The CERT was established to address one of our country’s greatest challenges in the exponential growth of the aging population. This report reviews the objectives of the center, the productivity history, and strategies going forward for achieving a sustainable interdisciplinary center.

1. **Mission**

   To create technology for proactive healthcare that helps older adults and people of all ages and needs, to lead healthier, more independent lives

2. **Objectives**

   The objectives of the Center follow the four missions: teaching, research, service, and economic development, as listed below:

   - Train students to do innovative research within an interdisciplinary team
   - Driven by actual clinical needs, develop new healthcare technologies and evaluate them in realistic settings
   - Advance, promote, and disseminate healthcare technologies to the world at large
   - Translate new technologies to commercialization to serve consumers

3. **Commercialization strategy**

   To truly make an impact on the lives of the people we serve, we must translate the best of the research into the commercial marketplace. Towards this goal, we have established a pipeline to commercialization as shown in the figure below. The process begins and is driven by the clinical needs, to ensure that the technology solutions developed have clinical relevance.

   ![Diagram](https://via.placeholder.com/150)

   **Fig. 1. The pipeline to commercialization includes validation in the lab (with gold standard measurement systems) and in the field (e.g., in TigerPlace apartments).**
Patents Applications and Invention Disclosures

Numbers 1-5 below have been licensed by Foresite Healthcare.


4. Academic departments involved

The following academic departments have been involved in the current interdisciplinary efforts. More will be added as new areas are identified.

- College of Engineering
  - Electrical Engineering and Computer Science
  - Mechanical Engineering
- Sinclair School of Nursing
  - Aging in Place project and clinical team at TigerPlace
  - Sinclair Home Care
  - Sinclair@Home
- School of Medicine
  - Health Management and Informatics
  - Family and Community Medicine
  - Orthopaedic Surgery
  - Cardiology
  - Psychiatry
  - Otolaryngology
- School of Health professions
  - Physical Therapy
  - Occupational Therapy
  - Health Psychology
- College of Human Environmental Sciences
  - School of Social Work
  - Architectural Studies
- School of Music
- School of Information Science and Learning Technologies
5. Faculty and Staff

Personnel
- Marjorie Skubic, Director
- Noah Marchal, Programmer/IT support
- MU Advisory Board: Marilyn Rantz, Jim Keller, Mihail Popescu, Prasad Calyam

MU Researchers Involved
- College of Engineering
  - Jim Keller, EECS
  - Dominic Ho, EECS
  - Prasad Calyam, EECS
  - Noah Manring, Mechanical Engineering
  - Zhihai (Henry) He, EECS
  - Scott Kovaleski, EECS
  - Giovanna Guidoboni, EECS
- Sinclair School of Nursing
  - Marilyn Rantz
  - Laurel Despins
  - Kari Lane
  - Greg Alexander
  - Bonnie Wakefield
- School of Medicine
  - Mihail Popescu, Health Management and Informatics
  - Richelle Koopman, Family and Community Medicine
  - Aaron Gray, Family and Community Medicine
  - Jay Bridgeman, Orthopaedic Surgery
  - Seth Sherman, Orthopaedic Surgery
  - Cristina Danila, Cardiology
  - John Lauriello, Psychiatry
  - Arnaldo Rivera, Otolaryngology
- School of Health professions
  - Carmen Abbott, Physical Therapy
  - Brad Willis, Physical Therapy
  - Rachel Proffitt, Occupational Therapy
  - Stephanie Reid Arndt, Health Psychology, Associate Dean
  - Micah Mazurek, Health Psychology
- College of Human Environmental Sciences
  - Erin Robinson, Social Work
  - Bimal Balakrishnan, Architectural Studies
- School of Music
  - Paolo Savvidou (has since left MU)
- School of Information Science and Learning Technologies
  - Isa Jahnke
Other Universities

- Washington University
  - David Brogan, Orthopaedic Surgery
- University of Delaware
  - Lorraine Phillips
- University of Wisconsin – Milwaukee
  - Colleen Galambos
- University of Pittsburgh
  - Judy Matthews, Nursing
  - Grace Campbell, Nursing

Current Commercial partners

- Foresite Healthcare
- Medtronic
- Nokia
- Americare
- Blue Strata


The performance of the current interdisciplinary research group is summarized below. See also www.eldertech.missouri.edu, which includes a complete list of the publications, researchers, and students involved.

<table>
<thead>
<tr>
<th>Total research expenditures (external funding) *</th>
<th>$11,291,641</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal funding received w/o PRIME *</td>
<td>$1,549,352</td>
</tr>
<tr>
<td>Return on investment w/o PRIME *</td>
<td>7.3</td>
</tr>
</tbody>
</table>

| Number of papers/abstracts total | 258 |
| Journal articles                | 95  |
| Post-docs **                    | 4   |
| PhD students **                 | 44  |
| MS students **                  | 42  |
| Undergraduate students **       | 102 |
### High School students

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<tbody>
<tr>
<td>Patents</td>
<td>3 issued; 1 allowed; 1 pending (licensed); 2 new disclosures &amp; provisional patent applications</td>
</tr>
<tr>
<td>Start-up company for commercialization</td>
<td>Foresite Healthcare has licensed Eldertech work</td>
</tr>
</tbody>
</table>

* All figures through FY17; includes all CERT projects, as listed below  
** MU Students and post-docs involved in the CERT projects

### Goals for the Last Year

- NIH grant (Skubic, PI)  
  - Accomplished with a $2M NIH grant
- Industry contracts(s)  
  - New industry projects with Medtronic and Nokia
- Cost-effective solution for IT infrastructure to support 24/7 operations and research  
  - Accomplished by leasing server space from Foresite Healthcare. This will facilitate very large research studies in which we will recruit participants from the FH customer base.
- Identify a successor for director  
  - A potential successor has been identified.
- Engage more engineering and computer science faculty in CERT  
  - Dr. Giovanna Guidoboni (new in EECS) is now part of the team. More faculty in engineering and computer science are needed.
- Explore alternative funding sources  
  - Revenue from licensed IP. This will require a renewed MOU with the departments of the inventors. Projected sales from FH show departmental revenue from licensing at about $15K in 2018 and $35K in 2019.
  - On-line courses. Revenue will depend on the specific revenue model negotiated, which could range from $6K to $26K for a graduate course with 25 on-line students.
  - Endowed professorships focused on CERT research areas would help to engage more faculty. Two $1M endowed professorships would contribute $80/yr.
8. Goals for the Next Year

- More NIH and NSF grants
- Submit an NSF IUCRC grant proposal
- Promote more collaboration with industry partners
- Finish the IT transition to the Foresite Healthcare server infrastructure for future large-scale studies
- Hire a postdoc in computer science or engineering
- Work on endowed professorship(s) for CERT faculty
  - Introduce a competitive process for current MU faculty in engineering and computer science
- Work on MOU’s for alternative revenue
  - Track revenue from licensed IP
  - Assuming an agreement can be reached, start with one on-line course

9. External Funding –$14M through April, 2018

9. Rantz, Marilyn. 2009-2013. Technology to Automatically Detect Falls and Assess Fall Risk in Senior Housing. AHRQ, $1.99M, co-Is: Marge Skubic, Jim Keller, Mihail
17. Matthews, Judith. 2015-2019. Self-Management via Health Kiosk by Community-Residing Older Adults. AHRQ, $140K to MU as subcontract + supplement (M. Skubic, PI of subcontract).

*** Not considered a CERT project for funding; however, some REU teams work on CERT projects and these students are counted. (Skubic’s shared credit is counted)

Pending / In Preparation Funding

5. Phillips, Lorraine (University of Delaware, formerly MU). In-Home Technology to Detect Changes in Function in Older Adults with Mild Cognitive Impairment. NIH R01, $2,486,748. In preparation for resubmission.

6. Campbell, Grace (University of Pittsburgh). Sensor-Based Functional Assessment to Detect Chemotherapy-Induced Peripheral Neuropathy-Related Balance and Gait Impairments. NIH R21, subcontract to MU, $81,208 (M. Skubic, PI). In preparation for resubmission.


Internal Funding


10. Students Trained in CERT Projects through April, 2018

Post-Docs/Fellows

1. Brian Hensel: Health Management & Informatics
2. Karen Olufokunbi: Health Management & Informatics
3. Erik Stone: Electrical & Computer Engineering
4. Anna Wilbik: Electrical & Computer Engineering
PhD Students

1. Aws Anaz: Electrical & Computer Engineering,
2. Derek Anderson, ECE, MS August, 2005; PhD, August, 2010
3. Tanvi Banerjee: ECE, PhD, August, 2014
4. Ronny Bazan Antequera: Computer Science, MS, 2015
5. Dimitri Chemodanov, Computer Science
6. Chao Chen, ECE, PhD, April 2016
7. Shanjie Chen: ECE
8. Xi Chen: ECE
10. Wenqing Dai: ECE (left to pursue a different discipline)
12. Moein Enayati: ECE
13. Jarod Giger: School of Social Work, PhD, August 2010
14. Zahra Hajihashemi: Computer Science, PhD
15. Tim Havens: ECE, PhD in August 2010
16. David Heise, PhD, ECE
17. Benjamin Hotrhabhavananda, ECE
18. Zhiyu Huo: ECE, MS in May, 2013; PhD in May, 2017
19. Omar Ibrahim, ECE
20. Akshay Jain: ECE
21. Jean Krampe: School of Nursing, PhD, May 2010
22. Yun Li: ECE, PhD in May 2013
23. Liang Liu: ECE, PhD in May, 2014
24. Zhijian Luan, Infomatics, PhD
25. Robert Luke: ECE, PhD in August 2010
26. Mengxuan Ma: ECE, MS, Dec, 2015; current PhD student
27. Abhishek Mahnot: Computer Science,
28. Yasin Matin, MS/PhD, CS
29. Anup Mishra: ECE, MS in Aug, 2015; current PhD student
30. Amber Moody-Dyer, School of Social Work
31. Nuerzati Resuli, ECE, PhD student
32. Licet Rosales: ECE, MS in December, 2011; PhD in August, 2016
33. Liyang Rui: ECE
34. Todd Ruppar: School of Nursing, PhD, May 2009
35. Manav Singhal: Computer Science,
36. Isaac Sledge: ECE, (left)
37. Erik Stone: ECE, MS in May, 2009; PhD in December, 2013
38. Bo-Yu Su: ECE, PhD in December, 2017
39. Shuai Tang: ECE (left)
40. Robert Wallace: Computer Science, PhD, December, 2017
41. Fang Wang: ECE, PhD in August 2011
42. Shuang Wang: ECE, MS in May, 2007; PhD in December, 2011
43. Jie Yu: School of Nursing, PhD, May 2008
44. Zhongna Zhou: ECE, on medical leave
MS Students

1. Tatiana Alexenko: Computer Science
2. Jessica Davis: Social Work
3. Chinonye Echebiri: ECE, MS, December, 2012
4. Shawn Fernandes: ECE
5. Elena Florea: HMI, MS, May 2009
6. Sharbari Ganguly: School of Social Work
7. Saurav Garg: HMI
8. Diane Garritsen, School of Social Work
9. Chad Godsey: Computer Science, MS student (left without writing his thesis)
10. Nate Green: Computer Science, MS student (left)
11. Rainer Dane Guevara, ECE, MS, August, 2011
12. Kevin Harris: Health Administration, MS, May 2006
13. Nick Harvey: Computer Science, MS, December 2009
14. Katherine Houts, School of Social Work
16. Samantha Kurkowski, ECE
17. Mengyuan Li: ECE, MS, May, 2015
18. Xin Li: ECE
19. Kathleen Loftus, School of Social Work
20. Erica Nanney Beck, School of Social Work
21. Hannah McNear, Social Work, MS
22. Michael Moore, ECE, MS, May, 2011
23. Rohan Ohol: HMI, MS
24. Femi Olowonefa, HMI, MS in May, 2018
25. Omid Pezeshkfar: ECE
27. Kevin Reed, ECE, MS, August, 2009
28. James Richardson: HMI, MS, May 2010
29. Mark Schaumburg: ECE, MS, May, 2015
30. Shradha Shalini, ECE, MS
31. Mary Sheahen: Computer Science, MS, May, 2015
32. Jingyi Shao: ECE, MS
33. Shuai Tang: ECE, MS in December 2011
34. Kai Tian: ECE, MS student
35. Akshith Ullal: ECE, MS Student, MS in May, 2018
36. Xingyu Wang, ECE, MS in 2017
37. Bethany Weger, School of Social Work
38. Di Wu, ECE
39. Wenlong Wu, ECE
40. Jialei Yang, ECE, MS in December, 2015
41. Ruhan Yi, ECE
42. Yueqi Yu, ECE, MS in December, 2016
Undergraduate Research and Projects (102 undergraduate students)

2. Jake Garner (ECE) UG research, 2005
3. Nick Harvey (ECE), Andrew Holt (ECE), Sarah Berry (Texas A&M University), summer interns for eldertech project, Summer, 2006.
5. Nick Harvey (ECE), Jordan Smarr, undergraduate research for summer, 2007
7. Chinonye Echebiri, ECE, UG research assistant, eldertech project, 2006-2007
8. Matt Nevels, ECE, UG research assistant on eldertech project, Spring-summer, 2008
9. Dan Lopez (Stanford University), Jun Liang (Dartmouth University), summer interns, eldertech project, 2008
10. Clay Staley, Sam Johnson, Adam Rankin & Chris Scheetz, ECE capstone project, power-assist wheelchair, 2009
11. Cyrille Goldstein, summer undergraduate intern, bed sensor project, 2009
12. Tatiana Alexenko, CS, UG research: Electronic Health Record and web interface, Fall, 2009-Fall, 2011.
13. Mark Schaumberg, ECE, UG research: bed load cells for sleep restlessness, pulse and respiration, Spring, 2010
14. Tyler Gill, UG research, Kinect depth data
15. Michael Ramer, ECE, UG research, bed sensor
16. Matthew Johnson, ECE, UG research, eldertech, Spring, 2010
17. Brian Satzinger and Matthew Mazzola, ECE, UG research: motion sensor design with Zigbee, Spring, 2010
19. Emily Christ, CS, UG research: web interface for eldertech sensor database and iPhone app, Spring, 2010-Spring, 2011
20. Patrick Ashby, ECE, UG research: Zigbee motion sensor, Summer, 2010
21. Oleg Izyumin, ECE, UG research, ZigBee motion sensor, Summer-Fall, 2011.
23. Zachary Legenzoff, ECE, Discovery Fellow, Radar fall detection and fall risk assessment project, Fall, 2011-Spring, 2012; UG research, Fall, 2012.
27. Lauren Griggs, Clark Buckles, Qinyuan Sun, Jing Lu, Hydraulic Infant Respiratory and Movement Monitor, ECE Capstone project, Spring, 2012.
29. Megan Biondo and Deya Banisakher, REU summer students, Android-based speech processing for eldercare robotics (resulted in conference paper), Summer, 2012.
30. Michael Butler, ECE, UG research, Kinect-based motion analysis on fractal dimension for fall risk assessment; Kinect-based sports injury assessment, Spring, 2013 - present.
32. Jie Chen, ECE, UG research, Hospital Kinect project, summer, 2013-present.
33. Daniel Pelzer, ECE, UG research, Vision-based gait analysis, Fall, 2013.
34. Aihua Peng, ECE, UG research, Consistency testing of Kinect depth sensors, Fall, 2013.
35. Isabel Hoss and Sara James, UG, linguistics for human-robot spatial language project
37. Anthony Forsythe, UG research, Smart App for creating a digital scrapbook with embedded stories, 2014; Sensor and EHR Database project, Summer, 2016
38. Zac Crane and Gary Grimm, Jr., REU summer students, Video interface for older adults to review depth videos, Summer, 2014
39. Alice Wong, Brian On, and Chandler Mendenhall, REU summer students, Mobile app and visualization of in-home sensor data for older adults, Summer, 2014
40. Taylor Rydahl, REU summer student, Networked Exercise Game for Preventing ACL Injuries
42. Sean O’Day, UG research on bed sensor, 2012-2015
43. Shining Sun, UG research on ACL project, 2015
44. Jeff Ruffolo, UG research on game-based exercise for ACL rehab, 2015-2016
46. Shining Sun, Yousif Abdulreheim, Michael Bowers, Fadi Muqeem, Undergraduate Capstone project, Device Free WLAN Walking Speed and Localization Detection for Activity Level Monitoring in Elderly People, Fall, 2015.
47. Nijaporn Hotrabhavananda, Andrew Dytuco, Nahom Ghirmatzion, David Nash, Undergraduate Capstone project, Intrusion Detection using IR CCTV, Spring, 2016.
48. Ethan Currier, UG research on accelerometer sensor project, Spring, 2016
49. Max Houck, UG help with Eldertech System Admin, 2016
50. Lemeng Zhang (ECE), UG research help on bed sensor study, 2015-2016
51. Benjavicha Hotrabhavananda, Mark Goldstein, Bryan Patten, Eric Sullentrup Undergraduate Capstone project, Contact to First Base Time Measurement System for Baseball Programs, Fall, 2016
52. Karen Ai and Jordan Hubbard, REU summer students, The Angel-Echo Project, 2016
53. Ariel Virgulto and Aaron Little, REU summer students, Rehabilitation Exercises for Environment Control, 2016
54. Princess Lyons, UG research, MIL algorithms for automated BCG processing, 2016-2017
55. Penghui Shang, UG research, bed sensor algorithms for apnea detection, 2016-2017
56. Akash Patel, UG research, Vicon data, PT functional assessment tool, spring, 2017
58. Gbenga Omotara, UG research in ECE, bed sensor data analysis, summer, 2017
59. Matthew Moore, UG research in CS, ECHO Consumer Interface to a Sensor-Based Early Illness Alert System, Fall, 2017
60. Trevor Levins, UG research in ECE, Fall, 2017-Spring, 2018
61. Haiyan Hu, UG research in ECE, Fall, 2017-Spring, 2018
62. Trey Shaw, Discovery Fellow, Automated Hand Measurement, Fall, 2017-Spring, 2018
63. Jeffrey King, Angelino Lefevers, Zachary Rump, ECE Capstone Project, Accelerometer-Based Sensor with Energy Harvesting for Non-Invasive Medical Monitoring Fall, 2017
64. Alyssa Nielson, Clark Walters, David Duenow, Chris Harling, Nicholas Toeniskoetter, Anthony Stegall, Keith Compton, Multi-Media Apps for Older Adults (IT Capstone), Fall, 2017
65. Yizhuo Du and Yiping Wang, Streaming Clustering, 2018

**High School Students**

1. Jun Liang, work on vision data for gait and movement analysis, 2008
2. Katy Lydon, work on algorithms for estimating heart rate using data from the MU hydraulic bed sensor, resulting in a conference paper, 2014-2016
3. Jasmine Jalai, work on algorithms for assessing respiration depth using data from the MU hydraulic bed sensor, 2016-2017