Guidance, Navigation, & Control
Call for Papers

(Complete) Draft Manuscript Deadline: 8 June 2020[1]

Final Manuscript Deadline: 1 December 2020

Submissions: www.aiaa.org/scitech

Organizing Committee

Technical Discipline Chair	Deputy Technical Chair	Deputy Technical Chair
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Event Synopsis

The AIAA Guidance, Navigation, and Control (GN&C) Technical Committee is inviting submission for the GN&C technical discipline tracks of the 2021 AIAA Science and Technology Forum and Exposition (SciTech), an event that provides the world's premier forum for presentation, discussion, and collaboration on science, research, and technology related to the aerospace industry.

The AIAA GN&C technical discipline at SciTech consists of numerous **technical sessions**, **invited sessions**, and a **graduate student paper competition** sponsored by the GN&C Technical Committee.

Individual papers may be submitted to the appropriate technical sessions, as detailed in the below Technical Area descriptions. Special topics may be proposed as Invited Sessions, per the below Invited Session guidelines. Eligibility criteria and submission requirements for the Graduate Student Paper Competition are also detailed below.

Please carefully read and follow the below submission requirements.

[1] The GN&C technical discipline requires a **full draft manuscript** for all non-invited sessions. Refer to GN&C guidelines below for further info.

Invited Sessions

Key Dates:

Invited Session Proposal Deadline: 16 April 2020

Notification of Invited-Session Acceptance/Rejection: 7 May 2020

Invited session proposals are solicited in any of the topic areas listed below as well as in new or emerging technical areas. Papers in an invited session should form a cohesive focus on the relevant topic. Inclusion of a reasonable diversity of viewpoints is encouraged.

Note: The procedure for submitting an invited session proposal is different from the normal paper submission procedure.

Procedure: The invited session organizer should submit the completed session proposal, in its entirety, to BOTH the technical chair and co-chair below by the above proposal deadline. Invited session organizers should invite authors to participate, collect the required information, assemble the Session Proposal, and submit the Session Proposal as one file to the Invited Session chairs listed below.

Session Proposal: The Session Proposal should be submitted as a single document that includes a Session Title and a one- or two-page Summary Statement that describes the motivation and relevance of the session. The document should have the session organizer contact information, and details on each paper, including title, authors, author affiliation, and a few sentences describing the paper. Note that SCITECH sessions rarely exceed six papers, so larger proposals will likely require multiple sessions. The Invited Sessions chairs will directly notify the organizer of the acceptance/rejection of their session.

Individual Paper Submission: Following the acceptance of a proposed invited session, each individual contributing author is required to submit an extended abstract to the AIAA SciTech submission website, with the topic and subtopic selected as "GN&C" and "Invited Session", respectively. Extended abstracts should be at least 1000 words (not including references) and must include sufficient detail to demonstrate the purpose of the paper, the technical foundation for the topics to be discussed, preliminary results to date, and the expected results of the final paper, including key figures, equations, tables, and references. Sufficient information must be included in the submission to convince the Invited Sessions chairs and reviewers that the author(s) will have a strong likelihood of completing the final manuscript by the final manuscript submission deadline.

The individual extended abstracts must be submitted by the SciTech forum abstract/draft manuscript deadline, and final manuscripts by the SciTech forum final manuscript deadline. Authors of individual papers must send their paper tracking number to the organizer of their invited session. The invited session organizer, in turn, must forward to the GN&C Invited Session Chair and Co-Chair, the complete list of paper tracking numbers for their invited sessions.

Evaluation of Individual Submissions: Please note that at the discretion of the Technical Program Committee, individual papers may be rejected and/or removed from proposed sessions and replaced by an appropriate contributed paper. Likewise, selected papers from rejected Invited Sessions may be placed into the regular program.

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Draft Manuscript Submission Guidelines for GN&C Technical Areas

Paper selection for non-invited sessions at the GN&C track will be based on a **full draft manuscript** of the proposed technical paper, which must include sufficient detail to allow informed evaluation by the assigned reviewers. ***There are no exceptions to the draft manuscript requirement.***

Draft manuscripts and final papers must not exceed a total length of 25 pages. Each draft must begin with a 100- to 200-word abstract, followed by an introduction that includes a brief assessment of prior work by others and an explanation of the paper's main contributions.

Technical Topics

Papers covering all aspects of guidance, navigation, and control of aerospace systems may be submitted. Specifically, papers should describe novel analytical techniques, applications, and technological developments in areas such as: the guidance, navigation, and control of aircraft, spacecraft, satellites, launch vehicles, missiles, aerospace robotics, unmanned/autonomous systems, and other aerospace systems; in-flight system architecture and components; navigation and position location; sensors and data fusion; aerospace vehicle performance analysis; and multidisciplinary control.

Please refer to the following individual technical area descriptions to determine the topic that most closely aligns with your paper. If your paper aligns with multiple topics, please choose the topic that seems most closely aligned. If you have further questions, please contact the technical discipline chairs of the individual area chairs.

Detailed descriptions of the topic areas follow (or, click on the topic):

Please note that, at the discretion of the Technical Program Committee, papers may be moved between topic areas during the review or paper session disposition processes.

Control Theory for Aerospace Applications

Papers are sought that develop new theories, generate new algorithms, derive new analyses/techniques/design-tools, or modify and improve existing techniques for general application to the control of aerospace systems. Topics of interest include robust control, nonlinear control, optimal control, multivariable control, adaptive and intelligent control, fault detection, redundancy management, formal verification and validation methods, and bio-inspired control.

Papers describing new analysis and synthesis techniques with illustrative and realistic aerospace control examples are also strongly encouraged. Papers discussing applications of existing control theoretic methods should be submitted to other technical areas based on which one most closely matches the application. Examples of specific topics appropriate for this area include the following:

- **Robust Control**: techniques for control design of systems with uncertainty; feedback stability, mu analysis and gain scheduling; multivariable stability margins and multiplier theory; mu-synthesis and H-infinity-optimal control.
- **Nonlinear Control**: techniques and methods for control of nonlinear models; Lyapunov techniques and their extensions; linear matrix inequalities; applications of nonlinear control methods, such as sliding mode or feedback linearization techniques.
- **Optimal Control**: optimization algorithms and methods; objectives and issues in optimal control of nonlinear systems; dynamic programming; solution methods; case studies in analysis and design of optimal controllers; robustness and stability margins; design tradeoffs; computational tractability.
- **Adaptive Control**: Model Reference Adaptive Control and variants, Lyapunov stability analysis of adaptive control laws; direct and indirect adaptive control for linear and nonlinear systems; computational challenges; adaptation rules; verification of margins for flight critical systems; models and learning rules in artificial neural networks; neural networks in system identification and control.
- **Fault Detection and Reconfiguration**: algorithms to detect sensor and effector faults; switchover control laws; simulations with fault injection and recovery performance.
- **Control Allocation**: control allocation laws including management of multiple effectors; verification and validation of redundancy management methods; implementation in real-time software.
- **Verification and Validation**: formal safety assurance techniques including model checking and theorem proving for studying complex aerospace systems; abstraction schemes; computational challenges; run-time assurance; implementation in real-time.
- **Other**: original theoretical contributions and arising areas of control and autonomy theory, motivated from aerospace applications, will also be considered.

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Navigation, Estimation, Sensing, and Tracking

Papers are sought that develop new and novel theory and general approaches, techniques, and design tools associated with navigation, estimation, sensing and tracking for aerospace systems. Examples of specific topics appropriate for this area include the following:

- **Estimation**: parameter estimation; robust and adaptive filtering; nonlinear filtering and smoothing; nonlinear observers; distributed estimation; hybrid estimation; integrated estimation/control.
- **Navigation**: navigation techniques using traditional, novel, or fused measurement sources, such as biologically-inspired, vision-based, X-ray source-based, terrain-guided, and radio navigation; autonomous navigation and control (including integrated GPS and inertial navigation, as well as integrated sensor modeling and fusion); simultaneous localization and mapping.
- **Sensing**: sensor testing and performance evaluation results from actual hardware; new techniques for designing, modeling, simulating, prototyping, calibrating and fielding sensors for use in estimation, navigation and tracking applications
- **Tracking**: nonlinear and multi-hypothesis tracking; data association; combined detection/tracking; sensor management; situational awareness; geolocation.

Papers that emphasize mission- and vehicle-specific applications should be submitted to the Aircraft, Spacecraft and Launch, Missile, or Multi-Vehicle GN&C technical areas.

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Distributed, Cooperative, and Multi-Vehicle Guidance, Navigation, and Control

Papers are sought that deal with the theory and application of all aspects of distributed and cooperative control of multi-vehicle and/or human-in-the-loop systems within aerospace GN&C. Of particular interest are manuscripts concerning innovative developments, implementation and certification issues, planner/controller/estimator design, distributed/cooperative decision-making and control of autonomous agents, and mixed initiative control of semi-autonomous teams for a variety of aerospace applications.

Examples of specific topics appropriate for this area include the following:

- **Planner, Controller, and Estimator Design**: multi-vehicle or distributed planners, controllers and estimators designed using rule-based and model-based techniques, machine learning, evolutionary algorithms, and bio-inspired control techniques.
- **Cooperative Decision and Control of Autonomous Agents**: cooperative task assignment and trajectory optimization; biologically-inspired group behavior and control schemes.
- **Mixed Initiative Control of Semi-Autonomous Teams**: team tasking, auto-routing, and coordinated rendezvous.
- **Cooperative Control and/or Navigation with Uncertainty**: accommodation of effects of model, vehicle, or environment uncertainty, for multi-vehicle/cooperative system objectives, such as formation flight or dynamic tasking.
- **Applications**: distributed and cooperative control and estimation applications for aircraft, missiles, spacecraft, smart autonomous vehicles, mission-planning management, multi-objective control, system integration, fault detection, identification, and accommodation issues. Platforms include but are not limited to: Unmanned Aircraft Systems (UAS) / Unmanned Aerial Vehicles (UAVs), Unmanned Combat Air Systems (UCAS), Unmanned Ground Vehicles (UGVs), Unmanned Underwater Vehicles (UUVs), Wide Area Search Munitions (WASMs), and satellite constellations and/or clusters.

Particular interests include the stability and robustness of complex distributed control tasks and in-real-time implementations.

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Autonomy and Artificial Intelligence for Aerospace Vehicle Guidance, Navigation, and Control

Papers are sought concerning novel methods for applying autonomy concepts, such as machine learning and artificial intelligence, to the design and execution of guidance, navigation, and control algorithms for aerospace vehicles. Of particular interest are papers that address the challenges and missions associated with unmanned systems.

Examples of specific topics appropriate for this area include the following:

- **New Designs/Capabilities**: new vehicle designs, and the interaction between the vehicle design and control synthesis process; sensor processing and control algorithms that enable autonomous perching and in-flight docking.
- **Sensors and Data Fusion**: state estimation algorithms suitable for implementation on autonomous systems; navigation in GPS denied environments; autonomous navigation. Innovative and new sensors, especially for small unmanned systems.
- **Flight Dynamics and Control**: dynamic modeling of autonomous systems; digital-twin modeling; effects of realistic atmospheric conditions on modeling and flight control; flight control architectures; bio-inspired flight.
- **Trajectory Planning**: planning algorithms suitable for implementation on autonomous systems; operation in constrained, uncertain and/or unstructured environments, near obstacles; effects of realistic atmospheric conditions on flight trajectories.
- **Experiments**: demonstration/performance analysis of autonomous GN&C algorithms in hardware and in high-fidelity simulation.

Please note that papers dealing with multiple unmanned vehicles (large or small) should be directed to the Distributed, Cooperative, and Multi-Vehicle GN&C technical area.

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Motion Planning, Sensing, and Operations for Aerospace Robotic Systems

Papers are sought that deal with the GN&C design and challenges related to aerospace robotics. Papers that present novel machine learning, control and robotics for proximity operations, rendezvous and docking, on-orbit servicing missions, and active space-debris removal are particularly welcome. Broad subject areas in air and space include: trajectory and motion planning, relative trajectory tracking control; pose tracking, computer vision/perception and relative navigation, dynamical modeling and control of robotic manipulators. Presentations of state-of-the-art robotics facilities and related experimental results are also welcome. Examples of specific topics appropriate for this area include the following:

- **Computer vision/perception and relative navigation**: relative navigation algorithms and pose estimation based on computer vision sensors such as mono camera, stereo camera, laser range finder, and LIDAR; vision-based navigation systems using optical flow and occupancy grids; neural network-based approaches, simultaneous localization and mapping (SLAM) concepts; Kalman-filter relative navigation techniques.
- **Trajectory Planning and Control**: methods of relative trajectory and motion planning in uncertain and unstructured environments, including nonlinear optimal trajectory planning, probabilistic methods, artificial potential field; collision avoidance and rendezvous and docking path planning, pose tracking in proximity operations.
- **Robot Dynamical Modeling and Control**: equations of motion for unique robotic aerospace systems and robotic manipulators, including the treatment of motion or dynamic constraints and control challenges; free-floating robot deployment and maneuvering; robotic capture of tumbling targets.

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Aircraft Guidance, Navigation, and Control

Papers are sought that address the development, simulation, and flight testing of GN&C systems for fixed-wing and rotary-wing vehicles. Papers on GN&C concepts in Air Traffic Management are also encouraged. Papers that emphasize novel theoretical designs, including high-fidelity and detailed simulation/simulator results, and/or experimental results are given priority. Examples of specific topics appropriate for this area include the following:

- **Augmented Flight Control Systems**: stability and control augmentation; automatic flight path and speed control; auto pilot design; integrated guidance and control; trajectory generation and energy management; interdisciplinary flight control and vehicle performance; nonlinear flight control; structural control and vibration suppression; aeroservoelasticity; adaptive/morphing structures for flight control; limitations of control effectors (e.g., saturation).
- **Fault Tolerance and Recovery Systems**: self-repairing or reconfigurable systems; situational awareness; command and decision support; flight envelope protection; trajectory recomputation and reconfiguration; failure/fault detection and isolation; stall recovery and control.
- **Navigation and Flight Management Systems**: navigation algorithms; GNSS positioning; alternative navigation sensors; autonomous navigation; GPS performance and status; trajectory design; flight director design.
- **Flight Control Analysis and Flight Test Evaluation**: aircraft handling qualities; human-machine interface; pilot-in-the-loop; integrated vehicle ground testing; taxi testing; robustness and performance analysis; hardware-in-the-loop.
- **Formation Flight Control with Uncertainties**: aircraft formation flight for drag savings/fuel reduction; swarming, platooning, mobile sensor air networks; accommodation of atmospheric uncertainties on formation control.
- **Aircraft GN&C Sensors**: sensor testing and performance evaluation results from actual hardware; new GN&C sensor concepts; new techniques for designing, modeling, simulating, and prototyping sensors; sensor calibration techniques; fielding of sensor systems that support GN&C; miniaturization of hardware and applications; redundancy management of multiple sensors used by the onboard avionics systems.
- **GN&C Concepts in Air Traffic Management**: development and testing of new air traffic control (ATC) decision support tools; future ATC concepts for separation assurance; development and testing of new flight-deck avionics and communication, navigation, and surveillance capabilities; integration of future concepts; new uses of weather information and integration in the cockpit; enhanced planning and scheduling concepts.

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Spacecraft and Launch Guidance, Navigation, and Control

Papers are sought on GN&C of launch and spaceflight systems. Broad areas cover the design and challenges for on-orbit operations; studies of human or unmanned missions; GN&C algorithms, analysis, and test results for all mission phases; novel sensors, avionics, actuators, and mission-enabling mechanisms; multidisciplinary mission/system design; and, flight software development and testing relevant to each of these topics. Theoretical discussions should be supported by simulation or test data where possible. Examples of specific topics appropriate for this area include the following:

- **Mission Phase GN&C:** algorithms and analysis for ascent, orbit raising, rendezvous, on-orbit operations, entry, landing and/or deep space operations; methods for increased trajectory design automation over complex, multi-phase missions; mission design under model uncertainty; dynamical theory analysis of mission design.
- **Attitude and Orbit Determination and Control:** estimation and control of spacecraft orbit and/or attitude; novel methods and mechanisms for vehicle/payload pointing and articulation.
- **Spacecraft Formation Control:** constellation and formation design, control and execution; collision avoidance; proximity operations; approach, rendezvous, and docking; situational awareness; distributed aperture satellite formations.
- **GN&C Systems for Unmanned Space Missions:** algorithms and analysis for LEO & GEO Earth and space science missions, resupply/service of on-orbit vehicles, small satellite applications (including CubeSats), and similar unmanned missions; performance analysis of recent in-orbit GN&C systems; methods for improving autonomy, capability, and reliability.
- **GN&C for Human Exploration Missions:** design and analysis of new considerations and capabilities for manned asteroid, lunar, Mars, and beyond missions; design, analysis, and/or demonstration of GN&C technologies that enable Commercial Crew Integrated Capability.
- **Spaceflight Vehicle Avionics:** avionics and sensor hardware testing and performance evaluation; new techniques and results for designing, modeling, simulating, and prototyping flight hardware; sensor calibration techniques; redundancy management of multiple sensors; real-time implementation of GN&C; novel sensors for autonomous vehicle applications.
- **Complex Space System Analysis and Management:** coordination and control of multi-body and flexible systems; reduction/management interaction or coupling between physical subsystems, actuation, and disturbances; verification and validation of complex systems; methods and analysis of GN&C fault-tolerance to system-level errors.
- **Innovative Techniques for Next Generation Space Systems:** GN&C methods for next-generation spaceflight systems (e.g., artificial intelligence, quantum computing); hardware miniaturization applications; GN&C design based on high performance actuators (e.g. electric propulsion) and sensors (e.g. based on cold atoms); GN&C for next-generation and reusable spaceflight systems; approaches for enhanced performance with existing hardware; rapid trade space and conceptual analysis tools; methods for development time and cost reduction.

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Missile and Trans-Atmospheric Vehicle Guidance, Navigation, and Control

Papers are sought on GN&C of missiles, launch platforms, and re-entry vehicles. Broad topics include design, analysis, simulation, and test of algorithms, subsystems, or complete systems with missile and other trans-atmospheric (i.e., exo- and endo-atmospheric or hypersonic) vehicle applications. Examples of specific topics appropriate for this area include the following:

- **Modern Autopilot/G&C Approaches:** applications of modern robust, stochastic, and adaptive control algorithms to missile and trans-atmospheric vehicle guidance and control; integrated/tightly coupled missile and trans-atmospheric vehicle guidance and control solutions; novel and low-cost actuation approaches.
- **Estimation, Tracking, and Filtering Algorithms:** novel estimation approaches, particularly for improving performance with lower fidelity sensors and for hypersonic systems; redundancy management and data fusion for improved navigation and tracking performance with multiple sensors; verification and validation of target discrimination and tracking algorithms.
- **Trajectory Optimization:** design and analysis of guidance laws to achieve optimum and/or robust trajectories for mission planning, intercept guidance, and reentry applications.
- **Computer-Based Design and Analysis Techniques:** advances in numerical guidance and control design and performance analysis methods; novel developments in computer-aided decision making and mission planning; verification and validation methods for offensive and defensive systems.
- **Conceptual GN&C for Missile Applications:** GN&C designs for applications such as semi-autonomous/autonomous missile and trans-atmospheric vehicle systems, ship defense, and strategic/theater missile defense systems. Theoretical discussions should be supported by simulation and/or test data where possible.
- **Missile and Trans-atmospheric Vehicle Sensors and Avionics:** sensor testing and performance evaluation results from actual hardware; new techniques for designing, modeling, simulating, and prototyping sensors and avionic subsystem components; sensor factory or in-situ calibration techniques; fielding of sensor systems that support GN&C; miniaturization of hardware and applications; implementation of GN&C in real-time software.

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Uncertainty Quantification and Analysis of Complex Aerospace Systems

Papers are sought on the modeling, analysis, and control of complex aerospace systems in a stochastic environment. In particular, papers that address high dimensional and/or nonlinear systems under complex forms of uncertainty (e.g. non-Gaussian, multi-modal, heavy tails, etc.) are encouraged. Advancements in non-deterministic (randomized) algorithms for system modeling, guidance, navigation and control are sought. UQ methods for PDE (partial differential equation) systems are also invited. Examples of specific topics for this area include the following:

- **Dimensionality Reduction and Data-Driven Control Methods:** model reduction methods, e.g. proper orthogonal decomposition and its variants; data-driven model reduction, such as dynamic mode decomposition; connections with Koopman theory.
- **Validation and Verification:** V&V paradigms for control design; formal methods; model adequacy and accuracy; control certification; V&V for GN&C software; design of experiments and data uncertainty; V&V for predictive computation.
- **Modeling and GN&C under Structured and Unstructured Uncertainty:** modeling, sensor fusion, and inference in environments with significant uncertainty; anomalous interactions between sensing and predictive/forecasting components; alternate frameworks such as evidential reasoning.
- **Uncertainty Propagation:** advances in uncertainty forecasting methods and their convergence characteristics; methods addressing curse of dimensionality; forecasting in hybrid systems and switching systems; prognostics of complex systems; prescriptive analytics.
- **Spectral Methods:** integration of spectral UQ methods, e.g. gPC with GN&C; convergence characteristics; advances in stochastic collocation and other non-intrusive methods; curse of dimensionality.
- **Chance-constrained Planning and Control:** learning methods for obstacles in an uncertain/unstructured environment; dynamic uncertain obstacles; effective surrogates for chance-constraints; numerical scalability; dynamic tasking and multi-agent trajectory planning.
- **Inverse Problems:** modeling input uncertainty; Bayesian analysis and alternatives; analysis of limits of extrapolation; model uncertainties; applications of V&V; calibration of experiments; sensitivity analysis.

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GN&C Graduate Student Paper Competition

The GN&C Technical Committee will host a Graduate Student Paper Competition at SciTech 2021. In addition to appropriate recognition, all finalists in the GN&C Graduate Student Paper Competition will receive a monetary award of $500 and complementary registration. The overall winner will receive an additional $1,000 award.

For this competition, full draft manuscript papers are sought from graduate students on GN&C technical research topics, from which up to six finalists will be selected by a panel of judges for inclusion in a special GN&C Graduate Student Paper Competition session. Author eligibility and manuscript submission requirements are described below.

Eligibility Requirements

- A student must be the primary or sole author, enrolled at an institution of higher learning.
- The student will be expected to sign a form, if selected as a finalist, stating that they contributed the overwhelming majority to the paper's written and technical content.
- The student author must be a member of AIAA to become a finalist in the competition.
- The student author must be a full-time graduate student in good academic standing at his or her university/institution at the time of submission.
- Full draft manuscript not exceeding a total length of 25 pages.
- The student author is not the overall winner of the preceding year's competition.
- Only one paper submission per primary author.

Submission Requirements

- Graduate Student Paper Competition submissions must adhere to the overall Forum Abstract Submission Requirements.
- Students must select the "Student Paper Competition" presentation type during the electronic submission process. Do not submit the abstract more than once. Only submissions with "Student Paper Competition" presentation type indicated will be eligible for the competition.
- All submissions must be made by the Forum abstract submission deadline (8 June 2020).

Finalists will be required to make two presentations at the Forum: once in the appropriate regular technical session and once in a separate GN&C Graduate Student Paper Competition session. Note that authors will receive an accept/reject notification first for the regular SciTech forum review process and later for the graduate student paper competition. The second notification will be from the GN&C Technical Committee. A paper can be (1) accepted for both the regular SciTech forum and competition, (2) accepted to the SciTech forum, but not the competition, or (3) not accepted to either.

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