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Autonomous Technology in Scenario by Rare Geophysical Processes (Underwater Focus)

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Abstract- From an ecological perspective, scientific investigation of the “Earth system” reveals its complexity, evidenced by the interaction of geophysical processes – which occur in the “global atmospheric system”; in the “world ocean” – both favoring the “world climate”; in "the interior of the globe"; and, between each of these parts and outer space. Environmental risks (geophysical) exist due to the configuration of extreme circumstances (CAPRA, 1982; MCWILLIAMS, 2006; SKINNER and MURCK, 2011). In the nuclear age, and taking into account the possibility of employing emerging autonomous technology as a weapon of this category, a geopolitical risk exists (KAHN, 2007; NICHOLS *et al*., 2022). Crossing between risks (geophysical and geopolitical) can be imagined (WEICK, 1989; GAUB, 2020; MCLENNAN *et al*., 2021). Analyzing the plausibility of the coincident occurrence of risks (crossed – geophysical and geopolitical) as a critical uncertainty for scenarios – and due to the vulnerability of autonomous systems to the (*sui generis*) flow of fluids by unlikely geophysical processes – the present study ratifies the technology "in the sea” (underwater, in focus) as a possible threat to the “Earth-system”; in the conception of scientific thought for the 21st century.

Keywords: autonomous technology; underwater vehicle; earth system; deterministic chaos; geophysical processes; scenario; war games.

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AUTONOMOUSTECHNOLOGYINSCENARIOBYRAREGEOPHYSICALPROCESSESUNDERWATERFOCUS

Autonomous Technology in Scenario by Rare Geophysical Processes (Underwater Focus)

Tecnologia Autônoma Em Cenário Por Processos Geofísicos Raros (Foco Subaquático)

Laís Raysa Lopes Ferreira

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Keywords: autonomous technology; underwater vehicle; earth system; deterministic chaos; geophysical processes; scenario; war games.

I. Introduction

From a broad investigative perspective, Skinner and Murck (2011) scientifically present the planet as the "Earth system" – analyzing the Earth holistically (a "closed system"), as a set of parts or subsystems (geosphere, hydrosphere, atmosphere, biosphere, and anthroposphere – each an "open system") and interactive processes – the basis of "earth system science" (SKINNER and MURCK, 2011).

Energy flows (external and internal) drive these processes (natural or anthropic) between the Earth's subsystems (SKINNER and MURCK, 2011). Due to systemic complexity, chaos theory (branch of mathematics) can be employed in its approach (for example, concerning the "global atmospheric system") (SKINNER and MURCK, 2011).

Most of the surface of the "Earth system" is dominated by the "world ocean" about the extreme importance of the ocean in "controlling atmospheric composition" (SKINNER and MURCK, 2011; KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b). Ocean modeling is relevant for many applications such as fisheries management, pollution control – as well as for many naval operations (including the defense needs and the commerce between nations) (KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b).

Dual-purpose, autonomous underwater technology (autonomous vehicles or systems; commonly known as drones or robots) challenges conventional maritime models. It is derived from industrial and scientific revolutions and also characterizes a specific aspect of the "military revolution" scenario (set up by elements such as technological change, systems development, operational innovation, and organizational adaptation) (FOSSEN, 1994; KREPINEVICH, 1994; FOSSEN, 2002; GRIFFITHS, 2003; MOURA, 2007; BREIVIK and FOSSEN, 2009; DO and PAN, 2009; INZARTSEV, 2009; FOSSEN, 2011; BAYLIS *et al*., 2018; FANELLI, 2020; YAN *et al*., 2021).

However, if used as a "weapon" the technology "at sea" poses risks (SPARROW and LUCAS, 2016; BAYLIS *et al*., 2018; PIOTROWSKI, 2018; FERREIRA, 2021a; FERREIRA, 2021b; NICHOLS *et al*., 2022; SLOFER, 2022; FERREIRA, 2022).

Once vast military power is concentrated in the hands of "unpredictable countries" in a nuclear age (KAHN, 2007); also, not being easy to obtain information about the perceptions that lead to conflict in international relations; geopolitical risk exists (KAHN, 2007; KAHN *et al*., 1976; GAUB, 2020; MCLENNAN *et al*., 2021).

Environmental risk also exists (MCLENNAN *et al*., 2021) – about processes in the flow of geophysical fluids (planetary – from the inside of the earth; from the oceanic circulation; and the atmosphere – and astrophysical), unpredictable (MCWILLIAMS, 2006; VALLIS, 2016). Due to the interaction of the geosphere with the ocean, fluids can escape from the ocean floor to the overlying water column, which can affect the

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activities on the seafloor (autonomous underwater technology, in focus). Also, atmospheric fluids can affect autonomous Technologies – even the underwater ones if they are, for example, on the surface. (FOSSEN, 1994; GRIFFITHS, 2003; MUKHERJEE, 2006; BREIVIK and FOSSEN, 2009; DO and PAN, 2009; INZARTSEV, 2009; FOSSEN, 2011; SKINNER and MURCK, 2011; KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; JUDD and HOVLAND, 2007; MCLENNAN *et al*., 2021; FERREIRA, 2021a; FERREIRA, 2021b).

Crossing between risks (geopolitical and geophysical) can be glimpsed (WEICK, 1989; SCHWARTZ, 1996; GAUB, 2020; MCLENNAN *et al*., 2021). Good scenarios are thought and perception devices that make visible a new reformulated perspective – plausible (WEICK, 1989; GODET, 2000; VAN DER HEIJDEN, 2005; WADE and WAGNER, 2012, RAMIREZ and SELIN, 2014; SCHWARTZ, 1996; MINVIELLE and WATHELET, 2020; GAUB, 2020).

There is a “sea of uncertainties” concerning the systemic environmental complexity, particularly from a perspective of responses (“self-regulation”) to anthropic interventions of harmful proportions, according to current holistic scientific thought (21st century) (CAPRA, 1982, CAPRA, 1983; KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; BERTUGLIA and VAIO, 2005; MUKHERJEE, 2006; JUDD and HOVLAND, 2007; SKINNER and MURCK, 2011; GAUB, 2020; ÖZSOY, 2020; MCLENNAN *et al*., 2021; MCLENNAN *et al*., 2021; MCLENNAN *et al*., 2022; NICHOLS *et al*., 2022; SLOFER, 2022).

However, one sure thing is the surprise: “a rule and not an exception in nature (CAPRA, 1982, CAPRA, 1983; STEWART, 1997; BERTUGLIA and VAIO, 2005; JUDD and HOVLAND, 2007; MUKHERJEE, 2006; SCOTT, 2007; SKINNER and MURCK, 2011; ÖZSOY, 2020).

Regrettably, “the understanding of terrestrial systems has often been influenced by social history, leaving future generations the task of responding to the environmental burdens of all past human activities” (ÖZSOY, 2020) – *post-factum*.

From the perspective of scientific thought for the 21st century, the present study ratifies autonomous technology (underwater, in focus) as a possible threat to the Earth-System (geopolitical risk); particularly for its vulnerability to (*sui generis*) flow of fluids by rare geophysical processes (geophysical risk) – analyzing the plausibility of the coincident occurrence of such perspectives (by crossing risks), as critical uncertainty for scenarios.

Despite being a delicate subject it is of broad interest due to the need for preparation, according to a present-day review of the theme. Considering the harmful consequences of a “thermonuclear war,” it is expected to contribute to the salvation, in some way, of a more significant number of people (FERREIRA, 2021b) around the world - from the correct exposure of knowledge (as a flash of revelation), and critical scientific analysis (in a context of various uncertainties); that is fundamental to decision making, by inferences.

Regarding the theme, given the fallibility of the human essence (FERREIRA, 2021a); and, as the decision-making action will always be in “man's hands” (about pressing “the button”); it is very relevant to understand that the hypothesis (WEICK, 1989) of a reaction through unlikely geophysical processes would indeed be extreme; however, responsive (divinely) (FERREIRA, 2021b).

II. The Threat of Autonomous Technology (Underwater) to the (Earth) System

The concept of systems is used in studying complex problems due to their many interacting parts, in which processes are often coupled – as is the case of the Earth system – highly complex and dynamic. The holistic approach to the planet, presented in Skinner and Murck (2011), would be the “key” to its understanding.

The Earth is considered a "closed system": this means that there is no loss or gain of matter – but energy can indeed enter or leave the system – which points to the need to understand the "science of the Earth system" as interdisciplinary interactions between all parts of the set (including how energy move out around the system) (SKINNER and MURCK, 2011).

In a systemic context, the most significant interest is in the necessary balance of all this energy (from external and internal sources); especially regarding the “life zone”: life on Earth occupies a narrow zone (no larger than 20 km), where interactions between the geosphere, hydrosphere and, atmosphere create a habitable environment (SKINNER and MURCK, 2011). “If the balance is not maintained, the Earth's life zone must heat up or cool down,” for example (SKINNER and MURCK, 2011).

As the earth is a “closed and complex system,” some implications are of interest, as Skinner and Murck (2011) highlights: a) the planet's mineral resources are finite (that is, limited); b) residues remain within the limits of the Earth system; c) changes or disturbances in one part of the system, eventually affecting other parts of it (an entire chain of events can happen, even); d) causes and effects of natural disturbances are very difficult to predict (one of the main challenges of earth system science); e) numerous disturbances constantly occur (since the formation of the earth until today), but in different places, and causing impact at different levels (SKINNER and MURCK, 2011).

Despite the complexity of the interactions processes, as the earth's subsystems are well balanced, the system is “characterized” as self-regulated (in its entirety) – in this case, mainly, about natural interventions. In any case, it takes a long time (especially on a planetary scale) for the Earth system to tend towards self-regulation and a state of equilibrium (SKINNER and MURCK, 2011).

To obtain a broad scientific approach to the Earth system (a real challenge), new tools for observation (at varying scales), measurement and management of large amounts of data would be needed (from multiple locations) – the representative modeling of systemic processes (on a manageable scale) is simplified (SKINNER and MURCK, 2011).

The oceans act as thermal flywheels and climate moderators due to their large extension (covering more than 70% of the earth's surface) and the high heat capacity of water. Also, they are huge reservoirs (sinks) of CO_2 (containing about 60 times the amount of CO_2 in the atmosphere) – gas exchange takes place from the ocean to the atmosphere: "almost all the oxygen found in the earth's atmosphere was created by oxygenated photosynthesis in the ocean, carried out by single-celled phytoplankton – with oxygen levels reaching current levels around 2.2 billion years ago" (KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; SKINNER and MURCK, 2011).

Concerning the geosphere, it is the main solid reservoir on earth "which appears to be constant and unchanging, but nothing could be further from the truth" (SKINNER and MURCK, 2011). It is a boundary layer – it is linked to the hydrosphere (about the ocean floor) as well as it reaches the atmosphere at the surface of the earth's crust (SKINNER and MURCK, 2011). The dynamic nature of the geosphere can be dangerous to human interests through geophysical processes (SKINNER and MURCK, 2011).

As quoted in Skinner e Murck (2011), immediate effects of this geophysical process are the earth's movements with the rupture of the surface itself; and the side effects are fires, landslides, soil liquefaction, and *tsunami* ("a seismic wave, initiated by the sudden movement of the sea bottom due to an earthquake, volcanic eruption or underwater landslide, and which have been particularly destructive in the Pacific and Indian oceans") (SKINNER and MURCK, 2011).

Due to the significant impact of their occurrence, much research focuses on earthquake prediction based on an understanding of the tectonic scenario and the history of local seismic activity. Despite advances in researchs, "success with issuing accurate and specific short-term forecasts and early warnings remains elusive" (SKINNER and MURCK, 2011).

"The scientific basis for modern forecasting efforts is the observation of precursor anomalies – any strange or unusual occurrences that could signal an impending seismic event" (SKINNER and MURCK, 2011). It turns out that such anomalies are highly inconsistent. Also, the erratic nature of such precursors, combined with the inherent difficulties in monitoring events that occur underground (at unexpected times and places), limits progress in earthquake prediction, according to the authors.

A curious account in Skinner and Murck (2011) is about a case of strange animal behavior (well-documented) hours before an earthquake in China (Tianjin): "the normally quiet pandas screamed, the swans refused to approach the water, yaks did not eat, and snakes did not enter their burrows" (SKINNER and MURCK, 2011) – the tremor (magnitude 7.4) happened around noon of the same day; and the animals were sensitive to the circumstances of the environment, in some way – by correct perception.

As for natural hazards and global climate change, for example, the uncertainty involved in the scientific understanding of the earth system is challenging for decision-makers and politicians. It is based on the precautionary principle – considering that if the potential consequences of an anticipated event are unacceptably severe, the authorities have a responsibility to take measures to avoid or mitigate those consequences (even if the probability of occurrence is small – and despite the scientific uncertainty) (SKINNER and MURCK, 2011).

The issue of human influence on Earth-system reservoirs, and the systemic reaction to this interference over time, is a problematic issue from a scientific point of view (SKINNER and MURCK, 2011). An anthropic circumstance – totally bizarre – according to Kahn (2007), is about the possibility of thermonuclear war: "the mind recoils from overthinking about it; one prefers to believe that this will never happen" (KAHN, 2007). Many of the military strategic concepts were developed from a "Cold War" era perspective in Kahn (2007), however it can still be verified (as an analysis parameter).

"Herman Kahn earned his reputation as a futurist through his public willingness to consider what most people denied in the early 1960s: that a nuclear war could take place [...]. By raising the possibility publicly, he helped people to really see what they had at stake" (SCHWARTZ, 1996).

People hardly consider the problems of thermonuclear warfare – "most of us simply do not believe in war, or at least in deliberate thermonuclear warfare, and most people also find it difficult to be concretely concerned about nuclear accidents and miscalculations" (KAHN, 2007). Kahn (2007) considers it essential to critically examine the crises resulting from war (hypothetical and potential) in an attempt to anticipate them in time to program corrective measures.

"Defense problems in the modern world are of unprecedented complexity" – they have become disordered, and their solution is unrelated to principles that the military has derived from experience (KAHN, 2007). Due to stockpiles of nuclear bombs in the world, Kahn (2007) argues that total nuclear disarmament is not possible: "even if all nations one day agree on total nuclear disarmament, it must be assumed that there would be the concealment of some weapons or nuclear components (as protection against the other side)" – and an international arrangement to prohibit war through disarmament would not be effective (KAHN, 2007).

The initial idea of thermonuclear war is wild and destructive for the parties involved, antagonistically however Kahn (2007) cites that some can be conceive it by a convincingly reasonable bias – "depending on the course of military events, it could be an unprecedented catastrophe for the attacker and also for some neutrals, or not" (KAHN, 2007).

Despite the hysteria and social fear about the consequences of a thermonuclear war, according to Kahn (2007), a catastrophe can be "quite catastrophic without being total" – "few would call it a "total catastrophe" if all survivors of a thermonuclear war lost few years of life expectancy" (KAHN, 2007).

Also, according to the author, a catastrophe (even if it is "unprecedented") would still not be an "unlimited" catastrophe – "the limits of the magnitude of the catastrophe seem to be intimately dependent on what kinds of preparations were made and how the war was conducted" (KAHN, 2007): from this perspective, the author considers it entirely possible to estimate the limits and consequences of thermonuclear war; he even shows some optimism about the *a posteriori* scenario – what exists "is an enormous psychological difficulty in dealing with the concept of thermonuclear war as a disaster that can be experienced and recovered" (KAHN, 2007).

From questions (followed by his immediate answers), Kahn (2007) makes a distinction between the "possible degrees of horror" of the many post-thermonuclear war states, examining their effects – as follows: a) "survivors will envy the dead ? [...] The world may be permanently (that is, for perhaps 10,000 years) more hostile to human life" (KAHN, 2007); b) "Can we restore pre-war living conditions? [...] No!" (KAHN, 2007); c) "how happy or normal lives can survivors and their descendants expect to have?" (KAHN, 2007) – "Objective studies indicate that while the amount of human tragedy would greatly increase in the post-war world, the increase would not prevent normal and happy lives for most survivors and their descendants" (KAHN, 2007). Regarding the last proposition, there was no better citation (about which "objective studies" the author referred to).

The analysis performed by Kahn (2007) for the "complete description" of a thermonuclear war included: a) several programs in phases of deterrence and defense and their possible impacts; b) wartime performance, with different pre-attack and attack conditions; c) problems with acute precipitation; d) survival and restoration; e) maintenance of economic dynamism; f) long-term recovery; g) post-war medical problems; and, h) genetic problems. However the post war environmental issue was not glimpsed in Kahn, mainly from a systemic, holistic, and ecological perspective (2007).

For Capra (1982), the threat of nuclear war is the greatest danger that humanity can face; since atomic weapons increase the probability of "global destruction." The lethal stock of nuclear weapons, and the endless arms race, in addition to other issues (such as contamination by a wide variety of chemical products), are some of the examples of threats to "ecological systems on which our existence depends" – modern physics understands that the development of such questions occurs in a systemic, interconnected, interdependent, and uncertain way (CAPRA, 1982; CAPRA, 1983).

Capra (1982) cites that at the end of the 20th century scientific investigation from the "exploration of the atomic and subatomic world" (submicroscopic) revealed the "limitation of classical scientific ideas" – the change of perspective led, therefore, to the "radical revision of innumerable basic concepts" – there was a profound change in the view of the world concerning the physical universe: from the mechanistic conception of Descartes and Newton (intimately linked to a rigorous determinism) to a holistic and ecological vision (which understands reality in terms of totalities integrated) (CAPRA, 1982; CAPRA, 1983).

"The natural world, in turn, is composed of infinite varieties and complexities; it is, in fact, a multidimensional world, where there are no straight lines or entirely regular shapes, where things do not occur in sequence, but concomitantly; a world where — as modern physics informs us — even empty space is curved" (CAPRA, 1983).

Bertuglia and Vaio (2005) identify the various stages in the historical evolution of scientific thought, from the confident certainties typical of the mechanistic or reductionist view (whose roots are in Cartesian philosophy) to the progressive recognition of intrinsic difficulties (TABLE 01):

Table 1: Stages of the Historical Evolution of Scientific Thought

Historical Phases of Scientific Thought	Main Researchers	Period
Determinism (classical mechanics)	Newton, Leibniz, Lagrange, Euler, Laplace.	From 1687, the year of publication of Newton's *Principia*, to the first decades of the 19th century.
Statistical Indeterminacy	Clausius, Lord Kelvin and Boltzmann.	In the second half of the 19th century.
Quantum Indeterminacy	Bohr, Heisenberg, Schrödinger, Dirac, etc.	From the first decades of the 20th century.
Deterministic Chaos	Poincaré.	At the end of the 19th century.
	Lorenz, Smale, Yorke, Prigogine, etc.	Last decades of the 20th century.

Source: Adapted from Bertuglia and Vaio (2005).

Regarding the uncertainties and risks due to the technological race, Kahn (2007) analyzes the possibility of using weapons of mass destruction (from history, in terms of their use); and evaluates defense weapons systems "in terms of the worst they can do," envisioning "ingenious and specially designed unconventional means (such as suicide ships or submarines carrying super-large bombs to explode on our shores, causing tidal waves or extreme precipitation)" (KAHN, 2007).

It turns out that, for the present days, the question of the use of technology as a threat is no longer "a glimpse" – Nichols *et al*. (2022) warn about the risk regarding the suitability of emerging disruptive technology as "weapons of mass destruction" (drones or robots), concerned about the future use of these cheap devices and their availability to malevolent actors.

Based on the most recent geopolitical conflicts and informations, Nichols *et al*. (2022) note the trend to employ autonomous air and sea vehicles (or systems) in the military operations of the future as having a massive impact in conflict, particularly, if abjectly used (chemical, biological, nuclear, radiological, electromagnetic, and explosive weapons – CBNRECy) (NICHOLS *et al*. 2022).

It is about a "new technological era" where emerging disruptive technology (robotics by artificial intelligence) will transform the war aspects, adding complexity to the conflict. Mainly, autonomous technology (underwater, in focus) raises concern because of a differential feature – occultation in the "blue planet" (hidden in an environment that is fundamental to the regulation of climatic conditions and to life itself) (LIANG and XIANGSUI, 1999; KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; SKINNER and MURCK, 2011; BEYERCHEN, 2007; MOURA, 2012: SPARROW and LUCAS, 2016; BAYLIS *et al*. 2018; PIOTROWSKI, 2018; FERREIRA, 2021a; FERREIRA, 201b; NICHOLS, *et al*. 2022; FERREIRA, 2022).

"Unfortunately, the dark side of human imagination and ingenuity cannot be ignored because, in the wrong hands, it can kill millions at the push of a button." (SLOFER, 2022) – of people... or, of (living) beings, apart from the "non-living" affected (and beyond): a threat to the (Earth) system (CAPRA, 1982; CAPRA, 1983; KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; SKINNER and MURCK, 2011; SLOFER, 2022; NICHOLS et al., 2022).

III. Probability of Chaos in Geophysical Fluids (for Models)

"The management and regulation of ecosystems is a complicated matter" (STEWART, 1997) – According to Stewart (1997) in the distant past of the human race, the absence of pattern in the natural world was attributed to the whims of the powerful and incomprehensible deities that ruled it (STEWART, 1997).

To deal with the complex phenomena of the 21st century (questions never before conceived concerning the physical world) the new scientific perspective is that of "non-linear science" (a metascience) through the recognition that in all of nature "the whole is greater than the sum of the parts" (SCOTT, 2007), "unexpected things happen" (SCOTT, 2007), and "minimal causes can explode into powerful effects" (SCOTT, 2007).

Systems composed of numerous elements, among which there are reciprocal, nonlinear interactions, are called complex systems (BERTUGLIA and VAIO, 2005). The phenomenology of complexity is relevant due to the transversality of the aspects that appear in such systems, and that characterize their nature (BERTUGLIA and VAIO, 2005).

Complexity and chaos are present in deterministic systems (deterministic because there is always a law that dictates their evolution) whose behavior is generally unpredictable, as it is extremely difficult (or impossible) to identify the effect of the various parameters of the system (considered individually, or in its entirety) (BERTUGLIA and VAIO, 2005).

Deterministic laws, which "apparently make the world algorithmically comprehensible," according to Bertuglia and Vaio (2005), are reduced from large data sequences (thanks to phenomenological recurrences). But systemic complexity is difficult to be completely described in a deterministic way – certain properties of complex systems are emergent (they are not intrinsically identifiable in any of their parts taken individually) (BERTUGLIA and VAIO, 2005).

The complexity demonstrates that causality is not linear since in the long term, it acts so that the links between causes and effects of systemic phenomena can dissolve (not being identified), as highlighted by Bertuglia and Vaio (2005). In the short time, if causality can be successfully "explained" by the "set of encoding, decoding and implication processes" of "deterministic" laws, then a model could be built (BERTUGLIA and VAIO, 2005).

The "butterfly effect" became the "popular slogan of chaos" (SMITH, 2007). Chaos, in the scientific sense, is a particular aspect of how something changes over time (in fact, change and time are the two fundamental themes that together form the basis of chaos), according to Williams (1997). Thus, chaos presents problems that challenge accepted ways of working in science, breaking down the lines that separate scientific disciplines – severing the principles of Newtonian physics, and eliminating the Laplacian fantasy of deterministic predictability (GLEICK, 1987).

In various configurations, chaotic behavior can be observed, even if the equations that describe the system are not. Even elementary systems, described by simple equations, can have chaotic solutions (to the surprise of many scientists). Furthermore, the same system can behave predictably or chaotically, depending on little changes in a single term of the equations that describe it (SPROTT, 2000).

Understanding that the study of chaotic behavior has received substantial attention in many disciplines, Berliner (1992) reviews mathematical models and definitions associated with chaos, emphasizing the relationship between chaos mathematics and probabilistic notions (pointing aspects of particular interest to statisticians and probabilistic), since chaos is related to complex "random" behavior and forms of unpredictability (BERLINER, 1992).

Chaotic processes are not random – but there is a relationship – as even simple rules can produce extreme complexity (a mixture of simplicity and unpredictability). It is widely understood by the scientific community that being "deterministic" does not mean being "predictable" (SPROTT, 2000).

As there are different ways of quantifying what is meant by complex or unpredictable behavior, a universally accepted mathematical definition of chaos does not seem to exist (some definitions related to chaos involve notions of ergodic theory – positive Liapunov exponents and the existence of continuous ergodic distributions) (BERLINER, 1992).

Regarding the concept of chaos and the concept of probability, Bartlet (1990) also recognizes the relationship of their properties with the concept of chance: "it can be said that events are governed in part by the operation of the "laws of chance" (BARTLET, 1990). For Bertuglia and Vaio (2005), chaos and chance manifest themselves in the same way, both characterized by the disorder – in chaos, determinism is present but hidden (apparent disorder). In chance, there is the absence of determinism (real disorder, in random phenomena) (BERTUGLIA and VAIO, 2005).

"The methods used to distinguish deterministic processes from stochastic processes are based on the fact that a deterministic system always evolves in the same way, starting from certain conditions" (BERTUGLIA and VAIO, 2005). The law of dynamics generates a single state consequent to a given state, according to the author. On the other hand, in a stochastic or random system, consequent to a given state, there are more possible states among which the dynamic system somehow selects (according to a probability distribution) (BERTUGLIA and VAIO, 2005).

In practice, however, it cannot be assumed that a time series consists of data that result only from a deterministic law, having no stochastic components (BERTUGLIA and VAIO, 2005). Any series of experimental data is always "mixed with a stochastic process" that overlaps it, as background noise (called "white noise"), which reduces the quality of the information – this is due to a series of reasons (for example, there are unavoidable practical difficulties in measuring data, or data when measured never constitute a continuous sequence in time, and also any measurement is always affected by approximations of various types and origins) (BERTUGLIA and VAIO, 2005).

And, to be sure of obtaining only the deterministic law for a system, it would have to be "closed" (no interaction with the outside environment). Thus, it would undoubtedly be deterministic since all its dynamics would be endogenous (BERTUGLIA and VAIO, 2005). However, in practice, the number of variables needed to consider the system closed would be so high as to make the calculation time unacceptably long to effectively identify the deterministic law at the origin of the observed dynamics, according to Bertuglia and Vaio (2005). That is, "it would certainly be closed and deterministic in theory, but impossible to treat from a practical point of view" (BERTUGLIA and VAIO, 2005).

Chance plays a central role in human understanding of the nature of things – a probability that is neither "0" nor "1" corresponds to an uncertain event; however, ignorance about it would not be total – since "chaos limits the intellectual control we have over the world" (RUELLE, 1993).

In reality, the "chance versus determinism" dilemma is a false problem – as follows: a) there is no logical incompatibility between chance and determinism (the state of a system at the initial instant, instead of being precisely fixed, can be disposed according to a particular law of chance); b) in practice, the state of a system at the initial instant is never known with perfect precision; and, c) the little chance at the initial moment can provide a lot of chance (or a lot of indeterminacy) at a later moment (RUELLE, 1993).

"The central epistemological impact of chaos research is on issues of long-term prediction, and on the computability of most nonlinear deterministic systems" (LEIBER, 1998).

The advent of deterministic chaos in the natural sciences has counter-argued the question of "perfect predictability" based on mathematical determinism, according to Leiber (1998). Since mathematical determinism is empirically meaningless, the assumption that mathematical determinism must imply long-term numerical computability is simply wrong (any kind of error, deviation, or perturbation is amplified exponentially). Based on systemic modeling for technologies, if there are severe quantitative limitations for long-term computability, there will also be limitations in terms of controllability (LEIBER, 1998).

Problems that present "exponentially increasing algorithmic complexity" (depending on some system parameter) are considered "intractable" by Leiber (1998).

As for physical systems of the marine environment (atmosphere and ocean), systemic complexity is characteristic (nonlinearity) – in meteorology and oceanography, one deals with fluids whose density depends on temperature and pressure (MARSHALL and PLUMB, 2008).

In the context of geophysics, with regard to ocean analysis: Kamenkovich (1977) understands that it is necessary to comprehend the characteristics of the large-scale movements of its waters (due to its fundamental role). Olbers *et al*. (2012) also look at the influence of the oceans on earth's climate, weather, and ecosystems.

Monin and Ozmidov (1985) highlight the primordial importance of turbulence in the formation of hydrological fields in the ocean for the governance of the "world climate" – heat is accumulated in ocean waters due to turbulent mixing in the tropics and is subsequently transferred by sea currents to temperate and arctic zones. Most of the energy in the ocean's motion is contained in turbulent vortices rather than the average circulation – this is a new conception which should replace the universally accepted notion of the ocean as a quasi-stationary system (with a pattern of turns on a constant scale) (MONIN and OZMIDOV, 1985).

According to Monin and Ozmidov (1985) turbulence is a phenomenon observed in a large number of rotational flows (liquids and gases) whose thermodynamic and hydrodynamic variables suffer chaotic fluctuations (velocity vector, temperature, pressure, the concentration of contaminants, density, speed of sound, electrical conductivity, refractive index, etc.) (MONIN and OZMIDOV, 1985).

Since the ocean is a vast reservoir of organic life, the intense turbulent movement in ocean waters is directly related to atmospheric exchanges. Otherwise, "the resources of biogenic material in the upper photosynthetic zone of the ocean and those of oxygen in the abyssal layers would soon be depleted [...] ocean would then change to a lifeless desert" (MONIN and OZMIDOV, 1985).

As described by McWilliams (2006) the atmosphere and oceans exhibit complex patterns of fluid motion on a wide range of space and time scales (climate is a combination of these motions, on a planetary scale – a response to solar radiation inhomogeneously absorbed by the compounds of the air, the water, and the earth). "Spontaneous, energetic variability arises from instabilities in planetary-scale circulations, appearing in many different forms, such as waves, jets, vortices, boundary layers and turbulence" (MCWILLIAMS, 2006).

"Geophysical fluid dynamics" (GFD) is the theoretical science of all types of fluid motion of complex nonlinear dynamics (planetary fluids – fluids from within the earth; lava flows from volcanoes; fluids from ocean circulation; and the atmosphere – and astrophysical fluids, since many of the scientific questions are similar). Mathematical analysis and computational modeling are essential research methodologies for the identification and study of dynamic processes behind of the observed phenomena (MCWILLIAMS, 2006).

Most of GFD is a branch of physics (relevant aspects of dynamics, energy transfer by radiation, and atomic and molecular processes associated with phase changes) – however, GFD does not cover the entirety of ocean-atmosphere physics (it merely provides a mathematical representation and interpretation of the facts about earth's natural fluids). Also there is some chemistry, and even biology, in GFD as they influence the movement and evolution of reactive materials (MCWILLIAMS, 2006).

Due to the complexity of geophysical motions (which is generally a consequence of fluid turbulence), "even tides, arising from spatially smooth and temporally periodic astronomical forces, can be quite complex in their spatial response patterns" (MCWILLIAMS, 2006).

Although the dynamic equations used in GFD are "deterministic" in a mathematical sense (with the property of sensitive dependence - where any little differences rapidly amplify over time) most geophysical time series are more appropriately called “chaotic” than “deterministic” (MCWILLIAMS, 2006).

Vallis (2016) also discusses the role of GFD in understanding the natural environment in the search for the phenomenological essence; noting that complex systems of interaction present “fluid dynamics emergent phenomena” (which emerge from the collective behavior of the system's constituents – not being a property of its components). According to the author, “at each new level of complexity, new properties arise that do not depend on the details of the underlying laws and qualitatively different behavior occurs” (VALLIS, 2016).

As some of the main goals (and past triumphs) of the GFD are in the explanation of “emergent fluid dynamic phenomena,” Vallis (2016) presents two reasons why such phenomena should be understood: a) the scientific understanding of the natural world is “an end in himself,” which affords admiration and respect, in proportion to his greatness; b) the understanding of phenomena enables better prevention, and finally, practical social benefits (public policies can be implemented with a focus on atmospheric and oceanic dynamics, for example).

In many geophysical systems of interest, information about systemic behavior can be obtained by quasi-direct numerical simulation of governing equations, for Vallis (2016). In this sense, GFD describes a method and an object of study (VALLIS, 2016).

It turns out that there is little scientific understanding regarding the intricate details of ocean circulation, the limits of its biological productivity, its interaction with the atmosphere, or its tolerance for waste dumped by the growing human population (KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b).

The task of faithfully modeling the circulation of the oceans (across the spectrum of their temporal and spatial variability), for example, is highly complex, challenging, and arduous – meticulous attention to detail is required, both dynamically and numerically (KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b).

IV. Plausibility of Rare Event by Geophysical Process (for Scenario)

In a world of great uncertainty, scenarios are tools for achieving a long-term vision, and a method for understanding, articulating and moving between the different possible future paths, from “[...] stories that can help us recognize and adapt to changing aspects of our current environment” (SCHWARTZ, 1996).

“The study of scenario-based planning is the study of learning and invention” (VAN DER HEIJDEN, 2005). There is a debate among scenario planners about the preference for plausible or probabilistic methodologies, according to Ramirez And Selin (2014). As the two species have incompatible conceptions (about knowledge and uncertainty), both can be approached by critical and etymological examining (from techniques and tools, schools of thought, criteria of effectiveness, epistemological and ontological differences) (RAMIREZ and SELIN, 2014).

Regarding the etymology of the words “plausibility” and “probability,” Ramirez and Selin (2014) address three different historical periods: a) in the first period (until the 16th century), both terms were used confusingly, for its origin (derived from classical Latin) – probability denoted “seeming true” (a perception associated with “likelihood”), and plausibility “seeming reasonable or probable” (a perception about “false appearance”); b) in the second period (17th century), probability started to be seen in a more scientific way, related to observational rigor; c) in the third period (from the 18th century onwards), probability becomes a central aspect of statistics (mathematically defined); and plausibility continued in its original sense of providing "the appearance of credibility and reasonableness" (RAMIREZ and SELIN, 2014).

The probabilistic approach for scenarios is deductive, positivist, and reductive, approximating absolute claims by exclusion and simplification (captured in formulas, statistics, and regressions) through a scientific, predictive vision, that providing the measurement of occurrences based on a degree of objective and rational belief. However, “this approach is based on facts, which are all in the past” (RAMIREZ and SELIN, 2014). On the other hand, “plausibility is considered a characteristic of credible cause and effect relationships” which, and not objectively, proposes “new beliefs” (RAMIREZ and SELIN, 2014).

Probabilistic scenarios would be epistemologically close to a prediction (RAMIREZ and SELIN, 2014). But prediction only makes sense in a domain where probabilities can be evaluated. Another issue regarding forecasts is the fact that, generally, people assimilate a specific routine and settle down, according to Van der Heijden (2005) (in reality, there is always a point in time when structural changes will occur, and behavior will have to change). “Forecasts can work very well for a period, but forecasters need to be aware of variables that will suddenly break the relationship with the past, creating a trend break” (VAN DER HEIJDEN, 2005).

For plausibility, the scenarios would only help, in intrinsically uncertain and unpredictable situations, according to Ramirez and Selin (2014). “The final confrontation concerns the roles of creativity and codified knowledge in alternative futures, making scenario planning something that involves “art” or “science” (RAMIREZ and SELIN, 2014).

Schwartz (1996) highlights that through a scenario the world of facts is connected to the world of perceptions (as in a theater, in which spectators suspend disbelief relative to any point and react to the scenes – as if they were actually following the real world). A good scenario leads people to "voluntary suspension of some disbelief," during the sufficient time to appreciate the impact of "new beliefs," according to the author.

As noted by Ramirez and Selin (2014), if the fundamental objectives of a scenario are to bring up implicit assumptions, test tacit knowledge, question prejudices of the impossible and the possible, and change views and minds – ambiguity and uncertainty would be productive. "If each scenario is as plausible as the next, every scenario is worthy of attention; and the defined scenario is not the only one – it is the comparisons between them that generate value" (RAMIREZ and SELIN, 2014). Van der Heijden (2005) highlights the importance of multiple futures (equally plausible), which serve the purpose of a test bed for policies and plans.

By the plausibility method, scenario planning only assesses plausible futures using qualitative tools; they can be produced inductively or deductively – if it were possible to establish probability about a certain end, there would be no need to build scenarios (RAMIREZ and SELIN, 2014).

"Scenarios emerged after the Second World War as a method of military planning. The US Air Force tried to imagine what its opponents might do and prepare alternative strategies" (SCHWARTZ, 1996). Indeed, conflict is a profoundly existential phenomenon, potentially destructive to lives and livelihoods, hence the numerous attempts by many researchers to make it more predictable (GAUB, 2020).

Concerning the military, although war is a prerogative of the state, creative works imagine how war might evolve in the future and directly influence it (for example, by speculating on possible new problems – testing the limits of new technocentric approaches) (GAUB, 2020).

On the possibility of nuclear conflict, Gaub (2020) points to the reasoning of experts at the "opposite end of the scale," who hold firmly to the theory of deterrence – the idea that the possession of nuclear weapons, in itself, is enough to avoid war. Although it is a plausible conception, it can generate relative comfort (in limiting knowledge, ideas, and action to be taken about an imminent conflict of this nature) (GAUB, 2020).

Focusing on the ways and means by which conflicts will be fought in the future, and "without the ambition to develop generalized theories or predict the beginning of a conflict before it happens" (GAUB, 2020), the author considers it relevant that societies and institutions are prepared for an imminent conflict, so that there are fewer surprises (GAUB, 2020).

Imagination must be applied to this (GAUB, 2020). Using imagination is working with the anticipation of facts, mainly due to possible impacts that, by chance, are possible to occur. The author also notes that there may be degrees of imprecision, especially if future conflicts are contemplated as an extrapolation of current trends, or if they are entirely different from the past (disruptive illusion) (GAUB, 2020).

In 1960, from the perspective of "conflict in a nuclear age" (thermonuclear wars), Kahn (2007) approached this problem for human civilization from the analysis of scenarios. Subsequently, Kahn *et al*. (1976) also used the same methodology to examine "other kinds of real problems" facing humanity (by presenting a partial report on crucial long-term issues of broad interest). About the scenarios developed by Kahn (2007) and Kahn *et al*. (1976), analyzes referring to environmental issues proved to be insipid (KAHN, 2007; KAHN *et al*. 1976).

The perspective for humanity presented in Kahn *et al*. (1976) credited as "the most likely and representative" for a 200-year interstice opposes what the authors cited as "popular and generalized discussions [...] that indicate bleak prospects" (KAHN *et al*. 1976). That is, the scenario described by Kahn *et al*. (1976) is entirely diferent, in the sense of being more positive for humanity, and not "doomsday literature" (KAHN *et al*. 1976).

A paradoxically intriguing observation concerns the credit given to the vision in Kahn *et al*. (1976) "as the most likely and representative" – since the perspective presented is "deliberately non-technical; suggestive and speculative; and may present errors and omissions" (KAHN *et al*. 1976).

That is, about "popular and generalized discussions [...] that indicate bleak prospects" (KAHN *et al*. 1976), Kahn *et al*. (1976), similarly, heuristically, and superficially discuss the future – only from an entirily optimistic approach, based on the belief in public policies, by the impact (directly, indirectly, and in a lasting way) of the thoughts and ideas resulting from their "investigations."

Based on the quote: "what is well known is misunderstood, and what is taken for granted is taken without thinking" (KAHN *et al*. 1976) – by a crude and simplistic interpretation of this – the authors justify their suggestive reasoning, also disregarding the discussion and the opinion of intellectuals and academics.

With some exceptions (for example, the problem of nuclear proliferation), Kahn *et al*. (1976) are in favor of "progress" (as exemplified by science, technology, and industrialization), considering that technological "progress" will help society to deal with facing absolutely "all" future problems (radiation, and chemical or toxic waste, also including) – "it seems quite likely that within a century or so man will be able to avoid harm, and that calculations of accumulated harm 10 to 100 generations hence are likely to become irrelevant" (KAHN *et al*. 1976) – in a perspective of "progress" at any cost[1]. A contradiction, at least, about science itself and its understanding (KNELLER, 1978).

Through a succession of movements, in the broad historical course of civilization, science (knowledge about nature that aims to fully explain its order, as well as all human activity to expand this knowledge) is a source of information indispensable to technology, according to Kneller (1978). However, being a human enterprise based on theories that accumulate in laws, it is fallible (KNELLER, 1978; FERREIRA, 2021a).

Therefore, every, each statement or set of scientific reports can be revised or replaced in the light of new evidence and ideas, and so, science can criticize itself and transform itself into a rational validation acceptable to other scientists in a community. The evolution of research traditions, with the accumulation of laws, makes science grow and scientific imprecision decrease, "towards true progress". However, if incommensurable theories exist, there is no way to know whether science advances towards the truth (KNELLER, 1978).

Kneller (1978) considers that science is progressive (by using an increasing number of increasingly precise investigation techniques), but not continuously since incorrect hypotheses can sometimes be preferred to correct ones. The progression, therefore, takes place on different bases, as one theory can be refuted by another, more credible, or more significant. Also, science is cumulative (by adding new data to past findings rather than replacing them); but not always (KNELLER, 1978).

Unfortunately, scientific knowledge, technological development, and innovations bring consequences: Longo (2007) highlights the "macro-social impacts caused by recent changes in the human environment," which, being slow initially, were accelerated for human satisfaction; and, after the Second World War, they turned to the production of military advantages aimed at the development of political-economic power at a world level. Thus, science and technology became a central part of national policies and strategies in developed countries, with a new distribution of power. Sachs (2000) even takes a curious approach to the close relationship between "technological power" and national sovereignty.

Longo (2007) argues that such scientific-technological performance has been reflected in an acceleration of social changes unprecedented in human history. Governments have not been able to carry out the proper monitoring and planning on the subject, generating, among many other social impacts, a "management gap," capable of affecting the environment and people's health.

Regarding the systemic environment, the inferences in Kahn *et al*. (1976) are obsolete, for example, by the association of "green plants" to the production of oxygen – about the ocean, there was no comment – however, there is active participation of the sea in this process (KNELLER, 1978; MONIN and OZMIDOV, 1985; KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; BERTUGLIA and VAIO, 2005; SKINNER and MURCK, 2011).

Kahn *et al*. (1976) also refute the idea of "environmental fragility" since "both the environment and most ecological systems must be resilient and largely self-correcting or self-healing" (KAHN *et al*. 1976), in the autors opinion. But about the particularities and the proportions of possible humans interferences in the earth system, there was no analysis (or measurement). Likewise, the action of unforeseen natural (geophysical) forces and processes was not envisaged (KAHN *et al*. 1976).

Kahn *et al*. (1976) disregarded the occurrence of "random events" of any kind (even the possibility of such circumstances – "undocumented") "because the underlying assumptions and conditions practically never happen" (KAHN *et al*. 1976).

However, concerning the "fragile envelope of the earth" (KAHN *et al*. 1976), for example, the "ground" may, unexpectedly, evaporate (MUKHERJEE, 2006; IDRISS and BOULANGER, 2008; SKINNER and MURCK, 2011) (FIGURE 01):

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[1] By analogy, Kahn *et al*. (1976) relate "science" to magic – a supernatural gift obtained by an irreversible commitment (pact) to be obligatorily employed (at all costs) – A "Faustian bargain" (KAHN *et al*. 1976, p.164). It turns out that "magical action" (even if mystical) is deterministic – its effects are governed "because of the pact" "as law" and "exact and inviolable" (the cost for breaking the "law" would be "high"). According to scientific thought for the 21st century, science (which can be seen from a mystical perspective) has deterministic and also stochastic characteristics, explicitly "assuming 'without' law behavior governed entirely by law" (STEWART, 1997). By the conception, one accepts at first, a "certain" uncertainty (about the Creator "of all scientific laws, etc." *modus operandi*); but without bargaining – and with "certain" clarity (through flashes of revelation - which help the perception) and exposition about possible consequences (at least, through inferences).

Figure 1: Tilting of Apartment Buildings Caused by the 1964 Niigata Earthquake.

Source: National Information Service for Earthquake Engineering (University of California, Berkeley) apud Idriss and Boulanger (2008).

V. Final Considerations

While the high seas are an ideal location for autonomous underwater vehicle operations, a suitable mathematical model is necessary for a high-performance technology. Specifically, the ability to precisely maneuver in ocean space is an essential quality for this category of " robots" – the governance, controllability, and trajectory issues of such systems are complex (FOSSEN, 1994; GRIFFITHS, 2003; BREIVIK and FOSSEN, 2009; INZARTSEV, 2009; FOSSEN, 2011; FANELLI, 2020; YAN *et al*. 2021).

Regarding the structure and dynamics of complex systems chaos theory can be applied to provide insights into nonlinear phenomena (including random aspects). In chaos theory, determinism and chance are like two sides of the same coin, and there is no cause and effect relationship between them (GLEICK, 1987; ÇAMBEL, 1993; WILLIAMS, 1997; SPROTT, 2000; BERTUGLIA and VAIO, 2005; BEYERCHEN, 2007; LASKEY and COSTA, 2009).

When it comes to understanding the operational particularities of autonomous underwater technology, an essential and challenging facet to be considered (in addition to the desired results) concerns the marine environment – the ocean is limited in terms of observation and constantly changing (GILL, 1982; CHASSIGNET and VERRON, 1998; KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; JUDD and HOVLAND, 2007; LOWRIE, 2007; INZARTSEV, 2009; BREIVIK and FOSSEN, 2009; SKINNER and MURCK, 2011; FOSSEN, 2011; ÖZSOY, 2020).

Numerical modeling of oceanic processes (ocean dynamics) involves the water masses dense structure that make up ocean basins, the radiative fluxes at their surface, the forces imposed on the ocean surface by the overlying atmosphere (the stress of wind and flows buoyancy), the astronomical tidal forces, in addition to the consideration of sea ice , and topographic information – "mid-ocean ridges and other topographic features important to the circulation of the basin, must be essential included in resolutions of numerical models". For reasons of efficiency and economy, most ocean circulation models can impose a limit on the depth of the model (a false bottom) (KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b).

The domain of geophysical processes is broad, reaching all the subsystems of the planet, due to the systemic interaction: the atmospheric boundary layer is connected to the earth's surface, but also to the ocean surface – and the oceanic boundary is "visibly" related to the atmospheric layer; however, it is also in connection with the ocean floor (in hidden) (GILL, 1982; CHASSIGNET and VERRON, 1998; KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; JUDD and HOVLAND, 2007; SKINNER and MURCK, 2011; ÖZSOY, 2020).

The scientific awareness is that dynamic geological processes drive the exchange of fluids (a wide range – of gases and liquids) at the "seafloor-seawater" interface. From coastal waters to deep ocean trenches, "it is remarkable how common is the flow of fluid on the seafloor" (JUDD and HOVLAND, 2007). "This interaction gives rise to flows that appear chaotic (turbulent) [...], and the resulting variability can be seen in measurements of properties such as wind speed, temperature, and currents" (JUDD and HOVLAND, 2007) (including of under the influence of the submarine relief, or of the oceanic circulation itself, and tides) (KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; JUDD and HOVLAND, 2007).

As the physical characteristics of the global ocean (in terms of shape and extent) are determined by tectonic forces, great topographical changes are challenges to ocean modeling (KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; SKINNER and MURCK, 2011; ÖZSOY, 2020).

"One of the few geological activities of dynamic importance to the oceans are underwater earthquakes, which generate destructive tsunamis" (KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; SKINNER and MURCK, 2011; MUKHERJEE, 2006; JUDD and HOVLAND, 2007; ÖZSOY, 2020).

Processes in the flow of geophysical fluids expose the vulnerability of human life (which occupies the surface layer of the crust, about the geosphere) – "possibly, the majority of the human population will increasingly be at the mercy of Nature for their sustenance" (KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b).

Likewise, due to the systemic interaction of the seafloor (geosphere) with oceanic waters autonomous underwater technology (underwater, in focus) is vulnerable to geophysical fluid flows – its behavior is influenced by environmental forces (winds, waves, and ocean currents) (FOSSEN, 1994; GRIFFITHS, 2003; BREIVIK and FOSSEN, 2009; INZARTSEV, 2009; FOSSEN, 2011; FANELLI, 2020; YAN *et al*. 2021; JUDD and HOVLAND, 2007; INZARTSEV, 2009; SKINNER and MURCK, 2011; ÖZSOY, 2020).

Considering the problem related to the controllability of a "robot" in a fluid medium, it will be as efficient as the limit imposed by the application of its computational model about the intensity of turbulent flows and parameterizations (FOSSEN, 1994; GRIFFITHS, 2003; BREIVIK and FOSSEN, 2009; INZARTSEV, 2009; FOSSEN, 2011; FANELLI, 2020; YAN *et al*. 2021).

However, if immense geophysical processes occur that generate *sui generis* type of flows (earthquakes from the sea floor for example) – it is very unlikely that the controllability of such autonomous technologies can be effective (underwater, in focus) (LEIBER, 1998; JUDD and HOVLAND, 2007; LOWRIE, 2007; SKINNER, and MURCK, 2011; ÖZSOY, 2020; FERREIRA, 2021a; FERREIRA, 2021b).

The Global Risks report is published by the World Economic Forum, based on sources believed by the authors to be reliable regarding statements about known, unknown, uncertain, and other risks. Helpful information may not be limited to what is published (new perspectives may arise) (MCLENNAN *et al*. 2021).

Specifically about "environmental risks" McLennan *et al*. (2021) cite "major geophysical disasters" as the most critical threats to the world, as well as the most potentially harmful to people and the planet – however, considering them as "long-term risks."

It turns out that, to geophysical processes and disasters, events of this category still seem to occur "suddenly and without obvious warning" (despite the significant global effort put into investigations) (MUKHERJEE, 2006; SKINNER and MURCK, 2011; ÖZSOY, 2020). "Earthquake prediction is, without a doubt, the biggest challenge for geoscientists today" (MUKHERJEE, 2006), even, there may be changes in the variables that precede the occurrence of earthquakes (in relation to the thermosphere, ionosphere, and atmosphere of the Earth), as they "probably depend on the integrated cosmic environment and Sun-Earth" (CAPRA, 1982; CAPRA, 1983; MUKHERJEE, 2006; SKINNER and MURCK, 2011).

The Global Risks 2021 report (MCLENNAN et al. 2021) presents "weapons of mass destruction" as an "existential threat" (deployment of biological, chemical, cybernetic, nuclear, and radiological weapons), being one of the most impacting risks to the next decade.

In fact, "as technology has evolved, so has the need and desire to create better and more efficient weapons and associated launch systems that can break through or neutralize an opponent's defenses" (SLOFER, 2022). This is the case of autonomous technology (underwater, in focus) if used in a way that causes significant wear due to the possibility of penetrating the opposing defense (SPARROW and LUCAS, 2016; BAYLIS *et al*. 2018; PIOTROWSKI, 2018; FERREIRA, 2021a; FERREIRA, 2021b; SLOFER, 2022; NICHOLS *et al*. 2022; FERREIRA, 2022).

Specifically about nuclear weapons McLennan *et al*. 2021 point to the "small-scale" factor as a trend – a new technology that allows the proliferation of lower-powered warheads, which compromises deterrence structures; therefore, there is indeed apprehension about the conduct of a global nuclear war.

Considering only the proportion of an attack by the use of weapons of the nuclear category, the consequences for the earth system would already be "catastrophic" – however, there are empirical and antagonistic opinions on the conception of such a circumstance due to the relativization of its concept (KAHN *et al*. 1976; CAPRA, 1982; CAPRA, 1983; KAHN, 2007; BEYERCHEN, 2007; SKINNER and MURCK, 2011; BAYLIS *et al*. 2018; PIOTROWSKI, 2018; SLOFER, 2022; NICHOLS *et al*. 2022).

Indeed, there is a "self-regulation" feature of the Earth system (to its long-term dynamic equilibrium) however it is still not well understood by science mostly if the cause of the changes or disturbances are the human activities (SKINNER and MURCK, 2011). The human impact on the environment can overload the system's resources, harming life (SKINNER and MURCK, 2011).

Interestingly, McLennan *et al*. (2021) emphasize the severe consequences of possible unwanted events in an "era of combined risks" (economic, environmental, geopolitical and technological) – also understood by the authors as a "cross between risks" (cross-risks).

From the remote possibility of a nuclear conflict a scenario can be imagined by the crossing of geopolitical and environmental risks (simultaneously), considering unexpected geophysical processes of immense proportion that generate *sui generis* flow of fluid (an earthquake coming from the sea, for example). As described, the concomitance between events would be very rare, however of "holistic" impact – and plausible – mainly if autonomous technology (underwater, in focus) is being used as a nuclear weapon or vector (WEICK, 1989; KANTHA and CLAYSON, 2000a; KANTHA and CLAYSON, 2000b; MUKHERJEE, 2006; JUDD and HOVLAND, 2007; KAHN, 2007; BEYERCHEN, 2007; SKINNER and MURCK, 2011; SPARROW and LUCAS, 2016; BAYLIS *et al*. 2018; PIOTROWSKI, 2018; GAUB, 2020; ÖZSOY, 2020; MCLENNAN *et al*. 2021; FERREIRA, 2021a; FERREIRA, 2021b; SLOFER, 2022; NICHOLS *et al*. 2022; FERREIRA, 2022).

Based on the scenario presented, the certainty that emerges concerns the harmful consequences to the Earth system even though scientifically the proportions of these damages are uncertain – because they are immeasurable (KNELLER, 1978; CAPRA, 1982; CAPRA, 1983; STEWART, 1997; LEIBER, 1998; SKINNER and MURCK, 2011; ÖZSOY, 2020).

As a support to productively deal with the discomfort, scenarios are helpful to reduce inconveniences and surprises about future situations (WEICK, 1989; GODET, 2000; VAN DER HEIJDEN, 2005; WADE and WAGNER, 2012; RAMIREZ and SELIN, 2014; SCHWARTZ, 1996; MINVIELLE and WATHELET, 2020; GAUB, 2020).

Sharing and putting a problem into perspective among stakeholders allows concrete ideas to be deduced by policymakers (GODET, 2000; VAN DER HEIJDEN, 2005; SCHWARTZ, 1996; MINVIELLE and WATHELET, 2020; GAUB, 2020; MCLENNAN *et al*. 2021).

In a conception of conflicts the use of previous simulations has accompanied the history of humanity - from Sun Tzu (for the creation of the game "*Wei Hai*") to World War II (by the use of simulation techniques, in the evaluation of possible results in operations, by Germans, Japanese, English, and Americans) (BRASIL, 2018). The importance attributed to the anticipation of scenarios became evident in conflicts, including the need to imagine a possible (or plausible) "element of surprise" (BRASIL, 2018; TALEB, 2007). In fact, during the Second World War, surprise (and unrestricted) Japanese tactics were employed (BRASIL, 2018; FERREIRA, 2021b):

> [...] excerpt from a lecture given by AE W. Nimitz at the Naval War College in 1960 [...]: "The war with Japan had been simulated in the game rooms of this School by so many people, in so many different ways, that nothing that happened during the campaign in the Pacific was a surprise – absolutely nothing, except the *Kamikaze* tactics used at its end, which we had not visualized" (BRASIL, 2018).

Regarding the risk of war in a nuclear age, scenarios were indeed imagined, however, by a reductionist, simplistic, and already obsolete "scientific" bias (KANTH, 2007; KAHN *et al*. 1976). In a holistic and ecological scientific approach (referring to the 21st century), the dimension of the damage is "unimagined"[2]. Adding cross risks, all of them; and in the long term (KNELLER, 1978; CAPRA, 1982; CAPRA, 1983; WEICK, 1989; STEWART, 1997; LEIBER, 1998; GRIBBIN, 2004; BERTUGLIA and VAIO, 2005; KAHN, 2007; SCOTT, 2007; BEYERCHEN, 2007; SKINNER and MURCK, 2011; HORGAN, 2015; MCLENNAN *et al*. 2021).

Political decision-makers are alerted to the non-use of technology (underwater, in focus) as a weapon of mass destruction (or vector), due to the threat to the Earth system.

The limit (or frontier) of science reaches – in the end – the uncertainty (BUSH, 1945; KNELLER, 1978; CAPRA, 1982; CAPRA, 1983; STEWART, 1997; BERTUGLIA and VAIO, 2005; SKINNER and MURCK, 2011; HORGAN, 2015).

Indeed, about the scientific laws that govern the material world, uncertainty is dealt with, which does not imply a lack of knowledge or scientific understanding but "evidence of its breadth, complexity, and mutability" (KNELLER, 1978; CAPRA, 1982; CAPRA, 1983; SKINNER and MURCK, 2011).

Interestingly, "in a closed system, only energy, not matter, can cross the boundary" (SKINNER and MURCK, 2011). By characterizing the Earth as a "closed system" it is noted that: the sum of the energy of the system (internal energy) can be changed by the transfer of energy (its addition or its removal from the system),

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[2] One can only "imagine" the despair of the survivors of a nuclear catastrophe – according to the relativization of the conceptual conception; or not – considering themselves as human beings in crisis or under pressure. There is a perception of a world government due to the belief in public policies (KAHN, 2007; KAHN *et al*., 1976), and indeed (in adverse circumstances), there will be an expectation of the survivors for a "salvation on Earth" referring to "on the Earth system" (SKINNER and MURCK, 2011). The human mind, "shaped by history and biology" would be easily manipulated (HARARI, 2018, p. 267). In Harari's (2018) perspective, "there is no authentic 'I' waiting to be freed from the shell of manipulation" (HARARI, 2018, p. 267).

as reported in Skinner and Murck (2011). Thus the plausibility of a "specific consideration of the 'output of the Earth system' in the form of energy (such as a rapture),"[3] may be inferred with hope for some people, by a conception "similar to the visions of mystics of all the times and traditions" (CAPRA, 1982; CAPRA, 1983), depending on "[...] how God plays dice" (STEWART, 1997).

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[3] "Popular and generalize discussions [...] that point to bleak prospects" (KAHN *et al*., 1976) – more appropriately: particular consideration about an apocalyptic event (as per theological inferences from the book "Revelation," Holy Bible). That it's like "bleak" in terms of being "mysterious, not fully revealed or exposed"; however, its outcome, fosters hope – "salvation" but from a metaphysical (transcendental) perspective, and victory (for some), and posteriorly, a "salvation of the Earth", referring to "the Earth system" (SKINNER e MURCK, 2011), or a renewal of all – from a mystical perspective. Another perspective, a widespread one, concerns "extraterrestrial beings" who abduct people – however, by a pseudo-scientific bias – in reality, theories must be: high in narrative rationality, self-consciously operated, deliberately separate as to validation, as well as being plausible; the expected result is by "knowledge growth by extension" – "when the relatively complete explanation of a small region is then transferred to the explanation of adjacent regions" (such as the gradual construction of a puzzle as more pieces become available) (WEICK, 1989).

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