INTRODUCTION

A major strength of the Aerospace and Electronic Systems Society (AESS) is its broad field of interest (FoI) that covers key phases in the development and operation of complex systems for multielement domains, including space, air, ocean, and ground, as well as their applications in civil, military, and dual realms. Within this rich and challenging frame, the activities of the AESS Technical Panels play a key role in conceiving and growing new areas of potential interest for the future of AESS. Currently, there are six active panels that cover avionics, cybersecurity, glue technologies for space systems, gyro and accelerometers, navigation, and radar.

It is certainly very important that each panel contributes to its focus area because this drives aliveness in key areas of AESS, like conferences, publications, and other initiatives for members and technical communities. Nonetheless, panels have another key task that transcends the aforementioned ambitious AESS FoI: to promote the osmosis, synergy, and cooperation among all AESS panels and, in this way, to pursue the enormous potential of incubating new technical perspectives with a beneficial impact for humanity, which is essentially the mission of the whole IEEE.

For the above reason, in 2021, each of the six panels was asked by the Technical Operations Vice President to identify a representative for contributing to a new working group (WG). The group was named “Vision and Perspectives” and it has been assigned the special task of identifying a “super topic” that, moving from the specific focus of each panel, would represent a common technical perspective. Starting from this perspective, the AESS community is encouraged to build a medium/long-term refreshing and unifying vision to drive future developments and growth within AESS. Therefore, this article first describes, for different areas of AESS, what is meant by autonomy and how it can contribute to the big challenge of sustainability, outlining the need to push for a novel design approach that takes sustainability as a key driver. Examples of this sustainable-by-design approach are also shown. Finally, the article suggests concrete actions with the final objective to make AESS play a central role in ensuring a more sustainable Earth and space. The WG activity has resulted in the identification of a common area for the growth of interpanel activities and, through it, of the whole AESS.

This article is organized as follows. In the section “Selection of the Super Topic,” the guidelines and thoughts that have driven the selection of the super topic are presented. In “The Sustainability Challenge” and “Autonomy for Sustainability” sections, the elements that concur to the super topic are introduced, paving the way to further evolutions and application realms. In “Call for Action” section, conclusions and future perspectives are provided.

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A major driver in the WG activities were derived from the intrinsic nature of AESS and its broad FoI. In fact, the group immediately reflected that the nature of the AESS is to solve “big problems,” with focus on the identification of the problem and scope and the application of multidisciplinary practitioners to address it. This is clearly the strength of AESS, and the basis on which the credibility of the AESS for continuing to address the big issues would continue. However, the WG also acknowledged that the challenges and concerns of the global society needed to be more strongly reflected in the vision of the AESS, in order to maintain relevance, and reflect the upcoming talent within the domains of interest of the Panels that, in turns, represent the technical interest of the members.

The selection of the super topic has also moved from the identification of key challenges of humanity and, at the same time, key opportunities that the extraordinary progress of technology is proving in some unprecedented directions.

Among the top challenges for humanity, there is the theme of sustainability, which includes an enormous amount of subchallenges and domains where quick and incisive actions are needed. The topic of sustainability involves all domains where the AESS FoI operates—from ground, to oceans, to air, up to space. For instance, sustainability drives a need for efficiency. Efficiency often results in the reduction of redundancy, which directly impacts resilience. Where our critical services and domains become more efficient and dependent on technology, our requirements for cyber resilience become more important.

Among the technologies that not only provide opportunities, but also challenges, to human beings is the development and application of autonomous elements. The progress in that field has been pushed by the tremendous advances of artificial intelligence (AI), its fascinating set of self-evolving and self-trained algorithms, as well as by the amazing growth of vertical domains where this technology is and is going to be applied [1]. However, the rapid expansion of AI in both horizontal and vertical domains is also perceived as a potential threat to humanity. In this respect, on 18 February 2023, the High Commissioner for Human Rights of the United Nations has highlighted how recent advances in AI technology could be harmful to human rights and dignity and that urgent actions are needed at governmental and business levels to cope with AI-related risks. This is a very important call for the technical community to contribute in order to prevent AI algorithms from becoming dangerous and to guarantee their beneficial contribution to present and future human activities. This goal could be achieved through a thoughtful and effective certification process of AI algorithms and of their integration into complex systems. The ethical application and implications of AI cannot be divorced from the use in which it is integrated.

Since AI is becoming a crucial asset for the progress of autonomous elements and complex systems they belong to, the AESS community could be, in principle, involved in contributing to make AI an ally and not an enemy of human beings and their future. Moreover, facing the challenge of sustainability urgently requires a new approach in the design of “complex systems” that sees sustainability as a driver. As shown in Figure 1, the AESS, through its Panels, is arguably the only IEEE society to have the complete systemic, technological, and applicative vision whose combination can really drive such a design change. The work done within the Vision and Perspective WG has identified in “autonomy” the key unifying element of a medium/long-term vision to drive future developments in terms of sustainability. Sustainability and autonomy have a key aspect in common, as they both bring along—directly or indirectly—an ethical dimension that has to be faced to manage the challenges and solve the issues in the “proper” way. At the same time, sustainability and autonomy can become a “good team” for guaranteeing a better future. In fact, this super topic embraces the augmentation by technology, enabling humanity to maximize its
potential, while ensuring that what is done is in the interests of global society. Where autonomy is implemented by technology, sustainability gives it a moral and ethical context, maximizing accessibility. Furthermore, sustainability drives us to reflect on the ongoing need to support technological developments within reasonable means, whether those limitations are cost, environmental impact, cognitive overhead, or other finite resources.

**THE SUSTAINABILITY CHALLENGE**

Sustainability is becoming the major challenge that Humanity has to face in order to guarantee a decent future to future generations. Due to the holistic nature of the problem, a sustainable Planet implies care on ground, oceans, air, and even in space. The goal is clear: to ensure that all the great things human beings have conceived and deployed remain great for future generations and remain accessible for them. In spite of the obviousness of the goal, the issue has been ignored for so long that now humanity and the Planet are in a critical emergency that needs an engineered and focused effort to contain the damages and to prevent a catastrophic future. As a clear example, the immediate crisis of climate change is a threat to sustainability. Furthermore, technology itself poses some threat if used for the wrong purposes. While the control of the uses to which technology is applied is an extremely challenging goal, the opportunity exists to provide leadership on the application of technology for the benefit of humanity. Further constraints to the sustainable adoption of technology can include costs, resources, accessibility, and cognitive overhead.

As younger generations enter the professions, the shape of global society in the future extends further and requires us to define what we want the world to look like. These future generations are more acutely aware of the need to consider these challenges and recognize the need to apply their ethical and moral beliefs to the problems that we are trying to address. As sustainability challenges are becoming more clearly understood, it becomes essential for all innovation to consider its impact on the future, and the WG expects our new members to be increasingly averse to applying their professional and technical disciplines in isolation.

AESS is increasingly focusing on the sustainability topic. In fact, as highlighted, all domains of the AESS FoI are impacted by the challenges related to sustainability: ground, oceans, air, and space. Furthermore, the actions needed to contain the damages need to engineer a very complex system of systems and a novel design approach, which again matches perfectly the AESS FoI. So, AESS is intrinsically the place where collegial efforts about sustainability can be harmonized and brought to success.

**AUTONOMY FOR SUSTAINABILITY**

Autonomous systems are becoming mainstream in many walks of life, as we consider unmanned aerial vehicles (UAVs), self-driving cars, robotic surgery, electronic home assistants, manufacturing and warehouse systems, space systems and surveillance, and many others. Humanity faces the challenge of increased interaction with autonomous systems in everyday life, and the AESS covers many of the areas where this impact will be felt, both in...
terms of advantages for global society and the risks and implications of accidental or malicious attempts to subvert these systems. By connecting this technology to the challenges of humanity, the WG envisages for AESS a key role in steering the development and adoption of autonomous technology for the betterment of society and the planet—enabling empowerment of the humans. This aligns with the previously highlighted IEEE vision of “Technology for the Benefit of Humanity.”

Autonomous systems are expected to impact global productivity, equality, and inclusion, and environmental outcomes, both in the short and longer term. Through the adoption of sustainability, the WG aims at highlighting the AESS role in exploring the broader societal impacts of technology, while continuing to demonstrate the society relevance to technology.

In what follows, the super topic of autonomy for sustainability is discussed in the space, radar, and cybersecurity realms. Those are only examples of how powerful the impact could be on the whole AESS FoI. The challenges and research directions that could be opened in that frame are potentially limitless.

**AUTONOMY FOR SPACE SUSTAINABILITY**

It is well recognized that space systems play a key role in supporting the U.N. Sustainable Development Goals (SDGs) [3]. Satellite communication technologies support a multitude of SDGs, including good health and well being, climate action, quality of education, sustainable cities and communities, reduced inequalities, and life on land by helping to protect terrestrial ecosystems [4]. On the other hand, the increasing role that satellite systems are currently playing both from the economic and governmental point of view, has led to a nonsustainable use of space. As will be described further in a moment, space is extremely congested, and the congestion is going to increase. Soon it will become impossible to further use the space in a safe way. Urgent actions are needed not only to mitigate the impact of the amount of “garbage” that is in space, but also to reduce the uncontrolled generation of space garbage by promoting a new approach to the design of space missions. Figure 2 shows the thousands of dead satellites and fragments of space debris orbiting the Earth. Figure 3 shows the evolution of space debris by object type.

As for January 2022, over 4000 satellites were orbiting Earth [5]. This orbital altitude range is referred to as low Earth orbit (LEO) and is the region where the next space race is currently booming, fueled by tech giants’ broadband Internet megastations (e.g., SpaceX’s Starlink, Amazon’s Project Kuiper, among others). Currently, SpaceX leads this race with over 4500 Starlink satellites already launched, of which more than 4400 are operational.

Furthermore, SpaceX is already approved by the Federal Communications Commission (FCC) to launch about 12,000 satellites and has filed to increase the number of satellites of their Starlink megastation to over 42,000. OneWeb, Amazon’s Kuiper, and China’s SatNet combined will deploy over 20,000 satellites. Some studies predict that by 2030, there will be more than 60,000 operational satellites in LEO. And as if broadband Internet LEO megastations were not enough—private companies as well as government agencies have been planning to launch their own LEO constellations, dedicated for positioning, navigation, and timing (PNT) purposes, despite the already populated medium Earth orbit (MEO) with 100+ global navigation satellite systems (GNSS) satellites, e.g., GPS, GLONASS, Galileo, and Beidou.

Together with active satellites, there are currently an estimated 330 million pieces of space debris, including 36,500 objects bigger than 10 cm, such as old satellites, spent rocket bodies, and even tools dropped by astronauts orbiting Earth. This crowded situation poses several challenges, such as

1) interference to astronomical observations;
2) radio frequency interference to other communication systems and challenging spectrum management;
3) challenges in space operations due to the reduced margin of error for maintaining separation between satellites;
4) high probability of collisions that will further increase the debris.

This space race, if not properly controlled and carefully planned, will have dire consequences on the sustainability and integrity of space as a shared environment for humanity [6]. With many satellites and space debris already in orbit, the overpopulation of space, particularly in the LEO region, may cause a domino effect of space junk generation, known as the Kessler Syndrome [7]. This scenario would be sparked by a collision, which becomes more likely as the number of satellites in orbit increases [8].

Threats are manifold, intentional, and not unintentional, and any solution based on the use of other space assets “to protect” makes the problem worse. Several
recent papers have outlined multiple technological issues related to the space sustainability but also regulatory issues, which are tightly related to each other [9], [10]. Several initiatives and projects are on-going to face the space sustainability challenge. Most of the initiatives and research activities are focused on mitigating the damages caused by a wild use of satellite orbits and an uncontrolled generation of space debris. A more general approach is presented in [4], where some enablers for safe and sustainable future satellite communication systems have been identified, such as space traffic management, debris detection techniques, spectrum sharing, and cyber-security aspects. However, a very urgent action that needs to be done now is to develop a sustainability-aware approach to the design of space networks with the following objectives: future missions should be designed to use as much as possible the already developed space infrastructure and should be open and flexible enough to be used for different missions in the future [11]. Such a design approach would contribute to reduce the number of objects that are launched in the space by enabling a more efficient use/reuse of the space resources and infrastructures. In this framework, autonomy will play a key role.

In the rest of this section, we first review current efforts in using autonomy in space systems with focus on the improvement of the space sustainability. Then, we highlight the role of autonomy in a sustainability-by-design approach [12].

Currently, the introduction of some level of autonomy is mainly related to the prevention of collisions due to space debris. Several approaches have been developed in the past for space debris detection and tracking, such as ground-based radars and space-based sensors using either radio or optical frequencies. Traditionally, management of in-orbit collision risk has been based on human decision making and intervention. As the number and density of space objects grows, it is clear that this approach encounters scalability challenges, with significant potential benefits brought by autonomy. At the same time, space sustainability and the necessity to avoid environment congestion requires new approaches such as the concept of space traffic management [13], which calls for technological improvements as well as for increased coordination by all the space actors, e.g., concerning the standardization of collision avoidance strategies. On the spacecraft side, autonomous satellites could use deep learning to detect external threats (space debris) and react to avoid collisions by replanning the route [14]. Recently, the U.K. Space Agency announced £1.7 million for new projects to support sustainable space operations. Such projects aim to track and remove dangerous debris in space and they are heavily based on AI tools to take autonomous action to avoid a collision. In [15], an innovative distributed satellite system (DSS) mission management approach was proposed, which exploits multiple heterogeneous space platforms capable of autonomously calculating attitude and orbit raising maneuvers to maximize mission efficiency and minimize the risk of collision with resident space objects. Furthermore, the article addresses the development of reactive mission planning capabilities and introduces predictive system functionalities. These functionalities provide DSS with higher levels of autonomy and support the introduction of new mission concepts while mitigating the threats of the space environment.

It should be noted that such an increased autonomy would also create more challenges to space traffic...
management as sudden maneuvers of a satellite could completely change the scenario and the consequent reactions of other satellites, thus, introducing additional levels of complexity.

On the other hand, we wonder whether a higher level of autonomy in space systems would enable a novel design approach to satellite systems, which could lead in the long term to a more sustainable use of space. The pillars of such a novel design approach are as follows:

- enabling the reuse of the same space infrastructure for different current and future missions;
- properly exploiting the 3D non-terrestrial-network (NTN) architecture.

Future missions/constellations should be designed to be “open” enough to interoperate with other constellations/missions already deployed and or that will be deployed. This would allow the “reuse” of the same infrastructure to provide other services. Such a concept has been formulated with the name of Federated Satellite Systems, as an evolution of DSS [16], [17]. In the short term, this concept could be implemented by using intermediate satellite nodes, so-called negotiators, which will act as a bridge to make two satellite systems communicate and interact even if they are not originally designed for that. In the long term, satellite payloads should be designed to enable the flexibility to communicate with different nodes. Another paradigm shift comes from the observation that the satellite systems are a component of a multilayered architecture that includes aerial and terrestrial nodes as shown in Figure 4. Aerial nodes are satellite in different orbits (GEO, MEO, and LEO), or high altitude platforms (HAPs) or UAVs. Such nodes have different characteristics (some are static, some move fast, some are big, and some rather small) and they might be connected with nodes of the same “layer” (intralayer links, in blue in Figure 4) or with nodes in other layer (interlayer links, in green in Figure 4). By properly exploiting such a multilayered architecture, it might be possible to reduce the number of satellites to be launched for a specific mission. This means solving complex design problems by considering all possible nodes and their characteristics to enable the flexible networking among different nodes of such architecture. In both cases, AI tools could play a key role.

Both abovementioned approaches call for a high level of flexibility at the payload level, platform level, and network level. Such a level of flexibility can be achieved by a high level of autonomy, i.e., the capability to reconfigure and act in different conditions and for different purposes. In this framework, other key enabling technologies, besides AI and machine learning, are: virtualization and softwarization (e.g., concepts like software-defined radio, software-defined network, software-defined-storage) [18]; cognitive spectrum access [19]; high data rate mmwave/optical links to meet the increased capacity demands of a space autonomous system. From a PNT perspective, cognitive spectrum sensing and SDRs could alleviate the need for launching dedicated LEO constellations for PNT purposes, and instead, we could reuse the same communication signals transmitted by LEO satellites for PNT purposes [20], [21]. This leads not only to space and spectrum efficiency and sustainability, but also to eliminating unnecessary cost and energy associated with building and maintaining “needless” new satellite constellations.

**AUTONOMY FOR RADAR SYSTEM SUSTAINABILITY**

Life-cycle engineering already deals with the challenge to pass from technological eco-efficiency to technology that supports a world that meets the development goals
and the absolute sustainability. In many cases, we can focus on the deep-end of the design side of technology, rather than the end-to-end lifecycle. Sustainability requires us to consider the context in which the design elements are deployed and adopt the theoretical foundations embraced by the various panels. As a society, we have to understand and embrace principles that enable us to design for autonomy and sustainability in each of our fields.

A radar designed for autonomy is simple to define: it should sense its environment and adapt its performance by itself, it should change its goals as the situation changes, etc. An autonomous radar designed for sustainability is less clear—but there are some things one could measure. It should reduce its own electromagnetic emissions as much as possible and it should cooperate with other systems to ensure effective operation of all systems. It should likely be designed with minimal energy use, and with the ability to run from solar or other sustainable sources of power. The design might need to minimize its dependence on exotic materials—here things become interesting, since typical design approaches do not consider the materials used in a specific chip from a specific manufacturer as part of design choice. There are, of course, radar systems that can directly be used to support sustainability—for example in remote sensing where the radar can help to detect and track the ability of society to remain sustainable—in climate change, in usage of biomass, in water health, etc.

### AUTONOMY FOR AIR TRANSPORTATION

**SUSTAINABILITY**

Within air transport technologies, the trend toward increased autonomy and the need for sustainability are tightly linked. Indeed, reducing the environmental footprint of aviation is one of the key goals of the current technological efforts. While this is tightly linked to the implementation of green propulsion technologies (hence, the efforts and the initiatives toward sustainable aviation fuel and hybrid propulsion systems), the evolution of avionics technologies, with emphasis on automation and autonomy [22], also plays a key role to increase air transport sustainability. As an example, in Europe, environmental sustainability has been listed as a key priority in the SESAR Strategic Research and Innovation Agenda [23].

In fact, the progress in autonomous navigation and automated air traffic management (ATM) enables more efficient traffic flow and more environmentally friendly routes, reducing fuel consumption as well as the impact on local communities in terms of noise pollution. Moreover, advanced autonomy in terms of sensing and decision making increases the resiliency of aviation with respect to bad weather conditions, which again has positive impacts in terms of decarbonization. An interesting case concerns approach and landing in low visibility conditions and the dependence on ground infrastructure such as the instrument landing system (ILS), which is typically available only at some airports. In this case, enhanced vision sensors and autonomous landing algorithms may allow safe operations at small airports with minimum (or even no) ground support for manned and unmanned aircraft. This limits or alleviates the need of alternative large airports and then of ground transport to bring people and/or goods to their final destination, with positive economic and environmental impact. Also, from a strategic perspective, the full exploitation of small airports in remote regions for manned/unmanned cargo missions makes these operations much more efficient and environmentally friendly. Indeed, autonomous landing capabilities may be helpful also where augmentation systems such as wide area augmentation systems (WAAS) are available to support precision landing.

Another framework where the concept of autonomy for sustainability is of paramount importance involves the new domain of urban/advanced air mobility (UAM/AAM), and related initiatives (see Figure 5). UAM and AAM have recently appeared as a new and disruptive dimension for aviation, potentially enabling mobility of goods and people at a different scale compared with current operations, while also emphasizing the need of seamless integration with the existing ATM framework. The envisaged adoption of electric aircraft and the attention toward energy consumption and noise pollution, which are tightly linked with social acceptance, clarify that UAM/AAM can be considered as a part of the aviation decarbonization strategy, and that sustainability is a priority. At the same time, autonomy again emerges as a key technological tool to realize the UAM/AAM vision.

In fact, autonomy is a prerequisite to scale up operations while keeping the required levels of efficiency, safety, and security. High-density scenarios involving beyond visual line of sight operations need the paradigm...
of a single onboard/remote pilot for each aircraft to be overcome, moving toward adaptive M-to-N scenarios where aircraft are highly autonomous, and the role of the human is more and more connected to the concept of supervision and fleet management. Reliable autonomous navigation is needed to ensure safe and secure operations before fully integrating UAM/AAM and small UAVs into the national airspace.

On one hand, we must address threats to navigation sources in urban environments, for example, in the case of GNSS: multipath leading to erroneous navigation solution, obstructions and signal absorption leading to poor coverage, intentional and un-intentional interference leading to loss of navigation, and spoofing leading to potentially catastrophic disasters. Radio frequency interference (RFI) has been a major issue for aviation over the past few years [24]. According to EUROCONTROL, a pan-European, civil-military organization dedicated to supporting European aviation, there were 4364 GNSS outages reported by pilots in 2018, which represents more than a 2000% increase over the previous year [25]. What is alarming is that while the majority of RFI hotspots appear related to conflict zones, they affect civil aviation at distances of up to 300 km from these zones. What is also alarming is that the majority of RFI (about 81%) affects en-route flights, even though this is where RFI should be at its lowest, as the aircraft is as far away from a ground-based interference source as possible. BVLOS UAM/AAM and UAV operations will only exacerbate this issue. To address this challenge, instead of erecting additional infrastructure, in the spirit of sustainability, we could look into reusing the existing infrastructure as an alternative navigation source to which we could fall back in case of loss or compromise of GNSS. For example, recent work has revealed the tremendous potential of utilizing the cellular infrastructure to navigate low- and high-altitude aircraft to meter-level accuracy [26], [27].

On the other hand, autonomous navigation and decision making have to be linked to increase the resiliency of flight operations against nonnominal conditions and contingencies. Autonomy is also required within the traffic management architecture, where the role and functions of human controllers in traditional ATM systems cannot be extended and need to be conceived in a different perspective, with intelligent path planning approaches to be exploited both at strategic and tactical levels. Furthermore, autonomy is also a key element for detecting and avoiding systems, which are the last protection layer against the possible loss of separation with ground and air obstacles.

As a final consideration, the fact that UAM/AAM represents a vision that brings aviation operations closer to everyday human environments, further emphasizes its links with fields of research linked to sustainability and climate challenges. As a first example, the spatial and temporal scale of the operations in urban environments is such that traditional information sources, such as weather forecasts and environmental knowledge also need a scale change. Urban microweather phenomena may heavily impact UAM operations due to the low speed of the aircraft. This creates a tight link with the research on urban weather and how it is impacted by anthropogenic effects and, in the long term, by climate change. As a second point, UAM/AAM developments in terms of technologies and required ground infrastructures cannot be conceived independently from urban planning and from multi-modal mobility concepts, which again frames autonomy in the wider picture of sustainable mobility of people and goods.

**AUTONOMY FOR CYBERSECURITY SUSTAINABILITY**

Cybersecurity threats are discovered in every facet that embraces technology development for society. So long as it provides a benefit for some subset of society, then a malicious party exists that would seek to undermine that benefit. In many cases, we already see attacks on technologies that serve the common good. Connected cars, smart meters, unpiloted aerial vehicles, and smartphones are only some of the applications where a cyberattack can be carried out.

For our technologies to be sustainable, every one of them must be resistant to attack or malicious interference. Much of this will be achieved as cybersecurity skillsets become common to every engineer or technologist, making this a key objective to enable technology sustainability. However, even then, the pace of new malicious techniques is never-ending, and the only way to scale out to address the volume of cyberattack capabilities will be through augmenting the human expertise with AI techniques to create adaptive protective and defensive security capabilities.

As outlined in Figure 6, autonomy benefits both a defender of a complex system and the adversary. Autonomy enables new technologies to adapt to threats, even those that have not yet been discovered, and enable continuity of services. It provides a means to scale out and manage increasingly complex control sets and technical indicators of malicious activity, which are already inundating human cybersecurity teams.

Furthermore, sustainability drives a “security by design” approach, where the design and engineering of the technology solution considers the environment in which it is adopted and embeds a lifecycle that enables it to maintain the appropriate protections, including where new threats become apparent. We have seen software platforms deployed in the past where security updates to address vulnerabilities have been expensive to deploy, or where emerging use cases have not considered the developing threat model.

Unfortunately, autonomy becomes of benefit to the adversary, where the dissemination of malicious attack techniques and skills will be accelerated through AI methods that minimize the amount of human knowledge
required to cause detrimental impact. There is no choice but to attempt to outpace these malicious capabilities, for these technology services to sustain deliveries.

Actions for the AESS community are to identify the security measures that can be embedded into technology platforms, to provide improved resilience. The AESS community can contribute toward the development of novel methods to identify and mitigate attempts to subvert systems, or to enable rapid recovery.

**CALL FOR ACTION**

This article presented the vision formulated by our WG to be shared with the AESS Community. To become an alive matter, such vision needs cross fertilization and a number of concrete initiatives. These concepts aim to be a “call to action” to stimulate the AESS community, within which our members can contribute to the vision, and the entire community can take advantage from the diversity of points of view with which the concept of autonomy for sustainability is progressed by colleagues from academia, industry, government, and regulatory entities.

Concrete initiatives that can be pursued include (in a list that by far is not exhaustive):

- injection of the autonomy for sustainability topic in panels and special sessions at AESS conferences;
- organization of ad hoc events on the topic, such as webinars and workshops, where colleagues with different roles and responsibilities can exchange their views;
- preparation of special issues of AESS journals and white papers, which deal with the super topic;
- organization of challenges/contests for ideas/awards focused on this vision, to stimulate students and the young professional community;
- publication of periodic “panel recommendations” by the AESS Technical Panels, which address how the AESS vision and strategy can be propagated forward;
- promotion of an AESS Ph.D. network program, to prepare a new class of professionals with the competences needed to develop innovative autonomous systems to address specific sustainability challenges.

**CONCLUSION**

Humanity is exposed to multiple challenges, the main of which is achieving sustainability. The countermeasures to the damages that human activities have already created need an engineered approach and a set of ally technologies to reach the goal on time for future generations. In this frame, the AESS WG on Vision and Perspectives has identified in the “Autonomy for Sustainability” a super topic, where the broad FoI of AESS and the related focus on complex systems in multiple domains can play the difference for an effective and timely implementation of the sustainability goal. AESS can pave a better future to Humanity in the sustainability challenge. It has been highlighted how a focused effort is needed to guarantee that a major enabler of autonomy (namely, AI) maintains a beneficial and cooperative role in human activities and, in particular, in autonomous systems through proper actions that include a suitable certification process of AI algorithms and their implementation in complex systems. Indeed, ignoring the implications of autonomy and the societal needs for sustainability would put the AESS on a path of adversity toward human society.

The article presented ideas and possible developments of the super topic in some of the technical domains of the AESS Panels. An important step in the challenging way forward for Humanity has been created. The contributions and energy of all members are required to make the road shorter and impactful for the benefit of future generations.

**REFERENCES**


