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Technology and Business Model Foresight for Border and Coastal Surveillance Systems☆

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Abstract

Emerging technology trends can seem both elusive and ephemeral but some become integral to business and IT strategies and form the backbone of tomorrow's business model and technology innovation. Companies (and Administrations) must examine the business impact of these trends and adjust business models and operations appropriately or risk losing competitive advantage to those who do. Rather the technology being difficult it is the implementation of it that could be a challenge. We're working in an environment where volumes and complexity are increasing, but budgets are decreasing. How to sense and act upon a future that remains unclear? It is required to think very differently about the way to conceive and deliver technology services. The technology is the last step of the foresight process.

The author aims to provide an answer to the above enquire starting from the identification of technologies and future technological concepts having potentially a significant impact on maritime traffic management and border control systems and the community in the medium to long term, i.e. 5 to 20 years. It is aimed at the idea of capacity building, not simply forecasting.

A brief history of Vessel Traffic Services (VTS) followed by some systems engineering considerations are presented in paragraph 1 with connections to technology trends such as intelligent, digital and mesh in the next paragraph. On maritime domain these means, for instance, moving from traditional VTS to Maritime Service Portfolios (MSP) for e-Navigation. Bioinspired technologies forecasts are presented in paragraph 3 with examples of concrete practical use and possible further applications: drones, camera tracking and classification systems and passive as well as cognitive radars. Conclusions and a brief outlook will close the text.

Keywords: bioinspired technologies, capacity building, cognitive systems

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1. Introduction

Technology foresight is one of the tools used by border and coast guard agencies, such as Frontex in Europe, to regularly assess the future of technology and science. The overarching goal is the identification of technologies and future technological concepts having potentially a significant impact on border security and the community in the medium to long term, i.e. 5 to 20 years. It is aimed at the idea of capacity building, not simply forecasting.

1.1. The origin of VTS

The movement of goods and people by sea have supported the world economies from centuries. Authorities around the world have supported commerce providing aids to navigate safely and efficiently in and around their coastal waters. At first aids to navigation were shore side lights and beacons followed by buoys and audible signals. Technology progress and the use of electromagnetic radiation applied to different systems were used effectively during World War II. For instance Britain develop a kind of early warning radar system, named Chain Home, deployed along the British Channel used to detect German's aircraft resulting very effective. Soon after World War II become clear that visual-audio aids to navigation were not enough to support port facilities in all weather and increasing traffic conditions. Consensus emerged among maritime community to enhance efficiency and safety in port areas, specifically for port approaches.

The first radar based Port Control station was established in Douglas, Isle of Man, in 1948. Later the same year, the port of Liverpool established a radar site and similar trials took place in Rotterdam followed by the port of Amsterdam in 1952 and the entire Rotterdam port area in 1956. It was then until the nineteen-sixties and seventies that some major shipping disasters (Torrey Canyon for instance) brings public opinion aware of the environmental damage that shipping accident could cause and rise concern that such disasters might happen in port approaches. Considerations on those emerging vessel traffic services were debated among port authorities, ship-owners and pilots until the adoption in 1997 of International Maritime Organization (IMO) Assembly Resolution A.857(20), the internationally recognised source policy document for VTS (Vessel Traffic Services) which state: "A VTS is a service implemented by a competent authority, designed to improve safety and efficiency of vessel traffic and to protect the environment. The service should have the capability to interact with the traffic and to respond to traffic situations developing in the VTS area".

Figure 1: VTS test site Rotterdam 1948

Source: collection D. Zwijnenburg, IALA Manual ed. 4, 2008, p.13

VTS was conceived as a live, interacting, solution for traffic management providing advice or assistance to vessels (and still have the same mandate). The idea of Surveillance System (i.e. VTS) comes by evidence of needs of safety and efficiency for vessels in port areas and their approaches, that traditional lighthouses and sound signals cannot guarantee. Keywords were as follows.

- Safety: minimise the number of shipping accidents in port's approaches and port areas.
- Efficiency: increase traffic flows per time unit, avoid traffic delays, provide better port's capacity utilization (increasing ports operational hours and therefore ports profitability).

Early VTS systems were composed by just a primary RADAR and a VHF radio, by the meanings of communication among ships and base stations.

In 1983 the Port of London uses, for the first time, a radar integrated with a computer. In the eighties many VTSs appear in North European Ports and in great Asian ports. As said, it was concluded that, in addition to providing better utilisation of a port's capacity, the number of accidents was also being reduced however the goal was (and still being) essentially economic:

- To limit risk of collision and incident.
- To avoid traffic delays and to increase the

speed of traffic flow in general.

- To improve the port efficiency.

1.2. Systems Engineering considerations

The term Systems Engineering (SE) was first used to Bell Telephone Laboratories in early 1940s as well as the US Department of Defence (DoD) in late 1940s with the development of missile-defence systems. As far as known the first attempt to teach systems engineering came in 1950 at MIT (Massachusetts Institute of Technology) by Mr. Gilman, Director of Systems Engineering at Bell.

Systems engineering were conceived (Hall, 1962) as a function with five phases: (1) system studies or program planning; (2) exploratory planning, which includes problem definition, selecting objectives, systems synthesis, systems analysis, selecting the best system, and communicating the results; (3) development planning, which repeats phase 2 in more detail; (4) studies during development, which includes the development of parts of the system and the integration and testing of these parts; and (5) current engineering, which is what takes place while the system is operational and being refined. Those definitions bring to the "waterfall" model with implement the true Command and Control (C2) approach based on an hierarchical three level structure with 'Leading' on top, followed by 'Managing' and 'Doing' at the bottom.

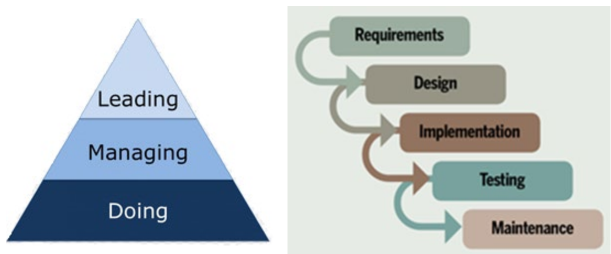

Figure 2: The "Waterfall" model

The continue emerging of technologies and new advances implementation of traditional discipline makes no single universal definition of systems engineering applicable. Frequently it is defined by the context in which it is embedded and could be referred as follows: "an interdisciplinary approach to translating users' needs into the definition of a system, its architecture and design through an iterative process that results in an effective operational system. Systems engineering applies over the entire life cycle, from concept development to final disposal".

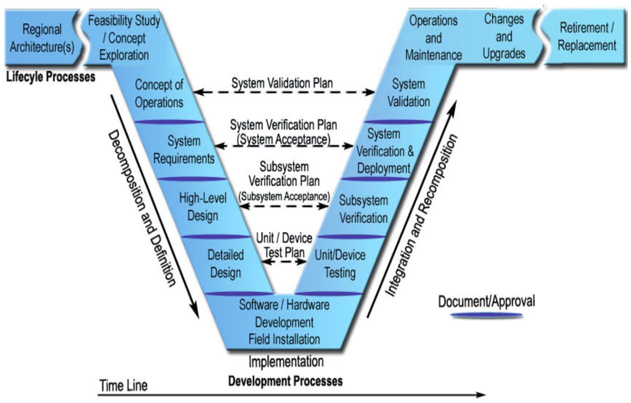

Figure 3: The "V" model

Source: redrawing of the V-model, U.S. Dept. of Transportation (2009)

Starting from a concept of operations, decomposing it by means of requirements (actually from user operational needs to system and subsystems requirements) down to implementation then moving up to system level, integrating and verifying unit by unit delivering and commissioning the system until final acceptance. And subsequent operational maintenance, disposal and possible replacement. The waterfall model was introduced by Royce (1970) to show relationship between design and testing activities as extensively described by Myers (1979) later on. While the V-model was first mentioned by Rook (1986) as a tool illustrating the concept of verification of products at establishing milestones. Might worth to note that the "V" model is a redrawn "Waterfall" having the last two phases (Testing and Maintenance) moved up. Both those models have some undesired issues, namely:

- Lack of prevention of defects.
- Failure to consider customer changes during the deployment phase (which could be years long) of the system

Lack of prevention of defects -as well as user needs changes- improve late costs and might delay the expected outputs. Experienced project managers know that one in three software projects are considered truly successful with large projects and even the smallest of software projects fails one in ten times according to Chaos report (2015). Mainly delayed or over-budget. However "quality comes not from inspection, but from improvement of the production services " as stated by Deming (2000) in his publication therefore a complete different approach should be adopted. The time for a more adaptive software development approach was ready and the *Manifesto for Agile Software Development* comes out from a ski resort meeting in the Wasatch mountains of Utah on February 2001. It could be snapshotted as:

- Individuals and interactions over processes and tools.
- Working software over comprehensive documentation.
- Customer collaboration over contract negotiation.
- Responding to change over following a plan.

There are 12 principles forming the Agile Manifesto but behind all at the very end is passion and communication. Should we focus on "building the right thing", "building the thing right" or "building it fast"? Ideally we want all three, but it's hard to find the balance.

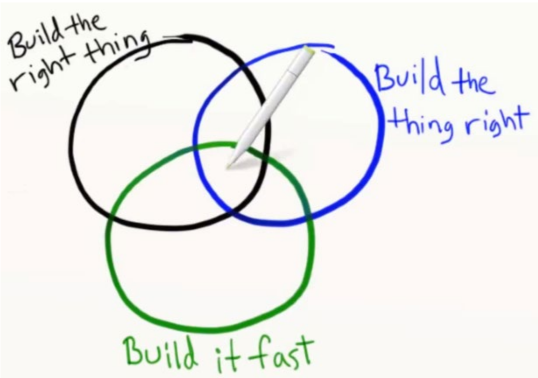

Figure 4: To build the right thing right and fast

Source: redrawing of Henrik Kniberg, *Agile Product Ownership in a Nutshell* (2012)

Product Owners (POs) tend to focus on building the right thing. Teams tend to focus on building the thing right. And Scrum masters, or agile coaches, tend to focus on shortening the feedback loop. Spending too much time to trying to get it perfect, may miss the market window or run into cash-flow problems. Otherwise rushing to turn a prototype into a usable product might be great for the short term, perhaps, but in the long term will soon be drowning in technical debt. Also building a beautiful cathedral in record time could be great except that the users didn't need a cathedral. Adopting Scrum and Kanban as Agile frameworks look like the panacea for few years, however using those tools do not guarantee that the teams being agile. People outside software development teams might find those additional Agile rules of zero value for them. It comes up to 2015 approximately when Dave Thomas, one of the creators of the Agile Manifesto, declared: "Agile as dead, stating that the values of being agile have been totally lost behind the implementation". Actually before committing to anything, it's important to experiment those rules to ensure they are value (not noise) added to the context. Between the main critics to Agile are:

- no-vision,
- lack of transparency, and, non the less,
- the Echo Chamber trap (it is a group situation where information, ideas, and beliefs are uncritically bounced from insider to insider and amplified, while dissenting views are censored and/or ignored) believing that certain Agile rules, successfully used for a product, should blindly be adopted to others.

Sometimes be agile is backed up by the Pareto principle, also known as (AKA) the 80/20 rule, which states that 80% of the results stem from 20% of resources. Those results are the best return of investment (ROI), therefore it might worth to switch to something else in order to maximise ROI. However empirically verified many times, the Pareto principle is arguably applicable in many contexts, it is not always easy or possible to escape from completing a task!

2. Embracing complexity

The true is that world around us changes and still changing fast, we need to embrace complexity even when considering technology developments.

Figure 5: Embracing Complexity, HBR magazine

Source: Harvard Business Review magazine, hbr.org (2011)

2.1. Society, Organisations, Actors and Innovations

It is not possible any longer to focus on physical dimension of the society alone as it happened in the past.

It run the risk of focusing upon the technology-oriented development, at the expense of consideration for the human-oriented development.

Our society becomes more complex and heterogeneous, it has to face the challenges of new situations typical for new domains. We move from system approach to service approach which is trans-disciplinary and trans-organisational, as a service is created by a multidisciplinary approach with the involvement of multiple organisations, but it does not belong to any discipline or any organisation. Developments -even truly technical, engineering developments- should focus to embracing the four domain dimensions of the society which are not independent by interacting each-other from physical to social domains.

- **Physical** Domain:
  - where effects take place and where other supporting infrastructure and information systems exist.
- **Information** Domain:
  - where information is created, manipulated and shared.
- **Cognitive** Domain:
  - where perceptions, awareness, beliefs, and values reside and where, as a result of sense-making, decisions are made.
- **Social** Domain:
  - where set of interactions between and among force entities take places.

In the context of the traditional economy, guided by added value and the copyright principles of protecting the rights for the goods developed by businesses, it becomes unclear why actors (users) should be encouraged to contribute ‘free of charge’; why the actors need to share their own knowledge, skills and make efforts to develop something, the results of which do not belong to them. However in the context of knowledge based and service-enabled society, the main risk is not the one of not returning one’s investments, but the risk of ‘no innovation’; the risk of being outside the revolutionary tendencies identifying the dynamics of society and participating in innovations arising around them, the risk of losing the knowledge and skills allowing sustainable leadership in each domain.

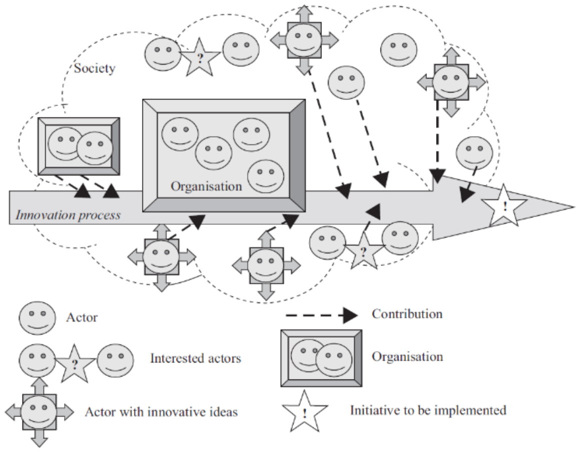

Figure 6: Society

Source: Michel Leonard and Anastasiya Yurchyshyna “Towards contributive development of services” Chapter 1 in “Clean Mobility and Intelligent Transport Systems”, The IET (2015)

We assist to the creation of the public-private partnership (PPP) oriented towards creation of services (PPPS) as reported by Fiorini and Lin (2015, p.11). The main challenge, in comparison to the traditional approach, is to accept the vision that a service is not a product. Services are:

- Information-driven.
- Customer-centric.
- Digital oriented (e-Gov., e-Commerce, etc.).
- Situation-orientation vs. problem-orientation.

Each actor (private, public or individual) is not any more seen as just a consumer or creator of a service, but has become a co-creator, namely “prosumer”. This introduce the cognitive unity in service creation. To make an example, just consider a traffic app for smartphones (such as Waze or CamSam), we all contribute to and benefit from the updated maps.

Figure 7: Example ‘CamSam’ application

Source: Michel Leonard and Anastasiya Yurchyshyna “Towards contributive development of services” Chapter 1 in “Clean Mobility and Intelligent Transport Systems”, The IET (2015)

2.2. Maritime Service Portfolios

The IMO defines e-Navigation (e-NAV) as a vision for the integration of existing and new navigation tools in a holistic and systematic manner with the overall goal to improve safety and reduce errors. The e-NAV "three sides of the coin" representation, shore side, ship side and links in between, should be represented in term of services (Fiorini, 2013, p.5). Mainly operational and technical services. The Maritime Service Portfolios (MSPs) aims to be a tool to define the full spectra of services using best practices in order to harmonise existing services and set framework for further development.

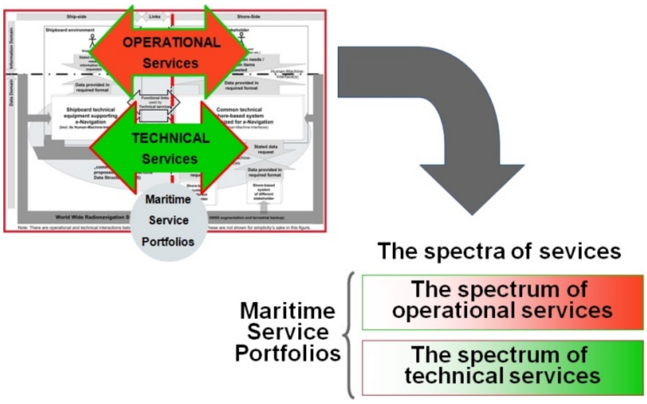

Figure 8: e-NAV Maritime Service Portfolios (MSP)

Source: M. Fiorini, "From Vessel Traffic Services (VTS) to e-Navigation Service Portfolios", Proc. 10th Maritime Systems and Technology conference, Amber Expo, Gdańsk, Poland, 4-6 June 2013, pp. 1-6, MAST (2013)

An example of Operational Service is Search And Rescue (SAR) which is deployed making use of Automatic Identification System (AIS), Communications and Radio Direction Finders (RDF). Communications could themselves be decomposed by VHF, HF, MF, SAT and so forth.

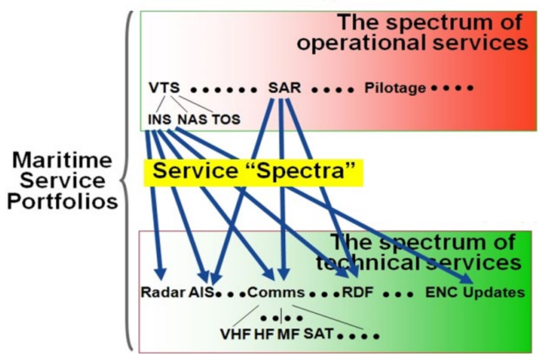

Figure 9: MSP – spectra of services

Source: J-H Oltmann, "The Structure of Maritime Service Portfolio(s) (MSP)", Proc. e-Navigation Underway 2013 conference, voyage plan Copenhagen-Oslo-Copenhagen, 29-31 Jan (2013)

2.3. How to do more with less?

World is changing constantly and product cycles are shorter and shorter. Doing the right things, right, and fast is not enough anymore. In order to lead the market companied need to do more all cheaper! To achieve those results Operational Excellence might help and one common mistake to avoid is to look at the available budget first and then decide the activities or products/services upon the budget. This approach, commonly used, bring more often than not to deliver something that is not fit-for-purpose and therefore produce waste. The concept should be extended to all resources required to complete each piece of work; budget is synonymous with resources.

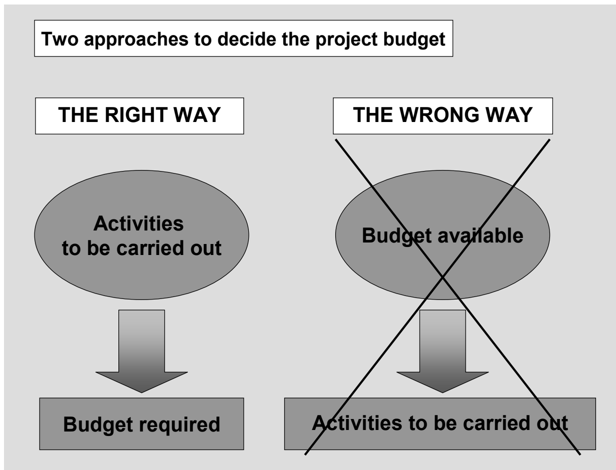

Figure 10: The right approach to resources (budget is synonymous of resources)

Source: Interact Point Qualification and Transfer: "Financial Management Handbook"; 2006; p. 80

2.4. The Community approach

In order to be competitive on the market an efficient cooperative business models have to be implemented.

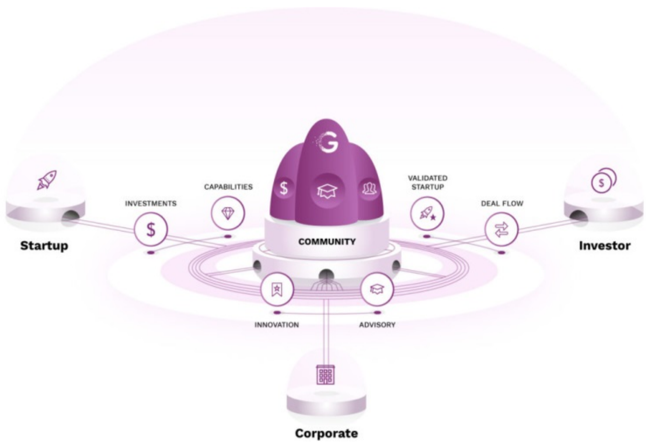

Figure 11: Startup, Corporate and Investor ecosystem

Source: courtesy of Gellify.com

The innovation is based on a platform that connects high-tech B2B start-ups with traditional companies to innovate processes, products and business models through investments and thanks to the know-how of experts specialised in software enterprise and Software as a Service (SaaS) products. For a start-up the model is interesting because it lays the foundations to solving organisational, operational and strategic problems that are typical of a new business keeping a focus on the key phases of business development by providing tools and competences that are consolidated on experienced corporate processes. It is a virtuous process whose business plan requires less financial support, allowing the founders of the start-up to acquire greater market value with a less risky business plan and better growth perspectives. At the same time consolidated companies are not always the ideal context for the most disruptive innovations: in these cases, in order to be successful, innovation should come in the form of a new business. This approach prevent corporate (i.e. consolidated companies) to be flexible and nimble to innovate at the market speed. Innovation needs specific competences that are connected to strategy and governance. Yet, in order to carry out significant changes, it is essential to create the prototypes and projects that make strategy turn into reality, by taking advantage of the typical competences and technologies of the digital world. In reality most of the project fails and the organization need to re-start constantly. That is possible only for a start-up, not for a large corporate organization. The Community approach is also a win-win for the investors who benefit from the agile and experience of the other two type of business partners.

2.5. From Performance to Experience

A current mantra is business organization of any size is to put customer at the centre but what does it mean to be customer centric? Currently business review meetings (as well as some manager's bonus) are regulated by a number of Key Performance Indicators (KPIs) which are quantifiable measures that companies use to gauge performances against key business objectives. They are fine but actually does not express any information about the customer experience. They are still focus on tangible outputs, few examples are: number of customers retained, percentage of market share, average ticket resolution time and so on. However to stay on top of the market is now necessary to start measuring customer experience and therefore move from KPIs to KEIs (Key Experience Indicators) which provide a quantitative score of a specific, important, and actionable phenomenon related to using a product or service. An example is the Google's HEART framework designed by Rodden et al. (2010, p.2) from Google's research team. The idea is a simple one; to deliver a series of user-centred metrics that allow you to measure the user experience on a large scale (Rodden, 2015). These metrics can then be used for decision making in the product development process (Bonnie, 2018).

	GOALS	SIGNALS	METRICS
Happiness	Users find the app helpful, fun, and easy to use	• Responding to surveys • Leaving 5-star ratings • Leaving user feedback	• Net Promoter Score • Customer satisfaction rating • Number of 5-star reviews
Engagement	Users enjoy app content and keep engaging with it	• Spending more time in the app	• Average session length • Average session frequency • Number of conversions (consuming content, uploading files, purchases, etc.)
Adoption	New users see the value in the product or new feature	• Downloading, launching app • Signing up for an account • Using a new feature	• Download rate • Registration rate • Feature adoption rate
Retention	Users keep coming back to the app to complete a key action	• Staying active in the app • Renewing a subscription • Making repeat purchases	• Churn rate • Subscription renewal rate
Task Success	Users complete their goal quickly and easily	• Finding and viewing content quickly • Completing tasks efficiently	• Search exit rate • Crash rate

Figure 12: Google HEART Framework Example

Source: Emily Bonnie (2018), How to Use the Google HEART Framework to Measure and Improve Your App's UX.

3. Bio-Inspired Technologies

Wrenches have two jaws, often shaped like crabs claws and – in some cases – one of them is arranged as a movable finger adjustable through a worm screw mechanism; cranes are used to lift and move heavy loads; fins are essential parts of surfboards, and airplanes have wings, some of them made of manufactured honeycomb structural materials. Helicopters owe their shapes to dragonflies, the same way as radar and sonar owe their functions to bats and dolphins and phased arrays radars to insect compound eyes.

The idea of getting inspired by Nature is not new. From time immemorial, humanity have seen in Nature the primary source of inspiration for solving problems of any kind, developing technologies and building artefacts and tools for everyday life. Though it is not a solution for every kind of problems, bio-inspiration is often a successful strategy in problem solving. To make a couple of meaningful examples, Gustave Eiffel was inspired by the structure of the human femur when designing the iconic shape of his Tower. Eiffel anticipated topology optimization, a mathematical method for optimizing material layout within a given design space for a given set of loads, boundary conditions and constraints with the goal of maximizing the performance of the entire system. Nowadays, topology optimization is used in conjunction with finite elements multi-scale modelling in bio-inspired multi-objective optimization. These methods are extensively used for additive manufacturing. Velcro is probably the best known example of bio-inspired material in everyday use. The sticky material was actually inspired by the way plant burrs stick to dog hair. In 1941, the Swiss engineer George de Mestral looked at the burrs under a microscope and noticed they contained hundreds of tiny hooks that could catch on loops of hair or clothing. He developed a material based on this and called it Velcro, from the French words velours, meaning velvet, and crochet, meaning hook. The Eiffel Tower and Velcro are two notable examples of bio-inspiration; none of the two is a biotech outcome. Indeed, bio-inspired technologies and biotechnologies are two different, well-separate concepts and frameworks; actually, many bio-inspired technologies have little to do with biology, except for being inspired from Nature; however, the vast majority of the new bio-inspired materials are produced through suited biotechnologies. Bio-inspired technologies are, as of today, an ever-enlarging array of technologies all of them inspired by Nature (although in many different degrees) including ‘smart’ functional materials, clinical medicine and prosthetics, artificial intelligence, autonomy, robotics, computer vision, nanotechnologies, communication networks and protocols, cyber security, etc. Also, design and architecture, and economy too, are experiencing a bio-inspired revolution.

3.1. Swarm Intelligence

Swarm intelligence is the collective behavior of decentralized, self-organized systems, natural or artificial. Which is the core of distributed, collective Artificial Intelligence (AI) mimicking complex organisations like bird flocks, fish schools and insect colonies. The expression was introduced by Gerardo Beni and Jing Wang in 1989, in the context of cellular robotic systems and are now at the forefront of research for practical applications with flying drones which are upon us for military and civil applications including the transport of people. Emirates announced that a chauffeur-less drone taxi service will made available to Emirates Skywards Platinum members between any location in Dubai and Dubai International Airport from April 2020.

Figure 13: Emirates Skywards (public domain image)

Source: arabianbusiness.com

The swarm intelligence algorithms are characterised of simplicity, uncertainty, interactivity, distributed parallelism, robustness, scalability, and self-organisation. As an example, it is possible to consider a swarm of fireflies. Each individual firefly has its own blinking frequency, but it perceives the local flashing of nearby fireflies. If the flash of other fireflies exceeds a given luminosity threshold, the firefly receies an excitation reinforcement feedback, so it flashes and it reset its excitation to zero, immediately after having flashed; otherwise it receives an inhibition feedback and it reset its excitation to zero, without flashing, as if it had just flashed, The simple, distributed algorithm results in swarm blinking synchronization. The protocol suitable for synchronizing a swarm of impulses is named Carrier Sense Multiple Access Collision Engagement (CSMA-CE), as opposite to Collision Avoidance.

Figure 15: Leonardo s.p.a. unmanned aircraft AWHERO, (public domain image)

Source: leonardocompany.com

Initially conceived to cater to military needs, the unmanned aircraft AWHERO is a new user in civil sector, used to patrol of land and sea borders, monitoring migration flows, combating human traffickers, tackling piracy and smuggling, as well as protecting critical infrastructure and supporting disaster relief operations. Currently AWHERO is used for maritime surveillance capability demonstrations on ships in the framework of the OCEAN 2020 initiatives contracted to Leonardo s.p.a. which lead a team of 42 prime European aerospace companies. OCEAN 2020 is an European defence fund strategic research programme for naval surveillance technology and maritime safety.

3.2. Optical tracking

Detection, classification, and tracking of people and vehicles are fundamental processes in intelligent surveillance systems. Optical tracking features are now present at different stages of development and integration in almost all surveillance applications, fixed or mobile, equipped with cameras. The marine and maritime sector is not excluded from the possibility of using UAVs (Unmanned Aerial Vehicles) based solutions. For example, underwater robots are able to gather environmental information, scour and sediment transport analysis, meanwhile remote controlled drone ships without crews on board are already at a later stage of development. To achieve the goal of developing (semi-)autonomous boats, reliable vision-based methods for vessel detection, classification, and tracking are presented by Bloisi et al. (2017, p.824). Cameras (as a passive system) are also used for tracking and classification of targets in context when electromagnetic emission are not allowed such as the Grand Canal in Venice, for example.

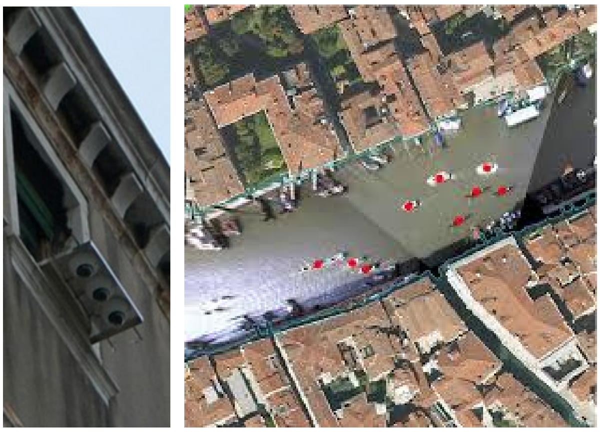

Figure 16: Automatic Remote Grand canal Observation System (ARGOS) installed in Venice, Italy

Source: D. D. Bloisi et al. (2015), “ARGOS-Venice Boat Classification”, 12th IEEE Int. Conf. on Advanced Video and Signal Based Surveillance (AVSS)

3.3. Passive Radar

Passive radar systems encompass a class of radar systems that detect and track objects by processing reflections from non-cooperative sources of illumination in the environment, such as commercial broadcast and communications.

Figure 17: Leonardo s.p.a. Passive covert radar AULOS®, (public domain image)

Source: leonardocompany.com

According to Greco et al. (2018, p.112) the Leonardo s.p.a. AULOS® is a passive covert radar system designed to provide detection and tracking capability for defence and homeland security applications. The system works by processing reflections from illumination sources such as commercial broadcast and communications signals. AULOS® in an eco-friendly system since it doesn't produce electromagnetic pollution.

3.4. Cognitive Radar

Cognitive radars are systems based on the perception-action cycle of cognition that sense the environment, learn from it relevant information about the target and the background, then adapt the radar sensor to optimally satisfy the needs of their mission according to a desired goal. The essential feature that differentiates cognitive radars from classic adaptive radars is the active feedback between receiver and transmitter which extend the classic concept of adaptivity, (already known since early 60’s) to the transmitter. The concept of cognitive radar was introduced originally for active radar but this paradigm can be applied also to passive radar. Applications are:

- cognitive active radars that work in a spectrally dense environment and change the transmitted waveform on-the-fly to avoid interference with the primary user of the channel, such as broadcast or communication systems,
- cognitive active radars that adjust transmit waveform parameters to achieve a specified level of target tracking performance, and
- cognitive passive radars, that contrary to the active radars cannot directly change the transmitted waveforms, but can instead select the best source of opportunity to improve detection and tracking performance.

A classical adaptive radar is able to extract information from the target and the disturbance signals through appropriate signal processing algorithms and to use that information at the receive level to improve its performance. A cognitive radar conversely is able to use all the extracted information not only at the receive level but also at the transmit level by changing on-the-fly the transmit frequency channel, waveform shape, time-on-target, pulse repetition frequency (PRF), power, number of pulses, polarization and so forth. In an adaptive radars all these parameters are pre-set and cannot be changed on-the-fly. It is often cooped with a database contain environmental information such as Digital Terrain Elevation Models (DTEMs) or Digital Elevation Models (DEMs), meteo data and SAR-GIS maps populated using an Knowledge-Aided (KA) cognitive data.

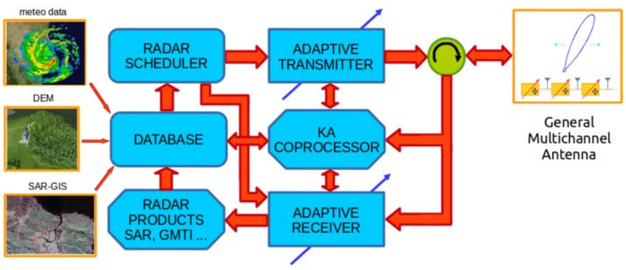

Figure 18: Block scheme of a cognitive radar signal

Source: A. De Maio, A. Farina, "Cognitive Radar Signal Processing", NATO lecture, EN-SET-216 -06

Similar considerations (the principle is the same) could be extended to systems, namely cognitive systems.

4. Conclusions

The observation of the Nature has driven humans evolutions from centuries and seems to continue to be an essential source of inspirations for engineers to innovate and drive the change. A new business model and some bio-inspired technologies have been presented and explored with some practical applications. The paper aims to offer the reader with an overview of technologies as well as business models foresight to drive future investments and developments for maritime traffic management and border control systems.

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References

Frontex website: https://frontex.europa.eu/, last accessed in December 2019

International Association of marine aids to navigation and Lighthouse Authorities - IALA (2008), *Vessel Traffic Services Manual*, ed. 4, St. Germain en Laye, France, pp. 195

Encyclopaedia Britannica, Chain Home – Radar Technology webpage: https://www.britannica.com/technology/Chain-Home, last accessed in October 2019

History of Systems Engineering, INCOSE website https://www.incose.org/about-systems-engineering/history-of-systems-engineering, last accessed in October 2019

Hall, Arthur David (1962), *A Methodology for Systems Engineering*, Bell Laboratories series, 4th ed., ISBN 978-0442030469, Van Nostrand Reinhold Inc., USA, pp. 478

Myers, Glenford (1979), *The Art of Software Testing*, New York (USA), John Wiley & Sons Inc.

Deming, William Edwards (2000), *Out of the Crisis*, MIT Center for Advanced Engineering Study, ISBN 978-0-262-54115-2, Cambridge, Massachusetts , USA, pp. 524

Rook, Paul (1986), *Controlling software projects,* Software Engineering Journal, Vol. 1, Issue 1, DOI: 10.1049/sej.1986.0003, The IET, UK, pp. 7-16

Royce, Winston Walker (1970), *Managing the Development of Large Software Systems*, proceedings of IEEE WESCON, pp. 1-9

Standish Group's 2015 Annual CHAOS report

Manifesto for Agile Software Development, the Agile Manifesto History , https://agilemanifesto.org/history.html, last accessed in October 2019

Fiorini, Michele and Lin, Jan-Chin (2015), *Clean Mobility and Intelligent Transport Systems*, The IET, Transportation Series 1, ISBN 978-1-84919-895-0, UK, pp. 464.

Fiorini, Michele (2013), *From Vessel Traffic Services (VTS) to e-Navigation Service Portfolios*, Proc. 10th MAritime Systems and Technology conference (MAST), Amber Expo, Gdańsk, Poland, 4-6 June 2013, pp. 1-6

Oltmann, Jan-Hendrik (2013), *The Structure of Maritime Service Portfolio(s) (MSP)*, Proc. e-Navigation Underway 2013 conference, voyage plan Copenhagen-Oslo-Copenhagen, 29-31 Jan 2013, pp. 1-4

The Lean Way Blog, the 8 Wasted of Lean by Nawras Skhmot, 5th Aug 2017, https://theleanway.net/The-8-Wastes-of-Lean, accessed in November 2019

The Interaction Design Foundation, Google's HEART Framework for Measuring UX, https://www.interaction-design.org/literature/article/google-s-heart-framework-for-measuring-ux accessed in November 2019

Rodden, Kerry, et al. (2010), Measuring the User Experience on a Large Scale: User-Centered Metrics for Web Applications, Proceedings of CHI, ACM Press, pp. 1-4

Rodden, Kerry (2015), *How to choose the right UX metrics for your product*, available on-line at https://library.gv.com/how-to-choose-the-right-ux-metrics-for-your-product-5f46359ab5be accessed in December 2019

Bonnie, Emily (2018), *How to Use the Google HEART Framework to Measure and Improve Your App's UX*, available on-line at https://clevertap.com/blog/google-heart-framework/ accessed in November 2019

Leonardo s.p.a. Collective Work (2018), *Chapter 1 Bio-Inspired Technologies*, in Technology Trends Digest - A selection of technologies that are to revolutionize our lives, Third Edition, pp. 5-18

Bloisi, Domenico Daniele et al. (2017), *Enhancing Automatic Maritime Surveillance Systems With Visual Information*, Intelligent Transportation Systems IEEE Transactions on, vol. 18, no. 4, pp. 824-833

Leonardo s.p.a., *A HERO for our times*, available on-line at https://www.leonardocompany.com/en/news-and-stories-detail/-/detail/hero accessed in November 2019

Open Cooperation for European mAritime awareNess (OCEAN) 2020, European Defence Agency 2018-2021 project, https://ocean2020.eu/ accessed in November 2019

Greco, Maria Sabrina et al. (2018), *Cognitive Radars: On the Road to Reality: Progress Thus Far and Possibilities for the Future*, IEEE Signal Processing Magazine, Volume: 35, Issue: 4, DOI 10.1109/MSP.2018.2822847 , pp. 112-125