1. What is the research area in which you are proposing investment?

Though originally developed for national security, autonomous robotic devices, such as unmanned airplanes and unmanned subs, are finding utility in a wide range of applications including hurricane research and sensing activities for environmental and agricultural functions. Further, with the development of self-driving transportation devices, e.g. Google’s Unmanned Car, the application of Autonomous Vehicles will revolutionize the highway system and will impact the lives of virtually everyone. Autonomous vehicle technology has advanced significantly in the past few years, and now allows for complete computer control of the vehicle. The U.S. Department of Transportation (USDOT), several automobile manufacturers, and other industries (e.g., Google) are heavily investing in the development of these systems with the expectation of insertion into public transportation networks within 10 years.

In the past, control of autonomous robots only required operation of a single element. As this field has progressed, controlling and protecting swarms of unmanned terrestrial, airborne or undersea units is now required. Even space is involved as satellite technology is now moving toward arrays of small units rather than large single satellites. DOT, DOD, NASA, and DOE envision swarms of unmanned systems operating in conjunction with manned systems while gradually reducing the degree of human control and decision making. This presents a number of challenges in the areas of systems level control, security and the human interface. For example, autonomous systems must be safe, responsive, adaptable, reliable, and resilient against tampering, accidents and natural disasters.
The College of Engineering is currently a world leader in development of autonomous undersea and airborne robots as well as in control of manned transportation systems. With addition of expertise in safety, security, control of large unmanned systems, and in the interaction of manned and unmanned vehicles, the University of Florida can be the premier national center for Autonomous Systems.

2. **Does this area fall under one of the broad thrusts identified by the SVPs and the VPR?**

   Global Security

3. **Why is this area important to the college and the university?**

   Autonomous systems represent the next great step in the fusion of machines, sensing, and communications to create intelligent systems capable of interacting with the complexities of the real world. **UF is primed to become a prominent international leader in the emerging area of autonomous systems**, due to the success of its existing research programs in miniature aerial and underwater vehicles and manned transportation systems; UF successes in unmanned vehicle research have been featured in national media such as CNN, Reuters, Smithsonian Magazine, and National Geographic. UF possesses expertise in the critical supporting disciplines of controls, optimization, wireless networks, and communications. This initiative is also supported by the UF Transportation Institute (UFTI) and the College of Engineering’s Institute for Networked Autonomous Systems. The UFTI has a strong national and international presence in the management and optimization of conventional transportation systems. Existing faculty work in the area of traffic control optimization, traffic simulation, travel demand modeling, and land use. Researchers affiliated with the UFTI have already developed and implemented system architectures for autonomous ground vehicle navigation and have designed the implementation of passive parallel mechanisms to be used for force control applications. UF was selected to compete in the 2004 and 2005 DARPA Grand Challenge autonomous vehicle development efforts and in the 2007 DARPA Urban Challenge. The DOD Integrated Roadmap (2011-2036) envisions unmanned systems seamlessly operating with manned systems while gradually reducing the degree of human control and decision making. While many institutions are pursuing autonomy, UF is well-positioned to take the national lead in the critical interface between humans and autonomous systems, which will have significant impact on the future wide spread implementation envisioned with autonomous transportation.

This area of research is also important to the local community and the State of Florida. The success of the college’s programs in Autonomous Vehicles combined with the training provided by the Engineering Innovation Institute has resulted in the creation of a number of local startup ventures based on technology developed at UF. **More successful startups like Altavian and Prioria are expected if this initiative is funded.**
Due to the broad spectrum interest in autonomous systems and their application in many fields (e.g., medicine, environmental monitoring, and defense) considerable long-term federal funding is available from various sources including NSF, DOD, DOE, NASA, and USDOT. Funding of this proposal would build on UF’s existing strength in Autonomous Vehicles and Manned Transportation Systems, resulting in the emergence of an international powerhouse in Autonomous Systems.

Examples of External Funding Available in Autonomous Systems Research:

The National Robotic Initiative was first announced by President Obama in 2011. Between NSF, NASA, NIH and USDA, this initiative released more than $50M for projects starting in 2013 and has announced an additional $42M for proposals due in 2014. The goal of the National Robotics Initiative is to accelerate the development and use of robots in the United States that work beside or cooperatively with people. Other agency announcements related to robotics that have been made since the President’s speech include DOD’s tens of millions of dollars for Defense University Research Instrumentation Program, the opening of the Navy’s cutting-edge Laboratory for Autonomous Systems Research, and DARPA’s Robotics Challenge to improve disaster response operations. Beyond this support, in recent years, DOD’s Multidisciplinary University Research Initiative (MURI) has supported at least 3-4 topics related to unmanned and networked systems. UF is poised to capitalize on the National Robotic Initiative, as it possesses national and internationally known expertise in unmanned bio-inspired micro and miniature aerial vehicles and underwater vehicles coupled with extensive experience developing and testing several generations of aerial and underwater autonomous systems in state-of-the-art facilities.

The U.S. Department of Transportation under the Research and Innovation Technology program (RITA) has made the development and deployment of an autonomous multimodal transportation system a high priority. Florida, California, and Nevada already have laws regulating the operation of autonomous vehicles in their highways. The industrial sector is also engaged, automobile manufacturers (e.g., Ford, General Motors, Volvo) and other companies (e.g., Google) are heavily investing in the development of these systems.

Investment in this initiative would help put UF at the forefront of intelligent transportation systems and their implementation. Safety is also a priority, as systems to enhance data connectivity between vehicles and between vehicles and infrastructure could reduce the probability of accidents by 71% and in turn prevent tens of thousands of automobile crashes every year. Thus, an investment in this area will raise UF’s competitiveness in securing partnerships with industry. As a national leader in transportation research, UF is on the brink of capitalizing on this initiative. A strategic hire in the right area would enable UF to compete for large USDOT center grants needed to develop the complex control systems for autonomous road vehicles. With an additional strategic hire of a faculty in the area of Intelligent Transportation Systems, UF will gain the expertise needed to become a world leader in this emerging field.
4. What faculty/capabilities/infrastructure/accomplishments does the college already have in this area?

UF has made considerable investments in the area of autonomous systems, unmanned bio-inspired micro and miniature aerial vehicles and underwater vehicles, and ground transportation. This opportunity leverages faculty expertise in 6 different engineering departments in areas ranging from control theory, small satellite systems, space guidance, navigation and instrumentation, sensing and data analysis, multi-modal transportation system optimization and modeling. The COE Space Systems Group is currently partnering with CLAS faculty to develop new technologies for small satellites that will improve the performance and autonomy of future satellite navigation systems and remote sensing platforms. A key focus of this work is on disaggregated space systems, where the individual capabilities of a single large satellite are separated and shared among a constellation of small satellites, working together to achieve a specific goal. The group has already earned an international reputation, and recently launched their first small sat aboard the US Air Force ORS-3 mission rocket. Successful funding at the multi-million dollar level has come from NASA, DoD and NSF, including the currently funded NSF I/UCRC Advanced Space Technologies Research and Engineering Center (ASTREC).

Two years ago the College of Engineering created the UF Institute for Networked Autonomous Systems to begin to capitalize on the emerging area of coordination of autonomous vehicles. In only two years this Institute has secured almost $1.6 M in new funding from the Office of Naval Research (ONR) and the Air Force Office of Strategic Research (AFOSR). The College has also developed several state-of-the-art facilities essential for this program, including two wind tunnels, a 70,000 gallon water tank for underwater robotics equipped with a motion capture system, and a biocompatible water tunnel.

UF has also had a long and successful history in transportation research and education, and the recent formation of the UF Transportation Institute (UFTI) allows for greater opportunities for interdisciplinary collaboration, to solve highly complex transportation problems. Research at UFTI involves the planning, design, operations, monitoring or optimization of transportation and other infrastructure systems towards achieving safety, sustainability, and economic efficiency. The UFTI successfully competed for the regional university transportation center in the southeast region (STRIDE, www.stride.ce.ufl.edu), and as a result has received more than $8 Million in funding from the US DOT and the Florida Department of Transportation since January 2012. This year’s total of active grants managed by faculty affiliated with the Transportation Institute was more than $18.5M, while associated research expenditures exceeded $5.6M.

Finally, the University has made a significant investment at the UF REEF (Research & Engineering Education Facility) campus adjacent to Eglin AFB. This modern facility has seen new contracts in excess of $1M per year in recent months, and the Air Force Research Lab directorate of Eglin AFB is eager to expand our collaborative efforts in aerospace and
autonomous systems, providing high-leveraging potential and ROI. UF is currently partnering with the Air Force and the local Economic Development Council to construct an Autonomous Vehicle Center (AVC) adjacent to the UF REEF facility. The AVC would be fully dedicated to the testing and evaluation of autonomous air and ground vehicles, and provides an excellent opportunity to leverage this Top 10 proposal if successfully funded. Expansion of existing partnerships with Eglin Air Force Base, and with companies such as Lockheed-Martin, Northrop-Grumman, and others from the private sector are envisioned as part of this initiative.

With the addition of expertise in a few key areas, UF will be able to provide the same kind of leadership in systems of autonomous vehicles as we have achieved in development and control of individual units. The requested faculty and their new expertise will allow UF to coalesce around larger system-level problems, enabling competitiveness for large center-level grants and the prominence that comes with such awards.

5. Will there be any interdisciplinary links between this proposal and work in other colleges?

Deployment of autonomous aerial, ground, and underwater vehicles holds promise as a truly disruptive technology. These problems are multidisciplinary, bringing together COE, IFAS and CLAS faculty to achieve state and national impact. The COE Space Systems Group is currently partnering with CLAS faculty to develop small satellite missions leveraging our expertise in instrument development, computationally intensive data analysis, fast attitude control, multi-robot cooperative systems, and formation flying. Investment in this emerging, multidisciplinary area complements existing strengths while offering a path to ownership of this new area. The UFTI works closely with the Department of Urban and Regional Planning in issues of land use planning and their relationship to transportation systems. Given the anticipated impacts of autonomous vehicles in transportation as well as in land use, there will likely be several more opportunities for further collaboration with this department. UFTI has also worked with the Department of Occupational Therapy and its Center for Mobility and Activity Participation Across the Lifespan. Additional potential collaborative opportunities relate to implementation policies for autonomous vehicles, as well as transportation economics.

Numerous synergies/partnerships also exist beyond the University, including Federal entities such as Eglin and Tyndall AF bases and KSC, and companies such as Harris Corporation and Lockheed Martin, as well as Gainesville-based Prioria Robotics and Altavian. Given current expertise within the COE in conjunction with CLAS and IFAS faculty resources, and with numerous critical applications, the opportunity exists to promote regional industry development and to achieve international recognition in aerial, ground, and underwater autonomous systems.
6. What Outcomes, Metrics, and/or Return on Investment will the college and university realize from this investment?

The intent is to hire seasoned, nationally known rising stars who are already successfully leading multi-disciplinary research groups. The three targeted faculty hires will work in concert with existing faculty to elevate UF to become the best program in the country in aggregated aerial, ground, and underwater autonomous systems. While a number of institutions are engaged in robotics research, none to date have assembled a team comprised of experts in all facets of autonomous vehicles (space, air, sea and land) and focused them on addressing the critical systems and human interface issues generated by implementation of these systems. Funding of this initiative will also result in significant positive publicity for the university with the general public. The subject of Autonomous Vehicles is one of great interest and high visibility as can be seen from the general media interest in our current work.

Significant productivity returns are expected from this investment due to the increased competitiveness that will enable UF to secure new federal funding for large programs and for center grants, and more publications in prestigious peer-reviewed venues. Under the National Robotic Initiative UF will compete for a share of an additional $42M in opportunities from NSF, NASA, NIH and USDA. Other sources of funding include DoD’s tens of millions of dollars from the Defense University Research Instrumentation Program, the Navy's cutting-edge Laboratory for Autonomous Systems Research, and DARPA’s Robotics Challenge to improve disaster response operations. There is also the Gulf of Mexico Research Initiative which seeks to award $105M from 2015 through 2017 to support research consortia investigating the fate, transport, and impacts of hydrocarbon releases in the environment of which autonomous monitoring systems is part of the solicitation call. And finally, there is the USDOT’s long term commitment to engender the development and deployment of an autonomous multi modal transportation system under the Research and Innovation Technology Program.

Thus, from each new hire we expect annual research expenditures of at least $400,000 per year for a total of $1.2 million. In addition, their hiring will also enable UF to successfully compete for more industry funding and for larger multi-investigator proposals resulting in an additional $1M in research expenditures per year.

The expected cost of this investment over five years (salary and fringe plus startup) is $4.25M; whereas, the expected increase in extramural research expenditures over the same five years is $9M. This represents a 2:1 return on investment. Over the long run, annual research expenditures increase by $2.2M for an annual cost of $450k in faculty salaries and fringe. This represents a 5:1 return on investment. Beyond the dollars, we expect each faculty hire to graduate 1 PhD per year after the fifth year for a total increase of 3 PhD graduates per year.

7. What is the total allocation (salaries plus fringes) being requested?
Total allocation (salaries plus fringe) being requested: $450,000

1 Associate or Full Professor. Control of Networked/Distributed Autonomous Systems. Expertise in control of autonomous systems, including networks of sensors and vehicles on land, air or space. Given the similarities of the issues in controlling large numbers of unmanned units, this individual will be engaged in all of the various types of systems described in the proposal.

1 Associate or Full Professor. Intelligent Transportation Systems. Expertise in planning, design, operations or control of intelligent transportation systems that leverage advanced vehicular, sensing and communications technologies. We are particularly interested in scholars who investigate optimal control, human system interaction, management and socioeconomic impacts of autonomous and connected vehicle systems.

1 Associate or Full Professor. Expertise in design for safety and security of networked autonomous systems. Security will include both protection of the public and protection of the Autonomous System. This faculty will also work closely with new hires in Cybersecurity.

8. **Have you identified space within your unit to house these faculty members and any associated laboratories?**

   Faculty will be housed in existing engineering facilities.

9. **Please estimate total startup costs needed for this proposal.**

   $2,000,000

   **What portion of this amount will be provided by the college?**

   $600,000