

# Workshop W3: Current Topics in Aerospace Controls

IEEE TCAC Workshop, 2020 ACC,

June 30, 2020, 8:30am-5:30pm (Denver Time)

0. 8:30 - 9:00 am Denver Time (10:30 – 11:00 am ET)

**Welcome, Introductions & Preliminaries,**

**Chair: Dr. Richard A. Hull** – Collins Aerospace Fellow, and Chair IEEE CSS TC on Aerospace Control (TCAC)

**Co-Chair: Prof. Zhihua Qu** – University of Central Florida, Chair Dept. Electrical and Computer Engineering

Housekeeping ...

Please Mute Your Microphone unless speaking!

Hold questions ... until end of each speaker's presentation

Speakers ... stop screen sharing when you are finished

Presentation Files (.pdf only) will be uploaded to TCAC Website following workshop (allow 1-2 weeks)

TCAC Website: <http://aerospace-controls.ieeecss.org/home>

All Registrants – may contact me at: [richard.hull@collins.com](mailto:richard.hull@collins.com)

# Workshop W3: Current Topics in Aerospace Controls

IEEE TCAC Workshop, 2020 ACC,

June 30, 2020, 8:30am-5:30pm (Denver Time)

Denver Time

## AGENDA

- 8:30 – 9:00am **Start-Up, Introductions & Preliminaries – Rich Hull**
- 9:00 – 9:45am **Stable Observers for Motion Estimation in Rigid Body and Multi-Body Systems using Lie Group Methods, - Prof. Amit K. Sanyal**, Dept. of Mechanical and Aerospace Engineering, Syracuse University, Syracuse, New York.
- 9:45 – 10:30am **Multi-Agent Safety and Resilience: Theory and Algorithms for Adversarially-Robust, Scalable UAV Teams, – Prof. Dimitra Panagou**, Department of Aerospace Engineering, University of Michigan.
- 10:30 – 10:45am – **15 Minute Break**
- 10:45 – 11:30am **Drift Counteraction Optimal Control for Aerospace Applications, - Prof. Ilya Kolmanovsky**, Department of Aerospace Engineering, The University of Michigan
- 11:30 – 12:15pm **Design of Secure, Spatially-Distributed, Data-Driven Control/Optimization Algorithms – Prof. Zhihua Qu**, Pegasus Professor and Chair, Department of ECE, University of Central Florida, Orlando, Florida

Denver Time

# AGENDA

12:15 – 1:15pm – **1 Hour Lunch**

1:15– 2:00pm **Aerial Co-robots of the Future: Safety, Intelligence, Certification – Prof. Naira Hovakimyan**, W. Grafton and Lillian B. Wilkins Professor of Mechanical Science and Engineering, University of Illinois at Urbana-Champaign

2:00 – 2:45pm **Optimal Planning Strategies for Multiple UAV Missions – Prof. Venanzio Cichella**, Assistant Professor, Department of Mechanical Engineering, University of Iowa, Iowa City, IA and **Prof. Naira Hovakimyan**

2:45 – 3:00pm – **15 Minute Break**

3:00 – 3:45pm **Robust Adaptive Control w/ Applications in Flight Control” – Dr. Heather Hussain**, Guidance, Navigation, Control and Autonomy, The Boeing Company, Tukwila, WA

3:45 – 4:30pm **Adaptive Flight Control of Missiles: Needs and Challenges, Dr. James Fisher and Dr. D. Brett Ridgely**, Fellow, Raytheon Missile Systems, Tucson, Arizona

4:30 – 5:15pm **Novel Guidance Solutions and Nonlinear Control of Gun Launched Guided Projectiles – Dr. Richard A. Hull**, Technical Fellow, Collins Aerospace, Orlando, Florida.

# Aerospace Control

(60 members, chair: Richard Hull)

**Scope:** Through this Technical Committee (TC), members advance the technology and provide forums for the theoretical and practical consideration of techniques, devices, and systems for the control of flight vehicles and the control of related aerospace systems.

## Membership:

- Open to any member of IEEE Control System Society (CSS) – contact Richard Hull
- 65% Academia, 20% Industry, 10% Government Labs - 25% International – 9 Fellows of the IEEE
- Please visit our website: <http://aerospace-controls.ieeecss.org/home>

## Main activities:

- Chairmanship roles in Organizing Technical Conferences such as the ACC, CDC, CCTA
- Organize Special Sessions, Invited Sessions, Tutorials and Workshops
- Contributions to IEEE Control Systems Magazine – Jon How was prior technical editor
- Nominations to serve as Associated Editors on the IEEE Conference Editorial Board and for IEEE Journals
- TC Members sponsored and raised over \$50K to endow the IEEE CSS Award for Excellence in Aerospace Control

## Workshops on Aerospace Control

- 2020 ACC (Denver), 2019 ACC (Philadelphia), 2017 CCTA (Hawaii), 2012 CDC (Maui)

## Many Distinguished Members and Awards (to name a few):

- Kevin Wise elected to National Academy of Engineering,
- Naira Hovakimyan was named recipient of 2019 Pendray Aerospace Literature Award
- Gokhan Inalhan received the IEEE Aerospace and Electronic Systems Society Exceptional Service Award
- Zhihua Qu named IEEE Distinguished Lecturer

## Many Authors of Books (to name a few):

- $L_1$  Adaptive Control Theory, Guaranteed Robustness with Fast Adaptations, Naira Hovakimyan, Chengyu Cao,
- Robust and Adaptive Control with Aerospace Applications, Eugene Lavretsky, Kevin Wise
- Cooperative Control of Dynamical Systems, Zhihua Qu



# IEEE CSS Technical Committees & Chairs

5

Joao Hespanha - VP Technical activities

1. Aerospace Controls  
Richard Hull (2018)
2. Automotive Controls  
Jason Siegel (2018)
3. Control Education  
J. Anthony Rossiter (2017),
4. Discrete Event Systems  
Kai Cai (2019)
5. Distributed Parameter Systems  
Yann Le Gorrec (2016)
6. Health and Medical Systems  
Alexander Medvedev (2018)
7. Hybrid Systems  
Ricardo Sanfelice (2016)
8. Intelligent Control  
Warren Dixon (2016)
9. Manufacturing Automation & Robotic Control  
Yue (Sophie) Wang (2017)
10. Networks and Communication Systems  
Giacomo Como (2019)
11. Nonlinear Systems and Control  
Hiroshi Ito (2016)
12. Power Generation  
Joseph Bentsman (2016)
13. Process Control  
Rolf Findeisen (2018?)
14. Robust and Complex Systems  
Constantino Lagoa (2017)
15. Smart Cities  
Rong Su (2016)
16. Smart Grid  
Ian Hiskens (2019)
17. Systems Biology  
Steffen Waldherr (2019)
18. Systems Identification and Adaptive Control  
Guillaume Mercere (2016)
19. Variable Structure and Sliding Mode Control  
Christopher Edwards (2019)

Can Everyone See and Hear?

Questions or Problems?

Use the Chat Feature ...

Welcome to the Virtual Workshop!

**1. 9:00 - 9:45 am Denver Time (11:00 – 11:45 am ET)**

**Stable Observers for Motion Estimation in Rigid Body and Multi-Body Systems using Lie Group Methods,**

**Professor Amit Sanyal** obtained the B.Tech. degree in Aerospace Engineering from the Indian Institute of Technology, Kanpur, in 1999. He obtained the Distinguished Graduate Student Masters Research Award for his MS thesis in Aerospace Engineering from Texas A& M University in 2001. He received the Ph.D. in Aerospace Engineering and his MS in Mathematics from the University of Michigan in 2004 and 2005 respectively.

He is now Associate Professor in Mechanical and Aerospace Engineering at Syracuse University.

His expertise is in geometric mechanics, nonlinear and geometric control, nonlinear observer design, and variational integration of Lagrangian/Hamiltonian systems, with applications to dynamics modeling, guidance, navigation, and control of unmanned and autonomous systems.

He is a senior member of AIAA and IEEE, and a member of ASME, AUVSI, and SIAM.

**2. 9:45 – 10:30 am Denver Time (11:45am – 12:30pm ET)**

**Multi-Agent Safety and Resilience: Theory and Algorithms for Adversarially-Robust, Scalable UAV Teams**

**Prof. Dimitra Panagou** received the Diploma and PhD degrees in Mechanical Engineering from the National Technical University of Athens, Greece, in 2006 and 2012, respectively.

Since September 2014 she has been an Assistant Professor with the Department of Aerospace Engineering, University of Michigan.

Dr. Panagou's research program emphasizes in the exploration, development, and implementation of control and estimation methods in order to address real-world problems via provably correct solutions. She is particularly interested in the development of provably correct methods for the robustly safe and secure operation of autonomous systems in complex missions, with applications in unmanned aerial systems, robot/sensor networks and multi-vehicle systems.

Dr. Panagou is a recipient of a NASA Early Career Faculty Award, of an AFOSR Young Investigator Award, and a member of the IEEE and the AIAA.



**10:30 – 10:45 am Denver Time (12:30am – 12:45pm ET)**

**15 minute Break!**

### **3. 10:45 – 11:30 am Denver Time (12:45 – 1:30 pm ET)**

#### **Drift Counteraction Optimal Control for Aerospace Applications**

**Prof. Ilya V. Kolmanovsky** has received his Ph.D. degree in Aerospace Engineering in 1995, his M.S. degree in Aerospace Engineering in 1993 and his M.A. degree in Mathematics in 1995, all from the University of Michigan, Ann Arbor.

He is presently a professor in the Department of Aerospace Engineering at the University of Michigan.

Professor Kolmanovsky's research interests are in control theory for systems with state and control constraints and in control applications to aerospace and automotive systems. Prior to joining the University of Michigan in January 2010, Dr. Kolmanovsky was with Ford Research and Advanced Engineering in Dearborn, Michigan for close to 15 years.

He is a Fellow of IEEE, a past recipient of the Donald P. Eckman Award of American Automatic Control Council, of 2002 and 2016 IEEE Transactions on Control Systems Technology Outstanding Paper Awards and of several innovation, publication and technical achievement awards of Ford Research and Advanced Engineering. He is also named as an inventor on 99 United States patents.

4. 11:30 am – 12:15 pm Denver Time (1:30 – 2:15 pm ET)

### Design of Secure, Spatially-Distributed, Data-Driven Control/Optimization Algorithms

**Prof. Zhihua Qu** received his Ph.D. degree in Electrical Engineering at the Georgia Institute of Technology in 1990. He is the SAIC Endowed Professor, Pegasus Professor, and the Chair of Electrical and Computer Engineering Department University of Central Florida.

Dr. Qu's areas of expertise are nonlinear systems and control, energy and power systems, and robotics. His recent research activities in controls have been cooperative control of heterogeneous dynamical systems with applications to autonomous vehicle systems.

Dr. Qu is the author of three books: *Robust Tracking Control of Robot Manipulators* (1996), *Robust Control of Nonlinear Uncertain Systems* (1998), and *Cooperative Control of Dynamical Systems with Applications to Autonomous Vehicles* (2009). As a co-editor, he contributed the cyber-physical systems security chapters to the book *Smart Grid Control: An Overview and Research Opportunities* by Springer (2018).

Dr. Qu is a Fellow of IEEE and AAAS and an IEEE Distinguished Lecturer. He is serving or served on Board of Governors of IEEE Control Systems Society, Chair of IEEE CSS TCSG, Vice President of ECEDHA, Past President of SECEDHA, Secretary and Board of Director of SCEEE, and as Associate Editor for *Automatica*, *IEEE ACCESS*, *IEEE Transactions on Automatic Control*, and *International Journal of Robotics and Automation*.

**12:15 – 1:15 pm Denver Time (2:15am – 3:15pm ET)**

**1 Hour Lunch!**

5. 1:15 – 2:00 pm Denver Time (3:15 – 4:00 pm ET)

### **Aerial Co-robots of the Future: Safety, Intelligence, Certification**

**Prof. Naira Hovakimyan** received her MS degree in Theoretical Mechanics and Applied Mathematics in 1988 from Yerevan State University in Armenia. She got her Ph.D. in Physics and Mathematics in 1992 from the Institute of Applied Mathematics of Russian Academy of Sciences in Moscow.

She is currently a W. Grafton and Lillian B. Wilkins Professor of Mechanical Science and Engineering at University of Illinois at Urbana-Champaign (UIUC), where she was named inaugural director for Intelligent Robotics Lab of Coordinated Science Laboratory at UIUC.

She has co-authored two books, six patents and more than 350 refereed publications. She was the 2017 recipient of *IEEE CSS Award for Technical Excellence in Aerospace Controls*, and the 2019 recipient of *AIAA Pendray Aerospace Literature Award*. In 2014 she was awarded the *Humboldt prize* for her lifetime achievements. In 2015 she was awarded the *UIUC Engineering Council Award for Excellence in Advising*.

She is Fellow and life member of AIAA, a Fellow of IEEE, and a member of SIAM, AMS, SWE, ASME and ISDG. She is cofounder and chief scientist of IntelinAir. Her work in robotics for elderly care was featured in the New York Times, on Fox TV and CNBC. Her research interests are in control and optimization, autonomous systems, neural networks, game theory and their applications in aerospace, robotics, mechanical, agricultural, electrical, petroleum, biomedical engineering and elderly care.

**6. 2:00 - 2:45 pm Denver Time (4:00 – 4:45 pm ET)**

**Optimal Planning Strategies for Multiple UAV Missions – Prof. Venanzio Cichella, and Prof. Naira Hovakimyan**

**Prof. Venanzio Cichella** received his B.S. and M.S. in Automation Engineering in 2007 and 2011, respectively, from the University of Bologna, Italy. He got his Ph.D. in Mechanical Engineering in 2018 from the University of Illinois at Urbana-Champaign, majoring in planning and control of multiple autonomous systems.

He is currently an Assistant Professor at the Mechanical Engineering department at the University of Iowa. His research interests include cooperative control of autonomous systems, collision avoidance, optimal control, machine learning, and human-centered autonomous vehicle design.

**2:45 – 3:00 pm Denver Time (4:45– 5:00 pm ET)**

**15 minute Break!**

**7. 3:00 - 3:45 pm Denver Time (5:00 – 5:45 pm ET)**

**Robust Adaptive Control w/ Applications in Flight Control” – Dr. Heather Hussain,**

**Dr. Heather Hussain** received the B.S. degree and M.S. degree in Mechanical Engineering from the Rochester Institute of Technology, Rochester, NY, in 2012, and the Sc.D. degree in Mechanical Engineering at the Massachusetts Institute of Technology (MIT), Cambridge, MA, in 2017.

Dr. Hussain is currently a member of the Guidance, Navigation, Control, and Autonomy group at the Boeing Research and Technology division in Tukwila, Washington. Her research interests lie in adaptive control theory, particularly with applications in aerospace.

Her work experience comprises several internships spanning the aerospace and consumer electronics industries—namely, in Product Design at Apple Inc., as a research Scholar at the Munitions Directorate of the Air Force Research Laboratory, and her work in the design and development of verifiable adaptive flight control systems at The Boeing Company. Dr. Hussain’s research at MIT was sponsored by the Boeing Strategic University Initiative under the direction of Dr. Eugene Lavretsky and Dr. Anuradha Annaswamy.

Dr. Hussain is a member of AIAA and IEEE.



**8. 3:45 – 4:30 pm Denver Time (5:45 – 6:30 pm ET)**

### **Adaptive Flight Control of Missiles: Needs and Challenges**

**Dr. Brett Ridgely** received his B.S.A.E. from the University of Maryland in 1980, an M.S.A.E. from AFIT in 1981, an M.S. from the E.E. Department of AFIT in 1983, and his Ph.D. from the MIT in 1991.

Currently, he is a Raytheon Engineering Fellow, and is the manager of the Flight Controls Department as well as the GNC Center Technology Director. Before coming to Raytheon, Dr. Ridgely was an Associate Professor of Aeronautical Engineering at the Air Force Institute of Technology (AFIT) from 1988 – 1997, and worked at the AFRL Flight Dynamics Lab at WPAFB from 1981 to 1985.

He is the author or co-author of over 60 technical conference and journal articles. He is currently the Secretary of the AIAA GNC TC, served as the Technical Co-Chair of the 2011 AIAA GNC, and was the AIAA Area Chair for the 2011 American Control Conference.

**Dr. James Fisher** received his BS and MS degrees in Mechanical Engineering from Texas A&M University in 2001 and 2004 respectively. He received Ph.D. degree in Aerospace Engineering from Texas A&M University in 2008.

Dr. Fisher has worked at Raytheon Missile Systems since 2008, where he has developed flight control and guidance designs for many demonstration and production systems. His research interests include development of high performance guidance, navigation, and control algorithms, adaptive control, integrated guidance and control design, probabilistic robust control, and geometric control.

**9. 4:30 - 5:15 pm Denver Time (6:30 – 7:15 pm ET)**

### **Novel Guidance Solutions and Nonlinear Control of Gun Launched Guided Projectiles**

**Dr. Richard A. Hull** received his B.S. in Engineering Science and Mechanics from the University of Florida, 1972, and his M.S. and Ph.D. in Electrical Engineering from the University of Central Florida in 1993 and 1996, respectively.

He is currently a Technical Fellow with Collins Aerospace, now a Raytheon Technologies Company, leading GNC development efforts in precision guidance systems across several sites. He has served as a Guidance and Control System Engineer in the Aerospace Industry for over 50 years, working for SAIC, Lockheed Martin, Coleman Aerospace, McDonnell Douglas, and Boeing companies.

He has authored or co-authored over thirty conference and journal articles in the fields of nonlinear or cooperative control. He is a Life Senior Member of IEEE, a senior member AIAA and a member of the IEEE Control System Society (CSS). He has served as an Associate Editor of the Conference Editorial Board for the IEEE CSS, and currently serves as the Chair of the IEEE CSS Technical Committee on Aerospace Control (TCAC).

Dr. Hull served as the Local Arrangements Chair for the 50th IEEE Conference on Decision and Control and European Control Conference in Orlando, Florida in December 2011, and helped organize the IEEE TCAC Workshop at the 2012 CDC the 2017 CCTA, the 2019 ACC and the 2020 ACC.

# Virtually the End!

## Thanks for attending Workshop W03 Current Topics in Aerospace Controls

Presented by members of the IEEE CSS Technical Committee on Aerospace Control

My contact info: [richard.hull@collins.com](mailto:richard.hull@collins.com)

.pdf files of today's presentations will be posted in the near future on the TCAC website at: <http://aerospace-controls.ieeecss.org/home>