I can't remember what age I first became enamored with space exploration and aviation, but attending airshows in my home state of Idaho and playing with toy NASA spacecraft as a young child was a factor. My need to learn and investigate was wonderfully fulfilled when I would observe aircraft, stare awestruck at the hero-pilots or when I read through encyclopedia books about the moon landings. In 3rd grade I "decided" my future would be in aerospace when I was one of two students selected to attend a talk given by an actual moon walker! At the age of 9, my conversation with Capt. Eugene Cernan changed my life. After that, my science projects were always space related and I was constantly showing my parents and teachers my new spacecraft designs I was certain NASA would love. I wanted to get a pilot's license and fly in the Air Force because it seemed that all the astronauts had this common background. In high school I joined the U.S. Army Junior Reserve Officer Training Corps (JROTC) to learn leadership and prepare myself for college Air Force ROTC and the subsequent service in the United States Air Force (USAF). Everything seemed perfectly planned out as the USAF would pay for my education and I would become an engineer-pilot just like the majority of astronauts I admired and sought to emulate.

In my junior year of high school, I suffered a severe injury that destroyed plans for college and my future career as an astronaut. My extracurricular activities included Bicycle Motocross (BMX) racing and I always tried to push past my limits. Unfortunately, the crash on my bicycle left me with titanium and steel in my arm, effectively killing the USAF's interest in me due to my medical ineligibility. In one moment, my path to college was destroyed. I was still in high school and many of the medical bills were in my name. Furthermore my parents were unable to provide insurance or financial support and I found myself dealing with collection agencies and unable to acquire student loans. With college financially out of the question, somewhat embittered, after graduation I turned to the working world and professional BMX racing with which I was familiar.

As the years passed I found myself leaving BMX behind and focusing on building and racing cars because the more intricate mechanical and thermodynamic systems attracted me. This somewhat soothed the feeling that I was not living the life I wanted because this new arena of building and racing cars offered a vast amount for me to learn in the physics and engineering of motorsports. I devoured it hungrily. The more I learned, the more I began to think that rather than depend on student loans, I could create a business, earn money, and then pay for my own education, allowing me to achieve what I wanted. This led me to Alaska where I worked on a commercial fishing boat in an effort to gain some startup capital. At the age of 22, I was no longer angry at my situation. Instead I had determined that I would not be stopped. By the time I came home from Alaska I had been at sea working tirelessly which changed me in a few important ways. First I noticed that I looked at obstacles and problems as opportunities to prove myself rather than as reasons for failure. Second, I had developed a longing to live near the ocean. Finally, the way in which I interacted with others had changed. While before I had always spoken up in a group and could sometimes take the lead, now I had self-confidence that led others to seek me out for problem-solving and answers trusting I would take action and solve their problems. I started my motorsports business, confident that my goals would be achieved after all.

It became obvious after about a year that starting a motorsports business is tremendously difficult for anyone let alone an uneducated 22 year-old. The company did not take off nearly as well as I hoped and within a year I found myself picking up a second job as a carpenter. Though my original idea had not proved successful, I did not let it define me. Instead, I continued building and driving my racecar while I progressed in my carpentry career. Over time I built my reputation in the motorsports world by volunteering as much as I could and through mentoring new young drivers. I enjoyed considerable success in my state and began traveling to semi-professional (pro-am) events in the surrounding region to earn a professional racing license. My problem solving abilities and charisma also propelled me in my career, and I sought out and obtained a position managing the service department for a high end luxury millwork and cabinet shop. It was not uncommon for us to win contracts for $250,000 of woodwork in a single multi-million-dollar home. My job entailed managing the installers, warrantee claims, and any product issues that arose. It was a stressful position that paid well but left me feeling like I was missing something. Once again I found myself constantly thinking about school and flying.

When the great recession hit in 2008, extravagant woodwork was extremely hard to sell and once again I found myself looking for work. This time, thanks to my hard work and outgoing personality, I had many options and much experience. Ultimately I leveraged my decade of motorsports experience to land a position as a light mechanic. Within a year, a much shorter timeframe than typical, ready to become Automotive Service Excellence (ASE) Master Certified at the next testing opportunity. My wife, daughter, and I weathered the financial hard times fairly well through hard work and creativity. In 2010 I co-founded BoiseDrift, an organization that provided an affordable way for people to experience driving on a racetrack in an open track-day format that allowed participants to enjoy non-competitive use of the track in their own vehicles. There had been nothing like this in Idaho when I had first become involved in motorsports and being able to create an opportunity like this for my community proved to be quite fulfilling. Then, in a moment emblematic of the idea that giving to others may bring good to you, after working so hard to create a positive experience for others via BoiseDrift, I received the greatest gift from my father-in-law Jack Ugaki who told me that if I went to school full time, he would help with financial support as I would not be providing a full-time income. After all my years… I am not ashamed to say that I was moved to tears, beyond excited at the opportunity to finally attend college.

I enrolled at Boise State University (BSU) and began studying ME because BSU does not offer Aerospace engineering. After three semesters I realized I wanted a deeper understanding of the science behind engineering, so I switched my major to Physics. I had always planned to pursue a research-based graduate degree due to my passion for space exploration and my desire to increase human presence in space through transformational research. I felt certain that a bachelor's degree in physics instead of ME would better equip me with the science oriented background needed to make the significant contributions I envisioned. I also recognized that as part of the much smaller physics department I would be able to develop personal relationships with the faculty, work as a research assistant, and gain teaching experience. After studying the department's faculty research site and speaking with department graduating seniors, I sought out a professor whose work intrigued me and explained my goals. Not only did I secure a paid research position but the physics department offered me a teaching position in the lower division physics labs during my last two years at BSU. My interactions with the students strengthened my understanding of the material while also giving me the chance to mentor and assist those students struggling with learning obstacles, helping them conquer and achieve success. Mentoring opportunities abounded, both with my students as well as my fellow classmates. My non-traditional age and diverse background gave me perspective on many of their individual challenges and I know I was able to positively affect those around me. One particular classmate was getting discouraged with physics and had wavered between sticking with it and switching to another major. After many conversations in which I shared my life experiences I helped him find internal motivation to follow whatever he was passionate about and to push through discouraging times. Through my continued mentorship, the student ultimately graduated and is now attending graduate school. From that experience I learned the power of true mentorship. Every piece of advice I gave also helped me as I felt a sense of accountability to my mentee, pushing me to set a good example and practice the behavior I advised. Furthermore, listening to a person's struggles provides insight into whatever problem they are facing and helps both mentor and mentee because the advice delivered and suggestions made can be applied by both parties. Finally, the sense of accomplishment and the rewarding feeling that comes from truly helping someone always serves as a powerful piece of motivation.

My research experiences while at BSU also proved hugely influential to my development. Dr. Tenne's lab utilizes Raman Spectroscopy and other methods to study advanced materials, and I found myself equal parts intimidated and excited to be involved. Intent on making the most of this opportunity, I resolved to spend as much time as possible there. Before the end of my first term I had not only learned how to run all the equipment but also how to keep the temperamental, aging lasers operational. In fact, I was the only person in the group able to get them going 100% of the time. To do so I applied my analytical thought process and automotive diagnostic experience to the problem at hand and devised a hypothesis for what the most likely failure modes would be. While I was able to zero in on the laser system's faulty parts, I still was not an expert on 1980's laser heads and power supplies and recognized I would need more input. After many hours of hunting I located an expert who was able to provide the insight I needed. My willingness to seek guidance rather than assume I had all the answers led me to solve the problem the first time. After my success with the faulty lasers, Dr. Tenne placed his "complete trust" in my abilities and I found myself much more involved in the research. During my time with Dr. Tenne I learned how to analyze and present data, conduct an experiment affectively, and setup an experiment that would deliver the needed data. Because of my work and input I was included as a co-author on my first publication entitled: **Adsorption-controlled growth of BiVO4 by molecular-beam epitaxy,** APL Materials**;** and I later presented that research at the 2014 Materials Research Society (MRS) Spring Meeting, a major international conference in San Francisco. By the time I graduated I had co-authored two more publications. The first of these, **Epitaxial CrN Thin Films with High Thermoelectric Figure of Merit** in the journal *Advanced Materials*, detailed an interesting study on CrN thin films that challenged me to acquire consistent data from a sample across a temperature range from 10K to over 1100K. For the second publication, **Magnetic Structure and Ordering of Multiferroic Hexagonal LuFeO3** in the journal *Physical Review Letters*, I spent countless hours handling a dizzying amount of samples and data working on my last spectroscopy project. It was truly wonderful and unique to be able to have that kind of experience as an undergrad and I hoped the next students to come behind me would get as much from it as I did. My lab experience as an undergraduate created a strong foundation for me to continue my academic career, yet I recognize that it was a unique experience thanks to my determination and Dr. Tenne's mentorship. Intent on sharing my knowledge with those following behind me, I held a training day in the lab for as many of the incoming assistants as possible. I not only compiled a comprehensive laser repair and maintenance manual and taught them how to diagnose and repair the lasers, but I also tried to pass on my enthusiasm for the opportunities they would have if they were willing to put in the work. These three years of research, teaching, and studying have been some of the most special times of my life.

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As I begin my graduate studies, I intend to earn a Ph.D. in Aerospace Engineering and dedicate my life to innovation and research in the space exploration industry. After school I plan to seek employment with companies such as SpaceX or JP Aerospace and tackle problems such as manufacturing and construction in the space environment, scramjet feasibility, and novel radiation shielding methods. more specific and powerful reference to research idea is needed here] I plan to make a significant contribution toward the goal of realizing a major increase in human activity and presence in space. University of Florida is among my top choices as I progress toward the goals I set for myself all those years ago when I shook the hand of a moon walker.

Motivation: The detection of gravitational waves will usher in a new era of astronomy and transform our understanding of the Universe. Advanced LIGO will directly detect gravitational waves before the year 2020. However, only gravitational wave experiments that are carried out in space can access the mHz frequency band. This band is where we will measure signals from compact galactic binaries, massive black hole mergers, and a host of other cosmic sources. The Laser Interferometer Space Antenna (LISA) [1] is top among current proposed space-based missions. These gravitational wave missions are centered around laser interferometry and require a stable optical bench. The current designs were conceived in the 1990s [3] using the knowledge and tech of the time. The bench material choice of these missions has always been an ultra-low thermal expansion glass like Zerodur because it was assumed that the pm/√Hz stability requirements demanded it. Current state-of-the-art stabilization technology no longer requires such a conservative design approach. Despite these advances LISA pathfinder (LPF), a mission that will prove some of the critical technology advances needed for LISA, still uses Zerodur for the entire bench with each optical component permanently and precisely hydroxide bonded [2]; a tremendously difficult and time consuming process. This design makes the optical bench one of the highest risk items in terms of schedule and cost. The complexity of the LISA bench far exceeds the LPF bench and LISA would require over 10 complete units including spares, engineering models, and flight units. Though human-kind stands at the threshold of the era of gravitational wave astronomy, *no such mission will take place* unless it is much more feasible in terms of cost and complexity. Massive reductions in cost and complexity are possible which will prevent further delays and ensure transformational scientific progress. We are truly on the threshold of a new era in our understanding of the universe. Advances in science and technology are often delayed due to cost and manufacturing constraints of sensing equipment. Our objective is to bring down the cost and reduce the manufacturing complexity of ultra-precise optical platforms. This will benefit a vast range of fields both in and outside of science. From Astrophysics and space exploration to medical sensing and materials science, affordable precision sensing solutions will the make-or-break component that will allow watershed breakthroughs that will change lives around the globe. Our ground-up redesign of the interferometer bench will reduce the number of critical paths and their lengths thus increasing stability while reducing manufacturing complexity. Optical fibers will be used to remove as many non-critical components from the bench entirely. We will use only conventional materials and commercially available components and will still meet or exceed a pm/√Hz standard while demonstrating long term stability.

Hypotheses: Commercially available optical components, common materials, stability-optimized design, and conventional assembly methods are sufficient to satisfy the pm/√Hz path length stability requirements for ultra-precise position measuring Laser interferometry optical benches.

Research Plan: There will be three main efforts to accomplish our objectives. Effort one will test and confirm the ability of high quality commercially available optical components to provide pm/√Hz stability. We will assemble a polarization multiplexed heterodyne interferometer using a phase meter readout from previous Advanced LIGO [5] work to verify our bench stability. This bench will be designed with a removable block that has a single optical component mounted to it. The block will be removed and subjected to thermal cycling and vibrational testing both in and out of vacuum. This procedure will be repeated numerous times with a variety of different commercially available components attached to the block. The result of effort one will determine the capabilities of the off-the-shelf components. Effort two uses finite element analysis to study bench designs that use various materials such as titanium and carbon-fiber reinforced plastic [4] and have been light weighted. Because our research will be implemented in a variety of fields we must study many different end use environmental conditions. We will study thermal deformation, and mechanical resonance frequencies to determine which materials and light weighting strategies are best suited for different environmental rigors. Effort three combines the results of the first two efforts in the assembly of benches built from the chosen materials with optimized light weighting. These benches will be tested in our vacuum chamber in which we will install thermistors and Peltier elements to control thermal conditions. We will also test the benches under a wide range of E and B field conditions which are often seen in medical testing environments. This will validate our bench design specifications under a wide and diverse parameter space and ensure applicability of our research across many fields.

Intellectual Merit: All LISA type missions and gravitational wave experiments as well as distributed aperture missions, coronagraphs, and Earth monitoring missions use laser interferometry and require a stable optical bench. Manufacturing processes such as advanced polishing and nano-machining depend on super fine distance measurements which can be realized through our research. The materials science field will also benefit from the technological developments realized through this work due to the ability to obtain more precise and consistent position data for synthesis and characterization processes. This will improve control of layer count in thin-film crystal growth and improve tip placement mapping in AFM enhanced micro-Raman spectroscopy. Precision measurement and repeatability are at the core of most cutting edge science and we will be able to provide a significant improvement in that category.

Broader Impacts: The implementation of our research will bring advanced manufacturing, medical sensing, space-craft manufacturing, and materials science research to a more affordable level. This will allow a far greater number of universities, businesses, and nations to participate in these arenas thus bringing the benefits of research and science to a much larger portion of the global population. Apart these global impacts are the more immediate and personal differences I will make in the lives of students through mentoring and active community involvement. Just as I did with BoiseDrift, I will start an organization called Chain of Mentors that will bring new opportunities to students facing extra challenges. The focus will be on under-represented groups, and individuals who have passion but need guidance. We will provide mentorship and also encourage our mentees to act as mentors when they can. We will build a chain of mentorship over the years from our early members that will connect to our newest. Thus the collective knowledge and life lessons can benefit new scholars who will spread across the world.

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Intellectual Merit Criterion

Overall Assessment of Intellectual Merit
Very Good

Explanation to Applicant
Grades are not as competitive as other applications.

Broader Impacts Criterion

Overall Assessment of Broader Impacts
Excellent

Explanation to Applicant
Interesting research topic and love the idea of creating a "Chain of Mentors"

Summary Comments
Applicant has overcome many obstacles to make it to this point and is succeeeding. Very good application.

Intellectual Merit Criterion

Overall Assessment of Intellectual Merit
Very Good

Explanation to Applicant
sThe applicant is certainly a non-traditional student. The path that this student has traveled between highschool and graduate school is one that will continue to inspire many students to come. Having had to deal with tremendous adversity for a young person, the student worked in different capacities and later on started his own motorsports business. He got an opportunity to attend college and as it is clear from his statement and his strong recommendation letters the student had many original contributions to the research he performed during his undergraduate tenure. At BSU, the student did research under Dr. Tenne and utilized Raman spectroscopy and other methods to study advanced materials. His research with Dr. Tenne resulted in three co-authored papers in highly rated peer-reviewed journals (APL, Advanced Materials, and PRL). At UFL, his research under Drs. Conklin and Muller is focused on future space gravitational wave observatory (LISA: laser interferometer space antenna) by assembling and testing optical components and other requirements for such precision measurement. As pointed out by his research advisor: "many good students are able to brainstorm and come up with ideals for solving problems. Daniel's solutions to this and other experimental challenges have been far more insightful and useful than those typically proposed by first-hear graduate students."

Broader Impacts Criterion

Overall Assessment of Broader Impacts
Excellent

Explanation to Applicant
the student used his own non-traditional background and great interest in Physics to help and mentor others and help in retaining student in the physics program. He has demonstrated that he has a great potential for leadership, is self-motivated and driven. A combination of his intellect and drive along with his compassion for others will sure place this student well to be a leader in the future and have high impact on advancing knowledge in his field and through mentoring of others.

Summary Comments

The student has demonstrated great potential as a leader in the future impacting both in advancing knowledge in his field of research/study and in mentoring students in STEM fields and having substantial societal impact by being a role model.

Intellectual Merit Criterion

Overall Assessment of Intellectual Merit

Very Good

Explanation to Applicant

The applicant has a good academic record. He has received a number of academic awards and has coauthored three articles. The applicant has prior experience working with lasers in a research setting. The goal of the proposed work is to reduce the cost and complexity of manufacturing ultra-precise optical platforms. The plan for doing so is presented well, having specific details and expected outcomes. The letters of support describe the applicant as dedicated to the field and capable of excelling in this area of research.

Broader Impacts Criterion

Overall Assessment of Broader Impacts

Very Good

Explanation to Applicant

The applicant has followed a nontraditional path to arrive at this point in his career. Much of his personal experience guides the broader impacts of his work. The applicant has been involved in mentoring and views this as an important activity to continue in the future. Reducing the various costs associated with producing high quality lasers will make the technology more accessible to the public.

Summary Comments

The applicant's objective is to develop techniques for manufacturing precise optical platforms that are more cost effective. The intellectual merits and broader impacts are both good. The applicant has had to over come a variety of different challenges to make it to this point. The letters of recommendation highlight his dedication to the topic and potential to do great things if given the opportunity.