

GNC V&V WORKSHOP - CALL FOR ABSTRACTS

The Inter-Agency GNC V&V Working Group invites researchers and practitioners to submit a technical abstract for a presentation at the second GNC V&V Workshop to be held on 9-10 July 2025 at the Institut Supérieur de l'Aéronautique et de l'Espace (ISAE-SUPAERO) in Toulouse, France.

The latest Workshop information is available at the Workshop's main Indico page at: <https://events.isae-supaero.fr/e/VVworkshop2025>

The Inter-Agency GNC V&V Working Group is an informal collation including representatives from the European Space Agency (ESA), the National Centre for Space Studies (CNES), the German Aerospace Center (DLR), the National Aeronautics and Space Administration (NASA), the French Aerospace Lab (ONERA), The Italian Space Agency (ASI), and ISAE-SUPAERO. The Inter-Agency GNC V&V Working Group is narrowly focused on exploring solutions to improve the collective capabilities of the space agencies and their industrial partners to perform efficient GNC V&V on modern algorithms for space systems. The Working Group recognizes that the V&V process is a significant cost driver in space mission GNC system developments. The Working Group seeks to identify the new GNC V&V technologies, approaches, methodologies, tools, and processes needed to deal with the evolving complex GNC systems of the future. The Inter-Agency GNC V&V Working Group has carefully considered this fundamental question: Will the GNC engineering community of practice be sufficiently prepared to perform the necessary V&V on evolving GNC architectures and algorithms that are driven by very demanding requirements for autonomy, resiliency, reconfigurability, adaptability, and mission cost-benefit balance? Additional information on the findings and recommendations of the Inter-Agency Working Group are provided here: <https://ntrs.nasa.gov/citations/20240003178>

The Inter-Agency Working Group is now soliciting abstracts for the Workshop. Abstracts should not exceed 2 single-sided pages in length including no more than 1 Figure (single spaced, Arial, 12 font). When submitting an abstract to the website please indicate the corresponding author and also indicate the author's affiliation.

Please note that the abstracts and the actual presentations will both be publicly accessible on the Workshop website. All material presented at this Workshop must therefore, before submission, be cleared of any restrictions preventing it from being published on the Workshop website.

The envisioned Workshop sessions are as described below. The organizers wish to stress that Workshop will not be structured as a typical conference, rather it is envisioned to be an informal forum conducive to group technical interactions. The specific details of the Workshop structure remain to be converged upon. It can be stated that those details will largely depend on the interest level of the community and the nature of the responses received to this Call for Abstracts. The Workshop will be articulated primarily around short presentations to stimulate discussion as well as around more interactive exercises (e.g., round-tables, break-out sessions interleaved with plenary session, etc.). The organizers view this Workshop as an opportunity for community members to informally share GNC V&V challenges, concerns, issues, ideas, potential solutions and priorities for future work and collaboration. The fundamental goal being to improve the reliability and the efficiency of the GNC V&V phase in a mission's life cycle.

As such the Inter-Agency Working Group is seeking several short 10–15 minute long presentations (i.e., brief “talks”) only, not the full technical papers as would occur for conferences. The Working Group is especially interested in receiving presentation abstracts that will support a collaborative effort by space agencies, industry, academia, and tool vendors to solve the GNC V&V challenges associated with the complex GNC systems of the future.

The planned July 2025 GNC V&V Workshop has two major objectives: 1) to raise awareness about GNC V&V challenges and issues within our community and 2) to provide an informal forum for knowledge sharing and learning on the topic of advancing GNC V&V to meet future challenges. It is envisioned, but potentially subject to some change, that the Workshop will include the following eight (8) sessions where it is anticipated that all domains can be represented:

1) Recent Real-World Space Mission GNC V&V experiences

Theme Statement: Most every space mission requires the investment of significant resources to perform the necessary pre-launch GNC V&V process. Current V&V methods and practices are stressful on project resources and are driven by GNC algorithm complexity where there are high levels of system interaction and interdependency. Performing such GNC V&V in the Earth’s 1-g environment is challenging especially in implementations where the various elements of the closed-loop system include complex nonlinear coupled dynamic behaviors (e.g., the de-stabilizing flexible body and propellant slosh effects) that will drive GNC algorithm complexity. The adequate modeling of system parameter uncertainties in this V&V context also presents a significant challenge as does the need to perform systematic sensitivity analysis. This session is envisioned to be a forum where the current challenges of performing GNC algorithm V&V can be highlighted and interactively discussed. Of particular interest are talks that describe the limits and constraints of the current GNC algorithm V&V methods and talks describing lessons learned. It is envisioned that interactive discussion on this topic could potentially identify where practical GNC algorithm V&V process improvements could be made. Talks that discuss successful examples of where recent improvements in the GNC algorithm V&V process have been made, especially in ways that would be compatible with an industrial setting, are of great interest for this session.

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2) Efficient V&V Tools and Methodologies for Systems Using Modern GNC Technologies

Theme Statement: This session is envisioned to be a forum to showcase new emerging GNC algorithm V&V methodologies, tools, and techniques. The term “modern” here in this context is meant to convey a range of GNC technologies, among them: adaptive flight control, real-time on-board trajectory optimization, AI/ML data-driven techniques (i.e., “learning systems”), optical navigation, as well as advanced methods for parameter uncertainty analysis, system sensitivity analysis, GNC fault management, and dynamic modeling for flexible bodies and propellant slosh. Modern methods for efficient large model reduction to improve the tractability of the system modeling aspects of the GNC

problem are also of interest. Of special interest are talks that highlight such new GNC V&V methodologies and tools that are most applicable to these modern GNC technologies the industrial spacecraft development environment where achieving cost and schedule efficiencies is a huge driver. Typically, the GNC V&V activities constitute a significant part of the overall system development costs for all classes of space missions. The space agencies and their industrial partners have an urgent need to develop V&V processes, tools, and testing capabilities to manage GNC system complexity and uncertainty in the trifecta of robustness, adaptability, and autonomy. This need is especially pronounced for the GNC systems that have adaptive elements and/or in-flight machine learning elements. These type of non-deterministic GNC systems are being designed for several mission-critical and (possibly safety-critical) space mission applications. The V&V of such systems, with their complex non-linear dynamic behaviors, poses a number of significant challenges and will likely necessitate new and novel V&V tools and methods. The purpose of this session is to identify what new and novel V&V tools and techniques are available today and to ascertain their readiness level for practical applications. In addition, talks are solicited to identify what GNC V&V tools and methods, not yet developed, will be need for future mission applications. In this session talks that identify new GNC V&V technologies (i.e., algorithms, tools, techniques, methods, processes, etc.) are of primary interest. Talks that also present roadmaps for maturing some of these GNC V&V technologies to the Technology Readiness Level (TRL) needed for their efficient industrial application are of special interest. Lastly, talks are also invited that can aid in the identification of new V&V technologies that permit the better understanding of the space system dynamic behaviors early enough in the design process to avoid costly iterations and extensive GNC design re-tuning late in the development cycle.

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3) Bridging the Research-Industrial Gap

Theme Statement: In the future it is likely that two different, and somewhat opposed, thrusts that will take place across our GNC community: 1) academic researchers will be developing new, modern, and mostly untested, algorithmic solutions to satisfy the future space mission GNC needs, and 2) industrial practitioners will be attempting to implement some of these modern algorithms in their real-world environment with the accompanying space agencies' cost and schedule constraints. Undoubtedly the space agencies and our industrial partners will be facing increased challenges to efficiently and comprehensively perform the necessary Verification and Validation (V&V) of evolving GNC systems that employ modern algorithms. Since the GNC V&V activity is a relatively expensive part of a mission's life cycle we must identify efficient methods for performing V&V on advanced GNC algorithms. In this session the expectation is to have interactive discussions, for the benefit of both the research and industry communities, on new ways to bridge the gap between the GNC state-of-the-art as defined by research organizations and the day-to-day work of the industry practitioners that develop the actual flight systems for the space agencies. This session is open to talks with topics ranging from theoretical

formulations of new efficient V&V techniques to innovative practical implementations of advanced GNC V&V methods in an industrial setting. Talks from industry that discuss successful examples of collaborations that span the academic and research community boundaries, especially in the New Space arena, are of special interest for this session. Collaboration in this context would essentially mean examples where one of the space agency's industrial partners adopted modern GNC technologies, techniques, or tools that were matured in academia and can present their experience. Also, of great interest are talks that would describe the space agency's experiences with facilitating such academic-industrial collaboration.

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4) GNC Benchmark Problems and Potential Solutions

Theme Statement: There is a need for a benchmark problem (or set of problems) to facilitate the transition of modern GNC algorithms from the research organizations to the industrial practitioners. Areas in which useful benchmark problems could be developed include, re-entry control, rendezvous and proximity operations, robotic servicing and assembly, and active vibration control. Such benchmark problems must address several challenges: physical modeling, dynamics, sensors, actuators, sensor processing, feedback control, online system identification, online state estimation, and decision-making. Recently NASA (together with the Aerospace Corporation) has developed a high-precision space observatory precision pointing benchmark problem. Other benchmark problems are also being developed at ESA. This session will have talks describing the existing benchmark problems and potential solutions. Talks that present ideas and concepts for the formulation of additional benchmark problems, especially ones that would aid in bridging the gap between the research organizations and industry, are of special interest.

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5) V&V Research in Academia

Theme Statement: The study of algorithms, tools, techniques and methods for conducting the V&V of GNC algorithms has held significantly less appeal in academia as compared to performing fundamental research that develops new technologies (e.g., algorithms) for GNC applications and then publishing those research results. There are several possible reasons for this situation. Perhaps academic researchers view the GNC V&V problems as something solely in the domain of the space agencies and

their industrial partners. Another possibility is the rise in data-driven machine learning algorithms for control design. Conferences now routinely having a large number of publications on this specific topic. The key point here being that the resulting controllers are not easily amenable to V&V analysis via proof techniques. Finally, another aspect to be recognized here is that the V&V work at the space agencies and in industry is typically embedded in a much larger Systems Engineering effort. Unfortunately, opportunities for fundamental multi-disciplinary Systems Engineering research within the academic environment appear to be much less prevalent than for the specific disciplines, such as electrical engineering or mechanical engineering. The overall result is currently an overemphasis on algorithm design as compared to V&V in the academic literature. Regardless of the exact cause this is a situation that bears some attention. The GNC community would greatly benefit if academic researchers paid equal attention to the V&V aspects of GNC as they do to GNC algorithms and developed both in tandem. Perhaps this could be achieved with improved communication and collaboration between the academic researchers and the industry practitioners, possibly facilitated by the space agencies.

This session desires to host talks on this topic of how to include more academic research in the area of GNC algorithm V&V. Talks on potential curriculum changes, the usefulness of ‘real-world’ benchmark problems, and specific research topics (e.g., uncertainty modeling and quantification) are of special interest for this session. Talks that discuss the potential for including V&V aspects into the on-going academic research on non-deterministic adaptive and learning systems would be especially relevant to this Workshop and this session in particular. This session, through its talks and associated discussions, should support the identification of several new potential innovative GNC V&V-related research topics on that could be performed in academia. It is anticipated that part of that discussion would focus on where the space agencies have existing technology development programs/projects that could potentially provide the required resources to sponsor innovative GNC V&V-related research activities in academia.

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6) New Space Alternative Approaches to the Traditional GNC V&V Process

Theme Statement: It should come as no surprise that there has been a great deal of movement away from the 1960s/1970s traditional model of centralized, big government-led space projects towards a new model that increasingly exploits the commercial space market in ways not previously done in order to obtain cost and schedule advantages. In this context the term “New Space” is used to refer to this time of unprecedented growth in the space community and to indicate the greatly expanded scope of what is now possible for launchers, spacecraft, and landers. The fundamental issue to be explored in this session is: Has there been a reduction in the GNC system V&V and thus a diminished level overall system reliability in the process of obtaining these New Space cost and schedule benefits? It is envisioned to also examine and discuss the counterpoint to this issue, namely: Have the New Space companies developed alternative, less costly and time-consuming approaches to performing flight

system GNC V&V work that the space agencies and their industrial partners could benefit from? Are there results from New Space mission In Orbit Demonstrations (IODs) that could inform ways to make GNC V&V more efficient? Can certain parts of the GNC V&V process (e.g., precision pointing performance verification) be performed in-flight, during the early checkout and commissioning phase of a mission? In this session it is hoped to explore the current New Space landscape in the context of GNC V&V. Talks that discuss fundamental philosophical changes from the traditional GNC V&V process are of special interest. For example, the innovative concept of deferring parts of the GNC V&V process until the early in-flight phase of the mission is an intriguing approach that would make for an excellent talk and discussion. The overall intent of this session is to better understand how space agencies and industry can manage the associated risks of alternative GNC V&V approaches and also how to leverage the new opportunities to increase the number of missions flown and to possibly develop new capabilities.

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7) V&V Methods and Techniques for Non-Space Safety-Critical Mission Applications

Theme Statement: The space GNC community recognizes that advanced autonomous GNC algorithms are being utilized in a number of non-space platforms and mission applications. It appears that multiple organizations are rapidly moving in the direction to develop and deploy various fully autonomous non-space platforms of the future. If true, this puts the organizations pioneering autonomous systems in non-space domains at a significant advantage and places them well ahead of their counterparts in the space domain. One such broad area where safety-critical V&V is required is in Advanced Air Mobility (AAM). Platforms for AAM missions provide both passenger transport as well as cargo/package delivery, emergency services, and general aerial work – a being performed within strictly regulated national airspaces. Clearly the autonomous algorithms employed on these AAM platforms must be certified to not only handle the rigorous safety-critical demands of routine flight under nominal conditions but also the ability to manage off-nominal flight contingencies. This obviously presents challenges for on-board algorithm V&V. Similar autonomous systems are being fielded in automobiles and marine applications (both surface platforms and underwater vehicles). Furthermore, reviewing the current literature, one can observe there is currently more V&V, testing, and evaluation activity in the robotics community than in the aerospace domain. So, the V&V of robotic systems may well be an area the aerospace practitioners can learn from. The workshop organizers are keenly interested in understanding how the space GNC community can potentially leverage and benefit from what we assume is the extensive advanced V&V work being done to certify these non-space platforms and systems highlighted above. In the hope that there could be significant ‘spin in’ to space from non-space domains short talks are sought for this session that describe advanced algorithm V&V methods, techniques and tools, either developed or being developed, for non-space autonomous systems. It is envisioned that these talks could trigger interactive discussions in this session on the topic of how the non-space V&V solutions can be adapted to the V&V challenges for autonomous space mission applications and space platforms. Talks that

identify and describe efficient methods to assure the safety of Artificial Intelligence/Machine Learning based autonomy of non-space systems are of particular interest for this session. Conceivably there could be a tie in here between the academic community, regulating agencies, and industry which can be explored at the workshop.

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8) Innovative Student Research in GN&C V&V (Poster Session)

Theme Statement: The academic community is home to a wide variety of multi-disciplinary engineering research related to GNC. As such, university students represent the next generation of GNC engineers. Some of the most innovative thinkers at universities are conducting research that relates to developing modern and efficient GNC V&V methods and tools. The Inter-Agency GNC V&V Working Group has a strong interest in engaging university graduate-level students in the Workshop. The Workshop organizers believe there is value in providing both a showcase for student research and an interactive forum for students to better understand the real-world GNC V&V challenges. Abstracts are solicited for this poster session from both MS and PhD candidates which highlight their current academic research and its potential impact on GNC V&V challenges. The student abstracts will be evaluated for this poster session but there is also the possibility of an exceptional abstract being accepted for oral presentation. Abstracts submitted must have a student as the primary author.

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As mentioned, the Inter-Agency Working Group is now soliciting abstracts for the Workshop sessions described above. Abstracts should not exceed 2 single-sided pages in length including no more than 1 Figure (single spaced, Arial, 12 font). When submitting an abstract to the website please indicate the corresponding author and also indicate the author's affiliation.

Feel free to contact the points of contact mentioned for each individual session if you have questions concerning the session themes and/or you wish to discuss your thoughts on the suitability of a potential abstract. The Working Group welcomes community feedback on the Workshop in general and the individual session in particular.

IMPORTANT WORKSHOP DATES (subject to change)**Abstracts Due: 6 December 2024****Author Notification: 31 January 2024****Presentations Due: 6 June 2025****Workshop Dates: 9-10 July 2025**

Please keep in mind that no paper is required for this Workshop, only a short presentation. Also please be aware that this Workshop has a strict no presentation/no podium policy.

SUBMIT ABSTRACTS HERE: <https://events.isae-supaero.fr/event/38/abstracts/>