

Lost and Found



Understanding Technologies Used to Locate Missing Persons with Alzheimer's or Dementia



BJA
Bureau of Justice Assistance
U.S. Department of Justice



This project was supported by Grant No. 2009-SJ-BX-K011 awarded by the Bureau of Justice Assistance. The Bureau of Justice Assistance is a component of the Office of Justice Programs, which also includes the Bureau of Justice Statistics, the National Institute of Justice, the Office of Juvenile Justice and Delinquency Prevention, the Office for Victims of Crime, and the Office of Sex Offender Sentencing, Monitoring, Apprehending, Registering, and Tracking. Points of view or opinions in this document do not necessarily represent the official positions or policies of the U.S. Department of Justice.

Summary

Alzheimer's disease and other forms of dementia affect not only those who are living with the disease; these afflictions also impact the caregivers, law enforcement, and even neighbors. As the disease progresses, physical and mental capabilities are negatively impacted, short-term memory loss increases, and a person with Alzheimer's might begin living in the past. As the person attempts to return to former places of employment or residences, they often get lost and need assistance returning to where they are currently residing. It is never possible to predict if or when a person with Alzheimer's will wander or be unable to navigate familiar routes. Initiating a search for a person with Alzheimer's can never be delayed, and conducting such searches can prove to be costly and consume extreme amounts of agency resources. It is crucial for law enforcement officers and other first responders to be familiar with and understand the signs of dementia and be aware of passive identification products used to identify persons with Alzheimer's. In addition to passive identification techniques, there are technologies and products available that can be used to actively locate an individual who is lost.

Cellular location techniques and Global Positioning System devices are examples of proven methods for aiding law enforcement in a search for a missing person with dementia. This document will provide a technical description of these technologies and outline some of the advantages and disadvantages when employing these products. It will also provide comprehensive lists of locating devices that are currently available. Provided in each section is a short technical description of the technology and its advantages and the disadvantages. Appendix I and Appendix II provide a list of passive and active locating devices currently available.

The most efficient way to counter the negative impact of Alzheimer's disease or related dementias is to be knowledgeable, increase communication and understanding, educate the entire community, and proactively promote processes and procedures that

will prevent wandering and facilitate the use of technology that will enhance efforts to locate those who are reported missing.

Acknowledgements

- Gene Saunders, Chief Executive Officer, Founder, Project Lifesaver
- Marie Boltz, Ph.D., APRN, BC, Associate Director for Practice, Hartford Institute for Geriatric Nursing and Assistant Professor, New York University
- Eric J. Hall, President and Chief Executive Officer, Alzheimer's Foundation of America
- Carol Steinberg, Executive Vice President, Alzheimer's Foundation of America
- Edward Hutchison, Director, TRIAD and Traffic Safety, National Sheriffs' Association
- Robert J. Koester, Chief Executive Officer, dbS Productions LLC
- David Lindeman, Ph.D., Director, Center for Technology and Aging, an Initiative of the SCAN Foundation and Public Health Institute; and Co-Director, Center for Innovation and Technology in Public Health
- Richard E. Powers, M.D., Associate Chief of Staff for Geriatrics and Extended Care, Tuscaloosa VA Medical Center, Tuscaloosa, AL
- Meredith A. Rowe, Ph.D., Professor, University of Florida
- Julie Skone, MEd., formerly with the Department of Criminal Justice Services, Commonwealth of Virginia
- Denise Guerty, MBA, Senior Electrical Engineer, Project Lifesaver
- Eileen M. Songer, MNO, Director of Marketing, The Engineering Society of Detroit, and former Project Manager, International Association of Chiefs of Police
- Gwenette Gaddis, Chief Editor

Table of Contents

Introduction.....	6
Potential Effects on Persons with AD/D, Caregivers, and Law Enforcement.....	7
Persons Living with AD/D.....	7
Caregivers.....	8
Law Enforcement.....	9
Public Alerts.....	10
Passive Identification Techniques.....	11
Bracelets and Information Cards.....	11
Tagged clothing.....	12
Active Locator Technologies and Devices.....	12
Radio Frequency—VHF Band.....	13
<i>Radio Frequency Identification (RFID) Tags</i>	15
<i>Passive RFID</i>	15
<i>Active RFID over the WIFI Network</i>	16
Global Positioning System (GPS).....	17
Cellular Triangulation.....	19
Assisted Global Positioning System (A-GPS).....	19
Global System for Mobile Communications (GSM).....	21
Wideband Code Division Multiple Access (W-CDMA).....	21
Appendix I.....	23
Passive Products (Currently Available).....	23
Appendix II.....	25
Active Locator Devices (Currently Available).....	25
Acronyms.....	28
References.....	29

Introduction

Alzheimer's disease attacks the brain's nerve cells, or neurons, resulting in loss of memory, cognitive impairment, and dramatic behavioral changes, and eventually the person may no longer be able to communicate.¹ As many as 5.1 million Americans currently have Alzheimer's disease, and it is the most common cause of dementia in persons over 65 years of age.² Although Alzheimer's disease is not a normal part of aging, age is the strongest risk factor for dementia. Incidences of dementia are rising exponentially among persons between 65 and 90 years of age.³

Persons diagnosed with Alzheimer's disease and other forms of dementia (AD/D) experience seven progressively worsening phases and eventually will be cognitively impaired to the point where they will become disoriented and can easily get lost. Eventually persons with AD/D will need full-time care. This presents a challenging situation for not only persons with these afflictions, but also their families, caregivers, law enforcement agencies, medical communities, and even neighbors and the communities where these persons reside. As the number of persons diagnosed with AD/D increases, there will be a growing need for required support, technology tools, and medical breakthroughs.

The purpose of this report is to provide a broad overview of the symptoms of AD/D and the potential impact on persons living with these afflictions, their caregivers, law enforcement, and the community. The report also provides a review of the passive identification techniques, public alert options, locating device technology, and current locative products in the field. The information in this report is designed to provide law enforcement, caregivers, families, and the community with improved skills to better deal with the challenges resulting from AD/D.

Potential Effects on Persons with AD/D, Caregivers, and Law Enforcement

Enforcement

Persons Living with AD/D

Dementia is not a disease but a set of symptoms, and Alzheimer's disease is the most common cause of dementia. Alzheimer's disease represents approximately 60-80 percent of all diagnosed cases of dementia, followed by vascular dementia and dementia with Lewy bodies.⁴ Brain cell damage in specific areas of the brain determines the type of dementia.⁵ The brain region called the hippocampus is the center of learning and memory in the brain, and the brain cells in this region are often the first to be damaged.⁶ As AD/D progresses, the individual will experience different symptoms in the seven phases, as indicated in Figure 1.

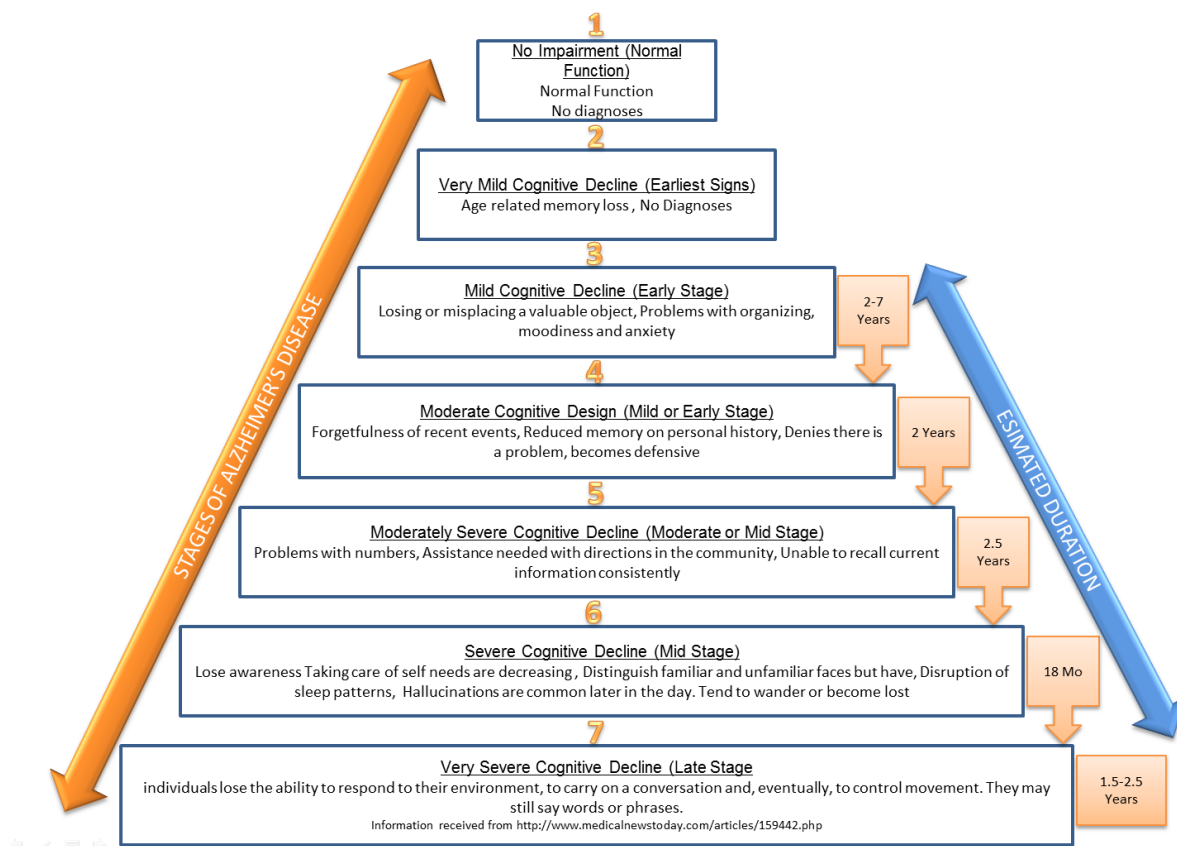


Figure 1⁷

Persons in Phase 1 display no symptoms of dementia. Memory loss begins to occur in Stage 2 and is often viewed as typical behavior associated with the age-related process. AD/D is not clearly identified or diagnosed in Stages 1 and 2. During Stage 3, a healthcare provider can detect dementia-related symptoms in most people. Because the distinguishing line between stages varies with each individual, not all individuals experience all symptoms documented with each stage. During Stage 4, the person cannot remember recent events and withdraws from social situations as a result. Persons in Stage 5 exhibit symptoms including confusion and memory loss regarding family members. The person experiences more profound severe physical and mental changes throughout Stage 6. Sleep patterns change, with many persons sleeping more during the day and less at night. Assistance with dressing and basic personal care may be necessary and the person may start to wander away from their safe environment. The term *wandering* is generally used to describe a range of behaviors. Less destructive wandering is referred to as *wandering around*. Critical wandering is referred to as *elopement*, with the potential for the person to go missing. Wandering is caused by restlessness, agitation, confusion, desire to fulfill previous obligations, and medication side effects⁸. In Stage 7, the individual loses the ability to respond to his or her environment and converse with others, and eventually the individual loses all ability to move.

Caregivers

Caregivers can be family members, friends, or financially compensated employees who take care of persons with AD/D. Approximately 43.5 million adult family members care for someone 50+ years of age, and 14.9 million care for someone who has AD/D.⁹

Most caregivers are familiar with the seven stages of AD/D and the behavioral changes associated with each stage. As illustrated in Figure 1, wandering can start in Stages 5 and 6, and caretakers need to focus on how to mitigate the risk of wandering based on observation of the person's cognitive skills.

Listed below are potential signs that can identify a person who is at risk of wandering:¹⁰

- Asks about the whereabouts of a current or past friend or member of the family.
- Acts as if performing a hobby or chore, but nothing gets done.
- Tries or wants to “go home” when at home.
- Tries to fulfill obligations, such as going to work.

Actions for caretakers to implement for deterring wandering behavior include the following:¹¹

- Hang a photo or picture on the back of the door.
- Consider installing locks on outside gates.
- Consider alarm systems to alert the caregiver when the individual leaves the house.

Caregivers have been known to cycle through many emotions when caring for patients with AD/D. The emotional cycle is defined as Caregiver Depression. Symptoms include feelings of hopelessness, loss of interest in activities, changes in appetite, agitation, restlessness, and feelings of worthlessness and guilt.¹² Caregivers provide the best care they are capable of and are under a large amount of stress and responsibility for their patient’s health and well-being.

Law Enforcement

Because there is no mandatory reporting of missing persons with AD/D, data regarding how many persons with AD/D have actually wandered is limited; however, it is estimated that as many as 6 out of 10 persons with dementia will leave the safety of their home and will be unable to find their way back. Research has shown that Alzheimer’s patients do not typically wander far when traveling by foot. Law enforcement and other public safety agencies are most often the first to be notified when a person with AD/D has wandered and is considered missing. Protocols for responding to such calls need to be somewhat different from those pertaining to other missing persons. The International Association of Chiefs of Police (IACP) has created a model policy to assist law enforcement and other public safety agencies in developing

search protocols for this category of missing persons. That model policy is available on the IACP web site.¹³

Many times, law enforcement officers encounter persons with AD/D who are still operating a motor vehicle and have become lost but have not as yet been reported missing. "Understanding and Helping Drivers with Alzheimer's Disease" by Linda Hurt, published in the November 2011 issue of IACP's *The Police Chief*, informs readers of the various indicators of AD/D that might be observed by an officer when performing a traffic stop.¹⁴

Various professional groups and associations provide training for law enforcement officials through online training and seminars. Equipping law enforcement with education and efficient processes is crucial in the timely recovery of a person with AD/D because of how quickly the person's life can become endangered.

Public Alerts

Public alert systems use a variety of mediums to distribute messages regarding a missing adult. Types of systems include digital roadway signs, automated mass notification, and social media.

When a person with AD/D wanders and is driving a vehicle, the first action for the caregiver is to call the local police department and report the person as missing. The police department then follows an established procedure and notifies the state or local highway public alert system, which in some areas is known as "Silver Alert systems." Such systems exist in all 50 states, but because the requirements of these systems vary from state to state, it is important for law enforcement officials to be familiar with the requirements and notification protocols of their state's system.

In some locales, community governments or law enforcement agencies offer automated mass communication systems that deliver detailed messages to a predetermined audience. Depending on the company providing the messaging service and/or the

client's choice, these messages can be relayed via phone, SMS text, email, webpage, social media sites, fax, and/or TTY/TDD. Industry leaders have developed systems and services that combine mapping and database technologies. Combining applications allows law enforcement and fire/EMS to notify citizens of an emergency situation within a certain geographic area. When subscribing to one of these services, county or city governments can automatically call and leave messages on citizens' home-based telephone lines. Messages include detailed information about the emergency situation.

Passive Identification Techniques

This section reviews passive identification techniques. Passive identification techniques refer to non-electrical items used for identification of persons with AD/D, including items worn on the body and items that are included in personal possessions.

Bracelets and Information Cards

Identification cards and bracelets are inexpensive products that provide personal information to law enforcement officials and others who may come into contact with a person with AD/D who has wandered and become lost.

Several jewelry product designs are available for both men and women. Bracelets are manufactured in clear, vinyl or latex, leather, and metal bands. The bands are easy to see and are designed not to be easily removed. The information on basic bands can include the patient's name and address and the caregiver's contact information. Bracelets are also available for caregivers to wear; in case a negative event involving the caregiver occurs, the bracelet will identify the person to whom they are providing care.

Other identification jewelry is designed to be more discrete and not openly display medical information. Universal Serial Bus (USB) memory drives are camouflaged inside dog tags and pendants that can be worn around the neck. The USB thumb drives, when

inserted into a computer, can provide medical records and the caregiver's contact information.

Identification cards can be purchased or downloaded for free (Appendix I). The cards are designed to be carried in a purse, wallet, or pocket. These cards can contain information on medicines, allergies, care instructions, and a Medical ID number. Companies such as American Medical ID and Medic Alert provide Medical ID services that record the patient's health information, including medical history, medications, allergies, family history, and contact information. The information is accessible 24 hours a day, 7 days a week through a website or telephone service.

Tagged clothing

Personal clothing can be marked by attaching tags that include the person's identification information. Because it is not known when the patient will wander, tagging all pieces of clothing worn by the individual is suggested.

Active Locator Technologies and Devices

This section reviews active locator technology and devices. The term active locator technologies applies to those devices that require a source of power and a wireless system technology, including cellular triangulation, radio frequency (RF), Active Radio Frequency Identification (RFID), Global Positioning System (GPS), Assisted Global Positioning System (A-GPS), Global System for Mobile Communications (GSM) , and Wideband Code Division Multiple Access (W-CDMA).

Active locator technologies used to locate wandering individuals have advantages and disadvantages associated with each system's base technology. Table 1 is an overview of the functioning characteristics and limitations of each technology.

Name	Locating Technology	Advantages	Disadvantages
RF (Radio Frequency)	RF signal transmitted from device to locating antenna	On -ground accuracy of signal and detectable from air	Sensitivity of the receiver
Active RFID (Radio Frequency Identification Device)	Wireless access points functioning as readers to active tags	No additional cost for network, as device is- implemented on a currently used infrastructure	Inability to locate a wanderer where a Wi-Fi hotspot is unavailable.
GPS (Global Positioning System)	GPS signals transmitted directly to device	Locates within 15ft of the wandering individual	Clear path to satellites needed. Time needed to get GPS fix
Cellular Triangulation	Cellular module included in device to allow the device to connect to the network	Using cellular towers in close proximity to determine device location operating device in lower power mode	NA
A-GPS (Assisted Global Positioning System)	Satellite -to -cellular base station to locating device	Clear path to satellites with regards to buildings. Shorter time to receive coordinates thanen standalone GPS	Positioning data may not be available in low cellular coverage
GSM (Global System for Mobile communications)	Satellite -to -cellular base station to locating device	Worldwide mature network	2G network phase-out to begin in 2016
W-CDMA (Wideband-Code Division Multiplexing Access)	Satellite- to -cellular base station to locating device	3G network ins that it is a more up-to-date network, in comparison to 2G	Estimated to phase out by 2021.

Table 1

Radio Frequency—VHF Band

Transmitting and receiving radio frequency (RF) signals in the VHF band (30MHz-300MHz) is used to locate individuals; radio waves are electromagnetic and are

monitored both visually and with sound using signal tracking equipment. Depending on the battery capacity of the product, the device that is worn transmits a continuous signal for up to 60 days. When tracking an RF frequency, various RF antennas are used and vary in size and process.

The least visible and obvious transmitters, and therefore perhaps the most acceptable locating device for persons with AD/D, is shoe-based tracking devices, though positioning the transmitter so close to the ground may create RF propagation challenges. The development of other “covert” body-worn devices that are less close to the ground (e.g., belts, jewelry-type bracelets) would be helpful in this regard. The key is for the person to not realize that the article of clothing is actually a locator/tracking device.

Two RF systems are currently offered: the manually activated system used by law enforcement, and receivers that create a geo-fence.

In the first system, each device worn by the wandering individual transmits at a preset frequency, which is assigned upon purchase of the device. The assignment of frequency will make each device distinguishable from all other devices. If a person with AD/D who is wearing a transmitter wanders, the caregiver first contacts the local law enforcement agency to report the person as missing. The law enforcement agency then dispatches a vehicle to the area where the person was last seen or known to be. The law enforcement vehicle is equipped with a receiver attached to an omnidirectional antenna, which receives signals from all directions. The law enforcement vehicle is driven around the area in an ever-widening manner until the antenna and receiver detect the strongest signal. Once the strongest signal has been detected, rescuers then continue on foot with a precise directional handheld YAGI antenna connected to a receiver that is tuned to the locating device’s specific frequency within 1 kHz.¹⁶ If the signal is weak, the antenna is rotated 180 degrees until a stronger signal is located.¹⁷ Law enforcement officials are guided to the wandering person based on the strength of

the signal. The average rescue time for locating a missing individual using this method has been 30 minutes.¹⁸

The second system (geo-fence) involves a locating product that transmits an RF signal to a mobile receiver that is preprogrammed for the RF signal within a preset distance. This creates a parameter (or geo-fence). If the wanderer's locating device moves outside the set range of the RF receiver, the receiver sends an alert to the caregiver. Alerts are sent over the cellular network in the form of email and text messages.

The advantage of using a VHF frequency is system accuracy. The process used by law enforcement can detect a signal within 12 miles from the air, should an air rescue be necessary. When rescuers travel on foot, the range of signal detection is between two and five miles. If using the geo-fence and the transmitting device moves outside the preset RF area, the individual can be tracked on a map over the Internet.

The sensitivity of the receiver is the main disadvantage to law enforcement when using RF technology. The receiver must be tuned to within 1 kHz of the transmitter frequency. Additionally, the range of the receiver varies with atmospheric conditions.

Radio Frequency Identification (RFID) Tags

RFID is a system that is used globally and utilizes four widespread frequency bands within the RF spectrum. Three RFID systems are available: passive, semi-passive, and active systems.

Passive RFID

Passive RFID systems used to identify wandering persons with AD/D include a passive high-frequency RFID tag in a transponder, an RFID reader, and application software. The RFID reader and software are needed to process the radio frequency data transmitted by the tag. The RFID tag is attached to the person and holds personal information, such as name, home address, medical record number, caregiver's name, and telephone number. The data is automatically transmitted when the patient passes by a stationary reader or a mobile handheld reader. In hospitals, the reader is most often stationary, and human interaction is not needed to gather information.

The advantage of the passive RFID system is that no power source is required and the tag does not need recharging. Packaging is small, featuring an ultra-lightweight design that is easily manufactured. The passive RFID tags require little to no maintenance.

The disadvantages to the passive RFID systems include range and security of information. The reader in the passive RFID system operates within a limited range and can read data from approximately 3 to 30 feet.¹⁹ It would be difficult for someone to steal Identity information from an RFID system, but it is possible if the code used to encrypt the information on the tag is acquired. Additionally, the product life of the tag is undefined, and if the person is no longer using the tag or the tag is lost, the tag continues to hold the patient's personal information until deactivated. The deactivation of the passive RFID tag includes physically destroying the device by either cutting the tag or electrically overloading circuitry with voltage overload.

Active RFID over the WIFI Network

The active RFID tag requires a battery and has a range of 300 feet (100 meters).²⁰ Wi-Fi-based active RFID systems use standard Wi-Fi technology—Institute of Electronic and Electronics Engineers (IEEE) 802.11—as a communications protocol. The IEEE 802.11 set of standards used for the wireless local area network (WLAN) enables products using the Wi-Fi trademark to utilize WLAN access points as active RFID “readers.”²¹

When using the Wi-Fi network to track active RFID tags outside of a medical environment, a cellular service provider will provide the mapping database capable of mapping all Wi-Fi hotspots in an area. Using this technology, a person with AD/D can be tracked each time he or she walks through a Wi-Fi hotspot. The use of Wi-Fi technology systems to locate wandering individuals has not been fully implemented, but is developing for future use.

The advantage of using active RFID tags on the Wi-Fi system is that it can be implemented on a currently used infrastructure and therefore has lower system installation costs. This locator technology is most effective in metropolitan areas.

One disadvantage associated with using active RFID tags over the Wi-Fi network is the inability to locate a tag that is in an area where a Wi-Fi hotspot is unavailable, making them less efficient for use in rural areas. Additionally, active RFID tags are more expensive than passive techniques.

Global Positioning System (GPS)

GPS currently incorporates approximately 24 satellites at an altitude of more than 12,000 miles above the earth's surface and moving at 8,700 mph with respect to earth.²² Each satellite transmits two signals: the time signal and the satellite position at the time the signal is transmitted. The time signal sent to the receiver on earth is based on the time of the atomic clock and is consistently precise. Locating devices based on this technology include a GPS receiver. This receiver, which is worn or carried by the wandering individual, must receive signals from three satellites in order to calculate a position. The method in which the position is derived is known as GPS trilateration. The receiver in the locating device receives the precise time signal from the three satellites and subtracts that from the time that the device received the signal on earth.

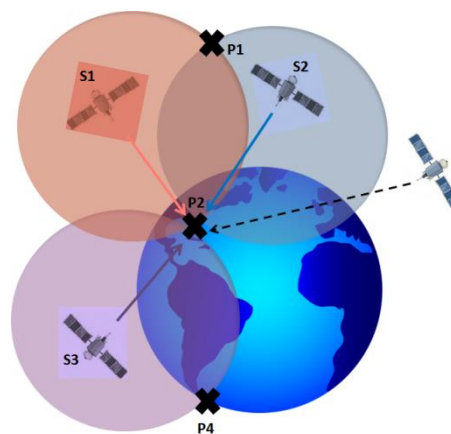


Figure 3

As shown in Figure 3, satellite 1 (S1) and satellite 2 (S2) intersect at two points (P1 and P2). When introducing earth into the calculation, S1, S2, and earth intersect at P2 and P3. (P3 is located on the other side of earth, which is not displayed.) When introducing satellite (S3) into the picture, S1, S2, and S3 intersect at only one point—at P2. Additional satellites can be added to the process to increase the accuracy of the location mapping process. For instance, when a fourth satellite is added into the calculation, the positioning coordinates are even more accurate than when based on only three.²⁴

The active tracking approaches that use GPS are very similar to the technologies used to track criminal offenders, the only difference being that most persons with AD/D do not require a highly secured tethering system, as do offenders. It should be noted, however, that semi-secure tethering may still be needed for this application. Companies are learning that the AD/D population is sometimes reluctant to wear tracking equipment and oftentimes remove the devices when leaving a designated area..

The advantage with current (as of 2007) Signal-in-Space accuracy is that well-designed GPS receivers have been achieving horizontal accuracy of 3 meters or better and vertical accuracy of 5 meters or better 95 percent of the time.²⁵

Disadvantages of using GPS are a high demand for battery power and the fact that the receiver needs a clear path to the satellites to accurately process the signals. Environmental shielding, such as from buildings and extremely dense foliage, can impact the accuracy and even interrupt a tracking. Therefore, when using a GPS tracking device, it is often difficult to detect a wanderer who is indoors. If using a standalone GPS system, the time to establish the initial location is longer than when using A-GPS.

Cellular Triangulation

A wandering individual can be located using cell phone networks. The device that the

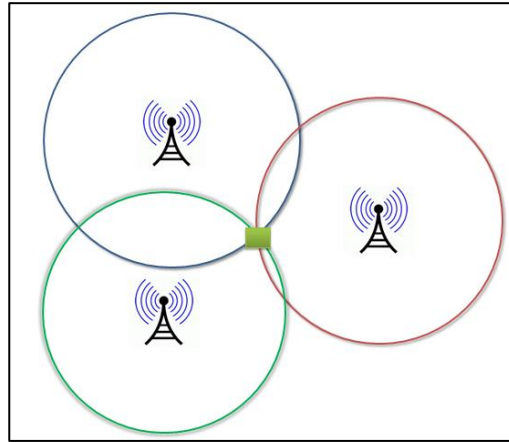


Figure 2

person wears or carries can exist on the network without having the functionality of receiving and transmitting voice conversations. A locating device worn by an individual at risk of wandering can be a simple, cellular module that allows the device to connect to the network. Positioning methods are handset based, network based, or a combination of the two. Cellular-based devices continuously communicate with the cell phone towers to ensure that the cellular module is connected to the closest tower and allow the device to operate in an average power mode. Figure 2 displays three towers and the distance that each cell phone tower is able to transmit a quality signal. The point where the three signals intersect is the position of the locator device. This is known as cellular triangulation. The four wireless technologies that utilize cellular base station positioning reviewed in this paper are A-GPS (see *Assisted Global Positioning System* below); Enhanced Observed Time Difference (E-OTD), and Uplink-Time Difference of Arrival (U-TDOA) (see *Global System for Mobile Communications* below); and Observed Time Difference of Arrival (O-TDOA) (see *Wideband Code Division Multiple Access* below).

Assisted Global Positioning System (A-GPS)

A-GPS is a handset-based system. The device utilizes the cellular base stations to receive timing and positioning signals from the satellites. The base station then

transmits the necessary data to the mobile receivers designed into the locating devices. (See Figure 4.) Because the cellular network is being used, device performance inside and outside of large buildings is much improved over regular GPS locator systems.

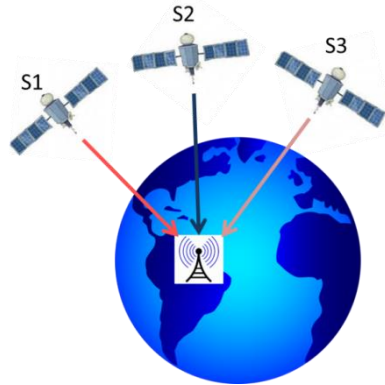


Figure 4

An increasing number of companies are offering devices that combine the collecting of A-GPS coordinate data and the location-based mapping service (LBMS). The inclusion of LBMS allows caregivers to not only locate the wandering individual but also see the path that the individual had taken displayed on a map over the Internet.

The advantages of using A-GPS are that the wandering individual can be located on a map over the Internet and the map can be accessed using a smart phone or a computer. Locator device designs are small and can be worn as a watch or placed in the sole of a shoe (Appendix II). A-GPS is accurate within 50 meters when used inside buildings and 15 meters outside.²⁶

The disadvantage of using A-GPS is that if the wandering individual is in an area with low cell phone coverage, then the location of that individual may become intermittent, causing the rescue to become more challenging. A monthly fee is charged when the device requires cellular service for sending alert emails and text messages.

Global System for Mobile Communications (GSM)

The GSM network standard was developed by the European Telecommunications Standards Institute (ETSI) and is on the second-generation (2G) network. The GSM network has both network-based and handset-based locating technology.

E-OTD is a device-based positioning method. E-OTD determines positioning by subtracting the difference between the observed time differences and the real time difference. Location accuracy ranges from 50 to 500 meters.²⁷

U-TDOA is a network-based positioning method that uses highly sensitive receivers attached to cellular base stations. The receivers are referred to as Location Measurement Units (LMUs). Since U-TDOA is a network-based technology, not device-based, LMUs that use the U-TDOA methodology do not need to have additional location-related circuitry designed into the device. To calculate the position of the device using U-TDOA, multiple time-synchronized LMUs receive device signals and report data, including device frequency, cell site, and time.²⁸ The Time Difference of Arrival (TDOA) of the signal is derived through complex mathematical calculations. The identified location is based on the known placement of the LMUs and the TDOA of the signals. The more LMUs used to calculate the positioning, the more accurate the calculation will be. Accuracy using U-TDOA technology ranges from 50 to 100 meters both inside and outside of buildings.

The advantage of using the GSM network is that it is a mature technology and is in use worldwide. The disadvantage of the GSM network is that it is in the 2G network and is being replaced by the 3G (UMTS) and the 4G (LTE Advanced) networks. The 2G network will be slowly phased out by major carriers such as AT&T, T-Mobile, and Sprint in the United States starting in 2016.²⁹

Wideband Code Division Multiple Access (W-CDMA)

W-CDMA is a network standard in the 3G network and is a handset-based system. The GSM network uses E-OTD to calculate positioning, whereas the W-CDMA network uses

O-TDOA. This handset-based system uses a navigation technique called multilateration, in which the device receives signals from more than two cellular towers and calculates the location of the handset.

When using the W-CDMA network, base stations transmit on the same frequency, which can cause co-channel interference. The signal from the closest base station dominates and can impair measurements from weaker base stations.³⁰

The advantage of using the positioning technologies on the 3G network is that it is a more up-to-date network than 2G. It is estimated that major carriers will continue to use this network until by 2021.

Appendix I

Passive Products (Currently Available)

Information Bracelets and Bands
American Medical ID
(http://www.americanmedical-id.com/marketplace/category.php?sel_pullid=340)



Information Bracelets and Bands
Sticky Jewelry
(<http://www.stickyj.com/personal-health-record-phr-system.html>)



USB Medical Information
American Medical ID




USB Medical Information
Sticky Jewelry



Information Cards

Free Information card provided

American Medic ID

 EMERGENCY MEDICAL IDENTIFICATION	
Medical I.D. for: _____	
Address: _____	
City: _____	St: _____ Zip: _____
Emergency Contact: _____	
Phone#: _____	
Physician: _____	
Physicians Phone: _____	
Contact Lens: Yes No Blood Type: _____	
Medical Conditions - Allergies	
Medical Conditions: _____	

Dangerous Allergies: _____	

Generate Med-ID Card - Save It - Update It at MedIDs.com	
Medications	
Name	Dose/Color/What for/When to take
_____	_____
_____	_____
_____	_____
_____	_____
Other: _____	
Courtsey of MedIDs.com - Medical Info Products.com	



USB Information Card







Sticky Jewellery

Appendix II

Active Locator Devices (Currently Available)

Locating with Radio Frequency		
Company	Device	Information
<p>Project Lifesaver</p>	 <p>Radio Frequency (216MHz) locating device</p> <p>Various band colors offered</p>	<ul style="list-style-type: none"> • Rescue and equipment training to law enforcement and public safety entities • Secure database for clients • Radio frequency search • Rescue equipment • Law enforcement involvement • Includes lightweight YAGI antenna for location • Car mount Omni antenna for location • 30–60 day battery life depending on product • Approximately \$300 for locating bracelet
<p>Safety Net LoJack</p>	 <p>Radio Frequency (216MHz) locating device</p> <p>Various band colors offered</p>	<ul style="list-style-type: none"> • Equipment training to law enforcement and public safety entities • Secure database for clients • Radio frequency search • Rescue equipment • Law enforcement involvement • Includes lightweight YAGI antenna for location • Car mount Omni antenna for location • 30–60 day battery life depending on product • \$30.00 monthly, \$99.00 enrollment

Active Locator Devices (Continued)

Locating with GPS and AGPS		
Company	Device	Information
Project Lifesaver PAL (Protect and Locate)		<ul style="list-style-type: none"> • RF (433MHZ) invisible boundary, cellular and GPS. • Includes digital watch and portable receiver • \$46.00 monthly fee • Notification email and/or text • Mapping tracking
Keruve		<ul style="list-style-type: none"> • GPS only • GPS receiver included • No cellular fee • Rechargeable battery life of 3.5 days • System cost: \$1499
GPS Smart Shoe GTX Corp. (available through Aetrex)		<ul style="list-style-type: none"> • A-GPS • Geo-fence based • Mapping tracking • Notification via email or SMS text to mobile phone • Shoe cost <\$300; tracking plan as low as \$19.99
Comfort Zone		<ul style="list-style-type: none"> • Device to be carried in pocket or purse • Cellular service requirement • Alerts via text and email • Care consultation • Call center • \$42.99/month with \$45.00 activation fee
Tracking System Direct		<ul style="list-style-type: none"> • Locking band option • Working wristwatch • Panic button safety feature • Geo-fence based • Two-way voice (communications available to wanderer) • Real-time tracking & two-way voice communication: \$29.95/month

Acronyms

IACP	International Association of Chiefs of Police
AD/D	Alzheimer's Disease/Dementia
SMS	Short Messaging Service
TTY/TDD	TeleTYpe/Telecommunications Device for the Deaf
EMS	Emergency Medical Services
RF	Radio Frequency
RFID	Radio Frequency Identification
GPS	Global Positioning Systems
A-GPS	Assisted Global Positioning Systems
GSM	Global System for Mobile Communications
USB	Universal Serial Bus
ID	Identification
A-GPS	Assisted Global Positioning System
E-OTD	Enhanced Observed Time Difference
O-TDOA	Observed Time Difference OF Arrival
U-TDOA	Uplink-Time Difference of Arrival
VHF	Very High Frequency
YAGI	A type of antenna (not an acronym)
kHz	kilohertz
WI-FI	A type of network (not an acronym)
IEEE	Institute of Electrical Engineering
WLAN	Wireless Local Area Network
SIS	Signal-in-Space
LBMS	Location-Based Mapping Service
ETSI	European Telecommunications Standards Institute
2G	Second-Generation Network
OTD	Observed Time Differences
RTD	Real Time Difference
LMUs	Location Measurement Units
TDOA	Time Difference of Arrival
UMTS	Universal Mobile Telecommunications System
LTE	Long Term Evolution

References

- ¹ Alzheimer's Foundation of America, *About Alzheimer's*, <http://www.alzfdn.org/AboutAlzheimers/definition.html>.
- ² U.S. Department of Health and Human Services, *National Institute on Aging, Alzheimer's Basics*, <http://www.nia.nih.gov/alzheimers/publication/home-safety-people-alzheimers-disease/what-alzheimers-disease>
- ³ Blossom Stephan and Carol Brayne, *Prevalence and projections of dementia*, pg. 20, <http://mcgraw-hill.co.uk/openup/chapters/9780335223756.pdf>
- ⁴ *Alzheimer's Association, Types of Dementia*, <http://www.alz.org/dementia/types-of-dementia.asp>
- ⁵ Alzheimer's Association, *Causes of Dementia*, <http://www.alz.org/what-is-dementia.asp>
- ⁶ Alzheimer's Association, *Causes of Dementia*, <http://www.alz.org/what-is-dementia.asp>
- ⁷ All information provided in Figure 1.0 was taken from Medical News Today, What is Alzheimer's disease? What Causes Alzheimer's disease, <http://www.medicalnewstoday.com/articles/159442.php>
- ⁸ Alzheimer's Association, *Safe Return*, http://www.alz.org/texascapital/in_my_community_14229.asp#Facts_on_wandering
- ⁹ Alzheimer's Association, *2011 Alzheimer's Disease Facts and Figures, Alzheimer's and Dementia*, [Vol.7, Issue 2.] (Nov.2012)
- ¹⁰ Yu, Winnie, Fisher Center for Alzheimer's Foundation, *Reduce the Risk of Wandering*, <http://www.alzinfo.org/02/alz-guide/reduce-risk-wandering>.
- ¹¹ Yu, Winnie, Fisher Center for Alzheimer's Foundation, *Reduce the Risk of Wandering*, <http://www.alzinfo.org/02/alz-guide/reduce-risk-wandering>.
- ¹² Mayo Clinic Staff, Mayo Clinic, *Caregiver depression: Prevention counts*, <http://www.mayoclinic.com/health/caregiver-depression/MY01264>.
- ¹³ International Association of Chiefs of Police, *Missing Persons with Alzheimer's Disease Model Policy*, www.theiacp.org/portals/0/pdfs/AlzheimersMissingPersonsPolicy.pdf
- ¹⁴ Hurt, L. (November 2011), Understanding and Helping Drivers with Alzheimer's Disease, *The Police Chief Magazine*, IACP. Available at www.policchiefmagazine.org/magazine/index.cfm?fuseaction=display_arch&article_id=2535&issue_id=112011.
- ¹⁶ Project Lifesaver International, PLI-5000 Receiver Owners Guide.
- ¹⁷ Project Lifesaver International, PLI-5000 Receiver Owners Guide.
- ¹⁸ Project Lifesaver International, 2,600 Rescues Another Milestone Reached!, <http://www.projectlifesaver.org/2012/12/10/2600-rescues-another-milestone-reached/> (Nov 2012)
- ¹⁹ RFID Journal, The Basics of RFID Technology, <http://www.rfidjournal.com/article/view/1337/2>.
- ²⁰ RF Code White paper, An Analysis of Active RFID for Asset Tracking, Page 1, (January 2010).
- ²¹ RF Code White paper, An Analysis of Active RFID for Asset Tracking, Page 5, (January 2010).
- ²² Global Positioning System - *Standard Positioning Service Performance Standard*, <http://www.gps.gov/technical/ps/2008-SPS-performance-standard.pdf> (September 2008).
- ²⁴ Harvey Mudd College, How does GPS work?, <http://www.physics.hmc.edu/research/geo/gps.html#2>.
- ²⁵ Global Positioning System Standard Positioning Service Performance Standard, 4th Edition (September 2008) Page v.
- ²⁶ Goran M Djuknic and Robert E Richton, Bell Laboratories, Lucent Technologies. Geolocation and Assisted GPS page 123-125.
- ²⁷ Costabile, Jim, Virginia Tech Wireless Symposium, Wireless Position Location, Page 21 (June 2010).
- ²⁸ Costabile, Jim, Virginia Tech Wireless Symposium, Wireless Position Location, Page 27 June (2010).
- ²⁹ Wireless Intelligence, Spectrum refarming at 1800 MHz key to LTE device adoption, <https://wirelessintelligence.com/analysis/2012/09/spectrum-refarming-at-1800-mhz-key-to-lte-device-adoption/349/>.
- ³⁰ Costabile, Jim, Virginia Tech Wireless Symposium, Wireless Position Location, Page 25 (June 2010).