

Testing, Evaluation, and Control of Heterogeneous Large-scale Systems of Autonomous Vehicles (TECHLAV)



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NDIA



<http://techlav.ncat.edu/>



TECHLAV



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of **A**utonomous **V**ehicles (**TECHLAV**) Center

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Outline



- Overview
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- Organization and Collaborating Institutions
- Research Thrusts and Milestones
- Demonstration, Implementation and Integration (DII)
- Education and Outreach
- Acknowledgments
- Q&A



Department of Defense Roadmap



Unmanned Systems Integrated Roadmap FY2013-2038

Goals		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2030+	
Technology Projects	UAS	<u>Near Term</u> Secure C2 Links. Certified GBSAA. Certified Displays. Improved Sensors. <u>Interoperable payload</u> Expand physical architectures.					<u>Mid Term</u> Certified ABSAA and Separation Algorithms. <u>Integrated equipment</u> Expanded Autonomy Systems and Avoidance Algorithms					<u>Far Term</u> Integrated SAA. Evolution with NextGen Autonomous Architecture		
	UGS	Increase Automation for Specific Tasks. V2V Comms					Effective Autonomy Systems and Avoidance Algorithms. Security Architectures							
	UMS	Improved Power, Comm, and Sensor Systems												
Desired Capability	UAS	Incremental access to the NAS. Effective information fusion					Routine Access to the NAS. Due Regard capability. Effective exploitation					Increased safety and efficiency for flights in NAS and worldwide. Effective forensics		
	UGS	Robust physical capabilities					Effective manned-unmanned teaming					Adaptable Systems		
	UMS	Autonomy for specialized missions in localized areas. Increasingly networked systems					Increased missions in expanded geographical areas					Autonomous missions worldwide		



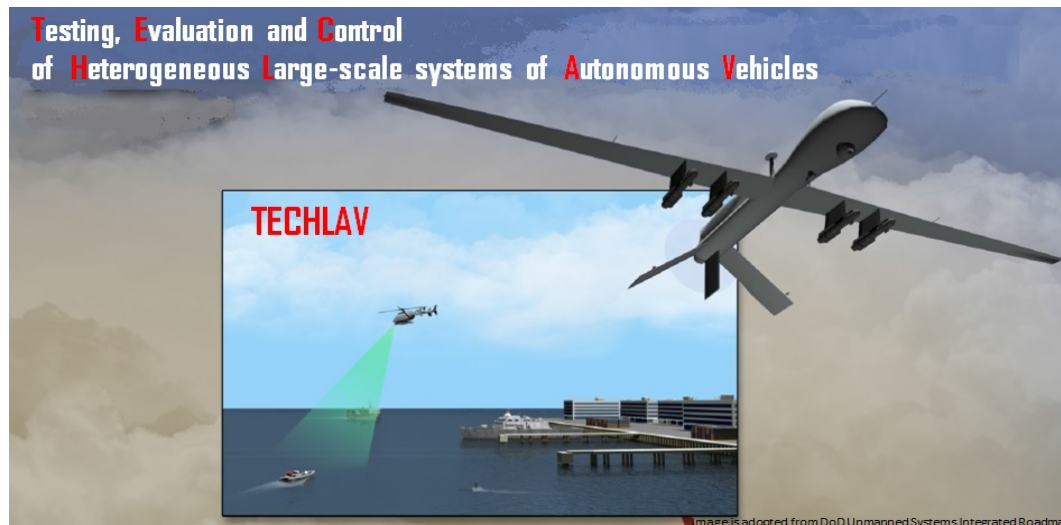


About TECHLAV



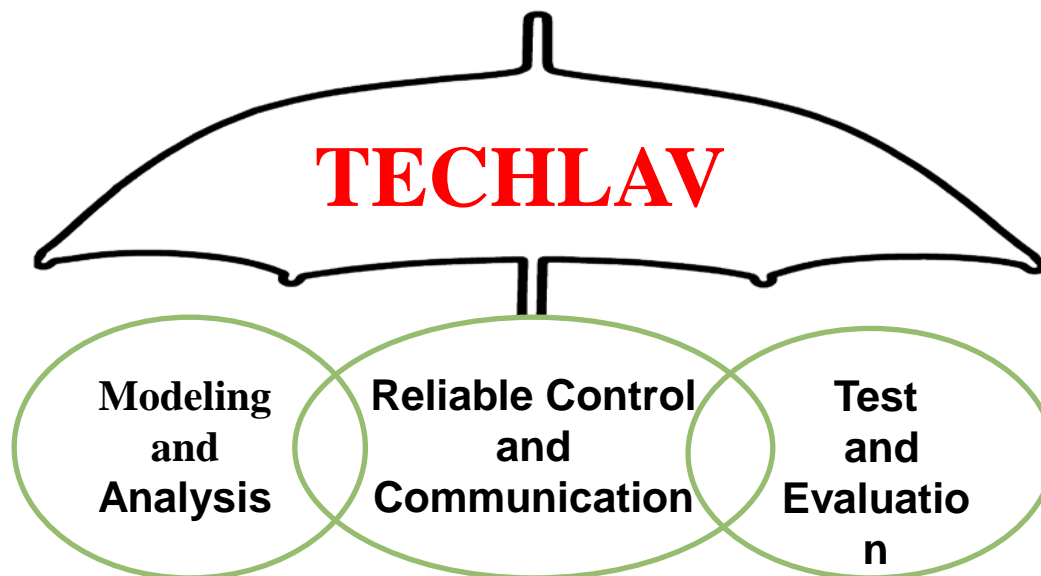
Testing, Evaluation, and Control of Heterogeneous Large-scale Systems of Autonomous Vehicles (TECHLAV) is a multidisciplinary research center on the leading edge of Control, Communication, Computation, and Human Cognition to address two main problems:

1. Teaming and Cooperative Control of Large-scale Autonomous Systems of Vehicles (LSASVs) integrated with human operators.
2. Testing, Evaluation, Validation, and Verification of LSASVs.





Challenges ...



- How to mathematically describe the collective behaviors of systems of vehicles?
- How to reliably design decentralized control and communication for systems of vehicles to achieve desired collective performance?
- How to test and evaluate the control and communication between systems of vehicles?

TECHLAV creates a comprehensive umbrella covering different aspects of systems of vehicles ranging from Modeling and Analysis to Control, Communication, Testing and Evaluation.



TECHLAV Vision and Objectives



Vision:

To become a recognized national leader in autonomy and to foster future leaders in STEM, especially in the field of autonomy.

As a Center of Excellence in Autonomy, the TECHLAV will:

1. Address **fundamental problems** in modeling, analysis, control, coordination, testing and evaluation of autonomous systems
2. Serve as a **national resource** in research and education in autonomy
3. Provide **outreach services** in autonomy-related areas
4. Foster linkages among **national institutions** of higher education, **government** agencies, and **industries**
5. **Commercialize** TECHLAV technologies for the benefit of the national economy



Collaborators

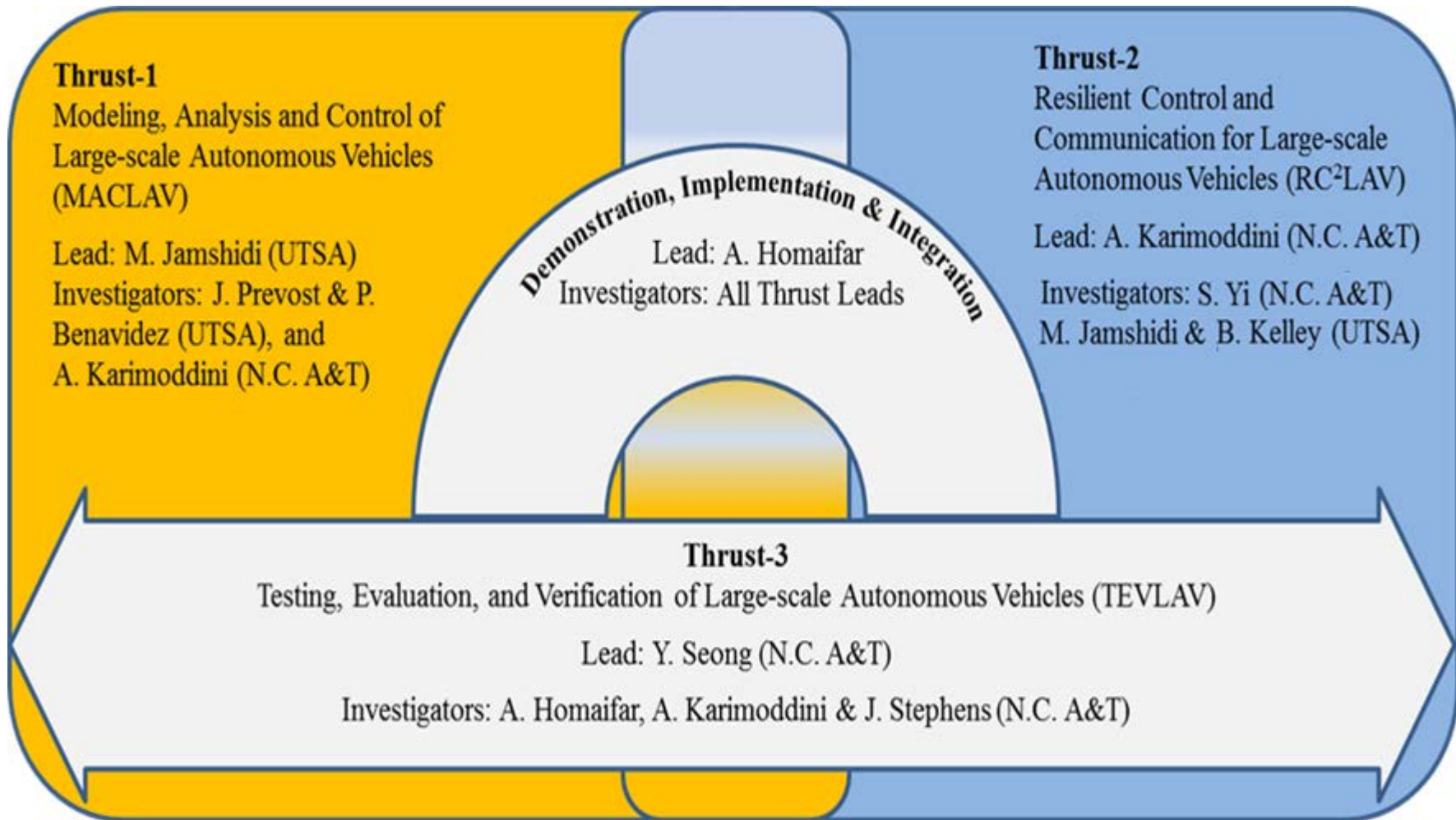


- TECHLAV is led by **North Carolina Agricultural and Technical State University (N.C. A&T)** in collaboration with the **University of Texas at San Antonio** to conduct strong integrated multi-disciplinary research and education activities on Large-scale Autonomous Systems of Vehicles (LSASV). [N.C. A&T lead: A. Homaifar, UTSA Lead: M. Jamshidi]
- The Center partners with **Southwestern Indian Polytechnic Institute (SIPI)** to provide and promote education and outreach activities and curriculum development to the larger Native American community. [SIPI Lead: N. Vadiee]





TECHLAV Core Research





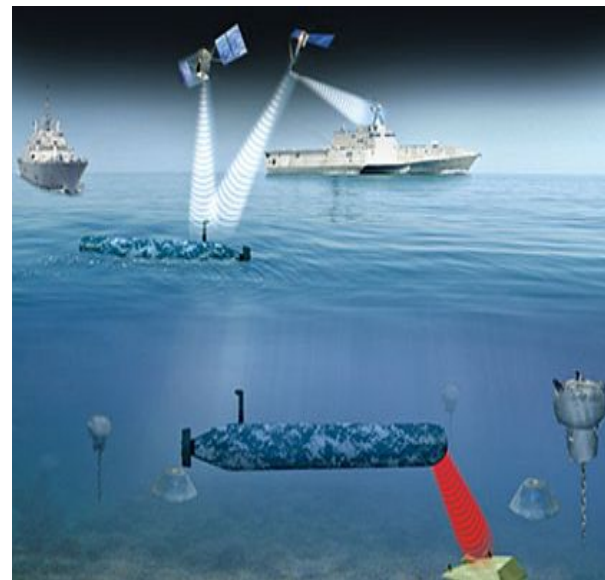
Research Thrust 1

Lead: Dr. M. Jamshidi, UTSA

Members: Dr. J. J. Prevost and Mr. P. Benavidez, UTSA; Dr. A. Karimoddini, N.C. A&T

Thrust 1 (Modeling, Analysis and Control of Large-scale Autonomous Vehicles [MACLAV])

- Develops scalable methodologies to improve **modeling, analysis, localization, navigation,** and control of LSASV
- Managing modern large-scale systems that require novel approaches to integrate **communication, control,** and **computation** (C3), which can simultaneously interact with humans





Challenges & Deliverables for Thrust 1

Challenges:

- System models are highly complex, nonlinear, interconnected and time-varying. They contain random signals, various delays (process, network, non-Gaussian noises), high levels of dimensions, etc.
- New tools for all aspects of systems engineering are being developed, including modeling, simulation, emergence, image processing and control.

Deliverables:

- Sub-thrust 1-1 will develop scalable mathematical and data-based models to capture the complex dynamics of LSASVs where control, communication, and computing components (C3) will simultaneously and interactively play key roles in determining the behavior of the system.
- Sub-thrust 1-2 will develop capable and scalable models for autonomous collaboration, robust and distributed decision-making, group coordination, planning, and tasking through effective interaction with human operators.



Research Thrust 2

Lead: Dr. A. Karimoddini, N.C. A&T

Members: Dr. S. Yi, N.C. A&T; Drs. M. Jamshidi and B. Kelley, UTSA

Thrust 2 (Resilient Control and Communication of Large-scale Autonomous Vehicles [RC²LAV])

- Develops systematic methods to enhance the reliability and efficacy of the control structure
- Communication backbone for LSASV integrated with human operators in dynamic and uncertain environments such as a battlefield





Thrust 2 Challenges & Deliverables



Challenges:

- Modeling and analysis of system failures, communication delays, network jamming, attacks, etc.
- Handling failures, robustness to communication delays, adaptation to operational and situational conditions, reconfiguration of the control and communication networks

Deliverables:

- Sub-thrust 2-1 develops a formal framework for fault-tolerant cooperative control of a team of autonomous systems comprised of heterogeneous autonomous vehicles
- Sub-thrust 2-2 designs an enhanced, efficient and flexible communication network that guarantees reliable connections among the agents which is robust against the failures in communication links



Research Thrust 3

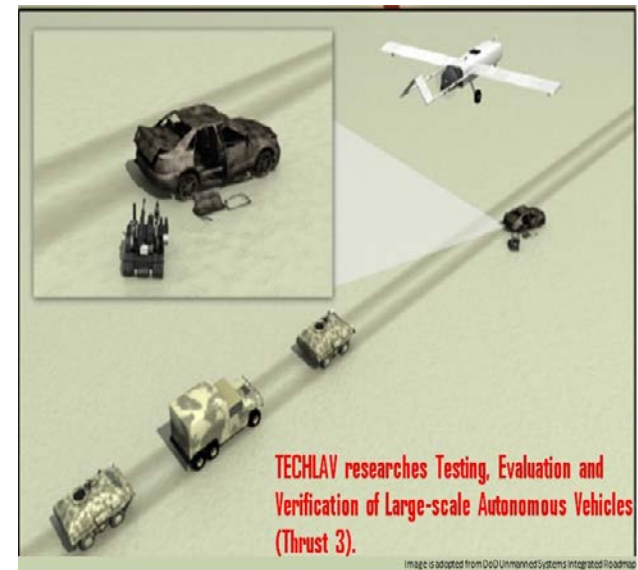


Lead: Dr. Y. Seong , N.C. A&T

Members: Drs. A. Homaifar, A. Karimodini, and J. Stephens, N.C. A&T

Thrust 3 (Testing, Evaluation and Verification of Large-scale Autonomous Vehicles [TEVLAV])

- Develops models and theories for TEVLAV integrated with human operators
- Ensures that the developed control & communication structure in thrusts 1 and 2 can accomplish the assigned mission in dynamic and uncertain environments





Thrust 3 Challenges & Deliverables



Challenges:

- Inherently dynamic, complex and “wicked” domain problem
- How to standardize heterogeneous environmental data
- Testing teaming of autonomous vehicles
- How to handle uncertainty in machine and human-machine interactions

Deliverables:

- Sub-thrust 3-1 develops formal verification methods for LSASVs by reducing the stated dimensions of the system model and developing divide-and-conquer methods to break the verification task into smaller tasks
- Sub-thrust 3-2 develops the Perception Inference Engine (PIE) for evaluating intelligent systems from a cognitive perspective and correlating their internal processes with observed behaviors
- Sub-thrust 3-3 will develop methods for testing human interaction with the simulated LSASV by examining human perception of system states, human trust in the system, and human judgment performance with the system



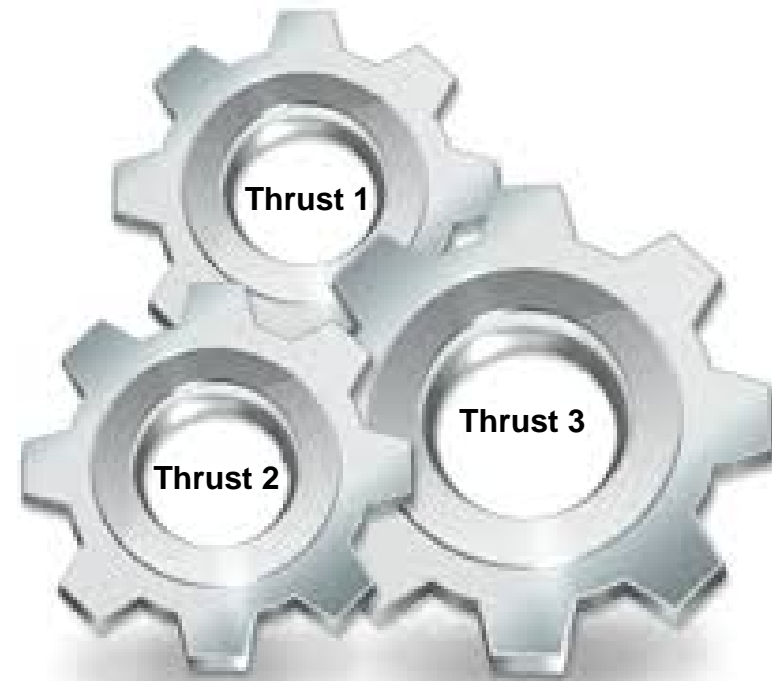
Demonstration, Implementation and Integration

Lead: Dr. A. Homaifar, N.C. A&T

Members: Drs. A. Karimodini, Y. Seong, N.C. A&T, Dr. M. Jamshidi, UTSA

Demonstration, Implementation and Integration (DII)

- Integrates proposed tasks
- Facilitates coordination among the team members to perform collaborative test scenarios
- Provides two heterogeneous testbeds of ground robots and aerial robots at N.C. A&T and UTSA
- Tests and validates the performance of the developed tools and protocols in real-world scenarios related to the DoD's mission





Collaborative Curriculum Development

- Developing shared courses and modules to address fundamental problems in autonomy
- Developed and offered two collaborative courses at both N.C. A&T and UTSA
- Increased student mobility in order to capture and disseminate our best practices

Sharing the research outcome with the community at large

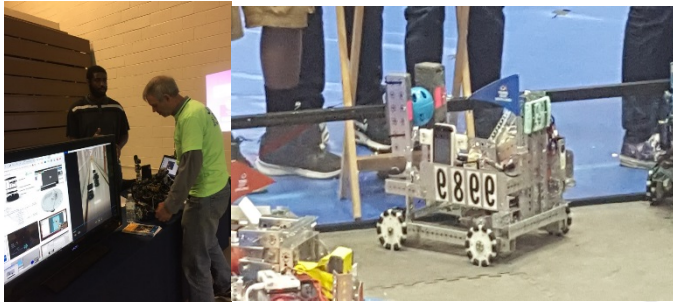
- Organizing seminars, technical sessions, seminar series, workshops and invitational talks <http://techlav.ncat.edu/seminars.html>
- Publishing and presenting research results in top-ranking journals and at conferences <http://techlav.ncat.edu/publications.html>



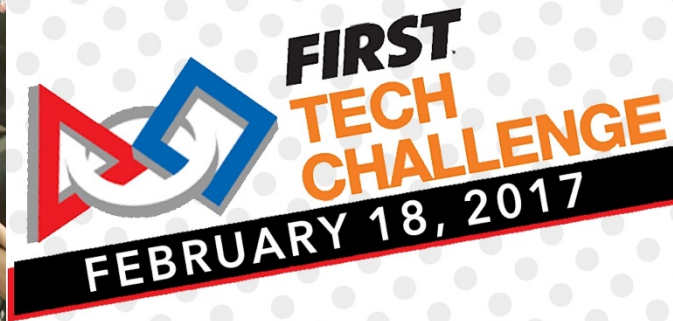
Co-sponsoring and Co-organizing FIRST Tech Challenge at NC A&T



- **TECHLAV has sponsored and organized the FIRST Tech Challenge workshop for Guilford County Schools teachers since 2015.**



www.zimzoomphotobooth.com
pw: FTC2017





TECHLAV Goals

Long Term Goal by 04/07/2020

- Develop and implement techniques for reliable control, resilient communication, testing and verification of LSASV
- Demonstration, Implementation and Integration (DII)

Mid Term Goal by 11/15/2018

- Technical Development of Large-scale Autonomous Systems of Vehicles (LSASV) – localization, navigation, reasoning, decision making, and cooperative control as well as testing techniques for training and testing

Short Term Goal by 10/14/2016

- Personnel and student recruitment
- Lab setup and the first advisory board meeting
- Equipment purchase and setup
- Preliminary steps for modeling, analysis, and control of LSASV



Co-organizing and Co-sponsoring SoSE 2017 Conference



- **TECHLAV organizes a technical panel on large scale systems of vehicles in the 12th International IEEE Conference on System of Systems Engineering (SoSE 2017)**



June 18-21, 2017
Waikoloa, Hawaii, USA

- The 12th International Conference on System of Systems Engineering (SoSE)
- Within IEEE System, Man, and Cybernetics Society and IEEE Reliability Society
- Focus: Theories, methodologies, and applications of System of Systems Engineering in science, technology, industry, and education are welcome.
- Topics: Covers numerous engineering fields such as control, computing, communication and information technology and includes applications such manufacturing, defense, national security, aerospace, aeronautics, energy, environment, healthcare, and transportation.
- Conference theme: **“Internet of Things as System of Systems”**.



TECHLAV Second Annual Meeting



- **TECHLAV's second annual meeting will be held from May 31, 2017 to June 1, 2017 in Greensboro, NC.**
- **The meeting will bring together researchers from academia, the military, and industry.**
- **The purpose of the visit is to provide updates on various tasks: modeling, control, testing, and evaluation of autonomous vehicles, as well as demonstrations and poster presentations on the most recent TECHLAV research outcomes.**
- **In addition, there will be a technical panel and two keynote speakers who will be providing an in depth exploration of the current world of autonomy.**

For further information, please contact Shar Seyedin, the TECHLAV Program Manager at **336-285-3271** or at sseyedin@ncat.edu.



TECHLAV Team



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Lead for Outreach
SIPI



Mrs. Shar Seyedin
Program Manager
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Dr. B. Kelley
Member,
UTSA



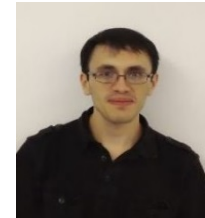
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