

## **Conversational Assistants for Quality Long-term Care In-Home**

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Technology for in-home long-term health care is rapidly becoming more elaborate and effective, but also more expensive and difficult to use. As a result, economics factors inhibit the use of effective treatments. For instance, it has been shown that readmission rates for patients who have experienced congestive heart failure can be significantly reduced with close home monitoring of patients by a nurse practitioner<sup>1</sup>. However, such procedures are prohibitively costly when considering the number of patients expected over the next decade. The long-term goal of this project is to develop automated in-home conversational assistants that can help patients manage their treatment and monitor their health. Dialogue systems for health communication hold out the promise of providing intelligent assistance to patients through natural interfaces that require no training to use. But in order to make the development of such systems cost-effective, we must be able to use generic techniques and components which are then specialized as needed to the specific health problem and patient population. We will demonstrate a prototype system, Chester, an intelligent assistant that interacts with its users via conversational natural spoken language to provide them with information and advice regarding their prescribed medications. While Chester is applied to the prescription compliance problem, the technology is generic and can be adapted for use in many other applications in the home, including the support of enhanced self-monitoring of diseases and conditions.

Prescription compliance is a significant problem, particularly for older people living at home who tend to have both complex medication schedules and, often, somewhat reduced cognitive faculties. Not only are patients taking more pills, but because of the increased specialization of medical practice and the way patients are assigned to specialists, prescriptions tend to be assigned by different providers at different times. The New York Times has labeled noncompliance the world's "other drug problem".<sup>2</sup> By providing a user-friendly, intuitive, interface, conversational systems such as Chester hold great promise for greatly enhancing the quality of health care in a cost effective manner in-home. Chester allows a person to speak in normal conversational speech, and the system is easily configured to handle different modes of interaction, such as speech via a telephone-like device, or interacting with a computer graphical interface using speech and/or keyboard. Chester is currently a research prototype, and work is planned to demonstrate its usability and medical effectiveness over the next five years.

<sup>1</sup> Mary Naylor, Transitional Care of Older Adults Hospitalized with Heart Failure, J.Amer. Geriatric Society, 52:675-684, 2004

<sup>2</sup> Abigail Zuger, The 'Other' Drug Problem: Forgetting to Take Them, The New York Times, June 2, 1998

**OneTouch System**  
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SNFs for the most part are hampered with the inefficient and outdated paper and pen mode of charting and manual record keeping; the result of which is less than optimum patient care, poor documentation, increasing liability exposure and no aid to nurse shortage and staff morale. In addition, the long term care industry operators experience constant financial pressure through constrained margins, due largely to increasing demands for new expenses and cost increases combined with the highly regulated and controlled revenue from the dependency on government payment programs.

OneTouch is the pioneer in integrating sophisticated and user friendly technology with the business of SNFs – clinical operations. Heretofore, software offerings to the LTC industry have focused on financial systems. By offering full electronic charting at the point-of-care the OneTouch System provides: full staff accountability, a date and time stamped record of care to assist in liability cases and to support billing; a full Electronic Medical Record available in real time for all caregivers; a medication administration control system to minimize medication errors; and the ability to integrate with disparate systems and thereby share the clinical information with billing systems, pharmacies, physicians, and hospitals etc. We propose to help revolutionize the government's survey and audit processes by making the clinical records available electronically and remotely.

Another transforming feature is the extensive installation and training support combined with a 24/7 help desk and monthly on-site QA visits. Finally, the OneTouch System offers its customers an attractive return on its investment in technology that is measured in months rather than years and contributes significant relief from the strained current financial structure of the industry. A two-year CMS funded study of the impact of OneTouch on patient care and facility efficiencies has concluded recently. A full report to be issued by the Missouri Sinclair School of Nursing is expected in early fall 2005. Preliminary results suggest improved patient care resulting from use of the OneTouch System.

Results from the customers indicates improved revenue, reduced nurse turnover, increased nurse efficiencies and improved documentation to aid in mitigation of possible liability claims and in audits and surveys. Annual economic benefits per facility range from \$200,000 to \$600,000 depending on the facility which results are an order of magnitude greater than costs to acquire and maintain the system.

## **Geriatric Risk Assessment Med Guide**

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The Geriatric Risk Assessment Med Guide™ (GRAM™) is a unique clinical software tool that identifies medications that may cause, aggravate, or contribute to common geriatric problems, such as falls, incontinence, and cognitive loss. The GRAM™ software is being studied in a three-year research project funded by the Agency for Health Care Research and Quality (AHRQ), U.S. Department of Health and Human Services. The study will evaluate the use of the GRAM™ software and quantify its effect on reducing the incidence of falls and delirium due to adverse medication effects (ADEs) in nursing facility residents.

Of the nearly 2 million ADEs suffered by older persons each year, nearly one-third are preventable. Of the life threatening, fatal ADEs that occur, more than one-half are preventable. Errors associated with ADEs occur most often at the prescribing and monitoring stages of the medication use process. Recommendations by experts to reduce the risk include systems to promote early recognition of ADEs, and improved education on the signs and symptoms of ADEs. Most efforts to reduce medication errors have focused on prescribing, dispensing, or medication administration; few have targeted the monitoring stage of the medication use process. The AHRQ/GRAM™ study is unique in that it focuses on the monitoring stage of the medication use process, to foster early recognition of potential adverse medication effects that can be avoided, managed, or reversed. In addition to identifying medications that may cause, aggravate, or contribute to geriatric problems, GRAM™ also provides medication monitoring recommendations (relevant indicators of adverse medication effects) for problems the medication regimen puts the patient at greatest risk for. GRAM™ was developed based on the federally-mandated Resident Assessment Instrument's Minimum Data Set (MDS) and Resident Assessment Protocols (RAPs), which is required in all Medicare- and Medicaid-certified nursing facilities. GRAM™ can assist in the problem identification and clinical decision-making process when evaluating complex medication regimens of geriatric patients, regardless of where they reside.

The AHRQ/GRAM™ study is a randomized-controlled trial involving 26 nursing facilities (13 intervention and 13 "usual care") served by two pharmacies in Ohio. The GRAM™ database was integrated into the pharmacies' commercial pharmacy software system, which generates GRAM™ reports based on the resident's medications. Two GRAM™ reports were used in the study: (1) the GRAM™ RAP-Med Report, which can inform the resident assessment process by identifying which problems the resident's medication regimen puts them at greatest risk for; and (2) the GRAM™ Triggered RAP-Med Report, for use by the consultant pharmacist when reviewing the drug regimen of residents who have or are at risk for a fall and/or delirium based on the assessment. Medication Monitoring Care Plans and Flow Records were developed for falls and delirium, and implemented for newly admitted residents receiving medications that may cause, aggravate, or contribute to these problems. Inservice programs for nursing staff were conducted to review medications and medication effects that cause,

aggravate, or contribute to the risk for falls and delirium; and reinforce the importance of early observation for signs and symptoms of ADEs.

The consultant pharmacist provided a targeted drug regimen review for residents who triggered the Falls and/or Delirium RAP, including evaluating the resident's medications for the potential to cause, aggravate, or contribute to the risk for falls and/or delirium; making and documenting appropriate therapeutic recommendations to the prescriber based on the evaluation; and reviewing the prescriber recommendations and any changes to Medication Monitoring Care Plan and Flow Record with the nurse. The evaluation of the study will rely on the use of existing data. MDS data will be obtained from the state and used to identify new onset delirium, the presence of indicators of delirium, and the occurrence of a fall. Hospitalization data will be obtained from CMS and used to determine the incidence of hospitalizations due to adverse medication effects, falls, and drug-induced delirium. Pharmacy claims data and pharmacist intervention data will be obtained from the pharmacy provider. In addition, staff of the nursing facilities and pharmacy were surveyed regarding the impact of GRAM™ on efficiency, productivity, workload, and job satisfaction. The early response to the intervention from nursing facility staff, especially MDS nurses, was very positive. The GRAM™ RAP-Med Report is generally viewed as a valuable tool in the resident assessment process. Many nurse assistants embraced the added responsibility of observing for adverse medication effects and charting their findings in the Flow Records. The observations charted on the Flow Records provide documentation for use in the admission assessment. The consultant pharmacists now incorporate findings from the resident assessment into their therapeutic recommendations. We believe the study will demonstrate the value of GRAM™ as a tool to enhance the problem identification process when evaluating complex medication regimens in nursing facility residents; raise awareness of medications as a potential cause or aggravating factor contributing to a resident's physical, functional, or cognitive decline; inform the Resident Assessment process; and foster incorporation of medication monitoring information into the resident's plan of care.

## **Intelligent Mobility Platform**

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The IMP (short for Intelligent Mobility Platform) is an assistive device for older adults who have trouble getting around. Developed at Carnegie Mellon and U. Pittsburgh and based on a commercial rollator-style walker frame, it includes robotic enhancements that allow it to "see" where it is and move around under its own power. These enhancements include a scanning infrared rangefinder, motors, position sensors, and a PDA-style display and input device. The robotic enhancements allow the IMP to provide advanced features such as:

- **Directions.** While it is being used in an extended care center, the IMP can guide its user via text, graphical, and/or voice prompts to locations like the physical therapy center, the library, or the hair salon.
- **Autopark.** When the user sits down and wants to get the IMP out of the way, he or she can press a button on the PDA to have the IMP park itself in a nearby corner. Pressing another button causes the IMP to return and position itself to help the user get out of the chair.

We are currently working on adding more features which take advantage of the IMP's unique capabilities, including:

- **Power assist** We will monitor the forces which the user applies to the walker, as well as the slope of the underlying terrain, and add power from the motors to make the walker feel lighter than it is. This power-assist function will help users walk farther, more safely, and without getting as tired.
- **Gait monitoring** We will analyze the user's foot placement and the forces which he or she applies to the walker to try to catch problems such as impaired balance or unsafe walker-use habits before they cause falls or
- **injury.**

**SilverSneakers**  
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SilverSneakers, a program of HealthCare Dimensions, offers an innovative blend of physical activity, healthy lifestyle and socially oriented programming that allows older adults to take greater control of their health. SilverSneakers members receive:

- A free fitness center membership at a nearby participating location with access to conditioning classes, exercise equipment, pool, sauna and other available amenities.
- Access to any participating fitness center throughout the U.S. while traveling.
- Customized SilverSneakers classes designed exclusively for older adults who want to improve their strength, flexibility, balance and endurance.
- Health education seminars and other events that promote the benefits of a healthy lifestyle

The SilverSneakers Fitness Program is a proven, results-oriented program that enables older adults, often burdened with chronic conditions, to take charge of their health and maintain an active, independent lifestyle.

HealthCare Dimensions (HCD) is a health management company that designs and delivers unique physical activity and preventive health interventions that help improve health, manage risk and reduce health care costs. HCD's programs are targeted to specific populations and are sold to health plans, insurance companies and employers.

**BOB'S "HIGH-TECH" ROOM: Telemedicine Suite for Parkinson's Disease**  
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Below is a brief summary of technologies (developed at the Presbyterian Home for Central New York) and currently being used in an existing room (Bob's Room) to enhance the independence of people with Parkinson's. It is a pilot project using various technologies that could be used in any residence by persons with Parkinson's. Design a room that would provide visual and auditory cues that would help break a freeze (inability to take a step, initiate movement) that Bob experiences due to his Parkinson's disease.

Use of voice recognition technology – Bob has a voice-activated entertainment center with a home theater and a panoramic music system complete with a subwoofer at the foot of Bob's bed. It is unique in that it is both a clinical tool and, as an enhancement of Bob's independence, it's all controlled by voice recognition technology. When Bob experiences a freeze, he can tell the entertainment center to play his favorite polka music with a heavy beat sometimes breaks the freeze. Visual cues, such as light from a lamp turning on or window blinds opening, can also break one of Bob's freezes. A lamp was purchased (only \$10) that turns on and off when tapped.

A technology consultant, John Miullo, hooked up many of the "anti-freezing" devices to a "command console" purchased from [www.smarthome.com](http://www.smarthome.com). The command console is an infrared module that's compatible with a voice-recognition device that sends signals over power lines to control a number of objects in the room (from the air conditioning and heating to the doors, windows, lights, fans, vertical blinds and the entertainment center).

Independence in bathroom use for Bob enhances his dignity and reduces the chance of infection. Mr. Miullo wanted to use infrared proximity switches to turn the sink water on and off with the pass of a hand or trigger a toilet to flush when a person stood up. The proximity switches he found were expensive (\$300-\$400) and only had a 2" area that you could "see" where movement would trip it to operate. Not only was the cost high, but the limited range would be frustrating for those with movement disorders. After an extensive search, a switch was found that can be tripped with movement within 8" and it cost only \$26. It also had an advantage of a manual bypass and could be tripped with a remote control beam. Using the switches and other devices, the bathroom is totally automated, electric soap and towel dispensers, tank toilet with manual and electronic flush. A bidet toilet seat (\$400) was installed so residents would be able to wash and dry if their movement disorders made the kind of self-care difficult.

Due to the high number of medications Bob was on, he was thirsty much of the time. Frequent calls were made to nurses to pour water. An automated infrared drinking fountain was put in Bob's room. He is now able to independently hydrate himself and allow nursing to use their time more efficiently. In addition to the technology infusion,

Bob's room was totally overhauled – safer flooring to cushion falls and walls padded to reduce the risk for serious injury.

Telemedicine can be described as the use of communication equipment to link patients and healthcare practitioners in different locations. The advantage of using this technology by providers includes increased cost efficiency, reduced transportation costs, improved patient access to specialists, improved quality of care and better communication among providers.

The computer is the heart of the system. The computer handles the communications, video, data and control aspects of the telemedicine suite. The diagnostic equipment is interfaced with the computer so that readings could be automatically recorded and transmitted to the physician/physicians on the other end.

The telemedicine suite includes a telemedicine work station developed by Dr. Ed Lipson, who is the CEO of SenSyr, LLC, and Chair of the Physics Department at Syracuse University. This cost-effective system includes off-the-shelf, low-cost commercial products. Collabworx video conferencing software (multi-point sites connected via a video bridge) was purchased and the other required elements include sufficient internet bandwidth using internet protocol (low cost), a computer system, a video digitizer and a microphone/headset.



## **Smart In-Home Monitoring System**

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The majority of the growing elder population, in the US and the rest of the world, requires some degree of formal and/or informal care either due to loss of function or failing health as a result of aging. According to findings of the Center for Disease Control, nearly three quarters of elders over the age of 65 suffer of one or more chronic diseases. The cost and burden of caring for elders is steadily increasing. If given the choice, many elders would prefer to lead an independent way of life in a residential setting with minimum intervention from the caregiver (i.e. to age in place).

On the other hand, the role of informal caregivers in providing care to the elder population has greatly increased over the past two decades in the US, due to change in the Medicare system, and has resulted in shifting the responsibility for care during recuperation, rehabilitation, and long-term disability from institutions to individuals and families in the community. Consequently, informal caregivers have come to be viewed as nurse-extenders, providing most of the nursing care to elders in long-term care. In fact, national data bases derived from different sources have provided unequivocal evidence that family and friends are the sole care providers for about three quarters of all community-dwelling elders.

The shift of long-term elder care responsibility to informal caregivers has increased their physical, financial burdens and emotional strains. A national study reports that 15% of caregivers admit to having physical or emotional health problems directly related to caregiving and that more women caregivers than men reported emotional stress and impaired physical health. It would be universally beneficial to lessen the burdens on the caregivers and to increase quality of care and quality of life issues for the elders. To this end, Medical Automation Research Center (MARC), at the University of Virginia, has developed technological solutions for in-home monitoring of residents in order to provide quality of life indicators. The in-home monitoring system is composed of a suite of low-cost, non-invasive sensors (strictly no cameras or microphones), and a data logging and communications module, in addition to an integrated data management system, linked to the Internet. We have generated preliminary data from an activity monitor that logs the activities of the subjects onto a computer database.

Using the appropriate data analysis tools, important observations can be made from the activity data generated by the monitored individual. These observations include: general health and activity levels, Activities of Daily Living (ADL), most Instrumental Activities of Daily Living (IADL), index of well-being, and a measure of the decline in ability over time. These observations may yield early indicators of the onset of a disease. Additionally, a sudden change of activity (or inactivity) can indicate an accident. Although the system is not meant as an emergency prompt system, the caregiver may receive alerts over the Internet or urgent notifications over the phone in case of such sudden accident indicating changes. Software tools can generate reports of health/

activity indicators and the overall well being of the individual. Moreover, the system will provide a confirmation of activity levels; thereby encouraging reality based decision-making. Feedback reports can be sent to monitored subjects, their designated informal caregiver and their health care provider. Feedback to the individual can encourage the individual to remain active. The content of the report may be tailored to the target recipient's needs, and can present the information in a format understandable by an elder person unfamiliar with computers, via an appealing user interface. Whereas feedback to the informal caregiver (family or friend) will provide them with peace of mind if their loved ones are doing well, and will improve the social content in their interactions with their elders. Hence, the informal caregiver will have access to the health and well-being status of their elders without being intrusive, having to call or visit to get such information interrogatively.

Additionally, formal care providers will receive a report on the health of the monitored subjects that will help them evaluate these individuals better during the short routine check up visits. The monitoring system integrates a low-cost, low-power, physiological sensor-suite that can passively acquire important physiological and environmental characteristics. The MARC research team has completed preliminary proof-of-concept of the bed monitor system, with added value in its ability to be deployed to collect data remotely. The bed monitor system will allow subjects to simply lie on a mattress pad, embedded with sensors, to obtain multidimensional data. The data collection sets can be selected to include: body temperature, heart rate, respiration rate, positional mapping and movement; additional development work is being done to monitor airflow. Furthermore, the system can also measure environmental conditions in the immediate surroundings including ambient light level, humidity, and temperature. Once validated, the bed monitor can be used as an effective screening tool for sleep quality assessment, identifying sleep disorders that require a detailed, clinically administered sleep study, as well as an aid to clinicians in the in-home longitudinal assessment of prescribed treatments to relieve sleep problems. Furthermore, the system's ability to accurately monitor these important physiological characteristics and sleep longitudinally will provide an individual baseline that can be utilized for assessment purposes, such as detection of trends and changes.

Furthermore, the system integrates a passive gait monitor that comprises a highly sensitive and selective sensor technology that is capable of measuring footfalls on the floor. The sensor's output signal will create a unique signature based in part on the individual's weight, gait, stride and average pace. The signal is then stored for establishing a baseline for the individual. Using this established baseline, analysis and comparison of gait patterns can be made over time. Consequently, gradual deviation from the baseline pattern can be detected, implying a change in an individual's health status, either for better or worse. A gait change that might predict a fall (such as the appearance of a pronounced limp) can prompt an automatic alert from the monitoring system to notify the individual, their informal caregiver and the formal health care provider, using a communications interface, such that a preventive intervention may be taken. Additionally, a detected fall followed by no gait signal indicates a situation where the user is potentially unconscious or unable to initiate an emergency call. In such a case the monitoring system can be preprogrammed to alert the caregivers, via e-mail, instant

messaging or phone to check up on their elders. Thus, the Gait Monitor operates in concert with “pendant” type alert systems but does not replace such emergency response devices. Preliminary tests on this Gait Monitor have demonstrated extremely encouraging results. The device has thus far proven capable of differentiating normal gait from, shuffling, limping, tiptoeing, as well as detecting change in pace, reduced stability (balance) and falling.

It is anticipated that the use of this technology will result in:

- Improved informal care effectiveness without increasing intrusion.
- Reduced cost of informal care, which is particularly high for older adult populations.
- Reduced burdens on the informal caregiver, and hence reduced stress and improved mental and physical health conditions.
- Involving the care recipient in health promoting activities and decision-making.
- An extended healthy, active and dignified life for the elders that can be widely accessible to the low-income strata of society.
- Delayed admittance to specialized institutions, and hence a reduced cost of formal elder care.
- Reduced formal care burdens, and hence improved formal care.

MARC Smart In-Home Monitoring System has the following unique characteristics:

- Implemented in simple low-cost sensor technology, which makes it affordable to the lowest 30% of income earners.
- Adaptively retrofits into existing home structures, with minimal impact, modification and cost.
- The data-mining component yields unique health status reports that can be made available to the occupants, their medical advisors and their family members.
- The system is customizable to the individual s needs, as well as different cultural needs.

**MIT House\_n Research Consortium**  
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*PlaceLab*

The House\_n research group of MIT and TIAX, LLC have developed the PlaceLab - an apartment-scale shared research facility where new technologies and design concepts can be tested and evaluated in the context of everyday living. Current PlaceLab research projects include the proactive encouragement of healthy behaviors related to exercise and medication adherence.

*MITes (MIT Environmental Sensors)*

House\_n researchers have developed a collection of small, portable, and inexpensive wireless sensors, wearable devices, and associated algorithms and methodologies enabling MIT researchers and sponsors to conduct research in everyday places of living. MITes are particularly useful for the prototyping and testing of proactive health systems in the home.

**Remote Monitoring Technology**  
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Quality in the 21st century will be driven by all stakeholders' access to information, which is timely and pertinent. Although technology is a mechanism of independence, without purpose there are consequences of disassociation and isolation. The purpose of Elite Cares' technology is to create a medium of connection and relationship thru transparency. Transparency for all stakeholders, allows for mutual peace and synergy in this system. Physician, (P) Extended Family (E), Administration (A), Caregiver (C) and Elder (E) = PEACE

Our transparency is a real time feedback system, which allows information on how well the environment, and resident are doing, to be viewed at the same time by everyone involved. The transparency and the quality of this information allows for close relationships and peace to develop between the facility, physician, caregiver, resident & extended family. The demographics demand that long-term care has to be a working partnership of everyone involved. All of us are going to have to take an active role, if we are to adequately be of service to our elders. Information has to be timely and accurate on a real time basis for this relationship to occur.

Our demonstration shows an integrated subject monitoring system. This system measures, collects and analyses data pertaining to the health status (mental and physical) as well as the quality of life of a subject, while being unobtrusive and friendly. A network-coupled computer and subsystems monitors a subject location within a defined space obtaining measurements of a subject's physiological or behavioral/cognitive parameters within the defined space as well as the responsiveness of that space. Parameter data is obtained primarily passively, without the cooperation or active participation of the subject or caregivers. Subject health and environment indicia parameters are continuously monitored, sampled and recorded. We will be demonstrate a few specific parts of our system:

- Web based, real time data. This data shows how well our residents and facility are doing. This is real information, which is currently available to residents; resident approved family members, caregivers and management. This information is helping us form strong working relationships with all stakeholders, lowering our labor cost, reducing our liability, while increasing the quality of our elder's lives.
- Our bed monitoring system co-developed with OHSU (Oregon Health Sciences University), which measures weight, restlessness, and duration in bed, frequency and length of stays as well as anticipating when you are getting out of bed. If you are at fall risk, a caregiver can be notified, or a walker can light up so you remember to use it, thus minimizing fall risk.

- A system, which can alter the environment, depending on needs i.e. turn on lights when needed and anticipate the level of those or even their color. (At night it is better to turn on red lights so that the enzyme in the back of your eye is not excited which wakes you up and tells you to get up and wander).
- A wander alert, which notifies if a person is on the move, and needs to be monitored or diverted.

**It's Never 2 Late**  
**Jack York, It's Never 2 Late**  
**Englewood, CO**  
**Online at [www.in2l.com](http://www.in2l.com)**

The mission of It's Never 2 Late (IN2L) is to link seniors, older adults with disabilities, and caregivers with technology. IN2L has been an innovator in a movement within the senior living industry to fully leverage technology to help address its quality of life, care and resource issues. For more than five years IN2L has been integrating the various hardware, software, media, ergonomic and adaptive components necessary to allow virtually any person with any interest in using a PC-regardless of background, physical or intellectual abilities. Its systems allow seniors as well as their family and professional caregivers to take full advantage of the communication, information, recreation and therapeutic potential of truly personal computers. IN2L has been recognized nationally for this pioneering work.

IN2L brings the benefits of unprecedented advances in computer technology and the Internet to older adults, by equipping nursing homes, assisted living communities and adult day centers with multi-user, ability-adaptive systems, coupled with comprehensive hands-on training. Longer term, IN2L intends to supply systems to seniors living independently, as the critical technology centerpiece of a support system that enables people to age in place. IN2L's approach involves working closely with technology and content partners to develop its unique programs, and working with its customers as partners to ensure those programs produce maximum benefit. These benefits center on maintaining individual dignity and independence for seniors, while at the same time improving quality of care and reducing care burdens and costs for housing and service providers.