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Commentary

Sustainable Design and Integrity Control of Onboard Health Tools for Humans and Their Environmental Urban Biodiversity

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ABSTRACT: Recently, onboard sensing and support devices have been used for the well-being of humans, animals, birds, plants and, more generally, biodiversity. The performance of these tools is closely linked to their electromagnetic environment, mainly artificially created by humans. Therefore, the presence of electromagnetic radiation linked to human activities near such tools constitutes a threat. The intelligent and sustainable manufacturing of these tools, which makes it possible to face such a threat, can be achieved through their design and optimization. This commentary aims to highlight the interaction of artificial electromagnetic radiation with onboard health tools involving living tissues in urban biodiversity (One Health concept) and the intelligent and sustainable construction and protection (Responsible Attitude concept) of these tools. The manuscript presents an overview of onboard devices, possible effects of electromagnetic radiation, durable construction and shielding, and analysis of electromagnetic compatibility integrity control. The main outcome of this contribution regarding sustainably designed onboard devices is that numerical analysis tools of electromagnetic fields could efficiently verify their integrity and the behavior of their necessary smart shields. These different themes are associated with examples of literature.

Keywords: Onboard devices; Electromagnetic perturbation; Sustainable design; Biodiversity; Integrity control

1. Introduction

Onboard medical tools for observation, diagnosis, stimulation, assistance, etc., reflect increasing use in recent years. This occupation started with man, followed by animals, birds, sea creatures, plants, etc. and therefore the majority of biodiversity. Biodiversity here refers to the variety of living species on Earth which interact with each other and whose existence is therefore, not self-determined. These health devices are configured as portable, removable or integrated, depending on their assigned functions. Their operation must be rapid and continuous, which implies the incorporation of corresponding technologies allowing the transport of energy and the transmission of data. Today, the most suitable equipment enabling such functions is using wireless means for energy transfer and data transmission, involving low and high frequencies respectively.

The operation of detection and assistance tools and their associated wireless systems is closely linked to their electromagnetic (EM) environment, essentially created artificially by humans. Thus, electromagnetic field (EMF) radiation, resulting from human activities implying EMFs, near these tools, constitutes a serious threat. In an urban context, onboard tools mainly concern humans, animals, birds, plants, and urban biodiversity. Threatening sources of EMF radiation in urban environments are linked to telecommunications, mobility and everyday urban EMF devices. Such radiation can be of a near or distant nature. The first concerns EM devices used daily by humans, such as e.g., mobile phones or wireless chargers used in the tool environment [1–3], while the far field corresponds to distant but powerful sources such as, e.g., Antenna relay towers for cell phones or Wi-Fi in general [4]. The interaction of EM radiation with onboard health tools involving living tissues in urban biodiversity evokes the One Health (OH) concept [5,6].

Onboard detection (sensors), e.g., [7–17] and support tools (assistance, stimulation, drug delivery, etc.), e.g., [18–22], should be insensitive to (or protected from) EM radiation. Ecological manufacturing of these tools can be accomplished through their design and adaptation to meet one of the two mentioned insensitivity and protection criteria. Insensitivity to radiation is related to the properties of construction materials, but protection can be achieved through intelligent shielding. The intelligent and sustainable construction and protection suggest Responsible Attitude (RA). Monitoring the possible effects of radiation and the effectiveness of the remedy used can be carried out by an EM compatibility (EMC) analysis.

This commentary intends to highlight the interaction of EM radiation of human origin with onboard health tools involving most living species of urban biodiversity (OH concept), and the sustainable manufacturing and protection (RA approach) of these tools. The following sections will introduce and review the onboard device framework, likely effects of EM radiation, durable manufacturing and shielding, and EMC integrity control analysis. These different topics are accompanied by examples of literature.

2. Onboard Tools Outline

As mentioned earlier, onboard tools are employed in biodiversity in portable, removable or integrated forms, which can perform inert (inactive) or dynamic (active). Their actions are situated in living tissues in general and mostly in humans, animals, aquatic living organisms, and plants. They can play a sensing role, e.g., diagnosis, forecasting, etc. [7–17] or a support function such as e.g., assistance, stimulating, drug deliverance, etc. [18–22]. These two duties could be separate or connected and remotely guided or autonomous. Thus, it is necessary to have continuous and real-time internal and external smart communication. Moreover, the necessary functional power of tools could be autonomously integrated or remotely transferred.

2.1. Sensing Tools

These detecting tools are generally non-invasive, working in real-time, permitting unremitting supervision of the concerned tissue and hence delivering suitable health data to conclude its global condition and, in addition, early image of health valuation. Such general sensing is achieved via portable tools [11,12,15]. More personalized cautions allied to physical disturbs concerning vital functions such as respiration rate, fluid circulation pressure, etc. [16,17] could be sensed through removable or connectable smart onboard tools. Other types of specific tools correspond to portable sequencing of DNA analyses connected to infectious entities, such as viruses, bacteria, etc. [6] or tools for species finding through the presence of DNA in the aquatic biodiversity environment [23–25].

2.2. Support Tools

These supporting tools are generally integrated (embedded) and fixed within tissue. They could be inactive, allowing recognition and forecast using mini sensors for specific tissue health maintenance. They could also be active and expected to stimulate or actuate a part of the tissue, such as pumps, tissue stimulators, etc. [18–22].

Besides the above-stated duties of supervision, forecast, assistance, stimulation, etc., of the different onboard tools, these similarly allow the supervision of thepost-treatment state in cases of preceding disorders. Thus, avoiding displacements, dislocations, and transpositions, while replacing face-to-face maintenance with an integrated, connected assistance approach.

2.3. Wireless Energy and Communication Routines

Wireless, power source and data communication routines are indispensable for smart functioning onboard tools [26]. This significant aspect related to EM wireless associated with onboard tools displays some weaknesses. Further to the regular safety of transferring private data via wireless communication networks, the feature wireless aspect could undergo EMF radiations. Therefore, added to the damaging consequences of exterior EMF radiation on the onboard tool, such radiation can disturb the wireless transmission network. There are various remote sensing strategies beyond wireless EM, such as satellite remote sensing for the observation, monitoring, and management of biodiversity [27].

3. EMF Interaction with Onboard Tools

External EMF exposures have different effects on onboard tools depending on their strength and frequency and the nature of the exposed components in such tools. The resulting induced fields in these components could alter tool functions and their corresponding possible dissipated energy could produce heating, which, in addition to disrupting the functioning, could provoke a temperature rise in the supervised organ.

3.1. Functional Perturbations

EMF radiations on onboard tool components could affect the tool function according to the constituted matter and the radiated field frequency. For electrically conductive materials, the induced currents, especially in the low-frequency range, will modify the magnetic field and affect the tool's behavior. In the case of dielectric matters, the electric field could be modified, particularly in the high-frequency range, and the tool behavior would be altered. In addition, in both cases, the dissipated energy in the matter would reflect a temperature rise that modifies the tool behavior.

3.2. Adverse Effects

The last mentioned onboard tools perturbations due to external field radiations would alter their functioning, causing adverse effects on the supervised living tissues. Moreover, the occasioned tool matter heating would provoke tissue temperature rise. These two categories of adverse effects could be serious depending on the nature of the supervised organ, e.g., its fluid circulation rate, vital role, the tool task in the organ, etc. Figure 1 illustrates the relationship between EMF exposure, the tool's artificial design (by humans), the tool's duty and the exposure side effects on biodiversity.

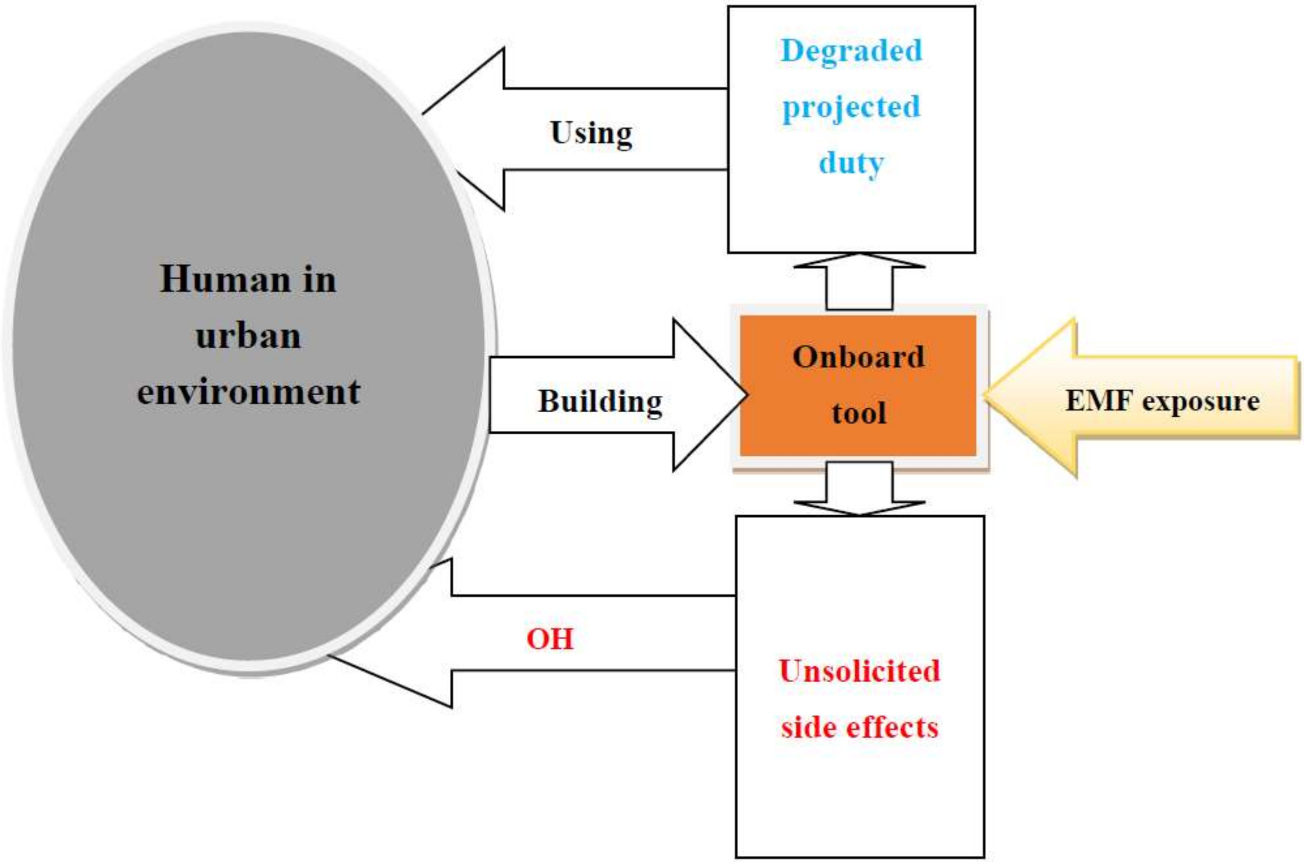

Figure 1. EMF exposure, design of onboard tool, its projected duty and its unsolicited effects on humans or the environment.

4. Sustainable Tool Design

The last mentioned perturbations of onboard tools could be avoided in two ways: via components sustainable design [28,29] or through shielding technologies.

4.1. EMF Insensitivity Optimization

In designing the different components of onboard tools, matter electric conductivity and permittivity play an important role in the EMF radiation perturbs. If possible, the EMF sensitivity could be reduced by choosing matters matching these properties, or even non-conductor and non-dielectric matters.

4.2. Shielding

Shielding technology could be used for the onboard tool constituents that are EMF sensitive. The common shields use electric conducting sheets. These would be efficacy for the tool function, but the induced currents due to external field exposure would heat the shield sheet and the supervised living tissue organ. Moreover, wireless power transfer to onboard tools could be significantly affected due to such induced currents [30]. Only smart shields can avoid such adverse effects. Actually, shields use components reflecting or absorbing EMF external radiations to prevent their crossing between the two shield boundaries. In addition, as an EMF wave is composed of electric and magnetic fields, which are perpendicularly oriented in space; thus the EM interference (EMI) shielding strategies could be electric, magnetic or both coupled. In addition, as EMF high-frequency radiation waves reflect interconnected magnetic and electric fields; thus, shielding one field is sufficient, thus allowing the simplest choice of electric conductive shield. However, due to the adverse thermal effect of the onboard tools mentioned above, an adjustment of the shielding conductive character is needed. The employment of multifunctional matched constituents permits low-reflectivity shields, thus decreasing the strong field reflection activated by the high material conductivity. Additionally, a specific manufacturing process permits weakening the reflected power coefficient of the material in conjunction with diminished dissipation of heat and improved isolation shielding matters [31–33]. Different shield constituents such as adhesives, rubbers, clothing fabrics, coatings, etc., could be used according to the fixing ability, the required elasticity, the easiness of processing, and consistency [34–43].

Figure 2 illustrates the impact of Eco-design involving RA and OH approaches through the optimization or shielding of onboard tools counting whole biodiversity by monitoring adverse EMF effects.

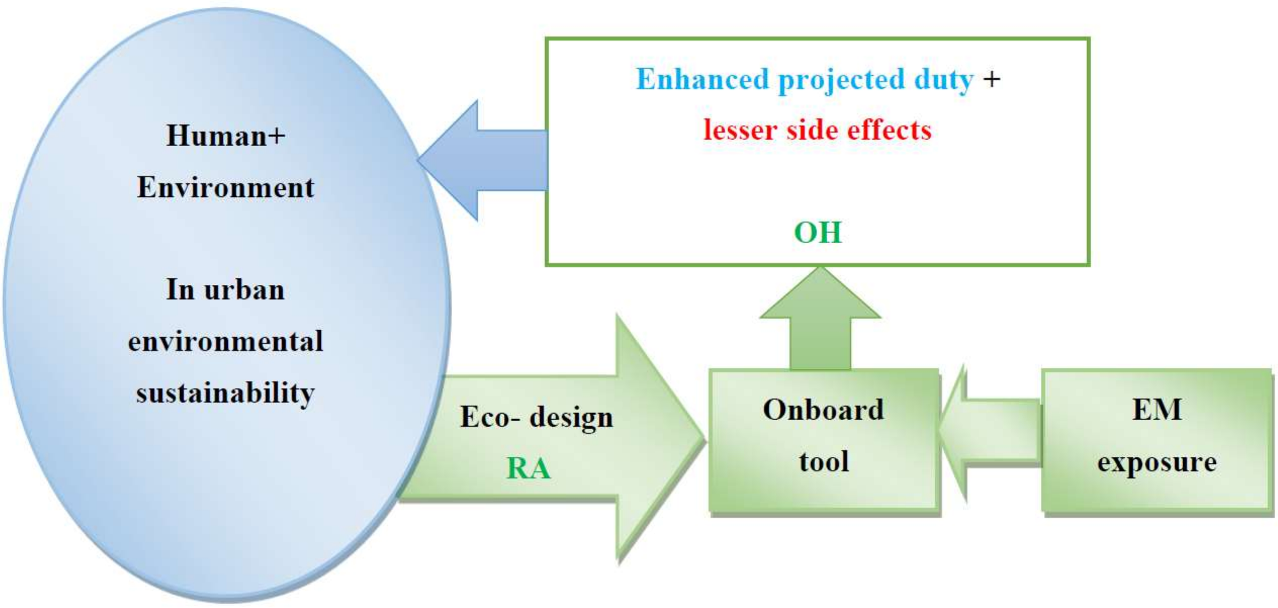

Figure 2. RA and OH approach through the design and use of onboard tools counting the whole biodiversity by monitoring adverse EMF effects.

5. Tool Integrity Control

An important characteristic of such a tool under external field exposure is its ability to operate normally in an emission environment, demonstrating its performance capacity. However, when this tool is exposed to external fields, its key performance may be affected by a reduced signal-to-noise ratio, signal interference, and other factors, potentially weakening its effectiveness.. Conditional on the practice field, a tool has specific concrete requirements and its EMC evaluation correlates to consequent norms [44,45]. Such standards are mainly founded on static techniques. Thus, the EMC inspection conducted on the tool is based on a broadly defined waveform, with the evaluation performed according to the results of an experiment. The challenge of accounting for dynamic behavior under complex EMF exposure is addressed by the tool's functionality. Several studies have been carried out to improve the validation methods for EMC assessment [46–52].

The control methods via experiences nominated above are quite intricate and often require dedicated and expensive shielded settings. In such conditions, a substitute response can be confirmed by arithmetical computations via an EMC analysis to check the consistency of different related tools [53–56]. Certainly, the legality of a design method or technique for protecting a tool against field exposure could be guaranteed by an EMC inspection confirming the invariance of the tool's fields due to external exposure.

The EMC assessment mentioned above concerning onboard devices is set up and governed by EMF equations that typeify the field conduct. This authenticates the likely disruption of local induced EMFs distributions in an entity suggesting EMF-sensitivity due to a certain field radiation. In the case of an EMF-insensitive object, the surrounding fields would remain unaffected.

6. Implicated Governing Equations

In the microscopic local behavior based on Maxwell's formulation, the differential form of the four general EMF equations [57] is given by:

$$\nabla \times \mathbf{E} = -\partial_t \mathbf{B} \qquad \text{(Maxwell–Faraday)} \tag{1}$$

$$\nabla \times \mathbf{H} = \sigma\, \mathbf{E} + \partial_t\, \mathbf{D} \qquad \text{(Maxwell–Ampère)} \tag{2}$$

$$\nabla \cdot \mathbf{D} = \rho_e \qquad \text{(Maxwell–Gauss)} \tag{3}$$

$$\nabla \cdot \mathbf{B} = 0 \qquad \text{(Maxwell–Thomson)} \tag{4}$$

The EMF harmonic field equations relevant to exposure (radiation) are given as follows:

$$\nabla \times \mathbf{H} = \mathbf{J} \tag{5}$$

$$\mathbf{J} = \mathbf{J_e} + \sigma\, \mathbf{E} + j\, \omega\, \mathbf{D} \tag{6}$$

$$\mathbf{E} = -\nabla\, V - j\, \omega\, \mathbf{A} \tag{7}$$

$$\mathbf{B} = \nabla \times \mathbf{A} \tag{8}$$

In (1)–(8), **H** and **E** are the magnetic and electric field vectors in A/m and V/m, **B** and **D** are the magnetic and electric induction vectors in T and C/m^2, **A** and V are the magnetic vector and electric scalar potentials in W/m and volt. **J and** $\mathbf{J_e}$ are the total and source current density vectors in A/m^2, σ is the electric conductivity in S/m, ρ_e is the volume density of electric charges in C/m^3, and ω is the angular frequency = 2πf, f is the frequency in Hz of the exciting EMF. The symbol **∇** is a vector of partial derivative operators. The symbol ∂_t is the operator of a partial time derivative. The magnetic and electric comportment laws corresponding to the relations **B/H** and **D/E** are represented respectively by the permeability μ and the permittivity ε in H/m and F/m.

Equations Solution and EMC

Generally, contingent on the geometric complexity and the nonlinearity in the materials, the solution of (5)–(8) needs to be local in the application utilizing discretized 3D methods as finite elements [58–66] in the appropriate components of the matter. The 3D discretized elements are volumes delimited by surfaces, each enclosed by edges, each ended by two nodes. Fields could be given at the nodes, edges, faces, or volumes, subject to the field character, such as consistency, continuity constraints, etc.

An EMC assessment targets to check, within the solution of EMF equations, troubles due to exposure of external EMF source in the field distribution of a recipient tool, informing its degree of exposure-reaction. In the present contribution, we are required to confirm the insensitivity of the onboard device to EMF exposures. Such a check may be achieved by contrasting the field distributions in the device counting and free of radiation sources. Also, the field consistency in shielded devices will be verified, deprived of and alongside exposure. For a certain source field $\mathbf{E_e}$ linked to $\mathbf{J_e}$, solving (5)–(8) will provide the induced EMF values, $\mathbf{E_i}$, $\mathbf{B_i}$ and $\mathbf{J_i}$ in each element (i) of the discretized domain. The resulting distributions of EMFs allow the control of EMC. In this case, the solution domain corresponds to the device's structure. The verified EMC control due to an EMF exposure involves the constancy confirmation of the field values in the domain. Such an EMC check could be accomplished on the single being checked instrument to ensure its running.

7. Discussion

In the last analyses, we have considered different onboard health tools for humans and their environmental urban biodiversity. These tools could be autonomous or externally connected for energy supply or data communication. The first could be protected by design and/or shielding, while the second needs extended protection restricting routines. The different situations of control and protection through RA and OH approaches are succinctly summarized in the following points:

- In all tool situations, a predictive check could be practiced using EMC analysis control, including perturbations, design, shielding, etc., thus embracing the roles of RA and OH concepts.
- Autonomous tools could include batteries or cells. These could be throwaway or rechargeable. In the last case, wireless charging could only be achieved in restricted biodiversity zones. Such an environment consists of protected spaces or areas free from sources of disturbing EMFs, in particular mobile phones, chargers, tower antennas, etc.
- Externally connected tools also need extended protection routines for restricted biodiversity zone environments.
- Smart shields could be used in the presence of EMF sensitive constituents.
- The restricted biodiversity areas could be located in "curative" parts of public parks, hospitals, nursing homes, zoos, etc., thus involving humans (adults and children), animals (domestic and wild), birds, aquatic creatures, plants (ornamental and wild) and all other members of biodiversity.
- Future progress could consist of introducing radiation presence indicators on onboard tools.

8. Conclusions

In this contribution, we have analyzed and examined the EMF disturbances of onboard health tools for humans and their urban environmental biodiversity. The EMC control by means of EMF analysis of the disorders of the devices has been studied through the mathematical solution of the EMF governing equations. The exploration and analysis included in the contribution have been supported by examples from the literature. Some final remarks are worth mentioning:

The disruptions of onboard health tools for environmental urban biodiversity could be lessened in two ways: via components sustainable design or through shielding technologies. The integrity of these devices could be efficiently managed through numerical EMF analysis tools. Similarly, the protection of these devices can be ensured by avoiding unshielded radiation sources, using smart shielding for onboard tools, and enhancing radiation detection indicators on these devices. Finally, in case of the impossibility of tool shielding, restricted environmental spaces should be preserved for the carriers of onboard health tools, including all those associated with urban biodiversity in the framework of the One Health concept.

Ethics Statement

Not applicable.

Informed Consent Statement

Not applicable.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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