Guest Editorial
Introduction to the Special Issue on Unmanned Aircraft System Traffic Management

I. Introduction

ADVANCES of unmanned aircraft system (UAS) technology have spurred a rapid investment of commercial UAS use in broad public domains, such as cargo transport, agriculture support, emergency response, on-demand communication, and infrastructure health monitoring. Urban unmanned aerial transportation that can transport passengers over short distances is also on the way. With the forthcoming dense operations of UAS particularly over urban regions, ensuring airspace safety becomes an urgent issue.

UAS traffic management (UTM) aims at ensuring the safety and efficiency of the low-altitude airspace integrated with UASs. Compared to air traffic management (ATM) solutions designed mainly for commercial airlines, UTM encounters many new challenges. Onboard autopilots have limited sensing, control, and communication capabilities due to UAS payload constraints. UASs are controlled through command and control data links, which can be affected by communication issues such as interference, jamming, and limited bandwidth. UASs are sensitive to weather disturbances such as strong winds due to their compact size and lightweight. UAS mobility is variable, uncertain, and heterogeneous, as UASs are expected to serve flexible on-demand missions with a wide spectrum of flight types and capabilities. The low-altitude airspace environment becomes more complicated with mixed manned–unmanned traffic, especially in urban areas where terrain features and ground properties also need to be considered.

This Special Issue aims to understand the fundamental challenges that are unique to UTM and develop solutions that address these challenges through collaborative efforts from multiple communities that span transportation, aviation, communications, networking, control, information systems, big data, computing, and cyber-physical systems. A total of 28 submissions were received in response to the open call for articles for this Special Issue. The articles went through a rigorous evaluation process according to the review standards of IEEE Transactions on Intelligent Transportation Systems. The accepted articles span broad topics on the fundamental research of UTM including airspace capacity, geofence, deconfliction, scheduling, traffic management, UAS guidance, navigation and control, weather studies, and contingency management. The Special Issue also covers application domains such as urban air mobility, drone delivery, disaster response, and the ecosystem. The accepted articles are categorized into five research directions and summarized as follows.

A. Airspace Capacity and Safety

In [A1], the article "Geofence definition and deconfliction for UAS traffic management" by Stevens and Atkins develops a formal geofence definition and a methodology to use geofences to temporally and spatially organize the airspace in support of a UTM system. Algorithms are presented to temporally and spatially deconflict requested geofences from existing approved geofences in the UTM system. A case study shows how deconflicted geofences impact UAS flight.

In [A2], the article "Statistical properties and airspace capacity for unmanned aerial vehicle networks subject to sense-and-avoid safety protocols," by Liu *et al.*, constructs a new modeling and analytical framework for unmanned aircraft UTM and UAS networking studies. In this framework, random mobility models (RMMs) are equipped with physical sense-and-avoid (S&A) protocols to succinctly capture the flexible, variable, and uncertain movement patterns of UASs subject to separation safety constraints. For the random direction (RD) RMM equipped with a commonly used S&A protocol, named sense-and-stop (S&S), statistical properties are developed, including stationary location distribution and stationary inter-vehicle distance distribution, using the Markov analysis. This study provides knowledge on the impact of S&A protocols to critical UAS networking statistics. In addition, collision probabilities and airspace capacity concepts for UASs are designed based on the inter-vehicle distance distribution, and their closed-form expressions are derived. This analytical framework mathematically bridges local autonomy with global airspace capacity and allows the impact analysis of local autonomy configurations for effective UAS airspace capacity management.

In [A3], the article "Improving productivity of low-altitude airspace: Speed versus direction control," by Bulusu and Sengupta, studies the type of onboard control for enroute separation to increase productivity without compromising safety in the low-altitude airspace. This article quantifies the impact of two conflict detection and resolution approaches—pure speed control and pure direction control—on airspace productivity. Small UAS traffic is simulated and three types of metrics are computed—throughput, travel time extension, and energy consumption. Inflow is increased and corresponding outflow, travel time extensions, and energy consumption for each type

Digital Object Identifier 10.1109/TITS.2021.3101543

of control are measured. A representative power consumption model is also developed. Without compromising safety, both controls are equally good, unless the UAS are designed to be highly efficient while hovering. If hover power consumption is equal to or less than 1.5 times the minimum power consumption, speed control increases airspace productivity more than the direction control.

B. UTM Scheduling and Traffic Management Initiatives

In [A4], the article "Control protocol design and analysis for unmanned aircraft system traffic management," by Zhou *et al.*, proposes a control protocol design and analysis method for UTM which can safely manage a large number of sUAS's. The benefits of the approach in the article are two-fold: at the management level, the effort for monitoring sUAS traffic (authorities) and control/planning for each sUAS (operator/pilot) are both greatly reduced under the proposed framework; and At the operational level, the behavior of individual sUAS is guaranteed to follow the restrictions. Mathematical proofs and numerical simulations are presented to demonstrate the proposed method.

In [A5], the article "An iterative two-phase optimization method based on divide and conquer framework for integrated scheduling of multiple UAVs," by Liu *et al.*, constructs a novel divide and conquer framework for multi-UAV task scheduling (DCF), which partitions the original multi-UAV scheduling problem into multiple scheduling sub-problems for all the UAVs. To be specific, DCF includes two phases: one is the task allocation phase which produces multiple scheduling sub-problems and the other is the single UAV scheduling phase which generates the scheduling scheme with sequential tasks for each single UAV considering constraints involving UAV capabilities and task demands. Two phases are iteratively performed until the predefined stopping criteria are met. The efficiency of the proposed DCF is demonstrated by extensive experiments and comparative studies.

In [A6], the article "Efficiency and fairness in unmanned air traffic flow management," by Chin *et al.*, studies congestion mitigation by assigning airborne delays (through speed changes or path stretches) or ground delays (holds relative to the desired takeoff times) to aircraft. While the assignment of such delays may increase system efficiency, individual aircraft operators may be unfairly impacted. Dynamic traffic demand, variability in aircraft operator preferences, and differences in the market share of operators complicate the issue of fairness in UTFM. The work considers the fairness of delay assignment in the context of UTFM. The authors formulate the UTFM problem with fairness and show through computational experiments that significant improvements in fairness can be attained at little cost to system efficiency. It is demonstrated that when operators are not aligned in how they perceive or value fairness, there is a decrease in the overall fairness of the solution. Fairness decreases as the air–ground delay cost ratio increases, and that it improves when the operator with dominant market share has a weak preference for the fairness of its allocated delays. Considering UTFM in a rolling-horizon setting with dynamic traffic demand, efficiency is adversely impacted, and fairness could be too depending on the metric used.

C. UAS Guidance, Navigation, and Control

In [A7], the article "Predicting state uncertainty bounds using non-linear stochastic reachability analysis for urban GNSS-based UAS navigation," by Shetty and Gao, presents a non-linear stochastic reachability analysis to predict bounds on the state uncertainty of a system while accounting for sets of uncertain measurement distributions. The analysis was derived for a fixed-wing UAS navigating using ranging measurements. It was then evaluated for GNSS-based navigation of the fixed-wing UAS by simulating a 3-D urban environment with multipath effects. The simulation results showed the applicability of the predicted bounds towards ensuring safe UAS navigation in a shared urban airspace.

In [A8], the article "Autonomous free flight operations in urban air mobility with computational guidance and collision avoidance," by Yang and Wei, proposed a computational guidance algorithm for unmanned aircraft in the urban air mobility environment. This problem is formulated as a Markov Decision Process and solved using the Monte Carlo Tree Search algorithm. Through sensed information, the onboard computational guidance algorithm will provide maneuver advisories to help the unmanned aircraft reach its goal position as well as avoid any potential conflicts with other aircraft. A free flight airspace simulator is built to validate the performance of the proposed algorithm. Through comparison with an efficient and effective path planning and conflict avoidance algorithm, the algorithm proposed in this article shows its benefits and limitations.

In [A9], the article "Aerial vehicle protection level reduction by fusing GNSS and terrestrial signals of opportunity," by Kassas *et al.*, develops a method for reducing the protection levels (PLs) of aerial vehicles by fusing global navigation satellite systems (GNSS) signals with terrestrial signals of opportunity (SOPs). PL is a navigation integrity parameter that guarantees the probability of position error exceeding a certain value to be bounded by a target integrity risk. For UAVs, it is desirable to achieve as tight PLs as possible. This article characterizes terrestrial cellular SOPs' measurement errors from extensive UAV flight campaigns, collected over the past few years in different environments and from different providers, transmitting at different frequencies and bandwidths. Next, the reduction in PLs due to fusing terrestrial SOPs with a traditional GNSS-based navigation system is analyzed. It is demonstrated that incorporating terrestrial SOP measurements is more effective in reducing the PLs over adding GNSS measurements. Experimental results are presented for a UAV traversing a trajectory of 823 m, during which the VPL of the GPS-based and GNSS-based navigation systems were reduced by 56.9% and 58.8%, respectively, upon incorporating SOPs, while the HPL of the GPS-based and GNSS-based navigation systems were reduced by 82.4% and 74.6%, respectively, upon incorporating SOPs.

In [A10], the article "Data freshness and energy-efficient UAV navigation optimization: a deep reinforcement learning approach," by Abedin *et al.*, designed a navigation policy for multiple UASs where mobile base stations (BSs) are deployed to improve the data freshness and connectivity to the Internet of Things (IoT) devices. The formulated energy-efficient trajectory optimization problem considers maximizing energy efficiency by optimizing the UAV-BS trajectory policy with age of information (AoI) constraints to ensure the data freshness at the ground BS. An agile deep reinforcement learning with experience replay model solves the formulated problem concerning the contextual constraints for the UAV-BS navigation. The proposed approach is well-suited for solving the problem since the state space of the problem is extremely large and finding the best trajectory policy with useful contextual features is too complex for the UAV-BSs. Using the proposed method, an effective real-time trajectory policy is developed for the UAV-BSs which captures the observable network states over time to make cooperative navigation decisions.

In [A11], the article "Optimized landing of drones in the context of congested air traffic and limited vertiports," by Zhou *et al.*, characterizes the fleet landing problem that drone fleet operators to land the whole fleet in short notice. The authors use mixed integer programming techniques and develop a series of computational enhancements to reduce the solution time from hours to seconds. The algorithms are implemented in practical software. For a fleet of 18 drones navigating within a 4-square kilometer area, all routing and trajectory computations can be completed in less than 5 s, and the entire fleet is able to complete landing at three landing spots in about 3 min.

D. Weather and Contingency Management

In [A12], the article "An assessment of the potential weather barriers of urban air mobility," by Reiche *et al.*, discusses the potential weather and public acceptance challenges for UAM operations in adverse conditions. This article presents a comprehensive seasonal and diurnal weather climatology using historical observations across anticipated operational altitudes (surface—5000 ft AGL) at ten metropolitan areas across the United States. Public perceptions of weather-related societal barriers are examined through a five-city general population survey (n = 1702) where respondents were asked about their views regarding flying in a small aircraft in a variety of adverse weather conditions. The results of the study found weather most favorable for UAM in Los Angeles and San Francisco, with less favorable conditions in Denver, New York City, and Washington, DC. In the future, equipping automated vehicles, unmanned aircraft systems, and VTOLs with meteorological sensors coupled with analysis from machine learning and artificial intelligence could enhance predictive capabilities that reduce flight cancellations and delays for UAM travelers.

In [A13], the article "Assuring intelligent systems: contingency management for UAS," by Neogi *et al.*, studies the assurance technologies that need to be integrated into the design process in order to guarantee safe behavior, thereby enabling UAS operations in the National Airspace System (NAS). In this article, formal methods are integrated with learning-enabled systems representations. The generation and representation of knowledge are captured via monadic second-order logic rules in the cognitive architecture Soar. These rules are translated into timed automata, and a proof of correctness for the translation is provided so that safety and liveness properties can be checked in the formal verification environment Uppaal. This approach is agnostic to the learning mechanism used to generate the learned rules (e.g., chunking, etc.). An example of a fault-tolerant, learning-enabled UAS deciding which of four contingency procedures to execute under a lost link scenario while overflying an urban area is used to illustrate the approach.

E. Market Analysis and UTM Applications

In [A14], the article "A traffic demand analysis method for urban air mobility," by Bulusu *et al.*, explores the addressable market for Urban Air Mobility as a multi-modal alternative. To justify public investment, UAM must carry a significant portion of urban traffic. The authors develop a traffic demand analysis method to estimate the maximum number of people that can benefit from UAM. The method is applied to about three hundred thousand cross-bay commute trips in the San Francisco Bay Area. The demand shift is estimated under two criteria of travel time flexibility and three criteria of vertiport transfer times. The results indicate that even with high commuter value of time, and long transfer times at vertiports, almost 45% of demand would benefit when the roads are highly congested. Even when the roads are mostly free, about 3% of the demand can benefit. The method also produces the number, location, and distribution of demand over vertiports that can support value proposition, policy-making, and technology research for UAM.

In [A15], the article "Energy-efficient delivery of goods with drones under varying wind conditions," by Sorbelli *et al.*, investigates the feasibility of sending drones to deliver goods from a depot to customers by solving what we call the Mission-Feasibility Problem (MFP). Due to payload constraints, the drone can serve only one customer at a time. The authors propose a novel framework based on time-dependent cost graphs to properly model the MFP and tackle the delivery dynamics. When the drone moves in the delivery area, the global wind may change thereby affecting the drone's energy consumption, which in turn can increase or decrease. This issue is addressed by designing three algorithms. The changes in the drone's energy consumption are reflected by changes in the cost of the edges of the graphs. The algorithms receive the new costs every time the drone flies over a new vertex, and they have no full knowledge in advance of the weights.

In [A16], the article "Distributed connectivity maintenance in swarm of drones during post-disaster transportation applications," by Kurt *et al.*, considers the post-disaster scenarios that involve intelligent traffic management and damage assessment where communication infrastructure may be temporarily down. The swarm-of-drones mesh communication architecture is proposed in such scenarios. Since drones may move to different locations upon request from the first responders, they must preserve the connectivity among them for reliable data transfers. To address this need, the authors propose a fully distributed connectivity maintenance heuristic. Specifically, a new connected dominating set concept is proposed, called E-CDS which considers the drone roles when calculating the virtual network backbone. Solving such an E-CDS is NP-complete and the authors propose a new distributed heuristic to solve it. Moving drone(s) are picked from drones that are not in E-CDS. Since moving a drone to a new location can cause disconnections in the network, other drones are also relocated to restore the connectivity. The proposed methods are implemented in ns-3 network simulator and the results indicate that the proposed distributed heuristic almost matches the performance of a centralized solution and presents negligible overhead.

In [A17], the article "Urban air mobility: history, ecosystem, market Potential, and challenges," by Cohen *et al.*, discusses the history, key concepts, current developments, and market potential of UAM. In the future, UAM could face several barriers to growth and mainstreaming, such as the existing regulatory environment; community acceptance; and concerns about safety, noise, social equity, and environmental impacts. UAM also could be limited by infrastructure and airspace management needs, as well as business model constraints. This article discusses recommendations for future research on sustainability, social and economic impacts, airspace integration, and other topics. The authors conclude that community engagement, impact evaluation, and public policy will be needed to guide sustainable and socially equitable outcomes.

Acknowledgment

The Guest Editors would like to thank the Editorial Office of the IEEE Transactions on Intelligent Transportation Systems, for their support of this Special Issue. In addition, they would also like to thank all the authors who submit their quality articles, and special thanks go to all the anonymous reviewers for their efforts and time to accomplish the review tasks.

Yan Wan, *Guest Editor*
Electrical Engineering Department
The University of Texas at Arlington
Arlington, TX 76019 USA
e-mail: yan.wan@uta.edu

Ella Atkins, *Guest Editor*
Department of Aerospace Engineering
University of Michigan
Ann Arbor, MI 48109 USA
e-mail: ematkins@umich.edu

Dengfeng Sun, *Guest Editor*
School of Aeronautics and Astronautics
Purdue University
West Lafayette, IN 47907 USA
e-mail: dsun@purdue.edu

Kyriakos G. Vamvoudakis, *Guest Editor*
Daniel Guggenheim School of
Aerospace Engineering
Georgia Institute of Technology
Atlanta, GA 30332 USA
e-mail: kyriakos@gatech.edu

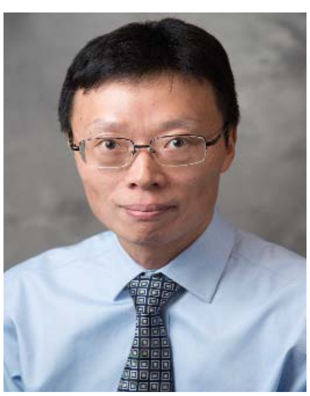
Konstadinos G. Goulias, *Guest Editor*
Department of Geography
University of California at Santa Barbara
Santa Barbara, CA 93106 USA
e-mail: goulias@geog.ucsb.edu

Appendix: Related Works Section:

[A1] M. Stevens and E. Atkins, "Geofence definition and deconfliction for UAS traffic management," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 5880–5889, Sep. 2021.
[A2] M. Liu, Y. Wan, F. L. Lewis, E. Atkins, and D. O. Wu, "Statistical properties and airspace capacity for unmanned aerial vehicle networks subject to sense-and-avoid safety protocols," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 5890–5903, Sep. 2021.
[A3] V. Bulusu and R. Sengupta, "Improving productivity of low-altitude airspace: Speed vs direction control," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 5904–5913, Sep. 2021.
[A4] J. Zhou, D. Sun, I. Hwang, and D. Sun, "Control protocol design and analysis for unmanned aircraft system traffic management," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 5914–5925, Sep. 2021.
[A5] H. Liu, X. Li, G. Wu, M. Fan, R. Wang, L. Gao, and W. Pedrycz, "An iterative two-phase optimization method based on divide and conquer framework for integrated scheduling of multiple UAVs," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 5926–5938, Sep. 2021.
[A6] C. Chin, K. Gopalakrishnan, M. Egorov, A. Evans, and H. Balakrishnan, "Efficiency and fairness in unmanned air traffic flow management," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 5939–5951, Sep. 2021.
[A7] A. Shetty and G. X. Gao, "Predicting state uncertainty bounds using non-linear stochastic reachability analysis for urban GNSS-based UAS navigation," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 5952–5961, Sep. 2021.
[A8] X. Yang and P. Wei, "Autonomous free flight operations in urban air mobility with computational guidance and collision avoidance," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 5962–5975, Sep. 2021.
[A9] M. Maaref, J. Khalife, and Z. M. Kassas, "Aerial vehicle protection level reduction by fusing GNSS and terrestrial signals of opportunity," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 5976–5993, Sep. 2021.
[A10] S. F. Abedin, M. S. Munir, N. H. Tran, Z. Han, and C. S. Hong, "Data freshness and energy-efficient UAV navigation optimization: A deep reinforcement learning approach," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 5994–6006, Sep. 2021.
[A11] Z. Zhou, J. Chen, and Y. Liu, "Optimized landing of drones in the context of congested air traffic and limited vertiports," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 6007–6017, Sep. 2021.
[A12] C. Reiche, A. P. Cohen, and C. Fernando, "An initial assessment of the potential weather barriers of urban air mobility," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 6018–6027, Sep. 2021.
[A13] N. Neogi, S. Bhattacharyya, D. Griessler, H. Kiran, and M. Carvalho, "Assuring intelligent systems: Contingency management for UAS," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 6028–6038, Sep. 2021.
[A14] V. Bulusu, E. B. Onat, R. Sengupta, P. Yedavalli, and J. Macfarlane, "A traffic demand analysis method for urban air mobility," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 6039–6047, Sep. 2021.
[A15] F. Betti Sorbelli, F. Corò, S. K. Das, and C. M. Pinotti, "Energy-constrained delivery of goods with drones under varying wind conditions," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 6048–6060, Sep. 2021.
[A16] A. Kurt, N. Saputro, K. Akkaya, and A. S. Uluagac, "Distributed connectivity maintenance in swarm of drones during post-disaster transportation applications," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 6061–6073, Sep. 2021.
[A17] A. P. Cohen, S. A. Shaheen, and E. M. Farrar, "Urban air mobility: History, ecosystem, market potential, and challenges," *IEEE Trans. Intell. Transp. Syst.*, vol. 22, no. 9, pp. 6074–6087, Sep. 2021.

Yan Wan (Senior Member, IEEE) received the Ph.D. degree in electrical and computer engineering from Washington State University in 2008. She did postdoctoral training at the University of California at Santa Barbara in 2009. She is currently a Distinguished University Professor with the Electrical Engineering Department, The University of Texas at Arlington. Her research interests include the modeling, evaluation, and control of large-scale dynamical networks, cyber-physical systems, stochastic networks, decentralized control, learning control, networking, uncertainty analysis, algebraic graph theory, and their applications to urban aerial mobility, autonomous driving, robot networking, and air traffic management. Her research has led to over 190 publications and successful technology transfer outcomes. She is a member of the IEEE CSS Conference Editorial Board and Technology Conference Editorial Board. She is also a member of the AIAA Intelligent Systems, the IEEE CSS Nonlinear Systems and Control, and the IEEE CSS Networks and Communication Systems technical committees. She was a recipient of the RTCA William E. Jackson Award (Excellence in Aviation Electronics and Communication) in 2009 and the NSF CAREER Award in 2015. She also serves as an Associate Editor for IEEE TRANSACTIONS ON CONTROL OF NETWORK SYSTEMS and IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS: SYSTEMS.

Ella Atkins (Senior Member, IEEE) received the B.S. and M.S. degrees in aeronautics and astronautics from MIT and the M.S. and Ph.D. degrees in computer science and engineering from the University of Michigan. She is currently a Professor with the Department of Aerospace Engineering, University of Michigan, where she directs the Autonomous Aerospace Systems (A2SYS) Laboratory and an Associate Director of the Robotics Institute. She is also a fellow of AIAA, the Small Public Airport Owner/Operator, the Private Pilot, and the Part 107 UAS Pilot. She is also the Past Chair of the AIAA Intelligent Systems Technical Committee. She has served on the National Academy's Aeronautics and Space Engineering Board (ASEB), the Institute for Defense Analysis Defense Science Studies Group (DSSG), and multiple National Academy committees on aviation safety, autonomy for civil aviation, and most recently urban air mobility. She has built a research program in decision-making and control to advance autonomy and assure safe contingency management in manned and unmanned aerospace applications. She is also the Editor-in-Chief of the AIAA *Journal of Aerospace Information Systems* (JAIS).



Dengfeng Sun (Senior Member, IEEE) received the bachelor's degree in precision instruments and mechanology from Tsinghua University, China, the master's degree in industrial and systems engineering from The Ohio State University, and the Ph.D. degree in civil engineering from the University of California at Berkeley. He is currently a Professor of aeronautics and astronautics with Purdue University, West Lafayette, IN, USA. Before joining Purdue University, he was an Associate Scientist with the NASA Ames Research Center, University of California at Santa Cruz. His research interests include distributed control and optimization: theory, algorithms, and computation; cyber-physical systems; unmanned aerial vehicle systems; air traffic control and air transportation; and intelligent transportation systems. He is also an Associate Fellow of the American Institute of Aeronautics and Astronautics (AIAA). He is also the Co-Director of NEXTOR III and the FAA Consortium in Aviation Operations Research. He also serves on the Technical Committee on Guidance, Navigation, and Control in AIAA. He is the Faculty Advisor of Sigma Gamma Tau, the National Honor Society for Aerospace Engineering. He is also a Private Pilot and a Drone Pilot. He was the Faculty Advisor of PPI (Purdue Pilots, Inc.) for a decade (2012–2021). He is also an Associate Editor of the IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS.

Kyriakos G. Vamvoudakis (Senior Member, IEEE) was born in Athens, Greece. He received the Diploma (a five-year degree, equivalent to the M.Sc.) degree (Hons.) in electronic and computer engineering from the Technical University of Crete, Greece, in 2006, and the M.S. and Ph.D. degrees in electrical engineering from The University of Texas at Austin in 2008 and 2011, respectively. From May 2011 to January 2012, he worked as an Adjunct Professor and a Faculty Research Associate with the University of Texas at Arlington and the Automation and Robotics Research Institute. During the period from 2012 to 2016, he was a Project Research Scientist with the Center for Control, Dynamical Systems and Computation, University of California at Santa Barbara. He was an Assistant Professor with the Kevin T. Crofton Department of Aerospace and Ocean Engineering, Virginia Tech, until 2018. He currently serves as an Assistant Professor for the Daniel Guggenheim School of Aerospace Engineering, Georgia Tech. He holds a secondary appointment in the School of Electrical and Computer Engineering. His research interests include approximate dynamic programming, game theory, cyber-physical security, networked control, smart grid, and safe autonomy. He was a recipient of the 2021 GT Chapter Sigma Xi Young Faculty Award, the 2019 ARO YIP Award, and the 2018 NSF CAREER Award, and several international awards, including the 2016 International Neural Network Society Young Investigator (INNS) Award and the Best Paper Award for Autonomous/Unmanned Vehicles at the 27th Army Science Conference in 2010. He has also served on various international program committees and has organized special sessions, workshops, and tutorials for several international conferences. He is also a member of the IEEE Control Systems Society Conference Editorial Board, an Associate Editor of *Automatica*; *IEEE Computational Intelligence Magazine*; IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS: SYSTEMS; IEEE TRANSACTIONS ON ARTIFICIAL INTELLIGENCE; *Neurocomputing*; *Journal of Optimization Theory and Applications*; IEEE CONTROL SYSTEMS LETTERS; and *Frontiers in Control Engineering*-adaptive, robust, and fault-tolerant control, a registered Electrical/Computer Engineer (PE), and a member of the Technical Chamber of Greece.

Konstadinos G. Goulias received the Laurea (B.S. and M.S.) degree in engineering from the Universita degli Studi della Calabria, Italy, in 1986, the master's degree in engineering from the University of Michigan, Ann Arbor, MI, USA, in 1987, and the Ph.D. degree from UC Davis in 1991. He has served as a Professor of transportation for the Civil and Environmental Engineering Department, The Pennsylvania State University, from 1991 to 2004, where he also directed the Transportation Operations Program, the CyberTrans Center, and the Mid-Atlantic University Transportation Center. He has been a Professor of transportation with the Department of Geography, UC Santa Barbara, since 2004. His research is on large-scale transportation systems modeling and simulation, travel behavior dynamics, sustainable transportation, economic geography and survey methods, and activity-based transportation demand forecasting. He has done research and consulting in Australia, Germany, Greece, Italy, Japan, The Netherlands, Portugal, Qatar, and the United States developing new data collection and modeling techniques, simulation frameworks, expert reviews of technologies, and engineering practice and policies. He also organized and chaired the 15th International Conference on Travel Behavior Research in 2018. He chaired the Standing Committee on Traveler Behavior and Values and the Task Force on Moving Activity Based Approaches to Practice of the Transportation Research Board (TRB) of the National Academies. He edited three books and published more than 350 research reports and articles, and he is the Co-Founder and Co-Editor-in-Chief of the *Transportation Letters* journal (Taylor&Francis). He is also the Chair-Elect of the International Association for Travel Behaviour Research.