integrated TCP splitting available for Linux OS under the GNU GPL license. Results presented herein indicate that the PEPsal architecture...
is able to remove the penalization suffered by satellite connections in heterogeneous environments. Of course, as other PEP solutions at transport level, its use should be carefully planned by satellite providers in order to minimize the possible disadvantages of these architectures. At present, PEPsal is adopted by WIALAN network devices manufacturer [22], which supplies some Internet satellite providers.

REFERENCES


strong clutter. The SCR-Gains of the filters are listed in Table 1, and the SCR-Gains are the average value of all of the sequences sets. From this result, we come to the conclusion that the hybrid EDARF further improves SCR on the basis of the original filters and enhances the ability of detecting weaker targets.

Then, Figure 6 shows a visual performance contrast of the three group clutter suppression filters. We see the improved algorithms using our hybrid EDARF perform much better than the original filters (LMR, MorF, MLF), in respect of either the probability of pre-detection ($P_{pd}$) or the probability of detection ($P_d$); at the same time, we kept the ratio of false alarms ($P_f$) still smaller than the original filters. The experimental results demonstrate that the hybrid EDARF is necessary and efficient in enhancing the detectability of the algorithms, and the capacity of target tracking.

CONCLUSION

Herein, we point out the conventional clutter removal procedure may cause the misadjustment (reversal) problem of the relative energy distribution of the input noise and signal of interest, and present a novel adaptive Energy Distribution Adaptive Rectification Filter (EDARF) to improve this procedure. An improved framework using EDARF is proposed to detect dim small targets under complex backgrounds. The extensive experimental results have proved that the algorithms using the proposed EDARF obtain a significant improvement and achieve an efficiently better performance of target detectability. The results also indicate that the thinking of the relative energy distribution adaptive rectification could be a promising approach for improving the conventional background prediction filters when the moving target is weak and the undulant clutter background is strong.

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REFERENCES

[1] S.D. Blostein and Haydn S. Richardson,
A sequential detection approach to target tracking,
IEEE Trans. on Aerospace and Electronic Systems,

[2] Y.J. Shen, X. He and Z.H. Hao,
Design and analysis of real-time detection system for small
targets moving (in Chinese),

[3] Z.Z. Li, N.L. Dong and G. Jin,
Dim small target detection in strong undulant clutter background
based on adaptive filter,
IEEE International Conference on Communications,

[4] Reed, I.S. and Gagliardi, R.M.,
Optical moving target detection with 3-D matched filtering,

[5] Reed, I.S. and Gagliardi, R.M.,
A recursive moving target indication algorithm for optical
image sequence,

[6] Brain, Y.,
Dynamic programming solution for detection dim moving targets,

[7] Blostein, S.D. and Huang, T.S.,
Detecting small, moving objects in image sequences using
sequential hypothesis,

[8] Gavruitt, H., Le Cadre, J. and Jauffret, C.,
A formulation of multitarget tracking as an incomplete data problem,

[9] G.W. Pulford and B.F. La Scala,
MAP estimation of target manoeuvre sequence with the
expectation-maximisation algorithm,
IEEE Transactions on Aerospace and Electronic Systems,

Bayesian target tracking after group pattern distortion,

Fixed-interval retrodiction approach to bayesian imm-nht
for maneuvering multiple targets,
IEEE Trans. Aerospace and Electronic Systems,

[12] Peter Willeit, Ruixin Niu and Yaakov Bar-Shalom,
Integration of bayes detection with target tracking,
IEEE Trans. Signal Processing,

[13] Henry Leung and Alyssa Young,
Small target detection in clutter using recursive nonlinear prediction,
IEEE Trans. on Aerospace and Electronic Systems,

[14] Y.S. Moon and T.X. Zhang,
Detection of sea surface small target in infrared images based on
multilevel filter and minimum risk bayse test,
Int. J. of Pattern Recognition and Artificial Intelligence,

[15] Hilliard, C.T.,
Selection of a clutter rejection algorithm for real-time target
detection from an airborne platform,
Signal and Data Processing of Small Targets,
Orlando, FL, USA, 2000,
Vol. 4048, pp. 74-842.

[16] Tom, V.T., et al.,
Morphology-based algorithm for point target detection in
infrared backgrounds,
Signal and Data Processing of Small Targets,

[17] J.Y. Chen and I.S. Reed,
A detection algorithm for optical targets in clutter,
IEEE Trans. on Aerospace and Electronic Systems, 1987,
Vol. 23, No. 1, pp.46-59.

[18] J.T. Rickard and J.R. Zeidler,
Second order output statistics of the adaptive line enhancer,

[19] Tarun Soni, J.R. Zeidler and Walter H. Ku,
Performance evaluation of 2-d adaptive prediction filters for
detection of small objects in image data,

[20] Y. Hu, G. Hua, and Z.K. Shen,
Detecting dim point target in image data using adaptive
prediction filter,
IEEE Conference on Aerospace and Electronics,

[21] J. Cao, C. Wu and S. Zhou,
A method of infrared pixel target detection (in Chinese),

[22] Shawln, S. Tournode,
Detection on tracking of small targets in persistance,
Proceedings of SPIE Signal and Data Processing of
Small Targets, 1991, 1481: 221-228.

[23] J. Xu, J.Q. Zhang and C.H. Liang,
Prediction of the performance of an algorithm for the detection
of small targets in infrared images,
Infrared Physics & Technology,

Moving weak point target detection and estimation with
three-dimensional double directional filter in IR
cluttered background,
Intelligent Transportation Systems in Transitional and Developing Countries

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ABSTRACT

Intelligent Transportation Systems (ITS) are state-of-the-art approaches based on information, communication and satellite technologies in mitigating traffic congestion, enhancing safety, and improving quality of environment. ITS are being used in many industrialized and emerging economies for the last two decades to facilitate traffic mangers in tackling surface mobility problems. In the case of many developing countries, policy makers and practitioners have neglected this “non-conventional” approach on the pretext inter alia, “technological sophistication,” cost and institutional ill-preparedness. This aims to underscore the importance and relevance of ITS for developing countries as a complementary tool in the 21st century. In so doing, the intention is to bestow some fresh thinking into the transport debate that will serve as a catalyst for resolving mobility problems in developing countries still dwelling on conventional options.

INTRODUCTION

The efficient functioning of road networks is indispensable for the optimal economic gains and overall prosperity of any nation. This realization has enthused huge road construction projects around the world since the inception of the industrial era. The economic prosperity and affluence, however, caused rapid motorization resulting in the emergence of new predicaments like congestion, accidents, and chaos that subsequently triggered further network extension projects. This vicious cycle incurred overwhelming environmental and social cost and some pundits [1,2] have even questioned the appropriateness of this approach.

Analyses of the past 50 years of transport systems’ development indicates that adoption of radically new technology has been moderately slow even in the industrialized world [3]. In particular, policy making with respect to application of modern technologies like Intelligent Transport Systems (ITS) in developing countries has to face a

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Fig. 1. Vehicle ownership per capita income 1971-2002;
Source: [9]
host of uncertainties owing to the lack of knowledge about technological development, functionality, and acceptance of the envisaged systems and the impact of these systems [4, 5].

In the future, major changes in transport technology can be anticipated re the environmental and energy constraints. With this perspective, developing countries can no longer afford to remain indifferent to the technological changes in tackling the mobility problem in order to compete with highly mobile societies. A careful transition can enhance mobility, reduce uncertainty, and provide a more sustainable transport [6].

Albeit mitigating surface mobility problems of industrialised countries, the viability of ITS applications for developing countries has always been a contentious issue on the grounds of cost, fundamental infrastructural, and supportive instrumental setup. It seems a deliberate attempt to overlook modern technology when some of the strategic policy documents of developing countries [6] do not even mention the term “ITS.” This apathy has resulted in further investment on the conventional solutions of infrastructural expansion.

This is a continuation of an earlier study [7] highlighting the significance and relevance of ITS for developing countries through a review of deployment projects of various ITS applications in a number of emerging economies and developing countries. While appreciating the limitation of the conventional approach, this paper bestows some fresh thinking on the transport debate. Primary audiences are skeptic practitioners and policy makers who are still banking heavily on conventional solutions to the mobility problems of the 21st century. The intention is to help various stakeholders to

“... build more constructive relationships with new technologies, saving them from the naive belief in either the transformative myth of the “technical fix” or the destructive criticism that new technologies cannot be part of any solution.” [8].

DYNAMICS OF TRANSPORT PROBLEM AND LIMITATION OF THE CONVENTIONAL APPROACH

Changing economic scenarios has stimulated a tremendous increase in road traffic during the past few decades. Vehicle ownerships starts to grow quickly when countries reach income levels of about US $2500 per capita [9] in purchasing power parity (PPP) terms. See Figure 1. In 1950, the world had 70 million vehicles that increased by nine times (630 million) until 1994. Since 1970, it has been growing at the rate of 16 million vehicles per year. At this rate, it is estimated that the world’s motor vehicle volume can grow as high as one billion by 2025 [10]. In developing countries, the extraordinary vehicular increase is also coupled with long periods of under-investment in some modes and regions that has resulted in a fragile supply and poor economy.

An exhaustive number of studies have revealed that facilitating mobility through supplying additional infrastructure may not be the preferable option considering the social and environmental costs. Holand et al. [12] reports:

“it has become increasingly obvious that the economic, social, and environmental cost of highway construction programs can be unacceptably high.”

Downs [2] also recorded the limitation of the supply-side based on the principle of triple-convergence. It is argued that any large initial reduction of peak-hour travel times on a major limited-access roadway will soon be offset by the subsequent convergence on that roadway of drivers who formerly: 1) used alternative routes; 2) traveled at other times; or 3) used public transit (mode change). This limitation of the conventional approach coupled with the tremendous development in the field of information and communication technology resulted in the emergence of the Intelligent Transport Systems (ITS).

INTELLIGENT TRANSPORTATION SYSTEMS

State-of-the-art computer technology has undergone an incomprehensible transformation in last two decades and has a great impact on every aspect of our lives with transportation being no exception. Although the rudimentary scope, goals, and value of the transportation to communities have not changed significantly, the advancement in information, communication, and sensor technologies certainly has enhanced our capacity for maneuvering ever-increasing surface transportation menaces more comprehensively and “intelligently.” The intellectualization of the transportation infrastructure is deep rooted on the principles of System Engineering where building blocks are conjugated for the deliverance of optimal benefits. The amalgamation of information technology with the communication and sensor network is termed as telematics [13]. It is called Intelligent Transport Systems when combined with the individual entities that are related with the mobility such as physical infrastructure, vehicles, and controlling agencies. See Figure 2.

ITS includes a myriad of products and services such as inter-modal transportation systems, intelligent traffic control systems, in-vehicle technologies, safety enhancement technologies, traveler advisory systems, and so on. ITS provides technology that, at the same time, dealing with traffic congestion, improves road safety through intelligent traffic management. Internationally, ITS installations recorded between 15% and 60% reduction in accidents [14].

It applies a systems approach that intellectualizes existing transportation infrastructure to make movement of people and goods more efficient. It enables the precise analysis of wide-ranging scenarios in real-time that enhances the effectiveness of the overall transportation network. The dynamic data acquisition, processing, and dissemination help traffic managers prepare more flexible strategies in accordance with local needs besides preserving global
management also enhances the versatility of the system with constant upgradation of existing hardware.

**ITS TECHNOLOGY CLASSIFICATION**

The goal of ITS is to increase the safety and efficiency of transport systems by integrating various subsystems including traffic-control systems. Information technologies for sensing, communication, and control are the keys to successful integration. Technology classification in each of the above categories is shown in Figure 3. These technologies are assisting public and private agencies across the globe to meet increasing demands on the surface transportation system. These technologies are briefly described below.

**Sensors**

All systems require sensors for their primary data collection. The sensors are either road- or vehicle-mounted. The road-based sensor may be concealed in the pavement or placed on the roadside posts. Infrared beacons, Close Circuits Television (CCTV) and signpost represents the off-the-ground infrastructure while inductive loop detectors, magnetometers, and piezoelectric detectors represent the in-pavement category. The vehicle-mounted sensors include the Global Positioning System (GPS) and Radio Frequency Identification Devices (RFIDs) [15].

**Communications**

Data, voice, and video communications among various entities of the transportation network and traffic flows is a fundamental part of ITS. The three categories of data are transmitted from vehicle to road, vehicle to the central management and control unit, and even vehicle-to-vehicle. Communication technologies can be both wireless as well as wire line. The former encompasses technologies like Global System of Mobile communication (GSM), Enhanced Specialized Mobile Radio (ESMR), and Personal Communication Service (PCS), etc. While Wire line technologies include Fiber Distributed Data Interface (FDDI), Integrated Service Digital Network (ISDN), Ethernet Synchronized Optical Network (SONET), and Asynchronous Transfer Mode (ATM). These are the high-speed network communication technologies that also support voice and video [15].

**Information Technologies (IT)**

Information Technology applies modern technologies (hardware, software, telecommunications, database management) to the creation, management, and use of information. The growing role of the state-of-the-practice information systems and technologies in transportation as well as the development of IT industry in the later part of the 20th century has enhanced the potential of the transport professionals to tackle the mobility problem. IT has been the kernel of ITS and is composed of various soft technologies like web (Internet, intranets, and extranets), GIS, and CAD.
These soft technologies are complemented with the hard technologies as shown in Figure 3. For example, in the case of incident management and Electronic Toll Collection (ETC) technologies like CB radios, cellular instruments, mobile computing (PDA), VMS, and smart card are employed.

**ITS EXPERIENCE IN TRANSITIONAL AND DEVELOPING COUNTRIES**

Many developing countries have been pursuing intelligent transportation to manage traffic during the last decade. The primary object of ITS deployment has been to improve road safety conditions and mitigate traffic congestion particularly in large cities. Rapid diffusion of cellular telephones and expanding use of internet along with inflow of technological support from manufacturers and system integration companies of industrialized nations provided the essential infrastructure support.

The systems’ selection criterion has been the optimum rate of return on investment that resulted in more vigorous deployment of electronic toll collection and fare payment systems, commercial vehicle tracking systems, and bus management systems [16]. Some of the other commonly used applications are traffic signal systems, traffic surveillance using CCTV, and traveler information systems with variable message signs (VMS). In this section we provide a precis of some of the ITS projects in transitional and developing countries based on studies by the World Bank [16], and others [13].

**Common ITS Applications**

World Bank Reports [16] provide an overview of different categories of ITS applications’ deployment in three major developing regions including East Asia, Latin America, and Eastern Europe (See Table 1). Traffic information traffic management, commercial vehicle operations, and public transport management are most widely used applications in the selected regions. The applications can be regarded as a manipulated version of commonly known applications in the industrialized world such as Advanced Travel Information System (ATIS), Advanced Traffic Management System (ATMS), and Commercial Vehicle Operation (CVO).

Corresponding to the regional characteristics, traffic information services that employ multiple broadcasting and communications media have become common in East Asia. Road management systems have been introduced in Eastern Europe to improve the maintenance of physical infrastructure; and in Latin America, border crossing systems have been introduced to increase the economic strength of the region [16]. The following section elaborates an account of common applications and its effects in the three selected regions.

1) Traveler Information System.

Uncertainty regarding traffic conditions and traveling times is one of the major problems and also the reason for introducing the traveler information system. In selected regions, the system is based on a diverse mixture of new and conventional technologies regarding data collection and information dissemination. It ranges from radio, fixed line phone, to fax, email, and internet. For example, Bangkok uses some 200,000 registered listeners of JS100 radio station and aerial observation to provide near real-time traffic information to the road users [16]. In Eastern Europe, harsh climate can create hazardous driving scenarios and require a thorough monitoring of the road surface. The trunk road linking Bucharest and Brasso in Romania has a number of temperature sensors and relay data to the control center through the GSM network that can further warn drivers through variable message boards installed at key locations.

2) Traffic Management.

Traffic management systems ensure that the road network capacity is used to its maximum. It employs coordinated traffic signals, traffic surveillance systems using CCTV, and post incident non-recurrent traffic congestion utilizations.
mitigation. The kernel of the system is the Traffic Management Center (TMC) that gathers data from the sensors network and relays information to the users. Figure 4 shows such TMC in Santiago (Chile) [17], and Prague (Czech Republic) [16].

3) Commercial Vehicle Operation (CVO).
Government regulations for commercial vehicles like weight control, licensing, and permits cause delays and subsequently increase the cost of delivery of goods. CVO employs Automatic Vehicle Identification System (AVIS), Weigh-in-motion scales, and commercial vehicle tracking (using GPS, Global Positioning Systems) to reduce likely incidences of theft and crimes and ensure timely delivery of goods. A satellite-based truck tracking system in Mexico and Brazil is a good example of this concept. The system has been extended from Brazil to Argentina. Similar systems are also in operation in Chile. In Shanghai (China), onboard GPS equipment is used monitor the position of individual taxis to achieve optimum vehicle dispatch by efficiently responding to customer calls.

4) Public Transport Management System (PTMS).
The main objective of PTMS is to improve the efficiency and user-friendliness of the public transport service. It includes improved information regarding time tables, fares, and electronic ticketing. For example, an IC-based electronic ticketing service has been introduced in Malaysia. The card can be used on multiple modes of transport like buses and Light Rail Transit (LRT). In Eastern Europe, public transport systems such as subways, buses, and LRT are significantly well-developed and important nodes are monitored through CCTV for safety, security, and interconnectivity. In Latin America, public transport service is improved through networking of trunk and feeder routes and better bus management. Based on Columbian experience of using the combination of cellular phone and GPS, authorities in Santiago launched a bus management system with the name of Transsantiago (Figure 5) to provide better operation and management of the public transport and delivery of quality service through basic data like volume and speed to identify traffic problems.

Fig. 4. Traffic Management Centre, Source: [16, 17]

The Problem Areas
Hasty adoption of ITS applications in most of the cases has not delivered the envisaged benefits due to lack of significant essential planning and management. Local and national road authorities have faced a plethora of ITS offerings from industry. Some of these offerings are being imported may necessarily not be compatible with local conditions. On the other hand, locally manufactured offerings sometimes use dubious design practices that lead to a disappointing performance [13, 16]. A number of problems experienced by developing countries during the deployment of ITS that were mentioned in the Technical Report [16] and also observed by the authors are summarized below:

- **Non-availability of supportive instrumental framework** to effectively enforce the obligatory arrangements essential for the ITS benefit realization. For example, it is reported that in Manila (The Philippines), because of the breakdowns or theft, only five out of forty on-board units (for speed measurement) remained functional.

- **Unavailability of basic data** like volume and speed to identify traffic problems.
Fig. 5. Public Transport Management System in Santiago (Chile),
Source: [17]

- The adoption of imported applications often mismatch with the local technological and human resource capacity.

- The indifferent attitude of many professionals who were unaware of the potential of the application.

- Lack of trust from the users over the claimed benefits.

- The ITS deployment in several countries has not followed clear-cut policy guidelines that resulted in the ineffectiveness of many applications.

**DISCUSSION AND CONCLUSIONS**

Considering the important role of mobility in the economic growth and prosperity and the way technology has assisted both industrialized and emerging economies, laissez-faire approach to the mobility scenario is neither recommended nor a desirable option. The information and telecommunication revolutionary deployment in developing countries provides the necessary underpinning to their versatility and potential. Therefore, the argument of incompatibility based on the technological sophistication can be challenged. In respect to cost, today there is a wide range of ITS applications that employ “off-the-shelf” technology which is low cost and yields high returns.

The perception of “technology fix” is neither valid in developed countries nor can it be suggested for developing countries. Nonetheless present mobility problems coupled with the limitation of the conventional approach ascertains the need for state-of-the-art technology. The immense propagation of information technology in developing countries during the last decade has proved the leap-frogging potential of developing counties to adaptability to a dynamic scenario. This availability of information and communication technologies’ infrastructure provides a suitable launch pad for the smooth deployment and development of ITS in developing countries.

Real socio-economical, administrative, technological, and institutional ill preparedness is one of the main reasons for many recorded “failures” for this system in developing countries. Thus, in the existing setup any shock therapy or the big bang approach cannot deliver the desired objectives. Truly sustainable ITS deployment and orderly reaping of ITS benefits requires a systematic and gradual transition and phased implementation.

**REFERENCES**

[1] Z. Wolfgang,
End of the Road: the World Car Crises and How We Can Solve It.

[2] D. Anthoney,
Stuck in traffic: coping with peak hour traffic congestion.

[3] P. Moriarty and D. Honnery,
Forecasting world transport in the year 2050,
International Journal of Vehicle Design (IJVD),

[4] M.V. Geenhuizen and W. Thissen,
Uncertainty and Intelligent Transport Systems: implications for policy,

Strategic Niche Management for the Intelligent Transport Systems deployment and development in developing countries,

[6] Government Of Pakistan,
Draft Transport policy, Planning and Development Division, Islamabad, Pakistan (2000).

[7] S.A.A. Shah and Byung Ha Ahn,
Intelligent transportation system – Is it a compatible tool for developing countries?
Journal of Advanced Transportation (Fall 2006 issue).

[8] Hoogma, Remco,
Experimenting for Sustainable Transport: The approach of Strategic
Correspondence continued from inside front cover

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<td>437</td>
<td>204.5</td>
<td>46%</td>
<td>71%</td>
</tr>
<tr>
<td>6.9 - 14.1.45</td>
<td>1012</td>
<td>320</td>
<td>32%</td>
<td>80%</td>
</tr>
<tr>
<td>3.3 - 29.3.45</td>
<td>157</td>
<td>87.5</td>
<td>56%</td>
<td>95%</td>
</tr>
</tbody>
</table>

At the same time as these last England V-1 phases, Antwerp and Brussels in Belgium were attacked. The SCR-584 was used without proximity fuses and only a 40% destruction rate achieved. There were over 10,000 casualties in Antwerp (Imperial War Museum).

At Anzio, 80% of the aircraft shot down were credited to the SCR-584.

Victor J.G. Brown, (brown@iaa.ea)  
Calle Primavera 22 IOB-D, Granada 18008, Spain
The 25th DASC, with a conference theme of *Network Centric Environments: The Impact of Avionics on Systems*, was held in Portland, Oregon, October 15-19, 2006. DASC, which celebrated its 25th anniversary in 2006, is a joint conference sponsored by the IEEE Aerospace and Electronic Systems Society (AESS) and the American Institute of Aeronautics and Astronautics (AIAA) Digital Avionics Technical Committee (DATC). DASC is the premier aviation electronics conference that focuses on all related systems aspects relating to Air Traffic Management of commercial transport, military avionics, as well as military and commercial space systems. It brings together leading experts from around the world to report progress and exchange notes. The focus of the 2006 conference was the impact of *Network Centric Environments (NCE)* on aerospace/avionics operations, commercial and government agencies, and other users.

Preceded by two days of tutorials, the conference was divided into six (6) tracks with about 20 separate sessions. Major tutorial topics included: the network centric environment, air traffic management, systems engineering, communications/navigation/surveillance, avionics hardware/software design, and test. Continuing Education Units (CEUs) were again offered for these tutorials. There was also an aviation electronics exhibitors display where a special evening reception was held.
Paul Kostek, Boeing, was this year’s Conference General Chairman; Paul is also a past Chairman of AESS. Technical Co-chairs were John Moore, Rockwell Collins, co-chair for the 2005 general conference), and Bob Lyons, Jr. (Xcelsi Corp.). Professional Education Chair was Maarten de Haag, Ohio University. Two regulars, Glen Logan and Gerard Drewek handled Exhibits and managed Registration.

DASC 2007 Scheduled for Dallas, Texas

The 26\textsuperscript{th} DASC will be held in Dallas, Texas, October 21-25, 2007. The theme will be: 4-Dimensional Trajectory-Bases Operations: Impact on Future Avionics and Systems. Conference Chair will be John Gonda, The Mitre Corp. For more information on either the 2007 or 2006 DASC, go to: www.dasconline.org.

25\textsuperscript{th} Anniversary DASC Highlights

To begin the opening session, Chairman Paul Kostek welcomed attendees to the first DASC held in the Rose City and encouraged them and their wives to take advantage of local sightseeing and planned special events. In addition to Portland’s historical background, beginning with the Lewis and Clark Expeditions, there was the Mt. St. Helens Park; on the last day a special evening reception was held at the Evergreen Aviation Museum, home to Howard Hughes Spruce Goose and other vintage aircraft.

The Distinguished Institution Award was presented to the NASA Glenn Research Center accepted by Dr. Gary Seng Plenary speakers representing various organizations were then introduced and went on to describe how digital avionics and systems would be impacted by the Network Centric Environments.

Bob Pearce, FAA Joint Planning and Development Office (JPDO) began the initial Plenary session presentations by describing the Next Generation Air Transportation System (NGATS). He described how autonomous navigation systems, such as ADS-B and the NGATS will transform airways and airport ramp capacity to meet future travel needs. A MITRE study has indicated that controller workload will exceed capability by 2015. Some of this workload is due to increased use of small jets flying point-to-point. The Network Centric Environment (NCE) along with ADS-B are the keys to future systems. A spiral develop approach using these new concepts is planned for next year in the Gulf of Mexico. Aircraft will need a minimum level of avionics by the 2020-2025 time frame to implement these concepts.

Distinguished Institution Award is awarded to NASA-Glenn Research Center
Gary Seng (R) and Paul Kostek

Vanessa Fong, MITRE CAASD Advanced Avionics, next described the Information Needs in Flight Monitoring. NGATS security is introducing a concept that improves ground-based information on aircraft performance, such as flight trajectory, and onboard status monitoring. Automatic updates in response to interrogation could provide more complete situational awareness that goes well beyond what is required for air traffic management today. This information can be distributed among many system operators: e.g.; air carriers, air traffic and air security, and defense. The purpose of the study is not to recommend a specific set of messages and reports, but to consider the types of information that go beyond the current broadcast services. A hybrid of broadcast and contracted services may be a starting point for initial concepts, experiment, ATM, and air
security communities will have to work closely to identify and allocate the new information.

Ken Reid, Eurocontrol, described *Implementing NCE in Europe*. Air Traffic Management (ATM) in Europe is conducted by a myriad of diverse organizations including air and ground crews, handling agents, engineering support, fuel catering, and safety and security services. 100 major Eurocontrol airports are connected by 600 aerospace sectors controlled by 65 ATC centers operated by 37 organizations. As a result, communications, coordination, cooperation, and management is a demanding task. Interfacing is a challenge even when operations go as planned, so collaborative use of NCE information could substantially improve efficiency. Key initiatives underway include System-Wide Information Management (SWIM), ATM/CNS Target Architecture and Aeronautical Information Management (AIM).

Substantial progress has been made and an updated system could be delivered by 2020.

— Ron Schroer

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Special Luncheons

At the Awards Luncheon the *Advancement in Digital Avionics Best Paper Award for 2005* was presented to Andon Lazorov and Chavdar Ninchev from Bulgaria. Mr. Lazorov attended and accepted the award.

---

A. Lazorov (C) receives the *Lubkowski Best Paper Award for Advancement in Digital Avionics* flanked by Jim Rankin and Denise Ponchok

Tom Smith (L) receives *DASC Service Award* from Jim Dieudonne
Because this was the 25th Anniversary DASC, all past chairmen were given a special invitation to the conference as well as to the Awards Luncheon. Two pioneers and long time contributors, Cary Spitzer from the IEEE AESS and Tom Smith of the AIAA received special awards. They dug into their memory banks for anecdotes, some humorous, on how the conference evolved.

Jim Dieudonne also received a Distinguished Service Award for his years of dedication to the DASC.

To wrap things up there was rousing musical entertainment using well known melodies with DASC-appropriate new words.
Representatives from across the emerging NCE field were brought together in the Special Network-Centric Environment (NCE) Panel. Speakers included:

**Glen Logan**, moderator and speaker, *American Systems*

**Don Ward**, FAA, *System Wide Information Management (SWIM)*

**Faye Francy**, Boeing, *Phantom Works*

**Gordon Uchemich**, PE Objective *Interface Systems*

A question and answer session followed the formal presentations.

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DASC Attendees from the Portland Students Aerospace Organization (IEEE/AESS Student Chapter)
Space Systems Panel:
Our Effective Connection among Institutions, Industry, and University

PANEL AIM

The Space System Panel was established in 2001 [1]. Since the beginning it was conceived as an informal but effective means to ease the connection and strive to forward the convergence of people, institutions, industries, initiatives, and ideas in a key area for the benefit of every country: space and its wise exploitation through space systems.

“Informal” means that the Panel gathers the efforts of many people without imposing upon them. Panel meetings different from those needed to undertake properly their specific activities and without obliging them to attend AESS events (e.g., conferences) different from those where the results of their activities could be effectively reported. The latter approach has implied a spontaneous interest of many people in AESS events, publications, and societal benefits, resulting, for instance, in an interesting increase of paper submission to the AES Transactions (TAES) Space Systems area.

Panel activities have been carried out also thanks to the efforts of many people that, in the beginning, were not familiar with AESS or, even with IEEE at all. Some have joined AESS and more will join in the future. This is a very effective way to approach a Society: the person that decides to join after participating actively in the Society activities will be an effective and lasting member. As Space Systems needs time, patience, and (a lot of) enthusiasm to be successfully deployed, we need long-lasting and optimistic people to join AESS in the area of Space Systems!

In what follows the most recent activities of the Panel are highlighted.

PANEL ACTIVITIES

The main “effects” and results of Panel activities have been grouped into the five topics: Conferences, Publications, Awards, Projects, and Students.

Conferences

One means to disseminate space systems activities and to ease the connection among people is to create sessions, panels, and tracks in space-related AESS and non-AESS national and international events. The IEEE/AIAA Aerospace Conference is an ideal example. Since 2002, the Panel Chair is also co-chair of Track 2 Space Missions, Systems and Architecture of the IEEE/AIAA Aerospace Conference, that takes place in Big Sky, Montana, USA, every year at the beginning of March. The event involves an increasing number of European and, particularly, Italian experts, both in the proposal and organisation of sessions and as authors and presenters of multiple contributions. In this frame, in the 2007 edition, a new session in Track 2 was devoted to Global Earth Observation System of Systems (GEOSS), that represents an innovative key topic for the space systems community. Moving from the success of the session, a broader introduction of the GEOSS topic in the Conference is envisaged for the 2008 edition with 2 sessions in Track 2, 1 session in Track 13, a panel in Track 14, and, eventually, a dedicated plenary talk. Additional information can be found on the on-line Call for papers (www.aerocnf.org).

Publications

The convergence and dissemination of space systems topics can be effectively developed through publications. The contribution can be as author on both AESS Conference Proceedings and AESS publications (Systems Magazine and Transactions) in the Space Systems area. As Editor of Space Systems in the TAES and Systems Magazine, the Panel Chair has the opportunity to stimulate contributions in the area and to highlight to potential authors the effectiveness of the publication tool for disseminating innovative ideas and results to the international community.

Awards

Awards in the area of space systems represents another means to gather the industrial and scientific community around discoveries and innovations in the field. The delivery of Awards during AESS Conferences provides another opportunity of meeting and exchange.

In 2006, the Robert Profet Award for “. . . outstanding organizational leadership” was conceived; the award was
presented for the first time and launched during the 2007 IEEE/AIAA Aerospace Conference.

During the same conference, the Judith Resnik Award was awarded for “...key contributions in the area of satellite constellations.”

**Projects**

The development of successful proposals for research projects in the field of space systems (e.g., satellite navigation, Q/V and W payloads, NavCom systems, advanced satellite constellations, and related applications) allows us to collect industry and research centers for a common goal that is eased by the intra-panel relationships.

**Students**

Students (undergraduate, M.Sc., Ph.D.) are an important part of panel activities. The “Space Systems” topic can be the core of the students’ training and thesis activities, M.Sc. stage and project works as well as Ph.D. research activities and dissertation. Through the connection with industry and institutions, students’ activities can be properly framed for paving the way to their future careers.

A successful example from this point of view is the M.Sc. in Advanced Satellite and Communications Systems at the University of Roma Tor Vergata (Italy), whose 5th edition is in preparation (www.masterpazio.it). An M.Sc. student of the 3rd edition received a fellowship from AESS to develop student-related activities in Italy and Western Europe. This activity is on-going and is involving also GOLD members that are interested in space topics.

**SPECIAL EVENTS**

A recent event that has gathered the space industrial, academic, and institutional communities has been the signature on September 28, 2006 at Villa Mondragone (Monte Porzio Catone, Italy) of the Memorandum of Agreement (MoA) for the establishment of the Italian branch of the Danish Center for Teleinfrastruktur (CTIF), namely CTIF_Italy, at the University of Roma Tor Vergata (Italy). This important MoA derives from the strong cooperation between the above University and Aalborg University (Denmark). The signature has been framed in an Event on Convergence Italy-Denmark, whose technical topics focused on the Italian and Danish aerospace activities.

A section of the program is devoted to the AESS Italian Chapter and the deployment of the first Danish AESCh Chapter. Robert Rassa, Executive Vice President-AESS, and the Italian and Danish AESS Chapters Chairs (Prof. G. Galati and Prof. R. Prasad, respectively) participated in the opening.

Another special event was the 2006 Tyrrhenian International Workshop on Digital Communications (TIWDC), focused on Satellite Navigation and Communication Systems, held in Ponza, Italy, on September 2006. AESS has been technical co-sponsor of the event and a book edited by Springer is being published including the papers of both invited speakers and speakers selected from the open call. AESS people have been deeply involved in the organisation of the event (general co-chair, TPC chair, TPC members) and again a strong connection among industry, academia, and institutions developed around the “space systems” topic.

**INTER-ASSOCIATION ACTIVITIES**

The activities of the Panel have been deeply integrated with those of the AESS Operations Directorate for Italy-Western Europe that the Panel Chair is coordinating. In particular an effective relationship was established with Armed Forces Communications & Electronics Association (AFCEA). In December 2006, the Panel Chair nominated Vice-President of AFCEA_Roma Chapter. This new role will certainly contribute to connect more deeply AESS and AFCEA interests and mutual benefits.

An example of the above connection is the Aerospace Technologies for Dual Use organized by the AFCEA Rome Chapter in Rome (Italy) on May 2006, where many representatives of the military and civilian institutions, enterprises, and scientific bodies involved in the topic have participated. An audience of about 300 was reached. This event was the starting point for an international event on Aerospace Technologies and Applications for Dual Use, that AFCEA Rome Chapter, with the technical co-sponsorship of AESS, IEEE System Council, and International Federation for Information Processing (IFIP), is organising in Rome on September 12-14, 2007. For further information: (www.afcearoma.it) or (www.sistinatravel.it).

**ACKNOWLEDGEMENT**


**REFERENCE**

[1] M. Ruggieri and G. Galati,
The Space Systems Technical Panel,

— Marina Ruggieri
FROM THE EDITOR-IN-CHIEF

You Win! — With Your Society Providing the Means

These pages bring you a variety of interesting and thought-provoking articles that are easy to read and add to your knowledge about the areas we cover.

We bring you the news of your Society that crosses our desk and feel will be of interest—and maybe of use—to you. An example of one of our recent initiatives is well-illustrated by the article below concerning our Distinguished Tutorial Program.

Initiated last year by Saj Durrani, the program is wonderfully successful if the Binghamton Chapter report is an example. Note: the Chapters reach not only IEEE Chapter-wide, but the technical community and individuals that may never have heard of IEEE, let alone AESS.

This provides an excellent example of how to provide your local technical community with resources for training and information probably not available locally, to the improvement of community outreach and the growth of our society.

The current “centerfold” will be followed this fall by Tutorial IV—another in our on-going series; and our Distinguished Lecturer Series continues to be popular.

Please give us your feedback! Let us know how to further our technical value to you.

— Evelyn Hirt

The Binghamton Chapter

The AESS Chapter in Binghamton, New York, hosted an Avionics Workshop in Endicott, New York, May 11, 2007. The full-day distinguished tutorial, facilitated by Cary Spitzer, offered many interesting technical classes and in-depth discussions. CEUs were offered.

About 80 people from different companies throughout the area participated in the workshop. The workshop was held to target local employer technical education needs by exploring emerging digital avionics technologies and innovation. Some companies that took part are Lockheed Martin, BAE Systems, Rockwell Collins, On Target Technology, Binghamton Simulator, and Endicott Interconnect, among many others.

This event was a result of our Binghamton Section officers talking to companies locally about what technical support the IEEE section should offer. There is a large concentration of avionics companies in the Binghamton area and they want to bring IEEE quality training to their employees.

The workshop was led by world-class avionics expert and author Cary Spitzer. He focused his topics on the recent publication of the second edition of his Digital Avionics Handbook. Topics included: Avionics applications, Core organizations and documents, Defining avionics requirements, Avionics building blocks, Crew station design and automation, Avionics power systems, and Modern avionics architectures.

Cary did an outstanding tutorial for our section. We had a wonderful event and the response from attendees was positive. The information was directly relevant to our attendees, as many are avionics engineers with local aerospace companies. Cary’s knowledge, anecdotes, and presentations were top-notch. He responded substantively to an interactive audience.

Our section could not have held an event of this quality without the Distinguished Tutorial Program offered by AESS. The program is a valuable resource to all IEEE AESS chapters as we were able to revitalize our chapter and recruit new members.

— Vince Socci, IEEE SM
Binghamton Section Chair
Obituary

In Memoriam
Itzhack Bar-Itzhack

Itzhack Yoav Bar-Itzhack, (M'73, SM’84, F’95), Professor Emeritus of Aerospace Engineering at the Technion - Israel Institute of Technology, died 9 May 2007 in his hometown of Haifa, Israel.

Itzhack Bar-Itzhack was born on 18 August 1937 in Metula, Israel. He received his B.Sc. (EE) and M.Sc. (EE) degrees in 1961 and 1964, respectively, both from the Technion - Israel Institute of Technology. In 1968, he received the Ph.D. (EE) degree from the University of Pennsylvania. He joined the Technion’s Faculty of Aerospace Engineering as a Senior Lecturer in 1971, was promoted to Associate Professor in 1978, and achieved the rank of Professor in 1984. Prof. Bar-Itzhack held the Sophie and William Shamban Chair in Aeronautical Engineering until his retirement in 2006.

Prof. Bar-Itzhack was a prominent and world-renowned member of the navigation community. He made seminal contributions to the art of Inertial and Aided Navigation Systems, and was one of the pioneers of the theory of strapdown Inertial Navigation Systems (INS). His first contribution was in his 1968 PhD dissertation entitled Strapdown Inertial Navigation. In 1977, he published his seminal paper on the navigation computation in Strapdown INS, titled Navigation Computation in Terrestrial Strapdown Inertial Navigation Systems. In 1985, he and a colleague published a ground-breaking paper, titled The Enigma of
False Bias Detection in Strapdown INS during In-Flight Transfer Alignment, where they explained, for the first time, a phenomenon unique to Strapdown INS. In 1988, together with another colleague, he published the widely referenced paper Control Theoretic Approach to Inertial Navigation Systems, in which they formulated the INS error model in terms of modern control theory. This assisted newcomers to the field in quickly grasping the unique characteristics of INS. In 1992, together with his student, he published a paper that unified the common theory behind all INS error models. This enabled the straightforward development of new models represented by variables chosen by the user. Another outstanding contribution to the art of navigation was published in the 2000 paper A New Inertial Azimuth Finding Apparatus, where he and co-workers presented a novel apparatus which they named IAFA, for quick North finding. Around 1995, Prof. Bar-Itzhack turned the focus of his research interests to the spacecraft attitude determination area. He quickly became a distinguished member of a select group of international experts in this field. He published extensively in this area, often with NASA co-workers, covering problems of attitude and angular rate estimation from vector measurements, attitude determination from GPS measurements, and combined attitude and orbit determination. Professor Bar-Itzhack contributed to the theory of applied optimal filtering as well, by developing, with students, batch-recursive data compression filters and eigenfactor-based square root filters.

In addition to his academic achievements, Prof. Bar-Itzhack worked on issues related to particular industrial systems. Between 1968 and 1971, he was employed by Bellcomm Inc. in Washington, DC, where he worked on the Apollo project, analyzing the navigation system of the Lunar Roving Vehicle (LRV). In this capacity, among other activities, he wrote a computer program used during the Apollo 15 mission to determine where to realign the LRV navigation system Directional Gyro. In 1977-1978, during his sabbatical, he worked for the Analytic Sciences Corporation in Reading, Massachusetts, where he was involved in the Improved Accuracy Program of the Trident missiles guidance system.

Prof. Bar-Itzhack was active in the national and international professional communities. He was a member of the AIAA Guidance, Navigation, and Control Technical Committee, and an International Advisor of the Journal of Guidance, Control, and Dynamics. He served as President of the Israeli Association for Automatic Control (national member organization of IFAC). At the Technion - Israel Institute of Technology, Bar-Itzhack served as Dean of the Faculty of Aerospace Engineering, member of the Technion’s Board of Governors, and member of the Senate Steering Committee, among numerous other positions.

Prof. Bar-Itzhack graduated 33 doctoral and master’s students. He published over 80 papers in major archival journals and 140 papers in conference proceedings. He received numerous professional honors, including the IEEE Third Millennium Award “... in recognition and appreciation of valued services and outstanding contributions,” the IEEE Kershner Award, awarded to “... individuals who have made a substantial contribution to the technology of navigation and position equipment, systems or practices,” the NASA Exceptional Technology Achievement Medal, the NASA Goddard Space Flight Center Group Achievement Award for “... exceptional achievement in advanced attitude determination and sensor calibration technology,” and four National Research Council associateship awards at NASA’s Goddard Space Flight Center. Prof. Bar-Itzhack was a Fellow of the AIAA “... in recognition of professional distinction and valuable contributions made to the arts, sciences and technology of aeronautics and astronautics.” He was also a Fellow of the IEEE “... for contributions to the development of inertial navigation systems.” Prof. Bar-Itzhack was chosen by the IEEE Aerospace and Electronic Systems Society to serve as a member of the Distinguished Lecturers Program, with his talk The Evolution of Inertial Navigation.

Prof. Bar-Itzhack is survived by two sons: Daniel (41) and Ariel (36) of Haifa, Israel, and by 3 grandchildren: Roy (7), Itay (5), and Shira (5 months). His wife, Nehama, to whom he was married for 46 years, preceded him in death by 6 months.

— Yaakov Oshman
THE IEEE AND THE ION® ARE HOSTING PLANS TOGETHER

The IEEE and the ION® are pleased to announce they will equally sponsor and support the technical program and conference management of the PLANS 2008 conference. As part of the agreement, the PLANS 2008 conference will replace the ION's annual summer meeting. The ION's annual awards and Fellow awards, which are typically awarded during the ION's summer meeting, will be awarded during the course of PLANS 2008. We invite you to participate in the joint IEEE/ION® meeting with exciting new opportunities for technical exchange and networking.

ABSTRACT SUBMISSION

Please submit all abstracts via the PLANS website no later than November 1, 2007. There are two ways to submit an abstract:

1. Go to www.plansconference.org, and click on the abstract submission link;
2. E-mail abstracts to abstracts@ion.org as a Microsoft Word or text file. Be sure to include the paper title, the most appropriate session topic for the paper, a list of all authors and affiliations, and the primary contact author's complete mailing address, phone, fax and e-mail. Abstracts should be limited to 300 words and should describe objectives, results, conclusions and the significance of your work. Abstracts will be acknowledged electronically. Abstract title and corresponding primary author will be posted weekly on the PLANS website. If your name does not appear after two weeks, please call the Institute of Navigation National Office at (703) 383-9688.

EXHIBITS

Exhibit booths are still available. See PLANS website for floor plan.

AUTHOR NOTIFICATION

Authors will be notified of acceptance in December and sent an electronic author's kit with presentation and publication guidelines. Papers will be published in the public domain. Classified or ITAR restricted abstracts and papers will not be accepted.

All presenting authors will received an author discount on registration fees.

FINAL MANUSCRIPTS

Final manuscripts are due at the ION® National Office by April 18, 2008. Revised papers will not be accepted after May 12, 2008.
# Distinguished Lecturers Program

**Dr. James R. Huddle, Chair**

All AESS Chapters and IEEE Sections are encouraged to take advantage of the AESS Distinguished Lecturers Program for their regular or special meetings. We have selected an outstanding list of speakers who are experts in their fields. The AES Society will cover up to $1000 of the speaker's expenses for travel in North America, with any remaining amount normally covered by the AESS Chapter or Section or by the speaker's organization. For travel outside North America, the AES Society will cover half of the speaker's expenses per trip, up to a maximum of $2500. The procedure for obtaining a speaker is as follows: If a Chapter or Section has an interest in inviting one of the speakers, it should first contact the speaker directly in order to obtain his agreement to give the lecture on a particular date. After this is accomplished, and if the Chapter or Section wishes to request financial support from the AES, it should contact James R. Huddle on (818) 715-3264, F (818) 715-3976, j.huddle@ieee.org at least 30 days before the planned meeting, in order to obtain approval for the financial support. The list of distinguished speakers who have expressed their willingness to speak to Chapters or Sections, along with their organization, topics, and telephone numbers, is given below.

<table>
<thead>
<tr>
<th>Title</th>
<th>Name</th>
<th>Contact Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Control Technology Applied to Aircraft &amp; Automobiles</td>
<td>Dr. Kinio Kanai, National Defense Academy of Japan</td>
<td>81-48-812-1244 (V&amp;F)</td>
</tr>
<tr>
<td>Avionics for Manned Spacecraft</td>
<td>Dr. Myron Kayton, Kayton Engineering Co.</td>
<td>(310) 393-1819</td>
</tr>
<tr>
<td>Evolution of Aircraft Avionics</td>
<td></td>
<td>(310) 393-3261 F</td>
</tr>
<tr>
<td>Navigation: Land, Sea, Air and Space</td>
<td></td>
<td><a href="mailto:m.kayton@ieee.org">m.kayton@ieee.org</a></td>
</tr>
<tr>
<td>One Hundred Years of Inertial Navigation Practitioner's View of System Engineering</td>
<td></td>
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<tr>
<td>Bistatic &amp; Multistatic Radar Synthetic Aperture Radar</td>
<td>Dr. Hugh D. Griffiths, University College, London</td>
<td>+44-20-7679-7310</td>
</tr>
<tr>
<td>Current Advances in Radar Technology</td>
<td>Robert T. Hill, Consultant and Lecturer</td>
<td>+44-20-7388-7325 F</td>
</tr>
<tr>
<td>Future of Electronic Warfare and Modern Radar Signals</td>
<td>Dr. Richard G. Wiley, Research Associates of Syracuse</td>
<td>(410) 770-4535 (V&amp;F)</td>
</tr>
<tr>
<td>Global Navigation Satellite System</td>
<td>Dr. Surendra Pal, ISRO Satellite Center (India)</td>
<td>(315) 463-2266</td>
</tr>
<tr>
<td>Multisensor Data Fusion</td>
<td>Dr. Pramod Varshney, Syracuse University</td>
<td>(315) 443-2013</td>
</tr>
<tr>
<td>National Missile Defense and Early Warning Radars</td>
<td>Dr. Larry Chasteen, University of Texas at Dallas</td>
<td>(972) 234-3170; (972) 883-2799 <a href="mailto:chasteen@utdallas.edu">chasteen@utdallas.edu</a></td>
</tr>
<tr>
<td>Novel Orbits &amp; Satellite Constellations</td>
<td>Dr. Daniele Mortari, Texas A&amp;M University</td>
<td>(979) 845-0734</td>
</tr>
<tr>
<td>Radar — Past, Present and Future</td>
<td>Dr. Eli Brookner, Raytheon</td>
<td>(979) 845-6051 F</td>
</tr>
<tr>
<td>Satellite Communication Systems</td>
<td>Dr. S.H. Durrani, Consulting Engineer</td>
<td>(301) 774-4607 (V&amp;F)</td>
</tr>
<tr>
<td>System Engineering for International Development for the 21st Century</td>
<td>Paul Gartz, Boeing Co.</td>
<td>(206) 954-9616</td>
</tr>
<tr>
<td>Target Tracking and Data Fusion: How to Get the Most Out of Your Sensors</td>
<td>Dr. Yaakov Bar-Shalom, Univ. of Connecticut</td>
<td>(860) 486-4823</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(860) 486-2285 F</td>
</tr>
</tbody>
</table>

All data on this page is under the purview of James Howard, VP-Member Affairs. Please send all corrections and omissions to him at the address on the inside back cover.
Distinguished Tutorials Program

The Distinguished Tutorials Program (DTP) was established in 2006. Many sections have expressed interest and some are currently in touch with Distinguished Instructors (DIs) to schedule a tutorial.

The Distinguished Tutorials Program allows a Section or an AESS Chapter to invite a Distinguished Instructor to give a tutorial at no cost to the hosts. The AESS picks up the travel cost and pays an honorarium. This allows members to benefit from tutorials, normally presented at major conferences that are not available locally, at a date convenient for the hosts.

The Program was approved by the AESS Board of Governors in 2006 and budgeted. Due to the better-than-expected response, funds are available for three or more Tutorials in 2007. Tutorials are as listed. Interested parties should contact the Instructor directly.

Radar Systems Performance Modeling
G. Richard Curry, Consultant
dickcurry@cox.net

Automated Testing
Michael Ellis, Northrop Grumman Corporation,
mteillis@aol.com

GPS and Inertial Data Processing
James Farrell, VIGIL, Inc.,
navaide@comcast.net

Systems Approach to Engineering Projects
Paul Gartz, Boeing Corporation,
p.gartz@ieee.org

Design and Use of Small Satellites in Education
Albert Helfrick, Embry Riddle Aeronautical University,
helfrica@erau.edu

Advances in Radar Technology
Robert Hill, Consultant,
janebobhill@msn.net

Navigation – Land, Air and Space
Myron Kayton, Consulting Engineer,
m.kayton@ieee.org

Space-Time Adaptive Processing for Surveillance Radar System
Michael L. Picciolo, SAIC,
Michael.L.Picciolo@saic.com
and
J. Scott Goldstein
s.goldstein@ieee.org

Digital Avionics
Cary Spitzer, Consultant,
c.spitzer@avionicon.com

Radar Reflectivity
Robert Trebits, Georgia Tech,
bob.trebits@gmail.com
IEEE AEROSPACE & ELECTRONIC SYSTEMS SOCIETY ORGANIZATION

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