

A Zachary Trimble, Ph.D.  
Associate Professor  
Department of Mechanical Engineering  
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Contact Information

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Professional Preparation

Massachusetts Institute of Technology (MIT)	Mechanical Engineering	Doctor of Philosophy, 2011
Massachusetts Institute of Technology (MIT)	Mechanical Engineering	Master of Science, 2007
University of Utah	Mechanical Engineering	Bachelor of Science, 2005
Weber State University	General Studies	Associate of Science, 2001

Research Interests

Precision Machine Design: next generation ultra-precision machining processes, exact constraint design (especially as applied to machine components, astronomical instruments and gizmos)

Industrial Automation Automation of manufacturing, re-manufacturing, assembling and recycling processes

Renewable Energy Utility scale renewable energy storage and grid integration

Autonomous Systems: advances in Unmanned Surface Vessels (USVs) and applications that include cooperative systems of UAVs, USVs, and UUVs.

Adrenaline Sports: technological advances in scuba diving with an increasing interest in re-breathers and other hyperbaric environments.

Patents and Publications

Journals

Yamamoto, B., Wong, A., Agcanas, J. A., Jones, K., Gaspar, D., Andrada, R., Trimble, A Z., 2019, “Received Signal Strength indication (RSSI) of 2.4 GHz and 5 GHz wireless local area network systems projected over land and sea for near-shore maritime robot operations.” Journal of Marine Science and Engineering, Accepted.

Yamamoto, B., Trimble, A Z., Minei, B., Nejhad, M., 2019, “Development of Multifunctional Nanocomposites with 3D Printing Additive Manufacturing and Low Graphene Loading”, Journal of Thermoplastic Composite Materials, 32(3), 383-408.

Woo, R., Wong, C. M., Trimble, A Z., Puapong, D., Koehler, S., Miller, S., Johnson, S. 2017, “Magnetic Compression Stricturoplasty For Treatment of Refractory Esophageal Strictures in Children: Technique and Lessons Learned.” Surgical Innovation, 1553350617720994.

Wang, W., Khan, H., Li, J., Miller, S., Trimble, A Z., 2017, “Classification of Failure Modes in Friction Stir Bind Riveted Lap-Shear Joints with Dissimilar Materials”, Journal of Manufacturing Science and Engineering 139(2), 021005.

Slocum, A., Maha, H., Trimble, A Z., Ferrara, M., Ghaemsaidi, S., 2016, “Integrated Pumped Hydro Reverse Osmosis Systems”, Sustainable Energy Technologies and Assessments, Volume 18, Pages 80-99, S2213138816300492.

Trimble, A Z., Yamamoto, B., Li, J., 2016, “An Inexpensive, Portable Machine to Facilitate Testing and Characterization of the Friction Stir Blind Riveting Process”, Journal of Manufacturing Science and Engineering, 138(9), 095001.

Yamamoto, B., Trimble, A Z., 2016, “An experimentally validated analytical model for the coupled electromechanical dynamics of linear vibration energy harvesting systems”, *Journal of Intelligent Material Systems and Structures*, 1045389X16642304.

Oehlerking, A., Meredith, J. D., Smith, I. C., Nadeau, P. M., Gomez, T., Trimble, Z. A., Trumper, D. L., 2011. “A hydraulically controlled nonoperative magnetic treatment for long gap esophageal atresia.” *Transactions of the ASME Journal of Medical Devices*, 5(2), 027511.

Trimble, A Z., Lang, J.H., Pabon, J., Slocum, A., 2010, “A Device for Harvesting Energy From Rotational Vibrations”, *ASME Journal of Mechanical Design*, 132(9), 091001

#### Conferences

Edwards, M., Trimble, A Z., Rognstad, M., 2017, “Hawaii Munitions Monitoring Station and Natural Laboratory”, *American Geophysical Union: AGU -Fall Meeting*

Yasunaga, C., Kalani, D., Harris, J., Martinez, M., Mau, S., Makai, R., Sonada, K., Shiroma, W., Trimble, A Z., 2017, “An Autonomous, Target-Detecting, Fixed-Wing UAS for Simulated, Search-and-Rescue Missions”, *IEEE-CYBER 2017*.

Ben Gershom, Y., Onodera, B., Rayno, M., Ang, J., Trimble, A Z., Nunes, M., 2017, “Design and Development of a 3U CubeSatADCS Testing Assembly with Matching Inertia Tensor”, *Proceedings of the AIAA/USU Conference on Small Satellites*, Poster Session 2, SSC17-P2-10.

Fitzpatrick, L., Trimble, A Z., Bingham, B., 2017, “Verification of a Marine Chemical Plume Model for Use in the Development of Autonomous Vehicle Tracking Systems”, *International Oil Spill Conference*, Long Beach, CA, USA.

Trimble, A Z., Shiroma, W. A., Garmire, D., Ohta, A. T., 2016, “Multidisciplinary Vertically Integrated Project (VIP) Teams at the University of Hawaii: Challenges and Synergy” Paper presented at 2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana. 10.18260/p.25766.

Yamamoto, B., Trimble, A Z., 2016, “Anisotropic Tensile Testing of Additively Manufactured Parts with Varying Interior Raster Geometries by Low-cost Fused Filament Fabrication Machines”, *American Society of Precision Engineering (ASPE), Summer Topical Meeting: Dimensional Accuracy and Surface Finish in Additive Manufacturing*, Session VI Functional Assessment of AM Components, p 139-145.

Trimble, A Z., 2015, “Vibration Energy Harvesting,” Session Talk, 4th International Symposium on Energy Challenges and Mechanics – Working on Small Scales.

Yamamoto, B., Trimble, A Z., 2014, “Investigating the Feasibility of Tuning the Natural Frequency of an Electromagnetically-Transduced Energy Harvester Using Passively-Controlled Inductance”, *ASME 2014 Smart Materials Adaptive Structures Intelligent Systems*, pp. V002T07A024, American Society of Mechanical Engineers (ASME).

Sylvester, A., Delmerico, J., Trimble, A Z., Bingham, B., 2014, “Variable Buoyancy Control for a Bottom Skimming Autonomous Underwater Vehicle”, 2014 Oceans-St. John’s, pp. 1-6, IEEE.

#### Other

Yasunaga, C., Kalani, R., Harris, J., Martinez, M., Mau, S., Mukai, R., Sonoda, K., Shiroma, W., Trimble, A Z., 2017, “A Student-Built Fixed-Wing UAS for Simulated Search-and-Rescue Missions”, *The Bridge, The Magazine of IEEE-Eta Kappa Nu*, Issue 3, Volume 113. - Peer Reviewed.

Trimble, A Z., 2011, “Energy Harvesting of Random Wide-band Vibrations with Applications to a Rotational Energy Harvester”, Ph.D. Thesis, Massachusetts Institute of Technology (MIT).

Trimble, A Z., Lang, J.H., Pabon, J., Slocum, A., 2011, “Manufacturing of high compaction factor surface-wound armatures by tube slitting”, *Internal Report*, Schlumberger, Held from public disclosure for proprietary reasons.

Trimble, A Z., Lang, J.H., Pabon, J., Slocum, A., 2011, “Electro-magnetic frequency tuning for vibration energy harvesters.”, Internal Report, Schlumberger, Held from public disclosure for proprietary reasons.

Pabon, J.A., Guerrero, J., Sihler, J., Lang, J.H., Slocum, A., Trimble, A Z., Ma, H., “Electromagnetic Device Having Compact Flux Paths for Harvesting Energy from Vibrations”, US Patent 12/366,119.

Trimble, A Z., Guerrero, J., Lang, J.H., Slocum, A., 2008, “Flexure based resonant structures for vibration energy harvesting”, Internal Report, Schlumberger, Held from public disclosure for proprietary reasons.

Trimble A Z., 2007, “Downhole vibration sensing by vibration energy harvesting”, MS Thesis, Massachusetts Institute of Technology (MIT).

#### In Progress

Li, T., Hortizuela, N. C., Ng, C., Trimble, A Z., Chun, M., “Finite Element Study of Self-Deflections in Low Aspect Ratio Mirrors Subject to Kinematic Mounting Conditions”

Leopold, S., Trimble, A Z., Chun, M., “Development of CAE Model of Imaka GLAO System to Investigate its Structural Behavior Effects on the Optical Path”

Takara, G., Trimble, A Z., Arata, R., Mora, C., “An automatized plant system to study the effects of climate on plants”, Under Review

#### Funding

##### PI

“UAS-based Imagery Collection, Analysis, Extraction, and Exploitation for Underway Force Protection”, COMSUBPAC N8, 10/2017-9/2018, \$38 k, N00024-08-D-6323.

“Energy Efficient Environmentally Complaint Surface Vessels, Department of Defense”, Office of Naval Research, 7/2018-6/2021, \$285 k, N00014-17-S-B001.

“Energy Efficient Environmentally Complaint Surface Vessels, Department of Defense”, Office of Naval Research, 8/2016-12/2018, \$100 k, N00024-08-D-6323.

“WAM-V for Kanaloa”, Office of Naval Research through AUVSI, 5/2016, \$60 k.

“Study of Interactive Effects of Multiple Climate Change Variables on Plant Growth Using an Intelligent Plant Growing System (IPS)”, University of Hawaii SeaGrant, 11/2014-6/2015, \$10 k.

“Design and Manufacturing of High Efficiency Electric Motors Using Low-resistance Slot-less Armatures by Micro Abrasive Waterjet”, Lawrence Berkeley National labs, 8/2013-6/2014, \$25 k.

##### Co-PI

“Will Plants Thrive or Struggle Under Multiple Co-occurring Climatic Changes?”, NSF 17-508/IOS - Integrative Ecologi Physiology, 3/2018-2/2020, \$1M, pending

“Impacts of climatic changes on native and an invasive Hawaiian plant using a newly developed Intelligent Plant Growing System (IPS)”, University of Hawaii, SeaGrant, 2/2018-1/2020, \$81 k

“Vertically Integrated Project (VIP) Program”, Board of Regents, University System of Georgia, 1/2015-12/2017, \$270 k.

“Array Burial Vehicle”, Department of Defense, Office of Naval Research, 8/2012-2/2015, \$248 k

## Honors and Awards

Hi Chang Chi Excellence in Teaching Award	2019
Seventeenth place overall, Second in Efficiency, SAE Formula Design Competition	2018
Chancellor's Citation for Meritorious Teaching	2018
Sixth Place, AUVSI SUAS Competition	2017
Hi Chang Chi Excellence in Teaching Award	2016
Sixth Place, AUVSI RoboNation RobotX Competition	2016
Third Place, ASME Human Powered Vehicle Competition	2015
Fifth place overall, First among US teams, SAE Micro Aero Design Competition	2014
Hi Chang Chi Excellence in Teaching Award	2013
Carl G. Sontheimer Prize for Excellence in Innovation and Creativity in Design - Flexure based resonant structures	2009
Member Pi Tau Sigma	2005-2007

## Academic and Teaching Experience

Instructor: Manoa Astronomical Technologies Vertically Integrated Project (VIP) University of Hawai'i at Manoa Integrating students across multiple colleges and majors (Mechanical Engineering, Electrical Engineering, Physics, Institute of Astronomy, Architecture, Communications, Business have so far been represented) and skill levels (Sophomore through Master of Science have so far been represented) to develop the next generation of astronomical instruments and the students that will be the next generation of professionals in astronomical instruments. To date, the team has successfully a 12.5 in Newtownian telescope. More details on the VIP philosophy can be found at <a href="http://www.vip.gatech.edu">www.vip.gatech.edu</a> .	2015-Present
Instructor: Kanaloa Vertically Integrated Project (VIP) University of Hawai'i at Manoa Integrating students across multiple colleges and majors (Mechanical Engineering, Electrical Engineering, Computer and Information Science have so far been represented - the team is looking to expand to more diverse disciplines) and skill levels (Sophomore through Doctor of Philosophy have so far been represented) to develop the next generation of autonomous surface vessels. More details on the VIP philosophy can be found at <a href="http://www.vip.gatech.edu">www.vip.gatech.edu</a> .	2016-Present
Instructor: ME 481/482 - Design Project I&II University of Hawai'i at Manoa Capstone senior design course consisting of lectures on: Engineering ethics, engineering design methodology, design process, project planning, decision making, materials selection, economic analysis, quality control, finite element analysis; and the initiation of an open-ended design project. Projects included a SAE Aero, SAE supermileage, SAE Formula, AUVSI UAS, AUVSI RoboBoat, Semi-autonomous satellite tracking station, magnetic torque rods for a satellite, solar and magnetic simulators for a satellite, a neonatal positioner, morcellating laproscopic bag, pulmonary care device, marine thruster, blood donor lounge, and an electric vehicle conversion.	2011-Present
Instructor: ME 492 - Introduction to Renewable Energy University of Hawai'i at Manoa Introductory course in renewable energy covering: Energy basics - Overall energy picture, Energy conversion basics, System boundaries, Exergy; Biomass - biodiesel; Solar Energy - Solar radiation basics, Resource assessment, Solar thermal, Photovoltaic; Wind Energy - Resource assessment, Turbine design implications; Ocean Energy - Wave, Tide, Thermal; Geothermal - Resource assessment; Energy Harvesting/Scavenging - Vibration, Thermal; Nuclear energy - Basics.	Spring 2013-Present

Instructor: ME 696 - Precision Machine Design Spring 2014-Present  
University of Hawai'i at Manoa

Graduate courses on the principles of precision machine design. Topics covered include machine kinematics, machine dynamics, error budgeting, kinematic constraints, component selection, machine structural statics, machine structural dynamics, and machine control strategies.

Instructor: ME 696 - Applied Machine Design Spring 2014-Present  
University of Hawai'i at Manoa

Hands on Graduate courses that requires student to apply precision machine design theory to develop a working machine aligned with a current research topic.

Scuba Instructor Trainer 2003-Present  
United Divers, Cambridge MA (2005-Present)

Alliance-4-Divers, Kaysville UT (2003-2005)

Teaching of all levels of recreational scuba diving from open water diver through dive instructor

- Develop lesson plans and materials for various levels of scuba certification
- Lectures on scuba physics, scuba equipment, and marine environments as pertaining to scuba certification
- Physical "hands-on" style instruction of scuba procedures

#### Professional Experience

Associate Professor of Mechanical Engineering August 2018-Present  
University of Hawaii, Honolulu, HI

- Instructor and mentor for capstone senior design class involving 3-5 design projects from SAE contests to satellite trackers for Hawaii Space Flight (HSFL) to medical products to all manner of gizmos
- Principle investigator of Renewable Energy, Industrial Automation, and Precision Engineering related research projects

Assistant Professor of Mechanical Engineering August 2011- August 2018  
University of Hawaii, Honolulu, HI

- Instructor and mentor for capstone senior design class involving 3-5 design projects from SAE contests to satellite trackers for Hawaii Space Flight (HSFL) to medical products to all manner of gizmos
- Principle investigator of Renewable Energy, Industrial Automation, and Precision Engineering related research projects

Engineering Consulting-Electro-magnetics, Precision Design September 2009-June 2010  
Active Spectrum, San Carlos, CA

- Consulting and bench-level experiments for a magnetic shaft clamp

Engineering Consulting-Vibrations September 2008  
Teradyne, North Reading, MA

- Consulting on vibrations transmitted through a concrete shop floor in an effort to develop environmental specifications for a proposed pick-and-place machine

Engineering Consulting-Expandable Structures, Precision Design May 2007-January 2008  
Schlumberger Doll Research Center, Cambridge, MA

- Consulting related to dynamic seals and expandable structures

Undergraduate Researcher-CNC machine coding January 2005-May 2005  
University of Utah, Salt Lake City, UT

- Using ProEngineer's ProManufacture module and NCpost utilities I wrote a custom post-processor to automatically post ProManufacture models/processes to a VMC bench top mill
- Using Machinery's Handbook, manufacturing process theory, and the machine's power specifications identify the machine's limiting speeds and feeds which are hard-coded into the post-processor for simpler user operation

Scuba Diving Instructor August 2003-Present  
 United Divers, Somerville, MA (2005-present)  
 Alliance-4-Divers, Kaysville, UT (2001-2005)  
 - Teaching of all levels of recreational scuba diving from open water diver through instructor  
 - Development of lessons and lesson materials

Retail Scuba Diving Shop Owner August 2003-August 2005  
 Alliance-4-Divers, Kaysville, UT  
 - Retail sales, inventory control  
 - Management and allocation of instructors and dive masters  
 - Equipment repairs, rental equipment maintenance, Air compressor repairs and maintenance  
 - Billing, cash flow, and other related capital management.

Haulage Truck Driver/Cable Gang/Drill and Blast Machineman January 1997-June 2003  
 Kennecott Utah Copper, Bingham Canyon, UT  
 - Operate mechanical (Caterpillar) and electric (Komatsu) 240 ton haulage trucks  
 - Responsible for deployment, retrieval, and periodic adjustment of 500KVA supply cables for electric shovels and drills  
 - Participate in layout and detonation of blasting  
 - Operate 120ft derrick pneumatic/electric drill including changing of bits and pipes  
 - Shift foreman for swing and graveyard shift drill teams

Excavation July 1995-December 1997  
 J.D. Horne Construction, Layton, UT  
 - Operate track hoe, tracked dozer, front end loader, and skid loader for excavation/backfill of residential basements  
 - Operate transport and dump trucks  
 - Lay sewer pipe and water lines for residential homes and subdivisions.

#### Research Projects

##### Unmanned Systems

Novel Applications of Unmanned Systems that include Unmanned Aerial Vehicles, Unmanned Surface Vessels and Unmanned Underwater Vessels. Technological improvement to unmanned systems that facilitate new or novel applications.

##### Friction Stir Riveting/Welding

Development of benchtop friction stir riveting/welding machine to facilitate research into the effects machine parameters and control strategies have on optimization of the friction stir processes.

##### Study of self-deflection in kinematically mounted mirrors under varying gravity vectors

Using Finite Element Analysis we are starting by studying the limitations of analytical solutions of kinematically mounted mirrors, then moving to characterizing the print through effects of various mounting strategies on the reflecting surface.

##### Advanced Pumped Hydro and Reverse Osmosis System

A symbiotic system that co-locates pumped-hydro energy storage and reverse osmosis desalination plants to reduce initial capital cost and to reduce the toxicity of desalination brine discharge.

##### IPS Climate Change Study Machine

We are developing a machine that can be cost effectively produced by middle and high schools that automates the study of plants under differing climate conditions. The initial prototype can control water, CO<sub>2</sub>, and Temperature over ranges that can be expected in the near future.

##### High efficiency electric armatures

I have developed a new method for manufacturing electric armatures using concentric cylinders where the conduction path is cut out using micro abrasive waterjet technology. The method

produces wire cross-sections that more completely and effectively fill the annular cross-section and thus improve the efficiency.

#### Study of UH88

We have developed a digital parametric solid model of UH88 and are in the process of verifying its kinematic and dynamic accuracy. This model will inform renovation and improvement decisions and provide researchers the ability to predict the effects various astronomical instrumentation will have on the performance of the telescope.

#### Passive Frequency Tuning of Electromagnetic Induction Vibration Energy Harvesters

Using passive, reactive, electrical components such as inductors and capacitors we were able to successfully change the natural frequency of a resonant, second-order, electromagnetically transduced vibration energy harvester by about 1 Hz in the natural frequency range of about 50Hz. The major limiter to larger frequency shifts is the electromagnetic coupling coefficient - a squared effect. Thus, increases in harvester efficiency result in exponential increases in the ability of a designer to shift the natural frequency of an energy harvester

#### Rotational Energy Harvester

Designed and built a rotational vibration energy harvester for use in the extremely high temperature/pressure environment of oil well drilling. As part of my Ph.D. research I expanded on the theory of resonant based harvesters operation in an inherently stochastic environment exploring theoretically non-resonant harvesters, farm type harvesters, mechanical rectifiers, and non-linear resonant harvesters. The research also involved integrated electro-magnetic motor design and involved significant effort on optimization of the electrical and mechanical components. Based on the optimization process the prototype includes an active tuning system for the electro-magnetic damping and spring components.

#### Magnetic Shaft Clamp<sup>1</sup>

Developed a magnetic shaft clamp to rigidly affix and dampen vibrations of an axially translating shaft for fine tuning of a radio receivers natural frequency. The clamp is passive (or zero energy input) while clamped and only requires minimal power when tuning the frequency.

#### Variable Diameter Seal<sup>1</sup>

Developed an expandable structure to be used as the structural backing for a dynamically variable diameter seal.

#### Vibration Energy Harvester for Automotive Doors<sup>1</sup>

Designed and built a cantilever type electro-magnetic energy harvester for use in automotive doors. The cantilever structure can be integrated into an existing door topology avoiding crash safety bars and window mechanisms.

#### Flexure Based Resonant Energy Harvesting Sensor

Designed and built a flexure based resonant structure which can act as a very narrow-band pass filter (very high Q structure). When connected to a permanent magnet, linear coils, and a ZeeBee wireless transmitter the structure acts as an input acceleration frequency (and Amplitude) alert. Using a priori knowledge of the transmitted bits and some statistical estimation an estimation of the actual vibration spectrum (not just alert monitoring) can be obtained. This work was done as part of my master's thesis.

#### Analysis of renewable resources for off-shore structures

Using the solar and wind maps published by NREL and tide and current charts published by NOAA, I developed a Matlab based code to evaluate the potential energy available in each resource for a given location and structure (i.e. surface area). As a test application the Aquarius Undersea Laboratory was evaluated in an effort to replace the current diesel generators with renewable sources. A system consisting of a small wind turbine a small tidal turbine (wind and tidal turbines sized and located to minimize pitching moment on floating structure) and an array

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<sup>1</sup> All project information is considered confidential

of solar cells all combined with a battery backup power management system which meets the power needs of the laboratory at a minimal cost was design.

#### Remote Aerial Survey Vehicle

Team leader of a group that designed and built an Unmanned Aerial Vehicle (UAV) capable of taking high-resolution images of wildlife up to 15 miles from the operator. The plane was never tested beyond visual range, but all performance expectations that were tested matched expectation.

#### Customized CNC post-processor

Wrote a customized post-processor using ProEngineer's NCpost utility to convert ProManufacture created tool paths to usable machine G-code. Additionally I identified the limiting feeds and speeds (and recommended feeds and speeds for a selection of materials) by experiment and calculation and hard-coded those values into the post-processor to automate solid model to manufacture process.

#### Other Skills and Personal Interests

- Private Pilots License - Obtained private pilots license in minimum number of hours (35hrs) currently have about 100 hours of PIC time
- Eagle Scout - I am an eagle scout and still participate in scouting with my 2 sons
- CDL - I obtained my commercial drivers license while working in excavation and have maintained those skills
- Volleyball - I am an avid volleyball player (both indoor and outdoor) and typically attend USAV adult open nationals annually
- Scuba Diving - I became an instructor because I love diving of all kinds, from the simplest recreational dives to "technical" diving and re-breathers.