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Sensor-to-Satellite Link Systems

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Abstract

Low power sensors are used to detect chemical, biological, nuclear, thermal and mechanical vibration activities in covert environments. A concept was developed to communicate directly between low-power randomly located sensors to a satellite or a constellation of satellites. The sensors are dropped or otherwise positioned in uncontrolled or unfriendly environments and are capable of detecting the required parameters. The self-powered sensor package can be camouflaged in many shapes and positioned at random in unsuspecting arrangements. The sensors operate independently and may relay the same information to create a built-in redundancy. The damage or discovery of some of the sensor packages will not affect the transfer of the required information, as the remaining sensors will transmit the same information. The sensors use scanning antennas to access the satellite(s) from the random locations and can also be arranged in an ad-hoc network. The antennas have hemispherical coverage and use small phased arrays with relatively high gain and narrow beam width, operating at a high frequency, such as Ka-band. The array beam is continuously scanned within the expected angular range of the satellite(s) with a pre-set dwell time at each scanning position, and transmits the coded sensor data in all scanning directions. The geostationary or moving low-earth-orbiting (LEO) satellite(s) will receive the data when the array beam is in the direction of the satellite(s). This data acquisition by the satellite is performed without the need for satellite tracking by the sensor. The hemispherical coverage can also be achieved using a low-gain hemispherical-beam antenna, in which case the sensor power has to be enough to compensate for the low gain of the antenna. The low gain antenna solution is appropriate for lower frequency operation. The concept has applications in homeland security, counter-terrorism and combat operations.

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Amir I. Zaghloul is with the US Army Research Laboratory on an IPA agreement with Virginia Polytechnic Institute and State University (Virginia Tech), where he has been with the Bradley Department of Electrical and Computer Engineering since 2001. Prior to Virginia Tech, he was at COMSAT Laboratories for 25 years performing and directing R&D efforts on satellite communications and antennas, where he received several research and patent awards, including the Exceptional Patent Award. He held positions at the University of Waterloo, Canada (1968-1978), University of Toronto, Canada (1973-74), Aalborg University, Denmark (1976) and Johns Hopkins University, Maryland (1984-2001). He is a Life Fellow of the IEEE and the recipient of the 1986 Wheeler Prize Award for Best Application Paper in the IEEE Transactions on Antennas and Propagation and the best track paper at the 2004 IEEE Digital Avionics Systems Conference. He is also a Fellow of the Applied Computational Electromagnetics Society (ACES), Associate Fellow of The American Institute of Aeronautics and Astronautics (AIAA), and a Member of Commissions A, B & C of the International Union of Radio Science (URSI). He was the general chair of the 2005 "IEEE International Symposium on Antennas and Propagation and USNC/URSI Meeting," held in Washington, D.C.

He is the author or co-author of more than 200 publications and over 30 patents and invention disclosures in the areas of antennas, RF and microwave systems, sensors, metamaterials, nano-technology, terahertz imaging, and satellite and wireless communication systems. He led successful product developments and patent licensing of consumer electronic equipment based on his patents.

Dr. Zaghloul received the Ph.D. and M.A.Sc. degrees from the University of Waterloo, Canada in 1973 and 1970, respectively, and the B.Sc. degree (Honors) from Cairo University, Egypt in 1965, all in electrical engineering. He also received a MBA degree in Management of Science, Technology and Innovation from the George Washington University, Washington, DC in 1989.

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