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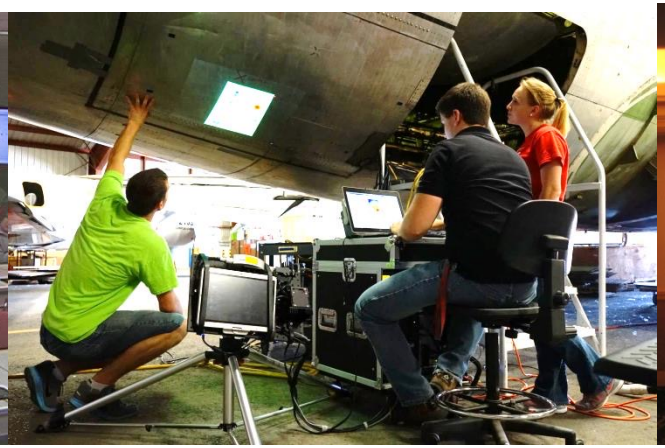
LA-UR-24-XXXXX

The Los Alamos Dynamic Summer School: A 25-year Pipeline and Education Program



Lectures & Tutorials

Project Research

Conference Presentations

Charles R. Farrar
Engineering Institute Leader

Los Alamos Dynamics Summer School

Los Alamos NATIONAL LABORATORY

The LADSS is part of the Engineering Institute

- **THE ENGINEERING INSTITUTE(EI)** is a research and education collaboration between LANL and the University of California San Diego (UCSD) Jacobs School of Engineering started in 2003.

- **MISSION:** Develop a comprehensive and coordinated approach for
  - conducting mission-driven, multidisciplinary engineering research and
  - recruiting, revitalization and retention of the current and future staff necessary to support LANL's diverse technology portfolio.
- **TECHNICAL FOCUS:** multidisciplinary engineering science that integrates advanced **predictive modeling, novel sensing systems and new developments in information technology.**

The EI Research and Education Components

- **Since 2003 LANL and Univ. of California have invested G&A, programmatic funds and UC Fee in the Engineering Institute (EI) to support:**
- **Los Alamos Dynamic Summer School (LADSS),**
- Judicial Science School
- Athena Scholars Program
- A joint LANL/UCSD multi-disciplinary graduate degree program,
- TAMU distance-learning MS Engineering programs
- Joint LANL/UCSD multi-disciplinary research projects,
- Engineering research support to Los Alamos line organizations,
- Workshops
- Short courses: 1. Structure Health Monitoring; 2. Model Verification and Validation
- International collaborations

The idea for the LADSS originated during LANL's Structural Dynamics 2000 Workshop & my time on the postdoc committee

STRUCTURAL DYNAMICS 2000
APRIL 11-16, 1999
LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS, NEW MEXICO, USA

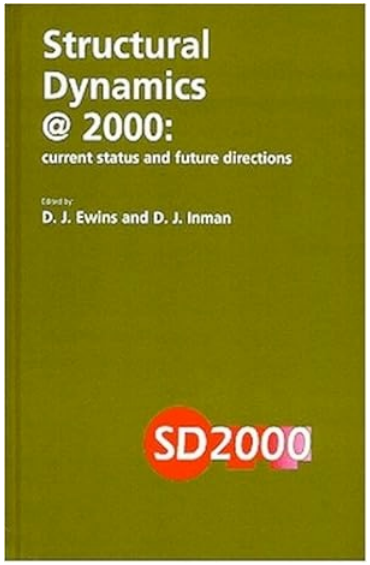
SD2000

PPER ROW: 1. Balmes, 2. Pickrel, 3. Cooper, 4. Sestieri, 5. Zimmerman, 6. Tomlinson, 7. Cudney, 8. Yang, 9. Friswell,10. Cogan, 11. Gaul, 12. Doebling, 13. Hemez. MIDDLE ROW: 1. Avitabile, . Sohn, 3. Shaw, 4. Mote, 5. Bergman, 6. Randall, 7. Lieven, 8. Link, 9. Hammond, 10. Martinez, 11. Farrar, 12. Davies. IMMEDIATE ROW: 1. Womack, 2. Reeves, 3. Nayfeh, 4. Imregun, 5. Caesar, . Ohayon. LOWER ROW: 1. Hunter, 2. Bucher, 3. Robertson, 4. Inman, 5. Brown, 6. Crandall, 7. Paez, 8. Ewins, 9. Richardson, 10. Vold.

CIC-9: RN-132-005

Summer School Motivation

- Recruitment of talented young engineers into engineering and computer science fields is a critical need for the economic competitiveness and national defense (see SD 2000 publication).
- Approx. 40% of graduate engineering degrees are awarded to foreign nationals (percentage is higher if you look at Ph.D. graduates). This demographic poses significant problem for U.S. defense industry.

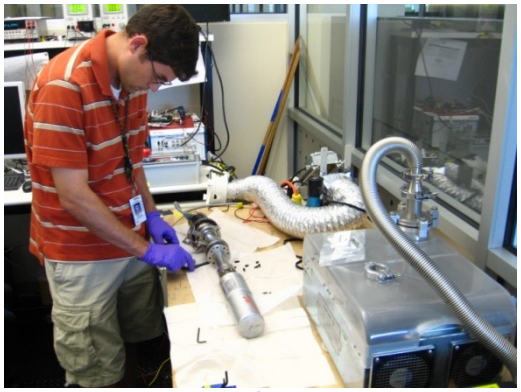


- The LADSS is a proactive approach to recruiting for LANL and other DOE- NNSA labs (Sandia and Lawrence Livermore)
- It has also been a graduate student recruiting program for the Univ. of California San Diego

The Los Alamos Dynamics Summer School

Since 2000, 15-21 top-performing undergraduate engineering students from around the U.S. enter our 10-week program

- Mean undergrad GPA approx. **3.7/4.0, 80+ student have obtained NSF or NDESG grad fellowships**
- Week long (1-hr/day) lectures (e.g. signal processing), Guest seminars on various research topics, tours and field trip.
- Students work on team research projects, produce conference paper, present paper the following February at an International Conference.
- **Our Goal: Motivate US citizens to attend graduate school**! Hopefully, many will return to LANL after they complete their graduate degrees.

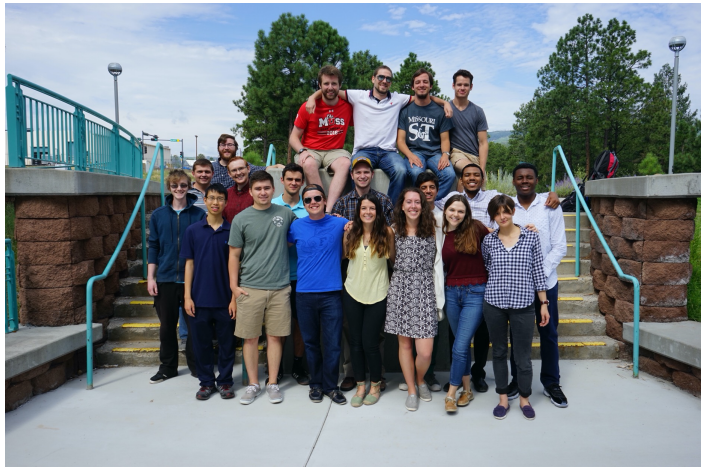


Vibration control of mechanically-cooled germanium detector

Vibro-tactile, haptic human-computer interface for damage detection

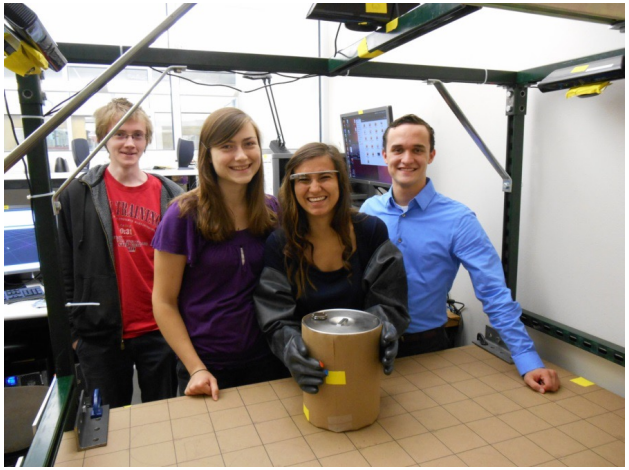
Summer School Goals

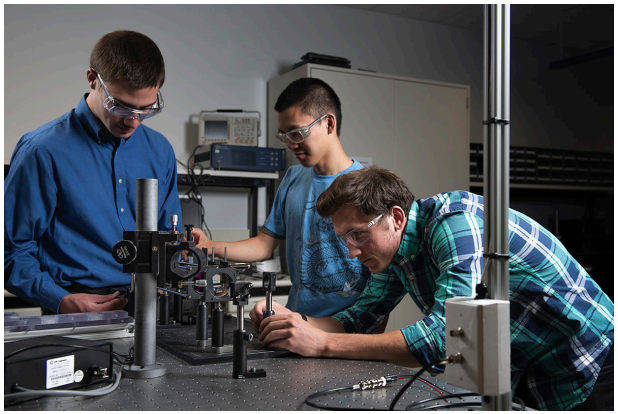
- **Students' goal is to produce conference paper at the end of the 10-week school**.
- Provide a graduate school-like experience and motivate top U.S. citizen undergraduate students to attend engineering graduate school.
- Develop students oral and written communications skills.
- Expose students to interesting, multi-disciplinary, research.
- Make students aware of graduate education opportunities with LANL/UCSD Eng. Institute (24 former LADSS students are/were grad students at UCSD)
- Make students aware career opportunities at LANL.
- Keep in mind that LANL hires BS, MS and Ph.D.-level engineers who are almost exclusively US citizens



Format

- **Ten-week research project with experimental and analytical component (define by LANL R&D Engineers)**
- Weekly lectures on various subjects related to dynamics
- Guest seminars on research and programmatic activities
- Professional development lectures(e.g. writing a conference paper, effective presentations, applying to grad school, applying for grad fellowships)
- Some external guest seminar speakers will spend time reviewing projects with each group as their schedules permit.
- Tours of some LANL facilities (e.g. linear accelerator, super computing center, environmental testing facilities)
- Prepare International Modal Analysis Conference (IMAC) papers
- Students will present papers at IMAC in Jan 29 – Feb 1, 2024 in Orlando, FL





Each week there is a lecture series each morning

Week 8 – Nonlinear Systems

Week 7– Introduction to Machine learning

Week 6 – Model Verification and Validation

Week 5 – Controls

Week 4 – Open

Week 3 –Dynamic Systems

Week 2 – Sensors and Data Acquisition (morning)
– Signal Processing (afternoon)

Week 1 – Probability & Statistics

Most weeks there are two guest seminars (every student must ask a question!)

Satellite Engineering

Weapons Testing

Offshore Wind Turbines

Aerospace Structural Dynamics

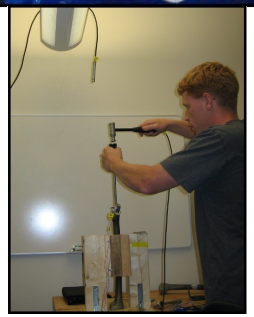
Unique Research Projects

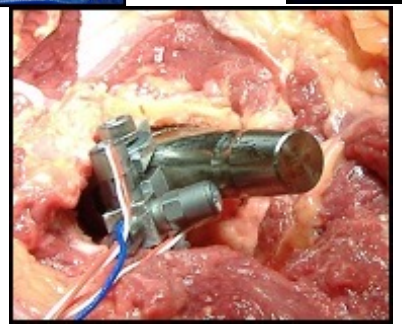
Goal: Develop a sensor that will give a surgeon an indication that the femoral component of an artificial hip is fully seated.

Mentors: Dr. R. Michael Meneghini, Indiana Univ. Orthopedics Department

Prof. Phil Cornwell, Rose-Hulman Institute of Technology

Ten cadavers donated by UCSD's Anatomy Lab for validation study





Does Anyone Read the LADSS Papers?

Ten Most Cited LADSS IMAC Papers	Citations
Light-Marquez, A., A. Sobin, K. Farinholt, and G. Park. “Structural damage identification in wind turbine blades using piezoelectric active sensing.” Proc. IMAC XXVIII 2010.	33
Deines, K., T. Marinone, R. Schultz, K. Farinholt, and G. Park. “Modal Analysis and SHM Investigation of CX-100 Wind Turbine Blade.” Proc. IMAC XXIX 2011.	25
JJ Granier, RJ Haundhausen, GE Gaytan, Passive Modal Damping with Piezoelectric Shunts Proc. IMAC XX 2002.	21
Flynn, E. B., R. A. Swartz, D. E. Backman, R. J. Hundhausen, and G. Park. “Active Piezoelectric Sensing for Damage Identification in Honeycomb Composite Panels.” Proc. IMAC XXIV 2006.	18
Kess, H. R., Rosnow, N., Sidle, B. "Effects of Bearing Surfaces on Lap Joint Energy Dissipation" Proc. IMAC XX 2002.	18
DD. W. Allen, S. Castillo, A. L. Cundy, C. R. Farrar, and R. E. McMurry, “Damage Detection in Building Joints by Statistical Analysis,” Proc. IMAC XIX 2001.	18
Thien, A., H. Chiamori, J. Ching, J. R. Wait, and G. Park. “Active Sensing for Damage Detection in Pipeline Structures.” Proc. IMAX XXIII 2005.	13
Carlson, C., A. Schlichting, S. Ouellette, K. Farinholt, and G. Park. “Energy Harvesting to Power Sensing Hardware Onboard a Wind Turbine Blade.” Proc. IMAC XXVIII 2010.	12
Fasel, Tim R., Seth W. Gregg, Tim J. Johnson, C. R. Farrar, and Hoon Sohn. "Experimental modal analysis and damage detection in a simulated three story building." Proc. IMAC XX 2002.	12
Dorn, C., T. Mancini, Z. Talken, Y. Yang, G. Kenyon, C. Farrar, and D. Mascareñas. “Automated Extraction of Mode Shapes Using Motion Magnified Video and Blind Source Separation.” Proc. IMAC XXXIV 2016	11

The LADSS has produced 121 IMAC papers that have been cited on average 3.7 times per paper

Some Projects Result in Refereed Journal Publications

Paper	Citations
Mascareñas D. D. L, Ballor J. P., McClain O. L., Mellor M. A., Shen C.Y., Bleck B., Morales J., Yeong L-M R., Narushof B., Shelton P., Martinez E., Yang Y., Cattaneo A., Harden T. A., Moreu F., Augmented Reality for Next Generation Infrastructure Inspections, *Structural Health Monitoring* , 2020.	
Van Buren, K.L., Reilly, J., Neal, K., Edwards, H., Hemez, F., "Guaranteeing robustness of structural condition monitoring to environmental variability," *J. Sound and Vibration* , 2017, **386**, pp. 134-148.	13
Yang, Y., Sanchez, L., Zhang, H., Roeder, A., Bowlan, J., Crochet, J., Farrar, C. & Mascareñas, D. (2019). Estimation of full-field, full-order experimental modal model of cable vibration from digital video measurements with physics-guided unsupervised machine learning and computer vision. *Structural Control and Health Monitoring* , 2019, ***26*** (6), e2358. **(one of the 10 most downloaded papers, June 2020)**	7
Van Buren, K.L., Hall, T.M., Gonzales, L.M., Hemez, F.M., Anton, S.R., "A case study to quantify prediction bounds caused by model-form uncertainty of a portal frame," *Mechanical Systems and Signal Processing* , 2015, **50-51**, pp. 11-26.	11
Yang, Y., Dorn, C., Mancini, T., Talken, Z., Nagarajaiah, S., Kenyon, G., Farrar, C. & Mascareñas, D. (2017). Blind identification of full-field vibration modes of output-only structures from uniformly-sampled, possibly temporally-aliased (sub-Nyquist), video measurements. J. Sound and Vibration, 2017, ***390*** , pp. 232-256.	64
Yang, Y., Dorn, C., Mancini, T., Talken, Z., Theiler, J., Kenyon, G., .Farrar, C. & Mascarenas, D. (2018). Reference-free detection of minute, non-visible, damage using full-field, high-resolution mode shapes output-only identified from digital videos of structures. *Structural Health Monitoring* , 2018, **17**(3), pp. 514-531.	44
Yang, Y., Dorn, C., Mancini, T., Talken, Z., Kenyon, G., Farrar, C., & Mascareñas, D. (2018). Spatiotemporal video-domain high-fidelity simulation and realistic visualization of full-field dynamic responses of structures by a combination of high-spatial-resolution modal model and video motion manipulations. *Structural Control and Health Monitorin g*, 2018, **25**(8), e2193.	6
Yongchao Yang, Charles Dorn, Tyler Mancini, Zachary Talken, Garrett Kenyon, Charles Farrar, David Mascareñas, "Blind identification of full-field vibration modes from video measurements with phase-based video motion magnification," *Mechanical Systems and Signal Processing* , 2017, **85**, pp. 567-590.	132
Cattaneo A., Bossert J., Guzman C., Haaker A., Gupta G., Mohite A., Dumont J., Purdy G., Miller K., Marchi A., Farrar C., Mascarenas D., A graphite oxide (GO)-based remote readable tamper evident seal, *Smart Materials and Structures* , 2015, **24** (10), 15pp	3
David Mascareñas, Crystal Plont, Christina Brown, Martin Cowell, N Jordan Jameson, Jessica Block, Stephanie Djidjev, Heidi Hahn, Charles Farrar "A vibro-haptic human–machine interface for structural health monitoring," *Structural Health Monitoring* , 2014, **13** (6).	17
Farinholt, K.M., Miller, N.A., Sifuentes, W., MacDonald, J.M., Park, G., Farrar, C.R., "Energy Harvesting and Wireless Energy Transmission for Powering SHM Sensor Nodes," *Structural Health Monitoring* , 2010, **9(**3), pp. 269-280.	49
Farinholt, K.M., Pedrazas, N.A., Schluneker, D.M., Burt, D.W., Farrar, C.R., 2009 "An Energy Harvesting Comparison of Piezoelectric and Ionically Conductive Polymers," *J. Intelligent Material Systems and Structures* , **20**(5), JIMSS-08-398	82
Barhorst, A., "Modeling Loose Joints in Elastic Structures-Variable Structure Motion Model Development," *J. Vbration and Control* , 2008, **14**(11) pp.1767-1797.	13
Anton, S. R., Park, G., and Inman, D. J., 2009, Reference-Free Damage Detection using Instantaneous Baseline Measurements, *AIAA Journal* , 2006, **47(**8), pp. 1952-1964	81
Flynn, E.B., Swartz, R.A., Backman, D.E., Park, G., Farrar, C.R., "Active-Sensing Lamb Wave Propagations for Damage Identification in Honeycomb Aluminum Panels," *J. Korean Society for Nondestructive Testing* , 2009, **9** (4), pp. 269-282	3
Meneghini, R.M., M. Guthrie, H. Moore, D. Abou-Trabi, P. Cornwell and A. Rosenberg,"A Novel Method for Prevention of Intraoperative Fracture in Cementless Hip Arthroplasty: Vibration Analysis During Femoral Component Insertion," *Surgical Technology International* , 2010, **20**, pp. 334-339.	5
Thien, A.B., Chiamori, H.C., Ching, J.T., Wait, J.R., Park, G. 2008, "The Use of Macro-Fiber Composites for Pipeline Structural Health Assessment," *Structural Control and Health Monitoring* , 2008, **15** (1), pp. 43-63.	46
M. D. Todd, K. Erickson, L. Chang, K. Lee, and J. M. Nichols, ``Using Chaotic Interrogation and Attractor Nonlinear Cross-Prediction Error to Detect Fastener Preload Loss in an Aluminum Frame,'' *Chaos: An Interdisciplinary Journal of Nonlinear Science* , 2004, **14** (2), 387-399.	66
J. M. Nichols, M. D. Todd, and J. R. Wait, "Using State Space Predictive Modeling with Chaotic Interrogation in Detecting Joint Preload Loss in a Frame Structure Experiment," *Smart Materials and Structures* , 2003, **12** (4), pp. 580-601.	92
Cornwell, P., J. Goethals, J. Kowtko, M. Damianakis, "Enhancing Power Harvesting Using a Tuned Auxiliary Structure," *J. Intelligent Materials Systems and Structures* , 2005, **16** (10) pp. 825-834.	172
Simmers, G.E., Hodgkins, J., Mascarenas, D., Park, G., Sohn, H., "Improved Piezoelectric Self-Sensing Actuation," *J. Intelligent Material Systems and Structures* , 2004, **15** (12), pp. 941-953	85
Average number of citations per paper (01-12-2021):	**50**

Metrics 2000-2023

- 439 students to date, approx. 100+ working on or have completed Ph.Ds, almost all have completed MS
- 8 alumni are university professors
- 81 students receive NSF or NDSEG fellowships
- 148 conference papers (mostly presented at the Society for Experimental Mechanics IMAC conference).
- 21 refereed journal papers have resulted from the students' research
- **LADSS H-index = 18**
- 58 students have been hired at LANL
  - More students have been hired at other DOE-NNSA laboratories

Recruiting Pipeline:

	Name	Group	Degree
1.	Aaron Feizy*	E-14	BS AE | Texas A&M
2.	Aleck Tilbrook*	E-14	BS ME* | Liberty
3.	Allison Davis*	E-1	MS EE* | Wyoming
4.	Cole Zemelka* (UCSD MS)	Q-18	MS Structural* | **UCSD**
5.	Joseph Lahmann*	NSEC-EI	PhD ME* | Cincinnati
6.	Sarah Johnson*	E-14	BS ME | Clemson
7.	Skylar Callis*	XCP-8	BS CE & Math | Michigan Tech
8.	Cole Maxwell*	NSEC-EI	MS ME* | Stanford
9.	Jabari Allen*	MPA-11	BS CompE | Florida A&M
10.	Samuel Hinerman* (UCSD MS)	W-11	MS SE* | **UCSD**
11.	Troy Sims*	Q-6	BS EE | New Mexico Tech
12.	Wilson Vogt*	PT-5	BS ME | Montana State
13.	Anand Iyer*	E-14	PhD ME* | Colombia
14.	Christopher Whitworth*	E-14	MS ME | UT-Dallas
15.	Jonathan Acosta*	E-1	MS ME| NM State
16.	Nadim Bari*	E-1	MS ME | Michigan
17.	Caleb Schelle* (UCSD MS)	E-14	MS SE | **UCSD**
18.	Erica Jacobson* (Grad Fellowship)	NSEC-EI	PhD SE* | **UCSD**
19.	Greta Colford*	E-14	PhD AE* | Michigan
20.	John Pederson Jr*	ISR-5	PhD AE*| Cal Tech
21.	Samuel Myren*	E-14	MS Statistics | Virginia Tech
22.	Thomas Roberts*	W-13	MS ME | Utah
23.	Alan Williams* (Grad Fellowship)	AOT-AE	PhD ME* | **UCSD**
24.	Andre Green*	E-1	BS CS | New Mexico
25.	Brian West* (UCSD MS)	ISR-2	MS SE | **UCSD**
26.	David Alexander IV*	E-6	PhD Material Eng | UTEP
27.	Peter Fickenwirth* (UCSD MS)	E-14	MS. SE | **UCSD**
28.	Martin Ward*	E-1	MS ME | UT Austin
29.	Milo Prisbrey*	MPA-11	PhD ME | Utah

	Name	Group	Degree
30.	Shannon Danforth*	E-14	PhD ME | Michigan
31.	Ian Cummings*	ISR-2	PhD EE | Michigan Tech
32.	Katrina Sweetland*	E-1	PhD ME* | Tennessee
33.	Lindsey Gaspar*	E-1	MS ME | Illinois
34.	Robert Migliori*	AOT-IC	MS Physics | Mississippi
35.	Mike Maestas*	E-1	MS ME | NMSU
36.	Nick Martinez*	M-3	MS ME | New Mexico
37.	Garrison Flynn*	E-14	PhD CE | Clemson
38.	Dustin Harvey*	E-14	PhD SE | **UCSD**
39.	John Heit	E-14	MS ME | Utah
40.	Scott Ouellette*	E-14	PhD SE | **UCSD**
41.	Colin Haynes*	E-14	PhD SE | **UCSD**
42.	Stuart Taylor*	Q-20	PhD SE | **UCSD**
43.	Brandon Stone* (UCSD MS)	W-13	MS SE | **UCSD**
44.	Ted Lyman*	A-3	PhD ME | Duke
45.	Logan Ott*	ISR-5	BS Eng | Fort Lewis
46.	Colton Lake*	ER-ES	BS CE | New Mexico Tech
47.	Erik Moro	XTD-SS	PhD SE | **UCSD**
48.	Eric Flynn* (EI Postdoc, SOS-ASI)	ISR-6	PhD SE | **UCSD**
49.	David Mascareñas* (EI Postdoc)	E-1	PhD SE | **UCSD**
50.	Nathan Miller*	W-13	MS ME | Colorado State
51.	Miles Buechler*	W-13	MS ME | Virginia Tech
52.	Andrew Thien*	W-13	MS ME | Cincinnati
53.	Isaac Salazar	W-13	MS ME | Texas A&M
54.	R. Jason Hundhausen	W-13	MS ME | Purdue
55.	Dave Allen	W-13	MS ME | Virginia Tech
56.	Daniel Stinemates	W-13	MS ME | Georgia Tech
57.	Jeni Wait	W-13	MS CE | Southern California
58.	Amanda Rutherford	W-13	MS EM | Virginia Tech

* By name indicates the person is still employed at LANL (48/58).

* By degree means the person is still in the process of completing their degree.

How is the LADSS funded?

- **LADSS Costs: Student Fellowships, Program Leader, Mentor time, Lab Materials, Conference Travel.**
- **2000 – 2002:** DOE had an education programs office that provided funding (approx. 50%) through a competitive grant program and ESA Division (predecessor to W, E & Q Divisions) provided the other 50%.
- **2003 – 2006:** DOE terminated its education programs funding and ESA Division funded the LADSS 100%.
- **2006 – present:** With the contract transition to LANS the LADSS formally became part of the Engineering Institute and funding has come from DDSTE and ALDW.

How can you get involved?

- Encourage prospective engineering students to apply:
  - https://ladss.lanl.gov/
- Suggest a research project and be a mentor:
  - Program Leader: Adam Wachtor
    - ajw@lanl.gov

The Most Important Metric

- Eight marriages between former LADSS students (nineth pending?)