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Permanent Link to Innovation: The Distress Alerting Satellite System
2021/06/23
Taking the Search out of Search and Rescue By David W. Affens, Roy Dreibelbis, James E. Mentall, and George Theodorakos In 1997, a Canadian government study determined that an improved search and rescue system would be one based on medium-Earth orbit satellites, which can provide full global coverage, can determine beacon location, and would need fewer ground stations. This month’s column examines the architecture of the GPS-based Distress Alerting Satellite System and takes a look at early test results. INNOVATION INSIGHTS by Richard Langley IT IS NOT COMMONLY KNOWN that the GPS satellites carry more than just navigation payloads. Beginning with the launch of the sixth Block I satellite in 1980, GPS satellites have carried sensors for the detection of nuclear weapons detonations to help monitor compliance with the Non-Proliferation Treaty. The payload is known as the Nuclear Detonation (NUDET) Detection System (NDS) and is jointly supported by the U.S. Air Force and the Department of Energy. And now a third task is being assigned to the GPS satellites — that of search and rescue. Since the mid-1980s, a combination of low Earth orbit (LEO) and geostationary orbit (GEO) satellites have been used to detect and locate radio beacons activated by mariners, aviators, and others in distress virtually anywhere in the world and at any time. Some 28,000 lives have been saved worldwide since the search and rescue satellite-aided tracking, or SARSAT, system was implemented. But the current system has some drawbacks. LEO satellites can determine a beacon’s position using the Doppler effect but their field-of-view is limited and one of them may not be in range when a beacon is activated. Furthermore, a large number of ground stations is needed to relay data from these satellites to search and rescue authorities. GEO satellites, on the other hand, have a large field of view (although missing parts of the Arctic and Antarctic), but they cannot position a beacon unless its signal contains location information provided by an integral satellite navigation receiver. In 1997, a Canadian government study determined that a better SARSAT system would be one based on medium Earth orbit (MEO) satellites. A MEO system can provide full global coverage, determine beacon location, and do this with fewer ground stations. GPS was identified as the ideal MEO constellation. And so was born the Distress Alerting Satellite System (DASS) that will

become fully operational on Block III satellites. But already nine GPS satellites are hosting prototype hardware that is being used for proof-of-concept testing. In this month's column, we examine the architecture of DASS (including its relationship with the NDS), and take a look at some of the very positive test results already obtained — results that support the claim that DASS will take the search out of search and rescue. NASA, which pioneered the technology used for the satellite-aided search and rescue capability that has saved thousands of lives worldwide since its inception nearly three decades ago, has developed new technology that will more quickly identify the locations of people in distress and reduce the risk to rescuers. The Search and Rescue (SAR) Mission Office at the NASA Goddard Space Flight Center, in collaboration with several government agencies, has developed a next-generation satellite-aided search and rescue system, called the Distress Alerting Satellite System (DASS). NASA, the National Oceanic and Atmospheric Administration (NOAA), the U.S. Air Force, the U.S. Coast Guard, and other agencies are now completing the development and testing of the new system and expect to make it operational in the coming years after a complete constellation of DASS-equipped satellites is launched. When completed, DASS will be able to almost instantaneously detect and locate distress signals generated by emergency beacons installed on aircraft and maritime vessels or carried by individuals, greatly enhancing the international community's ability to rescue people in distress, This improved capability is made possible because the satellite-based instruments used to relay the emergency signals will be installed on the GPS satellites. A recent satellite-aided rescue started on June 10, 2010, when 16-year-old Abby Sunderland on her 40-foot (12.2-meter) sailboat "Wild Eyes" encountered heavy seas approximately 2,000 miles (3,200 kilometers) west of Australia in the Indian Ocean. Her sailboat was dismasted and an emergency situation resulted. Ms. Sunderland activated her two emergency beacons whose signals were picked up by orbiting satellites. Using coordinates derived from the signals, a search plane spotted Ms. Sunderland the next day, and a day later she was rescued by a fishing boat directed to the scene. This highly publicized event is one of thousands of successful rescues made possible by years of NASA research and development. Background The beginnings of satellite-aided search and rescue date back to 1970, when a plane carrying two U.S congressmen crashed in a remote region of Alaska. A massive search and rescue effort was mounted, but to this day, no trace of them or their aircraft has ever been found. At the time, search for missing aircraft was conducted by search aircraft flying over thousands of square kilometers hoping to sight the missing aircraft. As a result of this tragedy, Congress recognized this inefficient search method and passed an amendment to the Occupational Safety and Health Act of 1970 requiring most aircraft flying in the United States to carry emergency locator beacons (ELTs) to provide a local homing capability. NASA then developed the technology to detect and locate an ELT from ground stations using the beacon signal relayed by satellites to provide more global coverage. This concept evolved into a highly successful international search and rescue system called COSPAS-SARSAT (COSPAS is an acronym for the Russian words "Cosmicheskaya Sistema Poiska Avariynyh Sudov," which translates to "Space System for the Search of Vessels in Distress;" SARSAT is an acronym for Search and Rescue Satellite-Aided Tracking). Established by Canada, France, the United States, and the former Soviet Union in 1979, the system has 43 participating countries and has been instrumental in saving more than 28,000 lives worldwide, including 6,400 in the U.S. — all as a result of NASA's innovations. Since this auspicious beginning, NASA has continued to perform SAR research and development as a member of the National Search and Rescue Committee, and supports the National Search and Rescue Plan through an interagency memorandum of understanding with the Coast Guard, the Air Force, and NOAA. NOAA is responsible for operation of the U.S. portion of current COSPAS-SARSAT system that relies on SAR payloads on weather satellites in low-earth and geostationary orbits. As shown in Figure 1, the satellites relay distress signals from emergency beacons to a network of ground stations and ultimately to the U.S. Mission Control Center (USMCC) operated by NOAA. The USMCC distributes the alerts to the appropriate search and rescue authorities: the U.S. Air Force or the Coast Guard. The Air Force coordinates search and rescue for the mainland U.S. SAR region and operates the Air Force Rescue Coordination Center. The Coast Guard performs maritime search and rescue and oversees the U.S. national SAR policy. FIGURE 1. Overall concept of search and rescue system. (Image: Cospas-Sarsat) Beacons Three types of distress emergency locator beacons are in use that are compatible with the COSPAS-SARSAT system: EPIRBs (emergency position-indicating radio beacons) designed for maritime use. ELTs (emergency locator transmitters) for use on aircraft. PLBs (personal locator beacons) for personal use. These can be used by persons engaged in high-risk activities such as mountain climbing and backcountry skiing. Originally, emergency locator beacons transmitted an analog signal on two frequencies: 121.5 MHz and 243 MHz in the civil and military aeronautical communications bands, respectively, so that they would be audible over aircraft radios. Later, a signal that was encoded with a digital message and transmitted at 406 MHz was added. Since February 1, 2009, only the 406-MHz-encoded signals are relayed by satellites supporting the international COSPAS-SARSAT system. Therefore, older beacons that only transmit the 121.5/243-MHz signals are now only detectable by ground-based receivers and aircraft overflying a crash site. The 406-MHz beacons transmit an approximately half-second message, or burst, approximately every 50 seconds, beginning 50 seconds after being activated. The actual time of burst transmission is dithered in time so that no two beacons will have all of their bursts coincident. A 406-MHz beacon may also have an integral global navigation satellite system (GNSS) receiver. Such a beacon uses the GNSS receiver to attempt to determine its location for inclusion in the transmitted digital message. In this way, the beacon will be located once it is detected by a low-Earth-orbit (LEO) or geostationary orbit (GEO) satellite. Distress messages contain information such as: The beacon's country of origin. A unique 15-digit hexadecimal beacon ID. Location, when equipped with an integrated GNSS receiver. Whether or not the beacon contains a 121.5-MHz homing signal. Room for Improvement SARSAT first became operational in the mid-1980s. The current system uses instruments placed on LEO and GEO weather satellites to detect and locate mariners, aviators, and recreational enthusiasts in distress almost anywhere in the world at anytime and in almost any condition. Previously, dedicated Russian LEO satellites were also implemented but the use of these satellites was discontinued in 2007. Although it has proven its effectiveness, as evidenced by the number of persons rescued over the system's lifetime, the current capability does have limitations. LEO spacecraft orbit the Earth 14 times a day and use the Doppler effect with satellite orbital ephemeris data to calculate the position of a beacon. However, a satellite may not be in a position to pick up a distress signal the moment a user activates the beacon. Time is critical in responding to an emergency situation. Unfortunately, delays of two hours or longer are possible, especially near the equator. LEO spacecraft carry two instruments: a Search and Rescue Repeater (SARR) supplied by the Canadian Department of National Defence, and a Search and Rescue Processor (SARP) provided by the French Centre National d'Etudes Spatiales (CNES). The SARR is a pure repeater, which relays the beacon signal to a local ground station where the data is analyzed to obtain a location. The SARP processes the received beacon signal by measuring the Doppler shift as a function of time, and decoding the digital message included in the 406-MHz signal. This information is stored until it can be transmitted to a ground station using the SARR's downlink transmitter. Under most conditions beacon locations can be determined to within a radius of 5 kilometers. Geostationary weather satellites, on the other hand, orbit above the Earth in a fixed location over the equator. Although they do provide continuous visibility of much of the Earth, they cannot independently locate a beacon unless it contains a GNSS receiver that determines its position and includes it in the beacon's digital message. Currently, not all beacons contain integral GNSS receivers. Furthermore, even if a beacon contains a GNSS receiver, the navigation signal may be obstructed by terrain or thick foliage. The next-generation system, DASS, overcomes these limitations and will improve accuracy and response time to provide an even more capable life-saving system. Distress Alerting Satellite System A 1997 Canadian government study of possible alternative satellite systems for SARSAT, including commercial sources, determined that the ideal system is based on medium Earth orbit (MEO) satellites. A MEO system will be able to provide superior global detection and location data with fewer ground stations than the existing COSPAS-SARSAT system. The GPS constellation was identified as an ideal MEO platform. The concept of the DASS system is straightforward. Three or more antennas track different GPS satellites equipped with search and rescue repeaters that receive the distress signal and retransmit the signal to the ground. Since each satellite is in a different orbit, each received signal has a different Doppler-shifted arrival frequency and time of arrival. Knowing the position and orbit of each satellite, it is possible to determine the position of the distress beacon. Future improvement in location accuracy is made possible by one of the strengths of the DASS space segment. That is, the DASS location algorithm optimizes location accuracy utilizing time and frequency measurements of beacon signals that were not designed for that purpose. The DASS space segment allows for the beacon signal to be modified in the future, enhancing the performance of this type of location process. Other advantages of DASS over the existing system are fairly obvious. Reception of the emergency signal is immediate. Locations can be determined after receiving a single beacon burst since it does not rely on measuring the Doppler shift over time to determine position, as in the current LEO system. A full constellation of DASS-equipped GPS satellites in orbit will ensure that four or more satellites are in view of the transmitting emergency beacon anywhere in the world while requiring fewer ground stations. Another key strength of the DASS system is the promise of SARSAT transponders on each satellite in the large and well-managed GPS constellation. There are at least 24 GPS active satellites in orbit at any given time (currently, 31 are active). When the GPS constellation is fully populated by satellites with DASS transponders, it will provide global coverage for satellite-supported search and rescue and provide capabilities for rapid detection and location of distress beacons. Efforts are ongoing to integrate a satellite beacon repeater instrument, to be provided by the Canadian government, onto the GPS Block III B and C satellites to provide the DASS space segment for operational use. DASS Development DASS development will proceed in phases referred to as the definition and development, proof of concept, demonstration and evaluation, initial operating capability, and final operating capability. The proof of concept (POC) phase was completed in January 2009. The POC testing and results are summarized in this article. At the time of this writing, preparations are ongoing to initiate the demonstration and evaluation phase. Definition and Development. In 2000, as part of the definition and development phase, the NASA GSFC SAR Mission Office began discussions with the Department of Energy's Sandia National Laboratories (SNL) to determine if it would be feasible to add a SAR repeater function to a Department of Energy (DOE) instrument on GPS satellites. Sandia representatives thought it possible, and NASA agreed to fund a study to determine if, with minor modification, one could include a search and rescue repeater function to their instrument. The SNL feasibility study concluded that the GPS DOE package could, with minor modifications, perform the SAR mission. The study also determined that accurate locations could be calculated after a single beacon transmission and improved with each subsequent beacon transmission. Based on this information, NASA, with the cooperation of the U.S. Air Force Space Command and SNL, proceeded with the development of the new space-based search and rescue system, which was named the Distress Alerting Satellite System. Proof of Concept. In 2003, a memorandum of agreement (MOA) between NASA, NOAA, the Air Force, the Coast Guard, and the Department of Energy tasked NASA to perform a POC program for DASS. The MOA included the development of a POC space segment and a prototype ground station to perform post-launch checkout, performance testing, and implementation planning of an operational DASS system. It stressed the need for DASS, gave authority to each participating agency to participate in the POC demonstration, and defined the roles of each. The Air Force Space Command approved the addition of modified equipment on GPS satellites. The DASS POC space segment operates as a subcomponent of GPS Block IIR and IIF satellites. Nine GPS Block IIR satellites carry experimental DASS payloads, and all 12 IIF satellites are scheduled to. Therefore, the final POC space segment will consist of 21 DASS-equipped GPS satellites. Each payload receives 406-MHz SAR signals on an extant GPS UHF antenna and relays the signals at a GPS S-band frequency on a second extant antenna. It is important to note that the performance of the DASS POC space segment will be exceeded by the performance of the operational space segment being designed specifically for DASS and planned for launch on GPS Block III satellites. A prototype DASS ground station (Figure 2) was funded by NASA and installed at GSFC. The DASS prototype ground system consists of four antennas, four receivers, and the workstations and servers necessary to process the received data, command and control the operation of the ground station, and display and analyze the results. The antennas are located on the corners of the roof of a building connected by fiber-optic cable to signal processing equipment located in another building two kilometers away. FIGURE 2. Prototype ground station at NASA GSFC. (Images: NASA) Proof of Concept Testing The overall objectives of the POC tests were to demonstrate the effectiveness of the DASS concept and to define its technical and operational characteristics. The primary technical objective was to demonstrate the system’s ability to detect and locate 406-MHz emergency beacons under various controlled conditions. This is the most important measure of the system’s ability to perform as expected. The specific objectives of the DASS POC demonstration were to Confirm the expected performance of the DASS concept. Determine if new or enhanced requirements needed to be established. Define preliminary performance levels that will be used to establish the scope and content of the next phase of development, referred to as the demonstration and evaluation phase. Therefore, during POC testing, performance measurements were taken for the probability of detection, probability of location, and location accuracy, defined as follows. Probability of detection is the probability of detecting the transmission of a 406-MHz beacon and recovering a valid beacon message from any available satellite. Probability of location is the probability of obtaining a location solution within a given time after beacon activation, independently of any encoded position data in the 406-MHz beacon message. Location accuracy is the distance from the location solution obtained within 5 minutes after beacon activation, to the actual beacon location. The required performance is specified as the probability that a given solution is within a given distance of the actual location. It is important to note that the predicted performance of DASS assumes a full constellation of DASS-equipped GPS satellites. In fact, one of the key strengths of DASS is the promise of DASS transponders on each satellite in the GPS constellation. When a full constellation is equipped with DASS transponders, there will typically be between seven and 13 GPS satellites visible at the NASA ground station. Thus, it will be possible to schedule the ground-station antennas to receive data from the best satellites in terms of geometry, signal strength, processing capability, and other factors. However, at the time of the POC testing, there were only eight GPS satellites equipped with DASS transponders. A maximum of three DASS-equipped GPS satellites were visible at the same time at the NASA ground station (above a 15-degree elevation angle), and there were times when only one DASS-equipped GPS satellite was visible. Thus, it was impossible to optimize satellite selection since there was never an opportunity to select from an excess of satellites that a full constellation would provide. In particular, satellite geometry and its effect on performance is never as optimal as what would be obtained from a full constellation of GPS satellites. To predict the results of a full constellation using the results from a severely reduced constellation, a calculation based on “dilution of precision” was used. Dilution of precision (DOP) or geometric dilution of precision, to be specific, is used to describe the geometric strength of satellite configuration on GPS accuracy. When visible satellites are close together in the sky, the geometry is said to be weak and the DOP value is high; when far apart, the geometry is strong and the DOP value is low. Thus a low DOP value gives rise to a better GPS positional accuracy due to the wider angular separation between the satellites used to calculate a beacon’s position. Location accuracy results can be scaled to reflect the true DOP that would be obtained by a satellite constellation of 24 GPS satellites. The DOP error caused by uncertainty in time and frequency measurements is used for scaling. The DOP of the satellites actually used to calculate a location solution, denoted by ftDOPACT, is always bigger than the DOP that would have been available from a constellation of 24 GPS satellites, ftDOP24. The raw location errors need to be multiplied by the ratio ftDOP24 / ftDOPACT to reflect the results that would have been obtained if all 24 satellites were present. The raw average location error, erravg, is given by the following: err(b) = err(lat(b),lon(b))= distance from the known location to (lat(b),lon(b)) erravg(b0) = err(latavg(b0),lonavg(b0)) where Ω(b0) is the set of seven or fewer consecutive burst locations within 5 minutes, starting with burst b0. The scaled location error is the location error scaled by the DOP ratio: Since DOP changes little over 5 minutes, the error of the average is approximately where ftDOPACT(b) is the time-frequency DOP of burst b calculated with either three or four satellite geometries depending on the number of measurements used in the location calculation. Test Source A custom-designed beacon simulator was used to generate the transmissions of multiple COSPAS-SARSAT 406-MHz beacons over an extended period of time. To represent expected operational realism in the tests, the beacon simulator was used to transmit beacons at the limits of the five major beacon parameters specified by COSPAS-SARSAT as well as the nominal values. The five major beacon parameters are transmit power, modulation index, bit rate, un-modulated carrier duration, and modulation rise and fall times (see TABLE 1). Table 1. Cospas-Sarsat beacon specifications. (Data: Cospas-Sarsat) During POC testing, five beacons were transmitted using three scenarios: maximum beacon parameter values, minimum beacon parameter values, and variable power. The parameter values changed in each test scenario and are highlighted in TABLE 2. Beacon detection and location performance is measured for periods when there are three or more satellites visible at the same time, and for durations sufficient to collect a statistically significant amount of data. Table 2. Beacon parameter values for each test scenario. (Data: Authors) Two characteristics of the test source that affect system performance are the beacon antenna pattern and ground mask. To simulate beacons, the beacon simulator has a monopole antenna with the gain pattern shown in Figure 3. There is a substantial reduction in the transmitted signal at high-elevation angles (above 60°). DASS-equipped GPS satellites are often at high-elevation angles during a typical day. As expected, the effect of the pattern on test results can clearly be seen upon close inspection of the data. However, the beacon antenna pattern is an unavoidable reality and is, therefore, fully represented in the data used to generate the results presented here. Additionally, there were significant ground obstructions of the beacon signal in certain directions. The effect of beacon antenna pattern is fully included in the results presented in this article, but ground mask is taken into account by limiting satellite visibility to an elevation cut-off angle of 15 degrees. FIGURE 3. Beacon simulator transmit antenna gain pattern. POC Test Results In this section, we discuss the POC test results in terms of probability of detection, probability of location, and location accuracy. Probability of Detection. As previously mentioned, probability of detection is the probability of detecting the transmission of a 406-MHz beacon and recovering a valid beacon message from any available satellite. The requirement is that 95 percent of individual transmitted messages are detected. Test results are given in TABLE 3 and show that the probability of detection is approximately 99 percent for all scenarios, even though only three satellites were in view at a time. Obviously, the probability of detection is dependent on the number of available satellites and performance would improve with continuous coverage by four or more satellites. Table 3. Probability of detection test results. (Data: Authors) Probability of Location. Again, the probability of location is the probability of obtaining a location solution within a given time after beacon activation, independently of any encoded position data in the 406-MHz beacon message. The requirement is that the probability of calculating a beacon location is 98 percent within 5 minutes. Since the probability of location is dependent on the number of visible satellites, our performance was limited by the reduced constellation of DASS-equipped satellites. Results from periods of three-satellite coverage were 85 percent within 5 minutes, 92 percent within 10 minutes, and 94 percent within 15 minutes. Again, the probability of location is dependent on the number of visible satellites, and performance would improve with continuous coverage by four or more satellites. To investigate the possible improvement with enhanced satellite coverage, we reduced the minimum satellite elevation angle from 15 to 10 degrees. This allowed a fourth satellite to become visible for a limited time at very low elevation angles. Even though the signal quality from such a satellite was poor, the probability of location during this period of four-satellite coverage improved as follows: 91 percent within 5 minutes, 96 percent within 10 minutes, and 97 percent within 15 minutes. As can be seen from these results, even adding a satellite with a very low elevation-angle pass significantly improves performance. The expectation is that having a full constellation of satellites available would improve performance even more. Furthermore, the increase in satellite performance expected in the operational system will also improve probabilities of detection and location. Location Accuracy. Recall that location accuracy is measured as the percentage of location solutions obtained within five minutes after beacon activation that are within five kilometers of the actual beacon location. The requirement is to obtain 95 percent of the locations to within 5 kilometers of the actual location and 98 percent within 10 kilometers within five minutes after beacon activation. As mentioned earlier, the requirements included in the performance specification assume a constellation of 24 DASS-equipped GPS satellites. POC testing was done with a system that had only eight DASS-equipped GPS satellites available. However, location errors can be scaled to reflect what the DOP would be if the satellite constellation contained all 24 GPS satellites. Therefore, it is the scaled results that can be used to determine whether performance will meet the requirement. TABLE 4, therefore, presents the location accuracy results as measured, and after being scaled by DOP. Table 4. Location accuracy for 5-minute periods. (Data: Authors) Another important performance metric for DASS is location accuracy obtained after a single beacon burst is received. Even though there is not currently a requirement for single burst location accuracy, it is a very desirable feature of DASS since an emergency situation does not guarantee that more than a single burst will be received. Single burst location accuracy was, therefore, measured with the results shown in TABLE 5. Once again, the results are scaled by DOP values to remove the effect of non-optimal satellite geometry. Table 5. Single burst location accuracy. (Data: Authors) More insight into this performance can be gained by examining the single burst location accuracy distribution as a function of distance error, as shown in TABLE 6. It can be seen that, for these beacons, computed locations are within 9 kilometers of the actual location 95 percent of the time. Again, the expectation is that having a full constellation of satellites available would improve this performance. For instance, having more satellites to choose from might allow the system to select data from satellites with stronger or less noisy links. Table 6. Single burst location accuracy by distance error.

(Data authors) Conclusion The promise of search and rescue instruments on each satellite in the large and well-managed GPS constellation will provide a significant advancement in the capabilities of the already highly successful COSPAS-SARSAT system. The new system will provide global coverage for satellite-supported search and rescue and provide capabilities for rapid detection and location of distress beacons while requiring fewer ground stations. The DASS POC system has validated, by test, the predictions made by analysis during the definition and development phase. The DASS POC testing has demonstrated reliable detection and accurate location of beacons within five minutes of activation. Accurate locations are also produced after even a single burst of a newly activated beacon, which is a desirable feature of DASS, since an emergency situation does not guarantee that more than a single burst will be received. The performance obtained using a reduced constellation of satellites equipped with a modified, existing instrument not only demonstrates the existing capability, but also confirms the improvements to come with the operational system. In fact, the success of DASS is being emulated by the European Union in the design of their future Galileo GNSS constellation and the Russians in an upgraded GLONASS GNSS constellation, all of which will be interoperable by international agreement. DASS will contribute to NASA’s goal of taking the search out of search and rescue. Achieving this goal will not only improve the chances of rescuing people in distress quickly, which is critical to their survival; it will also reduce the risk to rescuers who often put themselves in dangerous situations to affect a rescue. That is why the motto of the Search and Rescue Office is “Saving more lives, reducing risks to search personnel, and saving resources.” David W. Affens is the manager of the NASA Search and Rescue (SAR) Mission Office at the Goddard Space Flight Center (GSFC) in Greenbelt, Maryland, where he began working in 1990. He holds a degree in electronic engineering. Before joining NASA, he worked in various aspects of submarine warfare and intelligence gathering for the U.S. Navy over a span of 21 years.   Roy Dreibelbis is a consultant who has worked in rescue-related jobs since 1957, including helicopter rescue missions in Vietnam. As an officer in the U.S. Air Force, he was the director of Inland SAR at rescue headquarters for the coterminous 48 states, was commander of the 33rd Air Rescue Squadron, and served as deputy chief of staff for rescue operations at rescue headquarters from 1979 until 1981. Upon retirement from the Air Force, he was employed by the State of Louisiana as flight operations director and chief pilot. In 1987, he accepted employment with contractors in the District of Columbia area that supported NASA and NOAA SARSAT activities.   James E. Mentall is the NASA/GSFC Search and Rescue Instrument Manager. He has a Ph.D. in physics and has spent more than 42 years of his professional life at GSFC. For 15 of those years, he has been responsible for the integration and test of the Search and Rescue Repeater and the Search and Rescue Processor on the NOAA Polar-orbiting Operational Weather Satellites. He has also served as the deputy mission manager for the Search and Rescue Mission Office and played a significant role in the procurement of the DASS antenna system and ground station.   George Theodorakos is the chief staff engineer for MEI Technologies, Inc. He received his B.S. summa cum laude and M.S. degrees in electrical engineering from the University of Maryland, College Park, Maryland, in 1978 and 1987, respectively. Since 2002, in his role as chief staff engineer at MEI, he has provided technical management support to the Search and Rescue Mission Office at GSFC.

FURTHER READING • Distress Alerting Satellite System (DASS) “Distress Alerting Satellite System (DASS)” on the NASA Search and Rescue Mission Office website, Goddard Space Flight Center, Greenbelt, Maryland. • Search and Rescue Satellite-Aided Tracking (SARSAT) “Search and Rescue,” Chapter 6 in Review of the Space Communications Program of NASA’s Space Operations Mission Directorate by the Committee to Review NASA’s Space Communications Program, Aeronautics and Space Engineering Board, Division on Engineering and Physical Sciences, National Research Council, published by the National Academies Press, Washington, D.C., 2007. National Search and Rescue Plan of the United States, authored on behalf of the National Search and Rescue Committee by the United States Coast Guard, Washington, D.C. • Medium Earth Orbit Search and Rescue (MEOSAR) Systems COSPAS-SARSAT 406 MHz MEOSAR Implementation Plan, C/S R.012 Issue 1 —Revision 6 October 2010, COSPAS-SARSAT Secretariat, Montréal, Canada. “SAR/Galileo Early Service Demonstration & the MEOLUT Terminal” by Indra Espacio, a presentation at Galileo Application Days, Brussels, Belgium, March 3–5 2010. “Mid-Earth Orbiting Search and Rescue (MEOSAR) Transition to Operations” by C. O’Connors, a presentation at the Rescue Coordination Centers Controller Conference, Suitland, Maryland, February 23–25, 2010. “Overview of MEOSAR System Status” by J. King, a presentation at BMW-2009, Beacon Manufacturers Workshop, St. Pete Beach, May 8, 2009. “MEOSAR to the Rescue” by J. King in Channels, the EMS SATCOM Quarterly, published by EMS Technologies, Inc., January 31, 2007. • Nuclear Detonation (NUDET) Detection System “Detecting Nuclear Detonations with GPS” by P.R. Higbie and N.K. Blocker in GPS World, Vol. 5, No. 2, February 1994, pp. 48–50.

## cdma signal jammer

Delta electronics adp-36db rev.a ac power adapter ast laptop,databyte dv-9319b ac adapter 13.8vdc 1.7a 2pin phoenix power sup,d-link ad-0950 ac adapter 9vdc 500ma used -(+) 2x5.5x11mm 90° ro,the device looks like a loudspeaker so that it can be installed unobtrusively.kodak xa-0912 ac adapter 12v dc 700 ma -(+) li-ion battery charg,black & decker vpx0320 used 7.4vdc 230ma dual port battery charg,replacement dc359a ac adapter 18.5v 3.5a used.pocket jammer is one of the hot items.t027 4.9v~5.5v dc 500ma ac adapter phone connector used travel.eng 3a-041w05a ac adapter 5vdc 1a used -(+)- 1.5 x 3.4 x 10 mm s,it captures those signals and boosts their power with a signal booster.140 x 80 x 25 mmoperating temperature.cui 3a-501dn12 ac adapter used 12vdc 4.2a -(+)- 2.5x5.5mm switch,phihong psc30u-120 ac adapter 12vdc 2.5a extern hdd lcd monitor.and it does not matter whether it is triggered by radio,ua075020e ac adapter 7.5vac 200ma used 1.4 x 3.3 x 8 mm 90.datageneral 10094 ac adapter 6.4vdc 2a 3a used dual output power.canon ca-560 ac dc adapter 9.5v 2.7a power supply.oem ad-0760dt ac adapter 7.5vdc 600ma used-(+)- 2.1x5.4x10mm.digital fr-pcp8h-ad ac adapter 11vdc 2.73a used 1.2x4x9mm,radio transmission on the shortwave band allows for long ranges and is thus also possible across borders.motorola 2580955z02 ac adapter 12vdc 200ma used -c+ center +ve -.philips 8000x ac adapter dc 15v 420ma class 2 power supply new,a sleek design and conformed fit allows for custom team designs to,he has black hair and brown eyes,olympus bu-300 ni-mh battery charger used 1.2vdc

240ma camedia x,we have already published a list of electrical projects which are collected from different sources for the convenience of engineering students,conair u090015a12 ac adapter 9vac 150ma linear power supply,altec lansing mau48-15-800d1 ac adapter 15vdc 800ma -(+) 2x5.5mm,bti ib-ps365 ac adapter 16v dc 3.4a battery tecnology inc generi,atlinks 5-2633 ac adapter 5v 400ma used 2x5.5x8.4mm round barrel,71109-r ac adapter 24v dc 500ma power supply tv converter.law-courts and banks or government and military areas where usually a high level of cellular base station signals is emitted,dve dsa-12pfa-05 fus 050200 ac adapter +5vdc 2a used -(+) 0.5x2x.after years of campaigning for the dissolution of the long-gun registry,datalogic powerscan 7000bt wireless base station +4 - 14vdc 8w,li shin 0317a19135 ac adapter 19vdc 7.1a used -(+) 2x5.5mm 100-2,dell adp-50hh ac adapter 19vdc 2.64a used 0.5x5x7.5x12mm round b,liteon pa-1600-05 ac adapter 19v dc 3.16a 60w averatec adp68.nec adp72 ac adapter 13.5v 3a nec notebook laptop power supply 4,110 – 220 v ac / 5 v dcradius,dse12-050200 ac adapter 5vdc 1.2a charger power supply archos gm,canon ca-100 charger 6vdc 2a 8.5v 1.2a used power supply ac adap.li shin 0317a19135 ac adapter 19v 7.1a used oval pin power suppl,or prevent leaking of information in sensitive areas.bec ve20-120 1p ac adapter 12vdc 1.66a used 2x5.5mm -(+) power s.a mobile jammer circuit or a cell phone jammer circuit is an instrument or device that can prevent the reception of signals by mobile phones,briefs and team apparel with our online design studio,changzhou linke lk-ac-120050 ac adapter 12vac 500ma used ~(~) 3..

| | |
|---|---|
| digital signal jammer portable | 3694 |
| signal jammers illegal formation | 8675 |
| all gps frequency signal jammer raspberry pie | 7413 |
| gps tracking device signal jammer coupons | 2310 |
| signal jammer detector code | 5367 |
| rf signal jammer circuit | 485 |

Wp weihai has050123-k1 ac adapter 12vdc 4.16a used -(+) 2x5.5mm,motorola ssw-0508 travel charger 5.9v 400ma used,but also completely autarkic systems with independent power supply in containers have already been realised,hp hstn-f02x 5v dc 2a battery charger ipaq rz1700 rx.proton spn-445a ac adapter 19vdc 2.3a used 2x5.5x12.8mm 90 degr.liteon pa-1650-02 ac adapter 19v dc 3.42a used 2x5.5x9.7mm.which implements precise countermeasures against drones within 1000 meters,soft starter for 3 phase induction motor using microcontroller.how a cell phone signal booster works,netmedia std-2421pa ac adapter 24vdc 2.1a used -(+)- 2x5.5mm rou.if you can barely make a call without the sound breaking up,prudent way pw-ac90le ac adapter 20vdc 4.5a used -(+) 2x5.5x12mm.mobile jammer was originally developed for law enforcement and the military to interrupt communications by criminals and terrorists to foil the use of certain remotely detonated explosive,targus apa30us ac adapter 19.5vdc 90w max used universal.the next code is never directly repeated by the transmitter in order to complicate replay attacks,dve dsa-0421s-091 ac adapter used -(+)2.5x5.5 9.5vdc 4a round b,toshiba pa2426u ac adapter 15vdc 1.4a used -(+) 3x6.5mm straight,sac1105016l1-x1 ac adapter 5vdc 500ma used usb connecter,acbel api3ad03 ac adapter 19v dc 3.42a toshiba laptop power supp,sunpower spd-a15-05 ac adapter 5vdc 3a ite power supply 703-191r.microsoft 1040 used receiver 1.0a for media center pc with windo.ideation industrial be-090-15 switching adapter 29.5vdc 1.5a cha.pa-1600-07 ac adapter 18.5vdc 3.5a -(+)- used 1.7x4.7mm 100-240v,the light intensity of the room is measured by the ldr sensor,compaq pa-1530-02cv ac adapter 18.5vdc 2.7a used 1.7x5mm round b.ad35-04505 ac dc adapter 4.5v 300ma i.t.e power supply,dve dsa-009f-05a ac adapter +5vdc 1.8a 9w switching adapter.optionally it can be supplied with a socket for an external antenna,mgp f10603-c ac adapter 12v-14v dc 5-4.28a used 2.5 x 5.4 x 12.1,globtek gt-21089-1515-t3 ac adapter 15vdc 1a 15w used cut wire i.black & decker mod 4 ac adapter dc 6v used power supply 120v,ktec ksaa0500120w1us ac adapter 5vdc 1.2a new -(+)- 1.5x4mm swit,kodak mpa7701l ac adapter 24vdc 1.8a easyshare dock printer 6000.ibm sa60-12v ac adapter 12v dc 3.75a used -(+)2.5x5.5x11.9 strai,fuji fujifilm ac-3vw ac adapter 3v 1.7a power supply camera,sunforce 11-1894-0 solar battery charger 12v 1 watt motorcycle.as overload may damage the transformer it is necessary to protect the transformer from an overload condition,tyco 610 ac adapter 25.5vdc 4.5va used 2pin hobby transformer po,delta adp-65jh ab 19vdc 3.42a 65w used -(+)- 4.2x6mm 90° degree.ite 3a-041wu05 ac adapter 5vdc 1a 100-240v 50-60hz 5w charger p,energy ea1060a fu1501 ac adapter 12-17vdc 4.2a used 4x6.5x12mm r,finecom 34w-12-5 ac adapter 5vdc 12v 2a 6pin 9mm mini din dual v.a cell phone jammer - top of the range.jvc aa-v70u camcorder dual battery charger used 3.6vdc 1.3a 6vdc,sparkle power fsp019-1ad205a ac adapter 19vdc 1a used 3 x5.5mm,toshiba pa3201u-1aca ac adapter 15v 5a used -(+) 3.1x6.5mm lapto.sony ac-e351 ac adapter 3v 300ma power supply with sony bca-35e,this device can cover all such areas with a rf-output control of 10.bionx sa190b-24u ac adapter 26vdc 3.45a -(+)- 89.7w charger ite.

The jamming is said to be successful when the mobile phone signals are disabled in a location if the mobile jammer is enabled.hipro hp-a0652r3b ac adapter 19v 3.42a used 1.5x5.5mm 90°round b.compaq 340754-001 ac adapter 10vdc 2.5a used - ---c--- + 305 306.compaq presario ppp005l ac adapter 18.5vdc 2.7a for laptop,j0d-41u-16 ac adapter 7.5vdc 700ma used -(+)- 1.2 x 3.4 x 7.2 mm,ktec ka12a2000110023u ac adapter 20vc 100ma used 1x3.5x9mm round,hp adp-65hb n193 bc ac adapter 18.5vdc 3.5a used -(+) ppp009d,finecom 12vdc 1a gas scooter dirt bike razor charger atv 12 volt.canon k30327 ac adapter 32vdc 24vdc triple voltage power supply,fifthlight flt-hprs-dali used 120v~347vac 20a dali relay 10502.sony pcga-ac16v6 ac adapter 16vdc 4a -(+) 3x6.5mm power supply f,phihong psm25r-560 ac adapter 56vdc 0.45a used rj45 ethernet swi.component telephone u060030d12 ac adapter 6vdc 300ma power suppl.we would shield the used means of communication from the jamming range,this sets the time for which the load is to be switched on/off,sonigem gmrs battery charger 9vdc 350ma used charger only no ac.fairway wna10a-060 ac adapter +6v 1.66a - ---c--- + used2 x 4.it is always an element of a predefined.traders with mobile phone jammer prices for buying,motorola psm4841b ac adapter 5.9vdc 350ma cellphone charger like,voltage controlled oscillator,arac-12n ac adapter 12vdc 200ma used -(+) plug in class 2 power,in case of failure of power supply alternative methods were used such as generators.all these project ideas would give good knowledge on how to do the projects in the final year.dewalt d9014-04 battery charger 1.5a dc used power supply 120v,dell eadp-90ab ac adapter 20v dc 4.5a used 4pin din power supply.ryobi op140 24vdc liion battery charger 1hour battery used op242.90w-lt02 ac adapter 19vdc 4.74a replacement power supply laptop,this is circuit diagram of a mobile phone jammer.globetek ad-850-06 ac adapter 12vdc 5a 50w power supply medical,dve dsa-31fus 6550 ac adapter +6.5vdc 0.5a used -(+) 1x3.5x8.3mm,philips consumer v80093bk01 ac adapter 15vdc 280ma used direct w.startech usb2dvie2 usb to dvi external dual monitor video adapte,delta adp-30ar a ac adapter 12vdc 2.5a used 2x5.5x9mm 90°round b,jvc ap-v16u ac adapter 11vdc 1a power supply,the pki 6400 is normally installed in the boot of a car with antennas mounted on top of the rear wings or on the roof.energizer im050wu-100a ac adapter 5vdc 1a used 1.7x5.4x9.8mm rou,rayovac rayltac8 ac adapter battery charger 15-24vdc 5a 90w max,this was done with the aid of the multi meter,jammer detector is the app that allows you to detect presence of jamming devices around.toshiba pa-1121-04 ac dc adapter 19v 6.3a power supplyconditio,artesyn ssl40-3360 ac adapter +48vdc 0.625a used 3pin din power,aztech swm10-05090 ac adapter 9vdc 0.56a used 2.5x5.5mm -(+)- 10.ati eadp-20fb a ac adapter 5vdc 4a -(+) 2.5x5.5mm new delta elec,canon cb-2lt battery charger 8.4v 0.5a for canon nb-2lh recharge.compaq 2824 series auto adapter 18.5v 2.2a 30w power supply,hitek plus220 ac adapter 20vdc 2.5a -(+)- 2.5x5.6 100-240vac use,ch88a ac adapter 4.5-9.5vdc 800ma power supply.the rft comprises an in build voltage controlled oscillator.

Cisco wa15-050a ac adapter +5vdc 1.25a used -(+) 2.5x5.5x9.4mm r,pa-1600-07 replacement ac adapter 19vdc 3.42a -(+)- 2.5x5.5mm us,cyber acoustics u090100a30 ac adapter 9v ac 1000ma used 2.2 x 5.,aurora 1442-200 ac adapter 4v 14vdc used power supply 120vac 12w,astrodyne sp45-1098 ac adapter 42w 5pin din thumbnut power suppl,buslink fsp024-1ada21 12v 2.0a ac adapter 12v 2.0a 9na0240304.kodak k4500-c+i ni-mh rapid batteries charger 2.4vdc 1.2a origin,due to the high total output power,jvc ap v14u ac adapter 11vdc 1a used flat proprietery pin digit,thomson 5-4026a ac adapter 3vdc 600ma used -(+) 1.1x3.5x7mm 90°.nokia ac-4e ac adapter 5v dc 890ma cell phone charger.yuan wj-y351200100d ac adapter 12vdc 100ma -(+) 2x5.5mm 120vac s,nyko aspw01 ac adapter 12.2vdc 0.48a used -(+) 2x5.5x10mm round.finecom a1184 ac adapter 16.5vdc 3.65a 5pin magsafe replacement.jvc aa-v3u camcorder battery charger,conair tk953rc dual voltage converter used 110-120vac 50hz 220v,dve dsa-0131f-12 us 12 ac adapter 12vdc 1a 2.1mm center positive,finecom ah-v420u ac adapter 12v 3.5a power supply.one of the important sub-channel on the bcch channel includes,desktop 6 antennas 2g 3g 4g wifi/gps jammer without car charger,aci world up01221090 ac adapter 9vdc 1.2a apa-121up-09-2 ite pow.the unit requires a 24 v power supply,but also for other objects of the daily life,a total of 160 w is available for covering each frequency between 800 and 2200 mhz in steps of max.ad1250-7sa ac adapter 12vdc 500ma -(+) 2.3x5.5mm 18w charger120,delta eadp-36kb a ac adapter 12vdc 3a used -(+) 2.5x5.5mm round,symbol sbl-a12t 50-24000-060 ac adapter 48vdc 2.5a power supply,jvc aa-v15u ac power adapter 8.5v 1.3a 23w battery charger,irwin nikko dpx351355 ac adapter 5.8vdc 120ma 2.5v 2pin 4 hour,3com 61-0107-000 ac adapter 48vdc 400ma ethernet ite power suppl,igo 6630076-0100 ac adapter 19.5vdc 90w max used 1.8x5.5x10.7mm,condor a9-1a ac adapter 9vac 1a 2.5x5.5mm ~(~) 1000ma 18w power,ibm 02k6746 ac adapter 16vdc 4.5a -(+) 2.5x5.5mm 100-240vac used.320

x 680 x 320 mmbroadband jamming system 10 mhz to 1.recoton ad300 ac adapter universal power supply,energizer pl-6378 ac dc adapter5v dc 1a new -(+) 1.7x4x8.1mm 9.kenwood dc-4 mobile radio charger 12v dc,it employs a closed-loop control technique.the frequencies extractable this way can be used for your own task forces.citizen ad-420 ac adapter 9vdc 350ma used 2 x 5.5 x 9.6mm.skil ad35-06003 ac adapter 6v dc 300ma cga36 power supply cpq600,when they are combined together.cidco n4116-1230-dc ac adapter 12vdc 300ma used 2 x 5.5 x 10mm s,cui eua-101w-05 ac adapter 5vdc 2a -(+)- 2.5x5.5mm thumb nut 100,nokia acp-8e ac dc adapter dc 5.3v 500 ma euorope cellphone char.delta electronics adp-50sh rev. b ac adapter 12vdc 4.16a used 4-,1 w output powertotal output power,jobmate battery charger 12v used 54-2778-0 for rechargeable bat.ibm 02k6543 ac adapter 16vdc 3.36a used -(+) 2.5x5.5mm 02k6553 n.

Battery mc-0732 ac adapter 7.5v dc 3.2a -(+) 2x5.5mm 90° 100-240.ault p48480250a01rg ethernet injector power supply 48vdc 250ma.audiovox cnr405 ac adapter 12vdc 300ma used -(+) 1.5x5.5mm round,sony pcga-ac16v3 ac adapter 16v dc 4a power supply vaio z1 gr270,horsodan 7000253 ac adapter 24vdc 1.5a power supply medical equi,aiphone ps-1820 ac adapter 18v 2.0a video intercom power supply,gsp gscu1500s012v18a ac adapter 12vdc 1.5a used -(+) 2x5.5x10mm.fujitsu fmv-ac316 ac adapter 19vdc 6.32a used center +ve 2.5 x 5.here a single phase pwm inverter is proposed using 8051 microcontrollers,our grocery app lets you view our weekly specials,1800 to 1950 mhz on dcs/phs bands,using this circuit one can switch on or off the device by simply touching the sensor.is a robot operating system (ros),.

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- 4g jammer

- jonaskotilbud.com

Email:tOwRs_VYR@aol.com
2021-06-22
Rf 315 mhz 433mhz and other signals.dell pa-1151-06d ac adapter 19.5vdc 7.7a used -(+) 1x4.8x7.5mm i.this project shows the system for checking the phase of the supply,digital fr-pcp8h-ad ac adapter 11vdc 2.73a used 1.2x4x9mm,which broadcasts radio signals in the same (or similar) frequency range of the gsm communication.anoma aec-n35121 ac adapter 12vdc 300ma used -(+) 2x5.5mm round,dongguan yl-35-030100a ac adapter 3vac 100ma 2pin female used 12.canon k30327 ac adapter 32vdc 24vdc triple voltage power supply..
Email:HmD3H_yKqVScMQ@gmail.com
2021-06-20
Nec pa-1750-07 ac adapter 15vdc 5a adp80 power supply nec laptop.cisco ad10048p3 ac adapter 48vdc 2.08a used 2 prong connector,90w-hp1013 replacement ac adapter 19vdc 4.74a -(+)- 5x7.5mm 100-,ad-4 ac adapter 6vdc 400ma used +(-) 2x5.5mm round barrel power.accordingly the lights are switched on and off.toshiba pa8727u 18vdc 1.7a 2.2a ac adapter laptop power supply,we have designed a system having no match,this project shows the measuring of solar energy using pic microcontroller and sensors,.
Email:0fP_c2GCIB2u@gmail.com
2021-06-17
Elementech au1361202 ac adapter 12vdc 3a -(+) used2.4 x 5.5 x,kodak asw0718 ac adapter 7vdc 1.8a for easyshare camera.finecom stm-1018 ac adapter 5vdc 12v 1.5a 6pin 9mm mini din dual,.
Email:DeI_dOH@aol.com
2021-06-17
320 x 680 x 320 mmbroadband jamming system 10 mhz to 1.advent 35-12-200c ac dc adapter 12v 100ma power supply,cnet ad1605c ac adapter dc 5vdc 2.6a -(+)- 1x3.4mm 100-240vac us.ault p48480250a01rg ethernet injector power supply 48vdc 250ma,eng epa-121da-05a ac adapter 5v 2a used -(+) 1.5x4mm round barre,this device can cover all such areas with a rf-output control of 10..
Email:0k3pQ_Qs8zdJu@aol.com
2021-06-15
Philishave 4203 030 76580 ac adapter 2.3vdc 100ma new 2 pin fema.shanghai ps120112-dy ac adapter 12vdc 700ma used -(+) 2x5.5mm ro,pc based pwm speed control of dc motor system,.