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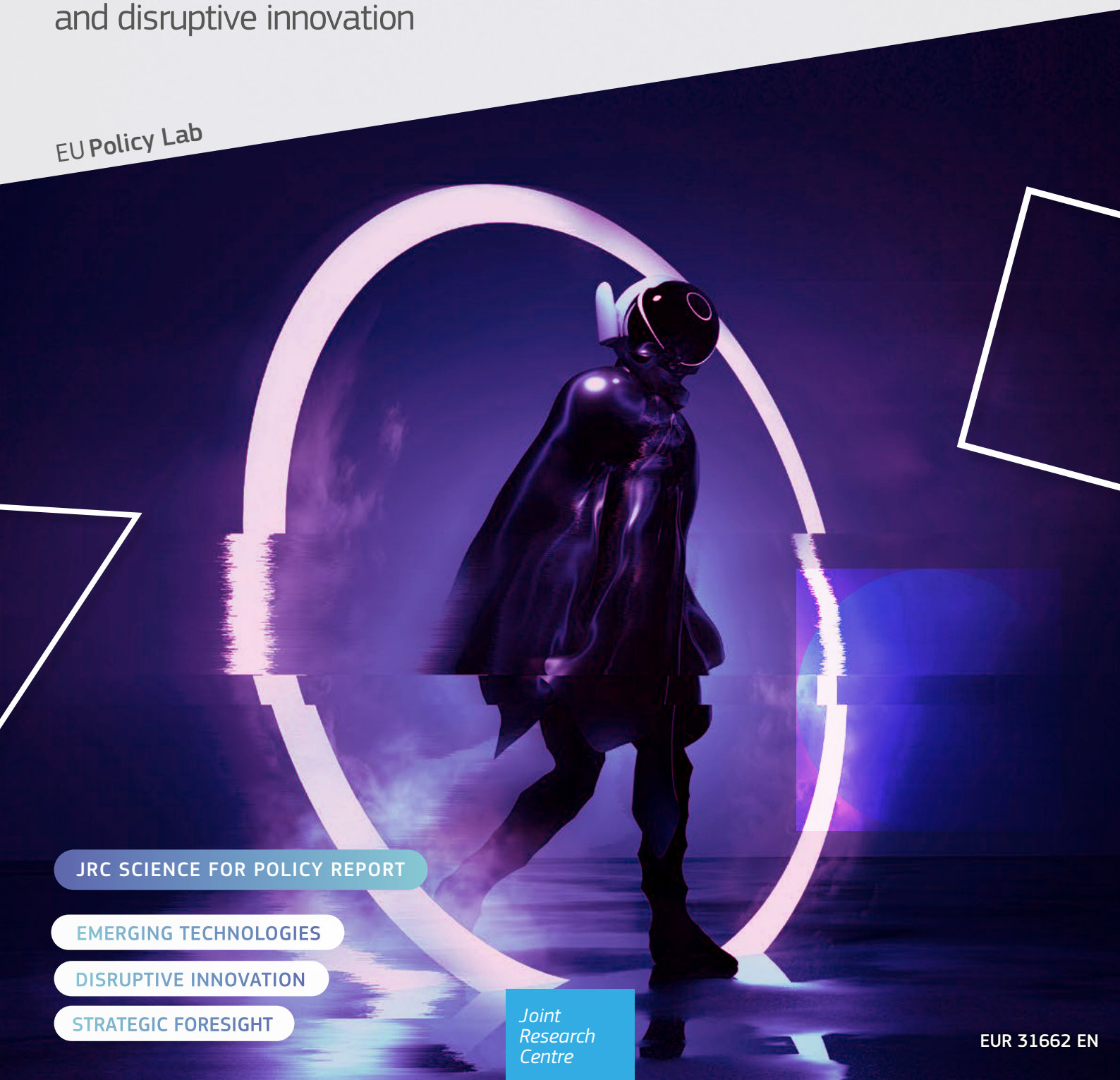
European Commission

EVERYBODY IS LOOKING INTO THE FUTURE!

A literature review of reports on emerging technologies and disruptive innovation

EU Policy Lab



JRC SCIENCE FOR POLICY REPORT

EMERGING TECHNOLOGIES

DISRUPTIVE INNOVATION

STRATEGIC FORESIGHT

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EVERYBODY IS LOOKING INTO THE FUTURE!

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This report is a part of the project 'Anticipation and monitoring of emerging technologies and disruptive innovation' (ANTICIPINNOV), a collaboration between the European Commission Joint Research Centre and the European Innovation Council (EIC).

The EIC is Europe's flagship innovation programme to identify, develop and scale up emerging technologies and disruptive innovations.

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Abstract

Growing volatility, uncertainty, complexity and ambiguity today present major challenges in policymaking. Anticipatory thinking and foresight are of utmost importance to help explore trends, risks and emerging issues, and their potential implications and opportunities in order to draw useful insights for strategic planning, policymaking and preparedness.

This report is a part of the project 'Anticipation and monitoring of emerging technologies and disruptive innovation' (ANTICIPINNOV), a collaboration between the European Commission Joint Research Centre and the European Innovation Council (EIC).

The findings include a set of 106 signals and trends on emerging technologies and disruptive innovations across several areas of application. It is based on a review of key reports on technology and innovation signals and trends produced by public and private bodies outside of the EU institutions. Its goal is to strengthen the EIC's strategic intelligence capacity through the use and development of anticipatory approaches that will - among other goals – support prioritisation in innovation funding. Other insights were identified, namely those related to the scope of EIC programme manager portfolios.

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Executive summary

This document contains a review of third-party reports (produced outside of EU institutions) in technology and innovation signals and trends. The main objective is to provide an overview of the technologies and innovations currently being highlighted and discussed in various forums, in order to support the European Innovation Council (EIC) strategic intelligence with benchmarking knowledge.

Sources and signals were selected to cover several policy and technology domains of interest for the EU, including, but not limited to, those already covered by the 10 EIC programme manager (PM) portfolios. Diversification of authors and their inherent perspectives was key, as was covering multiple technology readiness levels (TRL), policy and economic domains, and application use cases. The signals and trends present various degrees of novelty, coming from organisations as diverse as generalist and specialised consultancies, research and technology organisations, policy think tanks, intergovernmental organisations and public sector entities.

The main findings point out to a higher number of breakthroughs in the following application domains:

- healthcare;
- digital products & services;
- space;
- logistics & mobility;
- energy; and
- agriculture & food.

The technologies and innovations spotted more frequently were:

- artificial intelligence;
- gene-engineering;
- internet of things;
- augmented reality; and
- internet of the body.

The signals were connected to the 3 EIC Macro Areas (Digital & Industry; Green and Health) and to the current 10 EIC PM portfolios (see section 2.2.4 for the full list). This analysis allowed the authors to extract some insights that could support the EIC in adapting their PM portfolio strategy, namely by:

- covering domains not included in the scope of current PM portfolios (e.g. mobility);
- defining a strategy for enabling technologies that are cross-cutting (e.g. artificial intelligence);
- addressing possible overlaps of topics among two or three PM portfolios (e.g. health and green energy) or find their gaps and synergies (e.g. convergence of biotechnology and advanced medical devices);
- balancing the approach based on policy/application domains and/or technology fields; and
- addressing the challenges of PM portfolios covering a wide range of technologies (e.g. space, agriculture & food, architecture, engineering & construction).

CHAPTER 1

Introduction

Growing volatility, uncertainty, complexity and ambiguity today present major challenges in policymaking. Anticipatory thinking and foresight are of utmost importance to help anticipate trends, risks and emerging issues, and their potential implications and opportunities in order to draw useful insights for strategic planning, policymaking and preparedness. This is usually done through evidence-based processes in combination with participatory approaches in a structured and systemic way, to capture a diversity of viewpoints and a broader spectrum of novelty patterns.

This report was produced by the EU Policy Lab – Competence Centre on Foresight, Unit S.1 of the Joint Research Centre. It is a part of the project 'Anticipation and monitoring of emerging technologies and disruptive innovation (ANTICIPINNOV)", set up through a collaboration between the Joint Research Centre and the European Innovation Council (EIC), to strengthen the EIC's strategic intelligence capacity through the use and development of anticipatory approaches.

Its goal is to support EIC strategic intelligence capacity, ranging from EIC challenges and its work programme to EIC reporting and anticipatory governance, in partnership with EIC's main parent DGs such as DG RTD, DG CNECT and DG GROW.

This deliverable is deliverable 1.2 and part of the first work package of the project, which aggregates knowledge collection and production on new developments in future-oriented technology assessment or in science, technology, and innovation foresight at large. This final version (v1.0) builds on two previous drafts (v0.1 and v0.5). This iterative approach allowed the JRC and the EIC to jointly shape the final format and topics.

Even if initially conceptualised as a stand-alone deliverable, the findings presented in this report, have additionally supported the work developed under the second work package of this project (Horizon Scanning), namely by providing weak and strong signals that were analysed and prioritised by experts through participatory workshops. This experience has led to the conclusion that this type of desk research should be partially integrated into wider foresight processes conducted by the JRC in support of the EIC, which should happen in the likely renewal of the current collaboration.

1.1 Methodology

The literature review consisted of a qualitative analysis of third-party reports (published outside of the EU institutions) containing information on technology and innovation trends. Reports were referenced by experts and through online searches using keywords such as 'technology trends', 'trends in technology', 'trends and technology', 'emergent technologies' and 'disruptive technology trends'. Some of these trends are stronger and linked with established fields, others are emergent and weaker and better conceptualised as signals[1]. Therefore, we refer to these as 'signals and trends' throughout the report.

The initial search for sources was further based on selection principles agreed in advance with the EIC. These principles include:

- potential contribution to Europe's strategic interests in leading science, technology and innovation (STI) initiatives in key strategic areas;
- general relevance for the mission of the EIC and its current PM portfolios;
- relevance for the EIC's three strategic domains: Digital & Industry, Green and Health;
- relevance for EIC funding mechanisms, namely Pathfinder, Transition and Accelerator, taking into account information on the TRL or an initial qualitative assessment of its maturity;
- technologies that are emerging (not already commercialised to their full potential) and that may enable or accelerate the development of other emerging technologies or innovations;
- preference was given to sources and trends that provide promising market-oriented application of technologies and/or address a market failure or a field of particular public interest, always with a scale-up potential in mind;
- diversification of authors and their inherent perspectives, including:
  - international organisations or forums;
  - business and investor-oriented consultancy firms;
  - research-focused organisations;
  - media and platforms specialised in technology;
  - public agencies; and
  - preference to the most updated sources namely those published in 2021, 2022 and 2023.

The principles listed above were developed for v0.1 and maintained for later versions. For v0.5, special attention was given to specific technologies and domains of application that were under-represented in v0.1, namely: quantum, space, biotechnology, electronics, robotics, metaverse and others. In v1.0 of the report, new research sources were added by searching for technology trends directly connected to the blue economy and mobility, as these fields were identified for strengthening.

For the final version, signals and trends identified in new reports that were not considered as new technologies or new uses were connected to existing signals and trends, and were used to complement their descriptions. Some of the existing signals and trends that touched on subjects discussed in the new reports, even if not directly connected, were expanded upon. Additionally, most of the existing signals and trends were expanded with information from their original source.

From an initial mapping and review of more than 170 potential reports, websites or articles, the authors selected a total of 24 sources, following the principles listed above and based on what they considered to be the most comprehensive and forward-looking ones. Source reports and authors of v1.0 include those from v0.1 and v0.5, plus additional documents that provided additional signals and trends . The list of used sources is as follows.

Initial core sources reviewed in v0.1:

- *Top 10 Emerging Technologies of 2021* - World Economic Forum
- *Tech Trends 2022* – Deloitte

1 Signals are tangible manifestations of novelty in science, technology, innovation, markets, media, and other fields. They are raw informational material that can drive our focus to certain possibilities instead of others.

- *Game-Changing Technologies for Healthcare & Pharmaceutical (2021)* – ITONICS
- *Game-Changing Technologies for Energy (2021)* – ITONICS
- *Game-Changing Technologies for ICT (2022)* - ITONICS
- *Fraunhofer Institute for Technological Trend Analysis / Trend News* – Fraunhofer
- Digital healthcare: patient-first? – Dealroom
- *The Future of Biotech* – USA's National Intelligence Council
- *Future technology: 22 ideas about to change our world* - BBC Science Focus
- *Disruptor Alert newsletter* - Futures Platform
- *Technology Vision 2022 - Meet Me in the Metaverse* – Accenture

Additional core sources reviewed in v0.5:

- Future Uses of Space Out to 2050 – RAND
- Commercial and Military Applications and Timelines for Quantum Technology - RAND
- Top Technology Trends 2021 – IDTechEx
- Tech Trends Report - Key Insights - Future Today Institute
- Tech Trends Report - Metaverse, AR/VR & Synthetic Media - Future Today Institute
- Tech Trends Report - Synthetic Biology, Biotechnology & AgTech - Future Today Institute
- The Trend Radar for the mid-sized sector - What trends matter in 2021+ - Trend one
- Exploring Biodigital Convergence - Policy Horizons Canada

Additional core sources reviewed in v1.0:

- 2023 Tech Trends Report (2023) – Future Today Institute
- Tech Trends 2023 (2023) – Deloitte Insights
- McKinsey Technology Trends Outlook 2022 (2022) – McKinsey & Company
- 8 Trends Critical to a Vibrant Blue Economy (2022) – S2G Ventures
- The Travel and Mobility Tech Sector Attractiveness Report (2022) – TNMT (Lufthansa Innovation Hub)

The complete list of sources mapped and analysed can be found in Appendix 1 of this report.

The current literature review provides an overview of which recent third-party sources surface the most emerging signals and trends. Therefore, it should be complemented with detailed information contained in the sources themselves or other documents[2]. This is above all an exploratory and incremental output based on preliminary desk and qualitative research. Its goal is not to be exhaustive, but to help understand what kind of information was recently published by reference organisations in various fields. It is mainly through the lenses and filters of such sources that signals and trends presented in this report were mapped as relevant and potentially game-changing.

Finally, the reader should note that the taxonomies of the underlying technologies and of the areas of application, used throughout this report, were agreed with the EIC strategic intelligence team, even if they should still be treated as testbed for further developments. They bear different levels of granularity, assumed throughout the report as the likely result of the different levels of novelty of the signals and trends reviewed.

2 Given the targeted scope of the work in this administrative arrangement, this document does not aim to replace the independent expert report '100 Radical Innovation Breakthroughs for the future' produced in 2019 for the European Commission and containing significant information of emerging and disruptive technologies and potential applications.

Technology and innovation signals and trends

2.1 Overview

This final version includes 106 signals and trends as the result of an iterative process. 52 were identified in v0.1, from an initial list of 70 that was preliminarily shared and assessed with the EIC. Some were recurring or closely interconnected and have therefore been merged. For v0.5, an additional set of 30 signals and trends were added (from an initial group of 38 signals that were similarly assessed and merged) resulting in a second preliminary list of 82 signals and trends. For the current final version v1.0, a set of 24 additional signals and trends were added from an initial list of 45 (some of which were merged with pre-existing ones), resulting then in the final list of 106.

Signals and trends have been sorted according to the most applicable of the three EIC priority macro-areas that constitute the EIC challenges: Digital & Industry; Green; and Health. When a signal or trend is connected with more than one challenge area, the most relevant is selected; for instance, a digital solution for a healthrelated challenge was classified under Health, but a digital solution for businesses is under Digital & Industry. In the same way, a digital solution specifically developed for energy saving is classified under Green.

Each macro-area presents a different number of signals and trends. In v0.1, signals related with Health and Green presented a higher level of recurrence across the various sources and were later merged. Signals and trends under the 'digital' label were originally more diverse; since they can carry the potential for wider application areas, the authors decided to maintain its over-representation. In v0.5, this relative weight was increased, to around 46% in a total of 82 identified signals, and the label was renamed 'Digital & Industry' following the EIC's decision. Therefore, the signals included in v0.5 decidedly contributed to a higher representation of Digital & Industry, considering the need to include other technologies and application areas, such as robotics, space, logistics, consumable goods, and manufacturing.

This distribution was slightly altered in v1.0 with the inclusion of 24 new signals, most of which connected to the Green macro-area; among these new signals, travel and mobility, and advancements in clean energy, were highly represented. The relative weight of Digital &

Industry diminished but is still over-represented in relation to the other macro-areas, with a gap of almost 10% in incidence when compared with Green. Throughout the various versions of this report, the conspicuously stable macro-area is Health: from v0.5 to v1.0, only two new signals were added, resulting in v1.0 Health containing exactly half the number of signals of v1.0 Digital & Industry. Both these new signals were related to the blue economy, and particularly to aquaculture.

As of the report's current version, the relative weight of each EIC macro-area is as follows:

- Digital & Industry – 43%
- Green – 35%
- Health – 22%

A preliminary assessment was made for each entry, considering the level of consolidation of each signal or trend. They have been classified in a scale from 1 (emerging signal or trend) to 3 (consolidated trend).

2.2 Key insights

2.2.1 Number of signals and trends

The number of signals and trends per EIC macro-area are as follows:

- Digital & Industry – 46
- Green – 37
- Health - 23

2.2.2 Top areas of application

The following list presents the top areas of application in signals and trends that have been primarily classified in each one of the three EIC macro-areas:

- Digital & Industry
- digital products & services - 17
- space - 15
- logistics & mobility - 13
- healthcare - 9
- education & training - 5
- industry & manufacturing - 5
- Green
- energy - 12
- agriculture & food - 10
- building construction - 7
- environment & wildlife protection - 7
- industry & manufacturing - 4
- logistics & mobility - 4

Health

- healthcare - 19
- pharma - 10
- biotechnology – 7
- agriculture & food - 6
- genomics - 6
- scientific research - 4

2.2.3 Top underlying technologies and innovations

The top five underlying technologies and innovations across all signals and trends are:

- artificial intelligence - 11
- gene-engineering - 10
- internet of things - 7
- augmented reality - 4
- internet of the body - 4

The following list presents the top underlying technologies in signals and trends in each one of the three EIC macro-areas:

Digital and Industry

- artificial intelligence - 4
- augmented reality - 4
- in situ resource utilisation - 3
- internet of things - 3
- launch vehicles [for space] - 3
- metaverse - 3
- quantum sensing - 3

Green

- artificial intelligence - 2
- carbon capture - 2
- gene-engineering - 2
- internet of things - 2
- wind energy - 2

Health

- gene-engineering - 8
- artificial intelligence - 5
- portable medical devices - 3
- internet of the body – 2
- 3D Bioprinting – 2
- Bio-engineering -2

2.2.4 EIC programme manager portfolios

The following list presents the number of signals and trends that have been categorised as relevant for each one of the 10 EIC PM portfolios (some signals and trends are associated with more than one PM portfolio):

- health and biotechnology - 23
- food chain technologies and novel sustainable food - 21
- energy systems and green technologies - 21
- medical technologies and medical devices - 18
- space systems and technologies - 17
- advanced materials for energy and environmental sustainability - 14
- architecture engineering construction technologies - 12
- responsible electronics - 12
- renewable energy conversion and alternative resource exploitation - 8
- quantum tech and electronics - 7
- not directly related with any of the above – 18

Figure 1 below illustrates how signals and trends share connections with PM portfolios. There are at least two clusters of portfolios that overlap frequently on this aspect:

- the three PM portfolios connected with energy and green tech: a) advanced materials for energy and environmental sustainability; b) energy systems and green technologies; and c) renewable energy conversion and alternative resource exploitation; and
- the two connected with health: a) health and biotechnology; and b) medical technologies and medical devices.

These overlaps do not necessarily represent a redundancy. They could actually contain gaps, for instance topics not covered because their ownership is not 'claimed'. They could also represent potential synergies that can be advanced. As an example, signals point to a significant convergence of biotechnology solutions with medical devices. Other signals point to a multitude of solutions in green energy and electronics that might benefit from an integrated approached. In this sense, options to be followed could include merging, specialising, or making scope clear.

Other PM portfolios show more diverse and non-recurring connections. These include: responsible electronics; architecture, engineering and construction technologies; food chain technologies, novel and sustainable food; and quantum tech and electronics. Space systems & technologies is the PM portfolio that bears a higher number of exclusive signals.

In Chapter 3 (Tables 8 to 11), the reader can find the direct connection between each signal and trend and the PM portfolios.

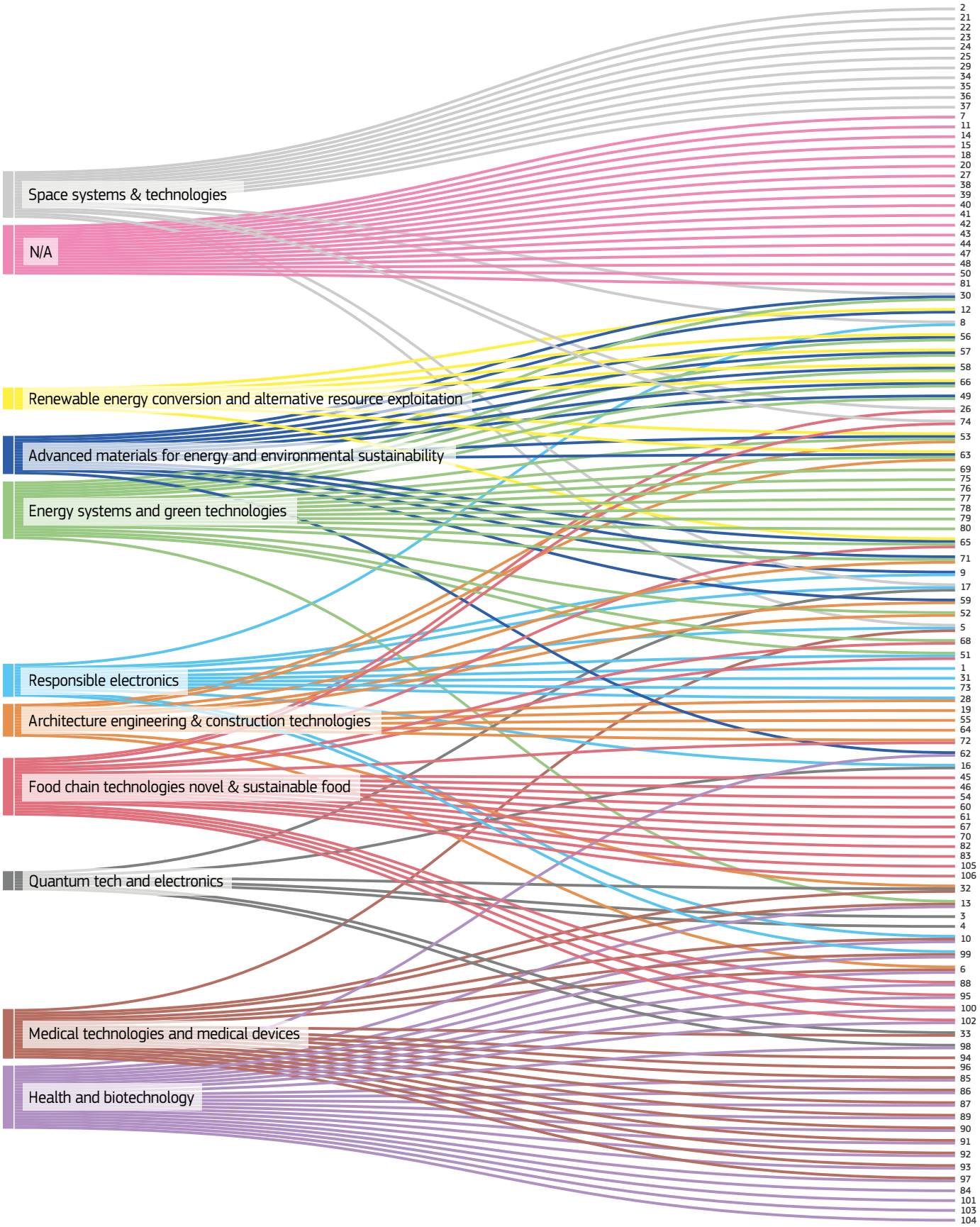
This categorisation of signals and trends further allowed us to bring to light underlying technologies or innovations for which there is currently no direct association with PM portfolios:

- metaverse
- low-code & no-code
- DNA-based data storage
- metacloud
- micromobility modes
- green primary materials
- transportation demand management

Some other underlying technologies or innovations are associated with PM portfolios (following the application examples given by the sources) but seem to lack a 'direct ownership'. In this sense, the EIC should analyse if these (some of them cross-cutting or enabling technologies) could or should be supported. The list is as follows:

- virtual reality
- augmented reality

Figure 1 - Connection between portfolios and signals & trends (see tables in Chapter 3 and 4 for more details)



- ambient computing
- magnetic levitation
- video games
- synthetic fabrics and artificial leather

The same applies to application domains. The following appear not to be covered explicitly by PM portfolios, even if sometimes the signals and trends do point to them through other related applications:

- logistics & mobility
- business administration
- education & training
- leisure & entertainment

These insights could help the EIC assess if and/or how these topics should be covered by existing or new PM portfolios and funding instruments. As third-party literature is pointing to relevant signals and trends in the above mention domains, it is suggested to consider both options, either the inclusion, by explicating or widening the scope of existing PM portfolios, or creating new ones.

Another point to consider is whether the level of granularity or specificity should be diverse from PM portfolio to PM portfolio, as it is today. In that sense, some PM portfolios cover multiple technologies and policy domains (e.g. architecture, engineering and construction), while others take a deep dive into specific technologies (e.g. quantum) or even specific solutions in concrete technology domains (e.g. renewable energy conversion and alternative resource exploitation). Some fields are actually covered by more than one, as pointed out by the clusters above. For further reflection, a final remark ought to be made on whether PM portfolios should be structured around policy domains (or application areas) technology fields (following a taxonomy to be adopted by the EIC), or whether they should continue to be a combination of the two, as they are currently.

2.2.5 Commission priorities

Following the last European elections in May 2019, the current President of the European Commission Ursula von der Leyen presented six political priorities[3] for the five-year mandate. These are derived from the Council's strategic agenda and from discussions with political groups in the European Parliament.

Three of the EC priorities are strongly linked with these signals and trends as the following list details:

- A European Green Deal – 41
- A Europe fit for the digital age - 62
- An economy that works for people – 27
- Promoting our European way of life - 27

As for the remaining two priorities (A stronger Europe in the world;; A new push for European democracy), the technology and innovation signals and trends captured for this report connect to them more indirectly. Some of them cover broader agenda topics in the field of diplomacy, migration, space, rule of law and democratic values and institutions that, even if connected with and/or dependent on some technology developments, they are not necessarily impacted specifically by the breakthroughs analysed in this report.

2.2.6 Missions in Horizon Europe

EU missions[4] are a new initiative of the Horizon Europe research and innovation programme for the years 2021-2027. They present a coordinated effort by the European Commission to mobilise funding and policies to support the EU's green transition and innovation in health, and cover five specific domains. They do not cover all the EU's policy domains or the EIC macro-areas. Therefore, 40% of the signals and trends could not be directly linked to at least one mission. Nevertheless, considering the forward-looking ambition of the missions, it is important to map these relations, in order to provide future-oriented insights to the responsible EC policy departments.

Regarding the signals and trends related with health, they were mainly connected with the mission on Cancer. This was done either because the sources point specifically in that direction, but also because most advances in biotechnology, medical devices or digital tech that enhance scientific research (e.g. high-performance computers, quantum computing, digital twin) could in fact play a role in advancing treatments for the disease and related conditions.

We identified signals and trends for the following missions:

- Adaptation to climate change - 41
- Cancer - 20
- Restore our ocean and waters by 2030 - 11
- 100 climate-neutral and smart cities by 2030 - 17
- A soil deal for Europe - 13
- Not related with at least one mission – 41

3 https://commission.europa.eu/strategy-and-policy/priorities-2019-2024_en
4 https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe_en

2.3 Summary list of signals and trends

The following three tables include the titles of the signals and trends collected. Numbers in the first column correspond to the trends presented in more detail in Chapter 4. They have been ordered by the related EIC macro-area – Digital & Industry, Green and Health.

Table 1-Summary list of signals and trends on *Digital & Industry*

SIGNALS AND TRENDS ON DIGITAL & INDUSTRY	
1	Wireless power feeds IoT devices
2	Low-cost satellites provide connectivity everywhere
3	Safe communication networks via quantum computing
4	More user-friendly quantum sensors to increase responsiveness and accuracy
5	Emotion AI to support decision-making
6	AR, VR and metaverse converge for enterprises and healthcare
7	Use of AI-driven cybersecurity against AI-cyber attacks
8	Soft robots to revolutionise the relation humans-robots
9	Integration of triboelectric nanogenerators for kinetic energy
10	Human-machine networks for human perception and cognitive capabilities
11	DNA for archival purposes
12	Supercapacitors to replace electrolytes in batteries
13	Xenobots for advanced medicine or ocean microplastic gathering
14	Services and data transactions impacted by metaverse and Web3 convergence
15	Ethical use of digital technologies for trust
16	Revolutionising industry with high-performance, biology-inspired and quantum computing
17	Digital twins for optimisation of product/service design
18	Convergence of IoT and edge computing for a decentralised internet of thinking
19	Convergence of IoT, IoB, AR and 5G leading to ambient computing
20	Low-code and no-code is transforming IT development
21	Tech advances and lowering of costs drive new applications and capabilities in space
22	Miniaturisation, satellite constellations and swarms
23	In situ space exploitation
24	A need for a space-based manufacturing
25	Transformative impact of industry 4.0 in space and industry

26	Space-based production of food and other resources and the cultivation of soil
27	Fostering social acceptability of the metaverse
28	Printed and flexible electronics technologies could become omnipresent
29	Modern defence, security and safety increasingly depend on space tech
30	Space-based in-situ resource
31	Magnetic levitation technology enhances industrial production
32	Quantum sensors' advance applications
33	Quantum imaging and illumination
34	Increasing amount of per satellite capacity
35	Growing number of suppliers in the launch market
36	Reusability of parts of launch vehicles
37	Rapid prototyping for cost efficiency
38	AI trust programmes based on social and ethical requirements
39	Metacloud centralises and secures multiple cloud instances
40	Advanced connectivity: IoT for automotive and assembly
41	New hardware and software for micromobility modes
42	Search, inspire and booking platforms attract early-stage investment
43	Software breakthroughs for vehicles
44	Hardware breakthroughs for vehicles
45	Fintech enabling seafood industry efficiency
46	Online food shopping as an enabler of mass changes in consumers' seafood consumption patterns

Table 2 - Summary list of signals and trends on *Green*

SIGNALS AND TRENDS ON GREEN	
47	Value chain decarbonisation in the mobility industry
48	Transportation demand management in cities
49	Lithium-ion, sodium-ion and potassium-ion batteries advances for the mobility sector
50	New propulsion system technologies contribute to the electrification of mobility
51	Intelligent land and crop management
52	Improvements in heating, cooling, and cooking for net-zero emissions

53	New materials such as renewable timber, low-carbon cement, advanced composites and ceramics to reduce carbon footprint of building construction
54	Nitrogen fixation increasing crops productivity
55	Natural materials for 3D printing
56	Distributed energy generation and storage for increasing electric vehicle power consumption
57	Perovskite photovoltaic cells for increased efficiency and as housing material
58	Ionic liquids and molten salts to replace volatile organic compounds
59	Atmospheric Water Generation against water scarcity
60	Ecosystem engineering for more efficiency and increased resilience
61	Genetically modified organisms beyond productivity gains
62	Green funerals to reduce carbon footprint
63	Red bricks as supercapacitors
64	Bio-concrete to heal its own cracks
65	Green hydrogen could help reduce carbon footprint in energy and agriculture
66	Blue hydrogen obtained through carbon capture
67	Growth and diversification of artificial meat, dairy and oils
68	Artificial leaves transform into organic fertilisers and enhance biosequestration
69	Greener fashion
70	Beer made from waste products
71	Recycling wind turbines
72	Bioplastic made of forest and farm waste
73	All-carbon recyclable and printable transistor
74	Terraforming for outer-Earth agriculture
75	Radiative cooling enables solar power to produce energy at night
76	AI in wind farms improving energy output
77	CO_2 storage and transformation into energy
78	First ‘supercritical’ geothermal plant running within the next 6 years
79	Biofuel development from hemp and algae
80	Break-even in fusion power
81	Development of solar-enhanced vehicles
82	Regenerative ocean farming costs may be going down
83	Cell-cultivated seafood will take off

Table 3 - Summary list of signals and trends on ***Health***

SIGNALS AND TRENDS ON HEALTH	
84	On-demand and remote drug manufacturing
85	Breath sensors improving medical diagnostics
86	Nanotech for personalised medicine
87	Intersection of biopharma and health-tech to enable faster treatments and cost reduction
88	Creation of synthetic organisms
89	Bra in-reading robots for personalised medicine
90	Digital twin for personalised medicine
91	Biotech to restore sight
92	Artificial neurons for advancements in medicine
93	3D printed drugs for personalised medicine
94	Videogames in medicine
95	Gene-engineering could revolutionise medicine
96	Proactive and decentralised digital healthcare
97	3D bioprinting of tissues and bones to revolutionise medicine
98	Computer-aided drug discovery augmented by artificial intelligence and quantum computing
99	Body-on-a-chip for testing new treatments
100	Molecular robotics
101	Reversing ageing
102	On-demand molecules and microorganisms
103	Speeding up the design process for biological circuits
104	Biocomputers for diagnosing and treating diseases
105	Innovation in pharma and therapeutics could enable disease prevention in aquaculture
106	Alternative aquaculture feed combines nutritional benefits and environmental gains

Chapter 3 contains summary tables showing the connection of each signal to the application areas and the underlying technologies or innovations. It also contains tables showing the connection of each EIC PM portfolio and the signals. These tables can help the reader develop different overviews, and are complementary to the summary analysis described above, and to the detailed information provided further on.

Chapter 4 contains individual files on each signal or trend regarding its areas of application and the underlying technologies and innovations and the individual categorisation regarding Commission priorities, missions in Horizon Europe, EIC macro-areas and EIC PM portfolios. The files also contain the sources from which the signals and trends were extracted. Appendix 1 lists the sources that were assessed and used in this report.

Summary tables

Table 4 - Areas of application for signals associated with the Digital & Industry EIC macro-area

	Agriculture & Food	Biotechnology	Building Construction	Business Administration	Consumer Electronics	Digital Products & Services	Education & Training	Energy	Environment & wildlife protection	Fashion	Financial Services	Genomics	Healthcare	Industry & Manufacturing	Leisure & Entertainment	Logistics & Mobility	Pharma	Scientific Research	Space	Telecomunications
1								■												■
2	■								■							■			■	■
3						■														■
4								■					■			■				
5				■			■						■		■				■	
6			■	■	■	■	■						■	■		■				
7						■														■
8		■											■						■	
9					■			■		■										
10													■		■					
11						■														
12					■					■										
13									■				■							
14						■														
15						■														
16						■					■					■		■		
17						■	■							■						

	Agriculture & Food	Biotechnology	Building Construction	Business Administration	Consumer Electronics	Digital Products & Services	Education & Training	Energy	Environment & wildlife protection	Fashion	Financial Services	Genomics	Healthcare	Industry & Manufacturing	Leisure & Entertainment	Logistics & Mobility	Pharma	Scientific Research	Space	Telecomunications
18																				
19																				
20																				
21																				
22																				
23																				
24																				
25																				
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38																				
39																				
40																				
41																				
42																				
43																				
44																				
45																				
46																				
Total signals per area	4	2	3	3	3	17	5	3	3	2	4	0	9	5	3	13	0	1	15	4

Table 5 - Areas of application for signals associated with the Green EIC macro-area

	Agriculture & Food	Biotechnology	Building Construction	Business Administration	Consumer Electronics	Digital Products & Services	Education & Training	Energy	Environment & wildlife protection	Fashion	Financial Services	Genomics	Healthcare	Industry & Manufacturing	Leisure & Entertainment	Logistics & Mobility	Pharma	Scientific Research	Space	Telecomunications
47																■				
48						■										■				
49																■				
50																■				
51	■																			
52			■																	
53			■																	
54	■																			
55			■																	
56								■								■				
57			■		■			■												
58								■						■						
59									■											
60	■																			
61	■																			
62									■											
63			■																	
64			■																	
65	■							■						■		■				
66								■								■				
67	■																			
68	■								■											
69	■								■	■										
70	■																			
71		■						■												
72			■						■					■						
73					■	■								■						
74	■																		■	
75								■												
76								■												
77								■	■											
78								■												
79								■												
80								■												
81									■							■				
82	■								■											
83	■																			
Total signals per area	10	1	7	0	2	1	0	12	7	1	0	0	0	4	0	4	0	0	1	0

Table 6 - Areas of application for signals associated with the Health EIC macro-area

	Agriculture & Food	Biotechnology	Building Construction	Business Administration	Consumer Electronics	Digital Products & Services	Education & Training	Energy	Environment & wildlife protection	Fashion	Financial Services	Genomics	Healthcare	Industry & Manufacturing	Leisure & Entertainment	Logistics & Mobility	Pharma	Scientific Research	Space	Telecomunications
84																				
85																				
86																				
87																				
88																				
89																				
90																				
91																				
92																				
93																				
94																				
95																				
96																				
97																				
98																				
99																				
100																				
101																				
102																				
103																				
104																				
105																				
106																				
Total signals per area	6	7	0	0	1	0	0	1	0	0	0	6	19	0	1	0	10	4	0	0

Table 7 – Total number of signals associated with each area of application and each EIC macro-area.

	Agriculture & Food	Biotechnology	Building Construction	Business Administration	Consumer Electronics	Digital Products & Services	Education & Training	Energy	Environment & wildlife protection	Fashion	Financial Services	Genomics	Healthcare	Industry & Manufacturing	Leisure & Entertainment	Logistics & Mobility	Pharma	Scientific Research	Space	Telecomunications
DIGITAL	4	2	3	3	3	17	5	3	3	2	4	0	9	5	3	13	0	1	15	4
GREEN	10	1	7	0	2	1	0	12	7	1	0	0	0	4	0	4	0	0	1	0
HEALTH	6	7	0	0	1	0	0	1	0	0	0	6	19	0	1	0	10	4	0	0
TOTAL	20	10	10	3	6	18	5	16	10	3	4	6	28	9	4	17	10	5	16	4

Table 8 – Underlying technologies or innovations linked to more than one signal.

UNDERLYING TECHNOLOGIES	SIGNALS	NR. OF SIGNALS
3D Bioprinting	91, 97	2
Artificial Intelligence	7, 15, 22, 38, 56, 76, 85, 89, 96, 98, 102	11
Augmented Reality	6, 10, 19, 27	4
Bioengineering	82, 88, 91	3
Carbon capture	68, 77	2
Digital Twin	17, 90	2
Distributed Ledger Technologies	14, 15, 56	3
Edge Computing	16, 18	2
Gene-engineering	60, 61, 88, 95, 99, 100, 101, 102, 103, 104	10
Industrial Internet of Things	25, 40	2
In-situ resource utilisation	23, 24, 30	3
Internet of the Body	10, 19, 87, 96	4
Internet of Things	1, 18, 19, 51, 56, 85, 96	7
Launch vehicles	35, 36, 37	3
Metaverse	6, 14, 27	3
New types of batteries	49, 77	2
Portable Medical Devices	85, 87, 96	3
Quantum communication networks	3, 16	2
Quantum computing	16, 98	2
Quantum sensing	4, 32, 33	3
Robotic assembly	23, 24	2
Robotics	22, 89	2
Virtual Reality	6, 27	2
Wind energy	71, 76	2

Table 9 – Underlying technologies or innovations linked to a single signal. Signals are coloured according to their association to the EIC macro-area.

UNDERLYING TECHNOLOGIES		UNDERLYING TECHNOLOGIES		UNDERLYING TECHNOLOGIES	
3D Building Printing	55	DNA-Based Data Storage	11	Net-zero emissions HVAC	52
3D Medicine Printing	93	DTC online food shopping	46	Next Generation Photovoltaic Cells	57
3D printing	37	Driving strategy	43	Object detection	43
5G	19	Engineered nitrogen fixation	54	Ocean monitoring	82
Aditive manufacturing	37	Exponential Intelligence	5	Organic Photovoltaics	28
Advanced manufacturing	25	Fintech	45	Passive Atmospheric Water Generation	59
Alternative decomposition	62	Flexible electronics	28	Propulsion	21
Alternative feedstock	106	Flexible Supercapacitors	12	Radar and Lidar for vehicles	44
Alternative Synthetic Fuels	66	Food from waste	70	Radiative cooling	75
Ambient Computing	19	Fusion nuclear power	80	Renewable Timbers	53
Artificial Dairy Products	67	Green Hydrogen	65	RNA therapeutics	105
Artificial Eyes	91	Green primary materials	47	SATCOM	34
Artificial Meat	67	Haptic Devices	27	Satellite constellations	22
Artificial Neurons	92	High Performance Computing	16	Satellite swarms	22
Artificial Oils	67	High-throughput satellite	34	Semiconductors	73
Asteroid mining	30	Hybrid life-support system	26	Sensing	27
Autonomous systems	22	Hybrid propulsion	50	SLAM	43
Bio-engineered Concrete	64	Hydrogen fuel cells	50	SIB platforms	42
Biofuel	79	Hydroponic gardens	26	Small satellites	22
Biological circuits	103	Industrial Digital Tools	25	Soft Robotics	8
Biology-inspired Computing	16	Industry 4.0	25	Software-as-Medical-Device	96
Biopharma	87	In-situ space-based food production	26	Solar-enhanced vehicles	81
Bioplastic	72	Ionic Liquids	58	Solar sails	21
Blue Hydrogen	66	Low carbon cement	53	Space debris removal	29
Boat engineering	82	Low cost nano-satelites	2	Space security and awareness	29
Body-on-a-chip	99	Low-code & No-code	20	Supercapacitor	63
Cell-cultivated food	83	Lunar landers and rovers	21	Supercritical geothermal power	78
Computer-Aided Drug Discovery	98	Magnetic levitation	31	Synthetic Fabrics and Artificial Leather	69
Computer-Human Interfaces	10	Metacloud	39	Terraforming	74
Continuous-flow Pharmaceutical Manufacturing	84	Micromobility modes	41	Transportation Demand Management	48
Crop production in microgravity	26	Molecular Robotics	100	Triboelectric Nanogenerators	9
Cyberphysical systems	25	Nanoships	21	Video-games	94
Distributed Energy Resources	56	Nanotechnology	86	Wireless Power Transmission	1
				Xenobots	13

Table 10 – EIC PM portfolios linked to each signal (Digital & Industry EIC macro-area)

	Advanced materials for energy and environmental sustainability	Architecture, engineering and construction technologies	Energy systems and green technologies	Food chain technologies and novel sustainable food	Health and biotechnology	Medical technologies and medical devices	Quantum tech and electronics	Renewable energy conversion and alternative resource exploitation	Responsible electronics	Space systems and technologies	N/A
1									■		
2										■	
3							■				
4							■				
5						■			■	■	
6		■			■	■					
7											■
8									■		
9	■								■		
10					■	■			■		
11											■
12	■							■			
13			■		■	■					
14											■
15											■
16							■		■		
17							■		■	■	
18											■
19		■									
20											■
21										■	
22										■	
23										■	
24										■	
25										■	
26				■						■	
27											■
28		■							■		
29										■	
30	■		■							■	
31									■		
32		■				■	■				
33						■	■				
34										■	
35										■	
36										■	
37										■	
38											■
39											■
40											■
41											■
42											■
43											■
44											■
45				■							
46				■							
Total signals	3	4	2	3	3	6	6	1	9	16	14

Table 11 - EIC PM portfolios linked to each signal (Green EIC macro-area)

	Advanced materials for energy and environmental sustainability	Architecture, engineering and construction technologies	Energy systems and green technologies	Food chain technologies and novel sustainable food	Health and biotechnology	Medical technologies and medical devices	Quantum tech and electronics	Renewable energy conversion and alternative resource exploitation	Responsible electronics	Space systems and technologies	N/A
47											■
48											■
49	■		■								
50											■
51			■	■					■		
52		■	■								
53	■	■	■					■			
54				■							
55		■									
56	■		■					■			
57	■		■					■			
58	■		■					■			
59	■	■									
60				■							
61				■							
62	■				■						
63	■	■	■					■			
64		■									
65	■		■	■				■			
66	■		■					■			
67				■							
68			■	■							
69			■								
70				■							
71	■	■	■								
72		■		■							
73									■		
74				■						■	
75			■								
76			■								
77			■								
78			■								
79			■								
80			■								
81											■
82				■							
83				■							
Total signals	11	8	19	12	1	0	0	7	2	1	4

Table 12 - EIC PM portfolios linked to each signal (Health EIC macro-area)

	Advanced materials for energy and environmental sustainability	Architecture, engineering and construction technologies	Energy systems and green technologies	Food chain technologies and novel sustainable food	Health and biotechnology	Medical technologies and medical devices	Quantum tech and electronics	Renewable energy conversion and alternative resource exploitation	Responsible electronics	Space systems and technologies	N/A
84											
85											
86											
87											
88											
89											
90											
91											
92											
93											
94											
95											
96											
97											
98											
99											
100											
101											
102											
103											
104											
105											
106											
Total signals per area	0	0	0	6	19	12	1	0	1	0	0

Table 13 - EIC PM portfolios linked to each signal (total numbers)

	Advanced materials for energy and environmental sustainability	Architecture, engineering and construction technologies	Energy systems and green technologies	Food chain technologies and novel sustainable food	Health and biotechnology	Medical technologies and medical devices	Quantum tech and electronics	Renewable energy conversion and alternative resource exploitation	Responsible electronics	Space systems and technologies	N/A
DIGITAL	3	4	2	3	3	6	6	1	9	16	14
GREEN	11	8	19	12	1	19	0	7	2	1	4
HEALTH	0	0	0	6	19	12	1	0	1	0	0
TOTAL	14	12	21	21	23	18	7	8	12	17	18

Signals and trends

This literature review provides an overview of what different sources present as the most emerging signals and trends, and should therefore be complemented with detailed information contained in the sources themselves or other documents. Therefore, its goal is not to be exhaustive, but to help understand what kind of information was recently published by reference organisations from different fields. It is mainly through the lenses and filters of those sources that signals and trends presented in this report are considered relevant and potentially game-changing.

This report contains 106 signals and trends. The ones numbered 1 to 46 are classified as belonging to the Digital & Industry EIC macro-area, 47 to 83 to the Green macro-area, and 84 to 106 to the Health macro-area.

Digital & Industry

1 Wireless power feeds IoT devices

Description	
Wireless power transmission over Wi-Fi and 5G could transmit energy that powers internet of things (IoT) devices in remote areas providing freedom from traditional energy infrastructure and fostering their application. With 5G, cell signals move into the higher (but still safe for humans) millimetre range of the electromagnetic spectrum for the first time. Along with higher information rates, 5G wireless signals transmit a greater amount of radiated energy than 4G. This capability points to a future where many low-power wireless devices never need to plug in to charge. Wi-Fi and 5G are electromagnetic waves - for devices to grab power from them, the first step of the process involves a receiving antenna that captures energy carried with the wireless signal. The antenna routes that energy into an electronic rectifier circuit, which in turn uses semiconductors to convert it into a direct-current (DC) voltage that can charge or power a device. This combination of antenna and rectifier (or converter) is called a rectenna. A power management circuit follows the rectenna, amplifying the voltage while consuming negligible power itself.	
Underlying technologies or innovations	**Areas of application**
Wireless Power Transmission, Internet of Things	Telecommunications, Energy
Source (Author | Year | Name)	
World Economic Forum | 2021 | Top 10 Emerging Technologies of 2021	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	1
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	Climate-Neutral and Smart Cities
EIC programme manager portfolios	
Responsible electronics	

2 Low-cost satellites provide connectivity everywhere

Description	
The number of active devices making up the internet of things (IoT) is expected to double within the next decade. Still, cellular networks span less than half the globe, leaving huge gaps in connectivity. A space-based IoT system could patch these gaps, using low-weight, low-cost satellites to provide connectivity to IoT devices in remote areas without mobile network coverage. This technology is enabling various data-driven applications in previously unreachable or difficult-to-connect locations, fostering its usage in domains such as agriculture. Space IoT still faces a multitude of challenges before becoming truly global. For instance, nanosatellites have a relatively short lifetime of about two years and must be supported by expensive ground station infrastructure. To confront the growing problem of orbiting space junk, plans are underway by NASA and others to either automatically de-orbit satellites at the end of their functional life or collect them using another spacecraft.	
Underlying technologies or innovations	**Areas of application**
Low-cost nanosatellites	Space, Telecommunications, Logistics & Mobility, Environment & wildlife protection, Agriculture & Food
Source (Author | Year | Name)	
World Economic Forum | 2021 | Top 10 Emerging Technologies of 2021	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	2
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	Climate Change, Soil Deal
EIC programme manager portfolios	
Space systems and technologies	

3 Safe communication networks via quantum computing

Description	
Quantum computing provides theoretically tamper-proof communication. Quantum communication is a hardware solution that uses principles of quantum mechanics to create communication networks that detect interception and eavesdropping. Among several techniques for achieving this level of secure communication is quantum key distribution (QKD), in which parties exchange highly secure encryption keys to transmit data across optical networks. Even though QKD technology is not fully mature, several quantum communication networks have either been deployed or are in development.	
Underlying technologies or innovations	**Areas of application**
Quantum communication networks	Telecommunications, Digital Products & Services
Source (Author | Year | Name)	
Deloitte | 2022 | Tech Trends 2022	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	1
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
Quantum tech and electronics	

4 More user-friendly quantum sensors to increase responsiveness and accuracy

Description	
Quantum sensors could deliver increased responsiveness and accuracy and replace conventional sensors if researchers achieve improvements in cost, weight, energy efficiency and portability. Thanks to the sensitivity of subatomic particles, quantum sensing devices are more responsive and accurate than conventional sensors. Quantum sensors are available, but at present are somewhat limited. Researchers are working to make them cheaper, lighter, more portable, and more energy-efficient. Within the next decade, it is likely that we see quantum sensors in diverse applications, as there are promising use cases in the energy, transportation, and healthcare sectors, among others.	
Underlying technologies or innovations	**Areas of application**
Quantum sensing	Healthcare, Logistics & Mobility, Energy
Source (Author | Year | Name)	
Deloitte | 2022 | Tech Trends 2022	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	1
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age, Promoting our European way of life	Climate Change, Climate-Neutral and Smart Cities, Restore our Ocean and Waters
EIC programme manager portfolios	
Quantum tech and electronics	

5 Emotion AI to support decision-making

Description	
Artificial Intelligence (AI) with increased intuitive and emotional capability will be able to make better sense of statistical correlations in order to support human decision-making. It could trigger the next generation of robots working as caretakers, educators, writers, physicians and even Chief Information Officers. During the next decade, affective computing will continue to change and grow as innovators train machines, through next-generation, deep-learning techniques, to both recognise and emulate human traits such as charisma, charm and emotion. They will, in turn, use 'symbolic' and 'connectionist' techniques to embed deductive reasoning and logical inference capabilities into AI and artificial neural networks.	
Underlying technologies or innovations	**Areas of application**
Exponential Intelligence	Healthcare, Business Administration, Education & Training, Leisure & Entertainment, Space
Source (Author | Year | Name)	
Deloitte | 2022 | Tech Trends 2022	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	3
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age, Promoting our European way of life	n/a
EIC programme manager portfolios	
Responsible electronics, Space systems and technologies, Medical technologies and medical devices	

6 AR, VR and metaverse converge for enterprises and healthcare

Description	
Augmented reality (AR) applications in the enterprise/business environment can help streamline and enhance functions and processes across organisations. The uses are diverse and include: monitoring supply chains; maintenance of equipment with augmented information on-site and/or through a digital twin; hosting remote meetings in 3D and providing workplace training. Despite the media focus on revenue potential, some of the best uses for immersive internet in business environments may be in creating equitable access to company processes and developmental opportunities. The metaverse used as a platform for knowledge sharing, workplace training and employee onboarding could make future HR and IT departments look like they are playing games, when actually they are optimising learning processes. In addition, in the Health sector, AR and virtual reality (VR) are already being used to train surgeons and support real-time surgical procedures. In the mid to long term, this technology could disrupt education and training in this sector and enhance the possibilities of telemedicine.	
Underlying technologies or innovations	**Areas of application**
Augmented Reality, Virtual Reality, Metaverse	Building Construction, Business Administration, Digital Products & Services, Education & Training, Consumer Electronics, Healthcare, Industry & Manufacturing, Logistics & Mobility
Source (Author | Year | Name)	
Deloitte | 2022 | Tech Trends 2022	
Future Today Institute | 2022 | Tech Trends Report - Key Insights	
Future Today Institute | 2022 | Metaverse, AR/VR & Synthetic Media	
Deloitte Insights | 2023 | Tech Trends 2023	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	2
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age, Promoting our European way of life	n/a
EIC programme manager portfolios	
Architecture, engineering and construction technologies, Health and biotechnology, Medical technologies and medical devices	

7 Use of AI-driven cybersecurity against AI-cyber attacks

Description	
AI-driven cybersecurity bridges the cyber talent gap, helping organisations address the overall chronic shortage of HR and will likely be the best defence against emergent AI-driven security threats. AI may help in preventing and combatting cyberattacks on multiple fronts: in accelerated threat detection; as a force multiplier in containment and response; in adopting a proactive security posture; and in evolving the role of human security analysts. The same features that make AI a valuable weapon against security threats (such as speedy data analysis, event processing, anomaly detection, continuous learning, and predictive intelligence) can also be manipulated to develop more effective attacks and detect system weaknesses.	
Underlying technologies or innovations	**Areas of application**
Artificial Intelligence	Digital Products & Services, Telecommunications
Source (Author | Year | Name)	
Deloitte | 2022 | Tech Trends 2022	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	3
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age, Stronger EU in the world	n/a
EIC programme manager portfolios	
n/a	

8 Soft robots to revolutionise the relation humans-robots

Description	
Robots made partially or wholly of compliant material based on biological systems can revolutionise the coexistence of man and machine, performing special tasks and even self-degrade if needed. In the future, soft robots could be used in many domains such as in space, search and rescue operations, handling sensitive devices and substances and in healthcare. Their main advantages are flexibility and adaptability, both when interacting with people and when used in adverse environments. Among the models that show-case design possibilities we find X-shaped crawler robots, caterpillar-like soft robots, fish and ray-like robots, and hand-like structures. Recently, advances were reached in healthcare application. Researchers at Northwestern and George Washington universities developed a cardiac pacing device that is absorbed by the body over five to seven weeks. This is ideal for postsurgical patients whose hearts do not require lifelong pacing. During surgery, doctors adhere the flexible device to the surface of the patient's heart. The device then harvests power from an external source using near-field communication, which eliminates the need for batteries or external leads. This is the second biodegradable device from the Northwestern lab: in 2018, the team demonstrated a biodegradable implant that accelerates nerve regeneration post-op.	
Underlying technologies or innovations	**Areas of application**
Soft Robotics	Space, Healthcare, Biotechnology
Source (Author | Year | Name)	
Fraunhofer | 2022 | Fraunhofer Institute for Technological Trend Analysis - Trend News	
Future Today Institute | 2023 | 2023 Tech Trends Report	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	1
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age, Promoting our European way of life	n/a
EIC programme manager portfolios	
Responsible electronics, Space systems and technologies	

9 Integration of triboelectric nanogenerators for kinetic energy

Description	
Integration of triboelectric nanogenerators (TENGs) into textiles and consumer electronics, including touchscreens, could allow the harvesting of kinetic energy and create almost power-self-sufficient devices. Power could be generated by just walking on a carpet, or small batteries could be charged by tapping the movement of the clothes a person is wearing. With TENGs, it will also be possible to develop touchscreens that not only supply their own energy, but can also be bent, rolled up or folded since they are mechanically flexible and very robust. In the near future, TENGs could also be used as small batteries in smartphones. With autonomous sensor networks and other small power users, there is already a large demand for further self-sufficient, reliable energy sources. In addition to existing technologies such as solar cells, TENGs will help address this demand.	
Underlying technologies or innovations	**Areas of application**
Triboelectric Nanogenerators	Consumer Electronics, Energy, Fashion
Source (Author | Year | Name)	
Fraunhofer | 2022 | Fraunhofer Institute for Technological Trend Analysis - Trend News	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	1
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
Advanced materials for energy and environmental sustainability, Responsible electronics	

10 Human-machine networks for human perception and cognitive capabilities

Description	
Future human-machine networks may overcome the limitations of existing computer-human interfaces and expand the range and depth of human perception and cognitive capabilities, also expanding current uses on medical treatments (to overcome neurological conditions) to include leisure and entertainment applications. These developments include sensory expansion (which would evolve to include experiences beyond visual and auditory stimulation, such as smell and taste experiences in virtual reality (VR) headsets and haptic gloves to deliver a sense of touch), thought-based control (brain-computer interfaces are starting to find their way into augmented reality (AR) and VR headsets), all-in-one devices (that serve as a way to connect users to the metaverse without additional headsets and handheld devices), and spatial interaction (smart glasses and motion sensors can enable spatial interaction, allowing users to interact directly with physical data without creating a digital copy).	
Underlying technologies or innovations	**Areas of application**
Computer-Human Interfaces, Augmented Reality, Internet of the Body, Virtual Reality	Healthcare, Leisure & Entertainment
Source (Author | Year | Name)	
National Intelligence Council - USA | 2021 | The Future of Biotech	
Deloitte Insights | 2023 | Tech Trends 2023	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	2
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age, Promoting our European way of life	n/a
EIC programme manager portfolios	
Medical technologies and medical devices, Health and biotechnology, Responsible electronics	

11 DNA for archival purposes

Description
Synthetic DNA might become a preferred medium for data storage applications when particular importance is given to low power consumption, significant data volume and longevity. Usage of DNA to encode and store data is already technically possible and being done in laboratories; DNA and similar chemical polymers will likely be used for archival purposes in the next 20 years. In an increasingly hyperconnected world, DNA offers a storage capacity much greater than most current technologies and thus holds the ability to hold vast quantities of data for an indefinite amount of time. This in turn could enable long-term monitoring on an unprecedented scale, with impact in both forms of control and forms of protection.

Underlying technologies or innovations	**Areas of application**
DNA-Based Data Storage	Digital Products & Services
Source (Author | Year | Name)	
National Intelligence Council - USA | 2021 | The Future of Biotech	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	1
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
n/a	

12 Supercapacitors to replace electrolytes in batteries

Description
New types of flexible supercapacitors will replace the electrolytes found in conventional batteries with sweat, allowing electronic devices and clothes to generate energy from the wearer's body and reduce the use of harmful materials. Engineers at the University of Glasgow have developed this supercapacitor to be fully charged with as little as 20 microlitres of fluid; the device works by coating polyester cellulose cloth in a thin layer of a polymer, which acts as the supercapacitor's electrode. As the flexible surface absorbs its wearer's sweat, the positive and negative ions in the sweat interact with the polymer's surface, creating an electrochemical reaction which generates energy.

Underlying technologies or innovations	**Areas of application**
Flexible Supercapacitors	Consumer Electronics, Fashion
Source (Author | Year | Name)	
BBC Science Focus | 2022 | Future technology: 22 ideas about to change our world	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	1
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age, A European Green Deal	Climate Change
EIC programme manager portfolios	
Advanced materials for energy and environmental sustainability, Renewable energy conversion and alternative resource exploitation	

13 Xenobots for advanced medicine or ocean microplastic gathering

Description	
Xenobots, living programmable organisms, are the result of experiments combining frog stem cells, a supercomputer, a virtual environment, and evolutionary algorithms. These living robots can undulate, swim, and walk, and even have the capacity to work together and self-heal. Due to their small size, they can be injected into and travel through human bodies, and may one day be able to deliver targeted medicine. In 2021, scientists managed to upgrade several aspects of xenobots, which now have different ways to move, live longer, and can sense their environments. They can also operate in robot swarms to complete a collaborative task.	
Underlying technologies or innovations	**Areas of application**
Xenobots	Healthcare, Environment & wildlife protection
Source (Author | Year | Name)	
Future Today Institute | 2022 | Synthetic Biology, Biotechnology & AgTech	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	1
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, A Europe fit for the digital age, Promoting our European way of life	Cancer, Restore our Ocean and Waters
EIC programme manager portfolios	
Energy systems and green technologies, Health and biotechnology, Medical technologies and medical devices	

14 Services and data transactions impacted by metaverse and Web3 convergence

Description	
Convergence of the metaverse (inhabiting experience) and the Web3 (new ways of data flows and transactions) will force public and private organisations to reshape their digital strategies, namely by rethinking what and how services are provided and how data transactions occur. The way organisations harness the opportunities of growth from this mixed reality experience and engagement can be divided into three categories: promoters (organisations that use the internet to promote their products and services will likely continue to do so in an enhanced manner in the metaverse); plussers (who will add to their offers via technologies like AR/VR); and pioneers (who are already developing key foundational platforms, products and services, and content). Organisations that are not digital natives, such as governments, can also benefit from these developments: the city of Santa Monica, South Korea, and Saudi Arabia are currently exploring how the metaverse may improve public services.	
Underlying technologies or innovations	**Areas of application**
Metaverse, Distributed Ledger Technologies	Digital Products & Services
Source (Author | Year | Name)	
Accenture | 2022 | Technology Vision 2022 - Meet Me in the Metaverse	
Deloitte Insights | 2023 | Tech Trends 2023	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	2
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
n/a	

15 Ethical use of digital technologies for trust

Description	
Commitment on ethical use of AI and the use of technologies such as distributed ledger technologies (DLTs) to establish provenance and authenticity may be crucial for organisations to maintain their users' trust. Currently, there is a digital trust gap: numerous surveys highlight the erosion of the public's belief in civic and private institutions. Social media and other current-internet ventures have facilitated the rousing of negative emotions towards individuals, businesses, and other organisations. Decentralised systems (with use cases in digital credentials and identities, data-sharing with third parties, provenance and traceability, micropayment and transactions) may come to revolutionise and rebuild the public digital trust by creating a shared record that can be inspected by selected third parties but cannot be controlled by any single superuser. On a wider scale, these processes may revitalise societal relations to power and state.	
Underlying technologies or innovations	**Areas of application**
Distributed Ledger Technologies, Artificial Intelligence	Digital Products & Services
Source (Author | Year | Name)	
Accenture | 2022 | Technology Vision 2022 – Meet Me in the Metaverse	
Deloitte Insights | 2023 | Tech Trends 2023	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	3
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
n/a	

16 DNA for archival purposes

Description	
High-performance, biology-inspired and quantum computing will revolutionise certain industry processes, namely where computation of high volumes of data could bring unparalleled efficiency and market advantage. While quantum computing is the pinnacle of next-gen problem-solving, high-performance computers (HPC) or massively parallel processing supercomputers can help businesses to actually process and deploy the huge amounts of data that are currently gathered in the digital world, while traditional computing might find this too costly or inefficient. Biology-inspired computing is a new class of capabilities which mirrors natural biological processes to store data, solve problems, or model complex systems in fundamentally different ways.	
Underlying technologies or innovations	**Areas of application**
Edge Computing, High Performance Computing, Quantum computing, Quantum communication networks, Biology-inspired Computing	Digital Products & Services, Financial Services, Logistics & Mobility, Scientific Research
Source (Author | Year | Name)	
Accenture | 2022 | Technology Vision 2022 - Meet Me in the Metaverse	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	2
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age, Promoting our European way of life	Cancer, Climate Change, Restore our Ocean and Waters
EIC programme manager portfolios	
Quantum tech and electronics, Responsible electronics	

17 Digital twin for optimisation of product/service design

Description	
Digital twin technology could revolutionise the process of designing a product or a service, making its implementation iterative and adaptive, allowing for ongoing optimisation and creating near-reality training environments. Digital twin technology creates a perfect replica used to run simulations and predict the behaviour of a product, service or process in real life. In addition, digital twins also allow for continuous tinkering, optimising a model even after its physical iteration has been manufactured. Digital twins have the huge potential to drastically reduce operational costs and increase efficiency and effectiveness across industries – however, to be truly successful, digital twins must be accepted and put into place throughout the whole value chain.	
Underlying technologies or innovations	**Areas of application**
Digital Twin	Industry & Manufacturing, Education & Training, Digital Products & Services
Source (Author | Year | Name)	
ITONICS | 2022 | Game-Changing Technologies for ICT	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	3
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
Quantum tech and electronics, Responsible electronics, Space systems and technologies	

18 Convergence of IoT and edge computing for a decentralised internet of thinking

Description	
Internet of thinking as the convergence of internet of things (IoT) and edge computing brings the advantages of not relying on a central cloud server and providing real-time insights where and when needed. The concept of internet of thinking refers to the possibility of processing data collected by IoT devices closer to their site of origin, without the need to rely on a central server. The major benefit of implementing analytics near the data sources is the speediness of decision-making and adjustments when faced with real-time insights – however, to be truly exploited to full potential, internet of thinking requires huge physical infrastructure interventions across the supply chain, making it a high-cost venture.	
Underlying technologies or innovations	**Areas of application**
Edge Computing, Internet of Things	Logistics & Mobility
Source (Author | Year | Name)	
ITONICS | 2022 | Game-Changing Technologies for ICT	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	3
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
n/a	

19 Convergence of IoT, IoB, AR and 5G leading to ambient computing

Description	
Ambient computing - an umbrella term for the convergence of an ever-growing number of technologies, such as internet of things (IoT), internet of the body (IoB), augmented reality (AR) and 5G, will allow for greater control, customisation, and automation in nearly any physical world environment, creating enhanced ways of experiencing both the real and the digital world, including new concepts of interacting with devices. Ambient computing will most likely become the norm in the coming decades, pushing us to interact with the world (digital and physical) beyond the screen of computers and cell phones. Some of the characteristics of this new type of interaction will include less friction (with enhanced and light user experience), proactive and intuitive models (as having a dedicated personal assistant with you at all times), and AR centricity (as to perpetually enhance the physical experience with digital elements).	
Underlying technologies or innovations	**Areas of application**
Ambient Computing, Augmented Reality, Internet of the Body, Internet of Things, 5G	Digital Products & Services
Source (Author | Year | Name)	
Deloitte | 2022 | Tech Trends 2022	
Accenture | 2022 | Technology Vision 2022 - Meet Me in the Metaverse	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	2
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	Climate-Neutral and Smart Cities
EIC programme manager portfolios	
Architecture, engineering and construction technologies	

20 Low-code and no-code is transforming IT development

Description	
Low-code and no-code could transform the nature and work of IT development teams from coders to assemblers of ready-made building blocks, reducing development time, time-to-market, and expenses associated with software development. It could also open the door of coding to citizen developers, reskilled workers from other sectors and a new generation of software entrepreneurs. As of now, technologies such as AI, big data, and API-based microservices are being used in low- and no-code platforms. However, in spite of being a highly efficient means of building simple products, these platforms are insufficient for complex or highly customised products or features, for which manual high-skilled coding personnel is still necessary.	
Underlying technologies or innovations	**Areas of application**
Low-code & No-code	Digital Products & Services, Education & Training
Source (Author | Year | Name)	
Deloitte | 2022 | Tech Trends 2022	
ITONICS | 2022 | Tech Trends 2022, Game-Changing Technologies for ICT	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	2
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
n/a	

21 Tech advances and lowering of costs drive new applications and capabilities in space

Description	
Technological advances and commercialisation have led to falling costs of access to space and new applications. Examples include partially or fully reusable rocket systems, which drive down costs by reducing the need to manufacture and replace rockets wholesale after each launch. This could overall improve the productivity and competitiveness of space industry. New capabilities provided by e.g. lunar or planetary landers; specialty lunar or planetary rovers for moving personnel, equipment and goods; propulsion systems for interplanetary travel or novel routing techniques; solar sails; and nanoships, might facilitate the launch and operation of a wide variety of satellites and other structures.	
Underlying technologies or innovations	**Areas of application**
Lunar landers and rovers, Propulsion, Solar sails, Nanoships	Space
Source (Author | Year | Name)	
RAND | 2022 | Future Uses of Space Out to 2050	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	2
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
Space systems and technologies	

22 Miniaturisation, satellite constellations and swarms

Description	
Continuing advances in miniaturisation and the launch and operation of ever-larger 'megaconstellations' are expected to drive continued interest in the future use of smallsats (<0.1 kg). The development of proliferated non-geostationary orbit satellite constellations has a high impact and changes the satellite communications (SATCOM) market. It increases overall capacity, data transfer speed, and accessibility. Such efforts are directed to make SATCOM more competitive in the larger telecommunications market, which is currently dominated by terrestrial service providers through fibre. The development of autonomous and robotic systems and Artificial Intelligence (AI) / Machine Learning (ML) may facilitate the future operation of 'satellite swarms'. These are different from traditional constellations of satellites, where each satellite functions as the basic unit or node of a constellation; satellite swarms instead focus on the disaggregation of the satellite itself, with multiple smaller systems acting in concert as a quasi-single entity, and forming the basic unit for a larger constellation.	
Underlying technologies or innovations	**Areas of application**
Artificial Intelligence, Robotics, Autonomous systems, Satellite swarms, Small satellites, Satellite constellations	Space
Source (Author | Year | Name)	
RAND | 2022 | Future Uses of Space Out to 2050	
RAND | 2022 | Commercial Space Capabilities and Market Overview	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	3
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
Space systems and technologies	

23 In situ space exploitation

Description	
There may be an establishment of larger structures in space or on other celestial bodies in the future. They could provide space, protection and support systems for a wide variety of different purposes, e.g. residential, scientific or commercial. For the construction and maintained running of such megastructures, advancements in robotics and in situ resource utilisation (ISRU) are needed to reduce cost and duration of launching building materials from Earth. Space-based manufacturing could produce a range of products through such approaches, contributing to a complex and populous space economy and society of satellites, habitats, research facilities, energy generation, storage facilities, ISRU sites, among others.	
Underlying technologies or innovations	**Areas of application**
Robotic assembly, In situ resource utilisation	Space
Source (Author | Year | Name)	
RAND | 2022 | Future Uses of Space Out to 2050	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	1
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
Space systems and technologies	

24 A need for a space-based manufacturing

Description	
Space-based manufacturing could produce a range of products, contributing to an increasingly complex and populous space-based ecosystem of different satellites, habitats, research facilities, energy generation and storage installations, ISRU sites, factories, propellant refuelling stations and other way stations connecting Earth orbit with the Moon, Mars and wider solar system. By manufacturing on-site, costs can be decreased, and time-consuming launches of materials and tools from Earth can be avoided. Highly lucrative industries, such as asteroids mining or other extractive activities, may have a dramatically enabling effect on space exploration and the establishment of human settlements on celestial bodies.	
Underlying technologies or innovations	**Areas of application**
Robotic assembly, In situ resource utilisation	Space
Source (Author | Year | Name)	
RAND | 2022 | Future Uses of Space Out to 2050	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	1
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
Space systems and technologies	

25 Transformative impact of industry 4.0 in space and industry

Description	
Given the capital- and technology-intensive and competitive nature of global markets, the aerospace sector at large has been at the forefront of developing and adopting new approaches that might offer productivity gains and improved efficiency. This includes transformative innovations in advanced manufacturing, industrial digital tools (IDTs) and industry 4.0 (i4.0) technologies and techniques. Advances associated with i4.0 have the potential to drive sweeping changes in industrial design, production and through-life support. Though many of the underlying technologies may already be in varying stages of adoption across the space sector, they are projected to have a collective transformative impact in industry if used in combination with novel manufacturing models.	
Underlying technologies or innovations	**Areas of application**
Cyberphysical systems, Industrial Internet of Things, Advanced manufacturing, Industrial Digital Tools, Industry 4.0	Space, Industry & Manufacturing
Source (Author | Year | Name)	
RAND | 2022 | Future Uses of Space Out to 2050	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	2
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
Space systems and technologies	

26 Space-based production of food and other resources and the cultivation of soil

Description	
In situ space-based food production through closed-loop ecosystems, hydroponic gardens and other techniques are expected to play an essential role for the establishment of space-based habitats in the long term, as well as in the pursuit of long-duration space exploration missions. As such, civil and commercial actors have already begun exploring in situ food production techniques, such as hybrid life-support systems and crop production in microgravity. Despite the current efforts and advancements, the characteristics of space environment present very complex botanical and engineering challenges and are expected to take time to bear fruit. In spite of this, these efforts are already contributing to Earth-based agriculture, since a number of space-based services (such as SATCOM or Earth Observation), enabling greater productivity and resource management.	
Underlying technologies or innovations	**Areas of application**
In situ space-based food production, Hydroponic gardens, Hybrid life-support system, Crop production in microgravity	Space, Agriculture & Food
Source (Author | Year | Name)	
RAND | 2022 | Future Uses of Space Out to 2050	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	2
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
Space systems and technologies, Food chain technologies and novel sustainable food	

27 Fostering social acceptability of the metaverse

Description	
Social acceptability of the metaverse could be fostered by advances in hardware that allow an enhanced immersive experience. Advances in sensing, haptic, display and optics technologies will allow augmented reality (AR) and virtual reality (VR) headset devices to improve the immersive, sensory and seamless experience of the metaverse. Light and comfortable devices (glasses or only lens) that we can wear all day will allow for a more natural experience of using AR and VR wearables. Nevertheless, other incremental advances are needed for a more immersive experience such as: microLED displays (to fit in a contact lens with high definition); combiner optics (overlaying of projected images on a transparent lens); eye-tracking technology (that improves the displays and can even be used to help project images directly into the retina); and haptic devices (with touch feedback that improves the virtual interaction with a physical world).	
Underlying technologies or innovations	**Areas of application**
Metaverse, Augmented Reality, Virtual Reality, Sensing, Haptic Devices	Education & Training, Leisure & Entertainment, Digital Products & Services
Source (Author | Year | Name)	
IDTechEx | 2021 | Top Technology Trends 2021	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	3
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
n/a	

28 Printed and flexible electronics technologies could become omnipresent

Description	
Printed and flexible electronics are technologies that could enable electronics to be present in a wide scope of applications, making them almost omnipresent in our lives, objects and spaces. In healthcare, the possible applications include skin patches that allow continuous monitoring of biometric parameters and internet connectivity. This will be an important step for making remote/tele health more efficient and easily available. In the automotive industry, the uses range from increasing the number and performance of displays and control surfaces, to high efficiency heating, which for electric vehicles is a challenge. Heating for buildings is also a promising application, either through new materials or in retrofitting. They can also be used to enhance the number of IoT devices in the built environment by reducing cost and powering them through indoor organic photovoltaics (OPV) that capture energy from ambient light. Some OPV solutions have the additional advantage of not using rare earth elements. Finally, integrating very low-cost printed and flexible electronics in smart packaging could allow for better tracking of progress and condition through supply chains and logistics.	
Underlying technologies or innovations	**Areas of application**
Flexible electronics, Organic Photovoltaics	Building Construction, Healthcare, Logistics & Mobility, Digital Products & Services, Industry & Manufacturing
Source (Author | Year | Name)	
IDTechEx | 2021 | Top Technology Trends 2021,	
Trend one | 2021 | The Trend Radar for the mid-sized sector - What trends matter in 2021+	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	3
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	Climate Change
EIC programme manager portfolios	
Responsible electronics, Architecture, engineering and construction technologies	

29 Modern defence, security and safety increasingly depend on space tech

Description	
Modern defence, security and safety functions have increasingly relied on space-based technologies. The commercialisation and presence of an increasing number of actors and objects in space has also created new security challenges, including increased risk of potential accidental or purposeful escalation of crises, damage caused by debris, or cyber, electronic and physical attacks against space-based assets. As such, space is now widely recognised as an operational domain for military forces and, out to 2050, ensuring space security is likely to represent an increasingly vital but complex and challenging task for ensuring the defence, security and safety of both space interests and terrestrial populations.	
Underlying technologies or innovations	**Areas of application**
Space security, Space debris removal	Space
Source (Author | Year | Name)	
RAND | 2022 | Future Uses of Space Out to 2050	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	3
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
Space systems and technologies	

30 Space-based in situ resource

Description	
In situ resource utilisation (ISRU) represents one of the key macro trends influencing the space-based economy. In relation to the terrestrial economy, the mining of space-based objects – including asteroids, comets, the Moon and Mars – for resources such as water, helium-3, rare earth minerals and precious metals has also been predicted to become 'the gold rush of the 21st century'. In light of the significant commercial value of space-based resource extraction, particularly asteroid mining, there has been increasing investment in exploring the technical and commercial feasibility of extraterrestrial resource extraction, with current ambitions aiming at some form of space-based extractive activity by 2030.	
Underlying technologies or innovations	**Areas of application**
Asteroid mining, In situ resource utilisation	Space
Source (Author | Year | Name)	
RAND | 2022 | Future Uses of Space Out to 2050	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	2
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
Space systems and technologies, Advanced materials for energy and environmental sustainability, Energy systems and green technologies	

31 Magnetic levitation technology enhances industrial production

Description	
Robot systems that use magnetic levitation technology will help confer industrial and logistics processes (including manufacturing, assembly and packaging) a higher automation, flexibility and precision. These kinds of systems, particularly suited for sterile environments, are composed by intelligent shuttles that move independently between stations, without being bound to a rigid and sequential production flow. Supported by the use of new, high-performing technologies of additive manufacturing, the integration of cloud computing and applications for artificial intelligence, the factory of the future will become a decentralised and partly self-organising production facility.	
Underlying technologies or innovations	**Areas of application**
Magnetic levitation	Industry & Manufacturing
Source (Author | Year | Name)	
Trend one | 2021 | The Trend Radar for the mid-sized sector - What trends matter in 2021+	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	3
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, A Europe fit for the digital age	n/a
EIC programme manager portfolios	
Responsible electronics	

32 Quantum sensors' advance applications

Description	
Quantum sensors could have applications in several fields. In the automotive industry, accelerometers could be used to improve the accuracy of autonomous vehicles navigation. In the biomedical domain, magnetometers could improve magnetic resonance imaging (MRI) and positron emission tomography (PET) scanners. Quantum gravitometers could be used for seismographic predictions of earthquakes and volcano eruptions and also for exploring underground natural resources or for assessing the conditions of ground and soil for engineering and building purposes. Highly precise clocks could be used to supervise financial markets and to manage smart power grids.	
Underlying technologies or innovations	**Areas of application**
Quantum sensing	Logistics & Mobility, Healthcare, Building Construction, Financial Services
Source (Author | Year | Name)	
RAND | 2021 | Commercial and Military Applications and Timelines for Quantum Technology	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	2
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, Promoting our European way of life	Cancer
EIC programme manager portfolios	
Quantum tech and electronics, Medical technologies and medical devices, Architecture engineering construction technologies	

33 Quantum imaging and illumination

Description	
Quantum imaging, or ghost imaging, could allow the detection of objects in difficult conditions such as very low light environment, cloud cover (with strong atmospheric turbulence) or disasters (with smoke caused by wildfires). It works by detecting both visible light and radio-frequency radiation. Quantum illumination is similar and could deliver even more improvements in sensitivity. While no large-scale quantum illumination radar has yet been reported in literature, tabletop prototypes have successfully produced an SNR (signal-to-noise ratio) higher than the possibility of a non-quantum device. Both quantum imaging and illumination could have applications in the biomedical domain, in situations where using conventional technologies might damage the samples or tissues.	
Underlying technologies or innovations	**Areas of application**
Quantum sensing	Healthcare, Biotechnology, Logistics & Mobility, Environment & wildlife protection
Source (Author | Year | Name)	
RAND | 2021 | Commercial and Military Applications and Timelines for Quantum Technology	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	2
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, Promoting our European way of life	Cancer
EIC programme manager portfolios	
Quantum tech and electronics, Medical technologies and medical devices	

34 Increasing amount of per satellite capacity

Description	
This trend relates to and contributes to the market dynamics. Geosynchronous orbit (GEO) high-throughput satellites (HTSs) provide an unprecedented amount of per satellite capacity. The goal is to increase overall capacity, data transfer speed, and accessibility. Such efforts are directed to make SATCOM more competitive in the larger telecommunications market, which is currently dominated by terrestrial service providers through fibre. Simultaneously, several satellite operators are starting to consider providing services through multi-orbit model. Because the several orbits have advantages and disadvantages when compared with each other, using geostationary and non-geostationary orbits together may provide optimised connectivity depending on the location and needs of users.	
Underlying technologies or innovations	**Areas of application**
High-throughput satellite, SATCOM	Space
Source (Author | Year | Name)	
RAND | 2022 | Commercial Space Capabilities and Market Overview	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	3
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
Space systems and technologies	

35 Growing number of suppliers in the launch market

Description	
The number of suppliers in the launch market is growing. In the 2010s, the market began to change, when SpaceX and Orbital Sciences entered the market. The US medium- to heavy-lift sector is now projected to have four operational launch service providers. The growth in the suppliers in the small-lift sector is even more significant, with the number growing from one (Orbital Sciences) in the early 2010s to potentially more than 20 in the near future. Within this medium- to heavy-lift sector, the main observable trend is reusability (also included in this report). Within the small-lift sector, the main observable trend is 3D printing with additive manufacturing. Both these trends are allowing the space industry to become ever more cost-effective and reduce carbon emissions.	
Underlying technologies or innovations	**Areas of application**
Launch vehicles	Space
Source (Author | Year | Name)	
RAND | 2022 | Commercial Space Capabilities and Market Overview	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	3
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
Space systems and technologies	

36 Reusability of parts of launch vehicles

Description	
Three of the four companies for the NSSL-2 (US National Security Space Launch) programme have proposed launch vehicles (LVs) with reusable first-stage boosters, which makes these systems more cost-effective. Therefore, these companies are likely to invest more into the technologies that enable higher rates of reusability. Furthermore, SpaceX is developing a new two-stage launch system with reusable first and second stages. With this new system, the second stage, named Starship, will re-enter Earth and land at a place where it can be refuelled, refurbished, and relaunched. This improvement in reusability would allow the company to be more cost-effective.	
Underlying technologies or innovations	**Areas of application**
Launch vehicles	Space
Source (Author | Year | Name)	
RAND | 2022 | Commercial Space Capabilities and Market Overview	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	3
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
Space systems and technologies	

37 Rapid prototyping for cost efficiency

Description	
In the small-lift sector, the main technology trend is 3D printing with additive manufacturing. Advancements in 3D printing have enabled rapid prototyping and a reduction in the number of parts needed, all leading to cost efficiency. Small-lift launch vehicles (LVs) under development are using 3D printing in the manufacturing process. The medium- to heavy-lift LVs also use 3D printing to a certain degree. For example, SpaceX prints engine chambers, and Blue Origin prints oxidiser pumps.	
Underlying technologies or innovations	**Areas of application**
3D printing, Additive manufacturing, Launch vehicles	Space
Source (Author | Year | Name)	
RAND | 2022 | Commercial Space Capabilities and Market Overview	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	3
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
Space systems and technologies	

38 AI trust programmes based on social and ethical requirements

Description	
The rapid growth of AI technology, both in applications and popularity, coupled with incomplete or inaccurate understandings of its functioning, has given rise to pushback and mistrust among workers and consumers. This can not only impact the rate of adoption of the tech but also have wider reaching societal impacts, as major companies and even bodies of government start to turn to the technology. The adopted strategies to promote trust among users lean on data transparency (enabling users to understand which and why data is collected, as well as deciding what data they are willing to provide), algorithmic explainability (transparent and understandable explanations on how decisions are made, targeted at end users and employees, in order to reduce resistance to opaque AI instructions), and AI reliability (helps set the bar for accuracy, so AI can meet established standards and be considered as reliable a work tool as previous technologies). For enterprises, while 73% of businesses see AI as critical to success, 41% are concerned about the ethics of AI tools, and 47% of leaders have concerns regarding transparency. For governments, explainability in AI systems is crucial for developing regulations and assessing fairness. Some governments, like South Korea, are already launching AI-powered metaverse platforms for increasing and simplifying access to public services but will have to carefully manage social trust and reliability to foster acceptance.	
Underlying technologies or innovations	**Areas of application**
Artificial Intelligence	Digital products & Services
Source (Author | Year | Name)	
Deloitte Insights | 2023 | Tech Trends 2023	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital and Industry	2
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
n/a	

39 Metacloud centralises and secures multiple cloud instances

Description	
As different solutions started appearing on the market, organisations started to adopt multiple platforms-as-a-service, as they wanted to utilise what was perceived as the best tool for the task regardless of what platform it was associated with. This gave rise to a multicloud reality, in which many services are redundant, security is compromised, and employees must learn and deal with several platforms, which may be time consuming. The solution to this unforeseen problem is an approach known as metacloud, which harnesses the various clouds' native technical standards and displays them in a common interface, allowing for centralised control and security. This is done through a compatibility layer that sits above the several clouds in use, functioning almost like a computer's operating system.	
Underlying technologies or innovations	**Areas of application**
Metacloud	Business Administration, Digital products & Services
Source (Author | Year | Name)	
Deloitte Insights | 2023 | Tech Trends 2023	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital and Industry	2
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
n/a	

40 Advanced connectivity: IoT for automotive and assembly

Description	
A series of new developments in existing technologies has enabled a new era for connectivity and internet of things (IoT) and unlocked new uses for industrial organisations by maximising geographic coverage, data throughput and spectrum efficiency, and minimising latency and energy consumption. These technologies include 5G/6G cellular, Wi-Fi 6, wireless low-power and wide-area (LPWA) networks, low-Earth orbit (LEO) satellites, as well as optical fibre wires. These advances have a particular application in the automotive and assembly industry, which may revolutionise the future of mobility. Increased connectivity may enable preventive maintenance, improve navigation, prevent collisions, enable various levels of vehicle autonomy and carpooling services, and provide personalised infotainment offerings.	
Underlying technologies or innovations	**Areas of application**
Industrial Internet of Things	Logistics & Mobility, Digital products & Services
Source (Author | Year | Name)	
McKinsey & Company | 2022 | McKinsey Technology Trends Outlook 2022	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital and Industry	2
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
n/a	

41 New hardware and software for micromobility modes

Description	
Despite COVID-19 stay-at-home rules, micromobility modes (bicycle and e scooter sharing, as well as ride-hailing) usage has returned to or even outperformed pre-pandemic levels. As people start to abandon the increased use of private cars brought on by the pandemic and climate change awareness continues to build, this usage may continue its upward slope, having the potential of contributing to lessen carbon emissions and increase citizens' active time. However, new solutions that reduce urban problems associated with these mobility modes must be reached; earlier in 2023, Paris was the first city to ban e-scooters for their public nuisance and potential for accidents. New hardware and app solutions related to drop-off sites, charging, maximum speed and integration into traffic best practices must be put into place and designed by companies alongside regulators to foster micromobility's continued growth and benefits.	
Underlying technologies or innovations	**Areas of application**
Micromobility modes	Logistics & Mobility
Source (Author | Year | Name)	
TNMT (Lufthansa Innovation Hub) | 2022 | The Travel and Mobility Tech Sector Attractiveness Report	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital and Industry	3
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	Climate-Neutral and Smart Cities
EIC programme manager portfolios	
n/a	

42 Search, inspire and booking platforms attract early-stage investment

Description	
According to a start-up funding analysis conducted by the Lufthansa Innovation Hub in 2022, early-stage deal funding has been decreasing since 2021, with start-ups in the mobility sector having a hard time raising capital. It seems investors are now more willing to invest in follow-through financing, indicated by a growing late-stage capital activity, perhaps due to the post-COVID economic downturn and rise of inflation. Interestingly though, the capital that does go to early-stage deals seems to be centring on an unlikely candidate: next-generation search, inspire and booking (SIB) platforms. SIB is therefore one of categories anticipated to suffer the most transformation in the coming years, after having lost investment traction 10 years ago when the first stages of the internet and tech era were booming. There were few early indicators that this would be the case, but SIB start-up outliers, like corporate travel management platform TripActions or Indonesian travel and ticketing platform Traveloka, may have spearheaded this change, influenced by changing travel behaviours and new consumer trends and preferences.	
Underlying technologies or innovations	**Areas of application**
SIB platforms	Logistics & Mobility, Financial services, Digital products & Services
Source (Author | Year | Name)	
TNMT (Lufthansa Innovation Hub) | 2022 | The Travel and Mobility Tech Sector Attractiveness Report	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital and Industry	2
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
n/a	

43 Software breakthroughs for vehicles

Description	
Mobility is shifting towards autonomous, connected, electric and smart (ACES) technology, built on automated systems that capitalise on AI and analytical capabilities to make decisions based on collected data. For vehicles to respond to this challenge, various software and intelligence developments must come together. Simultaneous localisation and mapping (SLAM) technologies may start to independently map out unknown environments and territories, while object detection will be made possible by perception technologies used for behaviour planning, route planning, and motion planning. Driving strategy will be implemented, powered by the development of autonomous vehicles, integrating hardware and software components in a full-stack solution.	
Underlying technologies or innovations	**Areas of application**
SLAM, object detection, driving strategy	Logistics & Mobility
Source (Author | Year | Name)	
McKinsey & Company | 2022 | McKinsey Technology Trends Outlook 2022	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital and Industry	3
Commission priorities	**Missions in Horizon Europe**
An economy that works for people	n/a
EIC programme manager portfolios	
n/a	

44 Hardware breakthroughs for vehicles

Description	
Mobility is shifting towards autonomous, connected, electric and smart (ACES) technology, built on automated systems that capitalise on AI and analytical capabilities to make decisions based on collected data. However, as software and AI developments are increasingly implemented into mobility, hardware solutions must accompany these advances. Radar and camera sensors with algorithms can be implemented to automatically detect objects, classify them, and determine the distance from the vehicle to them. Lidar (light detection and raging) technology, which relies on light travel time measurement, can help develop systems of range (variable distances) detection. Finally, traditionally mechanical linkages in vehicles, such as steer-, brake- and shift-by-wire, may be substituted for fully electrical or electromechanical systems.	
Underlying technologies or innovations	**Areas of application**
Radar, Lidar	Logistics & Mobility
Source (Author | Year | Name)	
McKinsey & Company | 2022 | McKinsey Technology Trends Outlook 2022	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital and Industry	3
Commission priorities	**Missions in Horizon Europe**
An economy that works for people	n/a
EIC programme manager portfolios	
n/a	

45 Fintech enabling seafood industry efficiency

Description	
The seafood industry is extremely fractured and complex, with low-income operators in developing countries which are, in many ways, the foundation of global economy. Recent advances in fintech have greatly contributed to financial inclusion that helps fishing ventures grow their businesses by lowering transaction costs, increasing liquidity and access to capital, and diminishing the risk to investment throughout the value chain. Furthermore, increasing access to formal credit enables operators to improve their cash flow, make more informed decisions, invest more wisely, and build a formal financial identity which may prove invaluable in growing their professional opportunities. A good example of the impact these developments can have is the SMS-based M-Pesa mobile money system, which transformed the economy of Kenya, directly contributing to lifting hundreds of thousands from below the poverty line.	
Underlying technologies or innovations	**Areas of application**
Fintech	Financial Services, Agriculture and Food
Source (Author | Year | Name)	
S2G Ventures | 2022 | 8 Trends Critical to a Vibrant Blue Economy	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	3
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	n/a
EIC programme manager portfolios	
Food chain technologies, novel & sustainable food	

46 Online food shopping as an enabler of mass changes in consumers' seafood consumption patterns

Description	
In many regions across the world, seafood consumption has long been hindered by barriers such as accessibility, cost, and a lack of knowledge among the general public about species and supply chain. Nevertheless, the COVID-19 pandemic may have ushered in a new era for the industry, as many people became more involved and knowledgeable about cooking; for example, purchase of non-essential kitchenware soared, as did the Food Network's channel ratings in the USA. This directly contributed to the development of seafood sales in direct-to-consumer (DTC) online channels, and seafood grocery sales rose by 28% in 2020. This surge in online shopping has shortened the supply chain, improving quality of the products offered at lower costs, traceability, geographical coverage, and data collection regarding consumer choices. Integrating food shopping experiences with social media content that builds confidence in preparing seafood is also viewed as an opportunity, as companies in the sector increase their online presence.	
Underlying technologies or innovations	**Areas of application**
DTC online food shopping	Agriculture and Food, Digital product & services
Source (Author | Year | Name)	
S2G Ventures | 2022 | 8 Trends Critical to a Vibrant Blue Economy	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Digital & Industry	3
Commission priorities	**Missions in Horizon Europe**
A European Green Deal, A Europe fit for the digital age	Restore our Ocean and Waters
EIC programme manager portfolios	
Food chain technologies, novel & sustainable food	

Green

47 Value chain decarbonisation in the mobility industry

Description	
Emissions are decreasing for the mobility and vehicle industry as a whole thanks to decarbonisation throughout the value chain. On the green primary materials front, new technology like green steel, carbon-reduced production technologies, green aluminium, and green plastics are paving the way for a more sustainable mobility sector. A 2020 McKinsey article has estimated that 29% of material emissions could be abated in a cost-positive way by 2030 - of these, 60% involve aluminium and plastics. Recycled aluminium, new smelting technologies, and green electricity can reduce emissions from aluminium production by about 73%; recycled materials such as polypropylene or polyethylene, especially for plastics in non-visible parts of vehicles, can produce savings and cut emissions from plastic production by 34%; scaling nylon recycling technologies could further decrease total plastics emissions by up to 92%. Further emissions abatement would add costs, but the associated technologies, such as electric arc furnaces and direct reduced iron for steel production, could scale in the long term. Regarding parts circularity, the emphasis on the reuse and refurbishment of modules or parts and recovery of quality materials from vehicles reaching end of life reduce the necessity for new parts production. Additionally, the development of lightweight materials (advanced composites and ceramics, metamaterials and nanomaterials) contributes to fuel efficiency.	
Underlying technologies or innovations	**Areas of application**
Green materials	Logistics & Mobility
Source (Author | Year | Name)	
McKinsey & Company | 2022 | McKinsey Technology Trends Outlook 2022	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	3
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change, Climate-Neutral and Smart Cities
EIC programme manager portfolios	
n/a	

48 Transportation demand management in cities

Description	
New hardware and advanced digital solutions are enabling the mass use of alternative forms of transportation in cities, particularly shared mobility, contributing to the replacement of gas-powered vehicles. One of these 'smart mobility' solutions is transportation demand management (TDM), which aims to optimise the use of locally available transportation resources to incentivise the transition to more efficient and sustainable modes of commuting. Uses of TDM include providing mobility-as-a-service, with integrated commuter experience across public transport, ride sharing and micromobility, and the introduction of congestion pricing based on traffic. This could eventually lead to investment in novel mobility services such as robo-taxis and purpose-built vehicles with increased durability that are designed specifically for shared mobility.	
Underlying technologies or innovations	**Areas of application**
Transportation Demand Management	Logistics & Mobility, Digital products & Services
Source (Author | Year | Name)	
McKinsey & Company | 2022 | McKinsey Technology Trends Outlook 2022	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	2
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate-Neutral and Smart Cities
EIC programme manager portfolios	
n/a	

49 Lithium-ion, sodium-ion and potassium-ion batteries advances for the mobility sector

Description	
The electrification of vehicles is well underway, with fully electric vehicles (EVs) gaining an ever-swelling share of the market. Nevertheless, developments on solutions replacing vehicle components with electricity-based ones still has a considerable margin for improvement. Regarding batteries, advances like lithium-ion batteries (Li-ion) may prove to be remarkably efficient. However, taking into account the issues in sourcing lithium for batteries, sodium-ion (Na-ion) and potassium-ion (K-ion) batteries are increasingly being pursued. Beyond this, the new field of battery analytics, applying intelligence to extend battery life, improve manufacturing, unlock end-of-life markets and prevent safety hazards, may prove invaluable to promote the sustainability of the automotive and assembly sector.	
Underlying technologies or innovations	**Areas of application**
New types of batteries	Logistics & Mobility
Source (Author | Year | Name)	
McKinsey & Company | 2022 | McKinsey Technology Trends Outlook 2022	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	2
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change, Climate-Neutral and Smart Cities
EIC programme manager portfolios	
Energy systems and green technologies, Advanced materials for energy and environmental sustainability	

50 New propulsion system technologies contribute to the electrification of mobility

Description	
The electrification of vehicles is well underway, with fully electric vehicles (EVs) gaining an ever-swelling share of the market. Nevertheless, developments on solutions replacing vehicle components with electricity-based ones still has a considerable margin for improvement. An efficiency and sustainability gain may come from new propulsion systems such as hydrogen fuel cells (in which energy stored as hydrogen is converted into electricity by the fuel cell) and hybrid propulsion (which combines several propulsion sources used together or alternatively, such as fuel and electric).	
Underlying technologies or innovations	**Areas of application**
Hydrogen fuel cells, hybrid propulsion	Logistics & Mobility
Source (Author | Year | Name)	
McKinsey & Company | 2022 | McKinsey Technology Trends Outlook 2022	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	2
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change, Climate-Neutral and Smart Cities
EIC programme manager portfolios	
n/a	

51 Intelligent land and crop management

Description	
Data from sensors connected via the internet of things will increasingly enable intelligent land and crop management, as well as fertiliser and water use, aiding in reducing further carbon emissions. The agricultural sector has a big impact in greenhouse gas emissions; on the other hand, it is itself a victim of climate change and critically important to world feeding. Therefore, programmes and solutions that have a direct impact on the effective use of resources and inputs in the agricultural sector are key to promote long-term sustainability. Sensors that collect real-time, accurate information on soil needs and status can unlock effective, efficient, and less wasteful uses of natural resources such as water, agricultural inputs such as seeds and fertiliser, and labour such as harvesting, trimming and other management practices.	
Underlying technologies or innovations	**Areas of application**
Internet of Things	Agriculture & Food
Source (Author | Year | Name)	
World Economic Forum | 2021 | Top 10 Emerging Technologies of 2021 | 5	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	3
Commission priorities	**Missions in Horizon Europe**
A European Green Deal, A Europe fit for the digital age	Climate Change, Soil Deal
EIC programme manager portfolios	
Responsible electronics, Energy systems and green technologies, Food chain technologies and novel sustainable food	

52 Improvements in heating, cooling and cooking for net-zero emissions

Description	
Reducing carbon emissions from fuels used for heating, cooling and cooking in residential and commercial buildings will foster and require larger adoption of net-zero emissions HVAC (heating, ventilation and air conditioning) and passive solar environmental systems. Another key factor will be adoption of 'greener' building materials that enable greater energy efficiency and thus reduce the need for HVAC altogether. Renewable timbers and low-carbon cement may come in aid of this goal. Therefore, this trend connects both developments and improvements to consumer electronics and infrastructure itself.	
Underlying technologies or innovations	**Areas of application**
Net-zero emissions HVAC	Building Construction
Source (Author | Year | Name)	
World Economic Forum | 2021 | Top 10 Emerging Technologies of 2021 | 5	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	3
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change, Climate-Neutral and Smart Cities
EIC programme manager portfolios	
Architecture, engineering and construction technologies, Energy systems and green technologies	

53 New materials such as renewable timber, low-carbon cement, advanced composites and ceramics to reduce carbon footprint of building construction

Description	
There is a growing need for new materials that reduce the carbon footprint of building construction such as renewable timbers and most especially low-carbon cement. Ideally, the introduction of these new, low carbon and durable materials will reduce not only the footprint of construction but also the footprint of heating and cooling by being more energy-efficient. Other advancements such as advanced composites (polymer matrix composites with unusually high strength or stiffness) and ceramics (carbon-fibre-reinforced plastics that could substitute steel) also show great promise.	
Underlying technologies or innovations	**Areas of application**
Renewable Timbers, Low-carbon cement	Building Construction
Source (Author | Year | Name)	
World Economic Forum | 2021 | Top 10 Emerging Technologies of 2021	
McKinsey & Company | 2022 | McKinsey Technology Trends Outlook 2022	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	3
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change, Climate-Neutral and Smart Cities
EIC programme manager portfolios	
Architecture, engineering and construction technologies, Renewable energy conversion and alternative resource exploitation, Energy systems and green technologies, Advanced materials for energy and environmental sustainability	

54 Nitrogen fixation increasing crops productivity

Description	
Whereas staple food crops such as corn and other cereals rely on inorganic nitrogen from the soil to fertilise, legume plants such as soy and beans produce their own. The roots of legumes interact with soil bacteria, leading to bacterial colonisation of the root and the formation of symbiotic organs called nodules. Researchers have shown that the formation of the nodules involves intimate molecular communication between soil bacteria and legume roots. New approaches to engineering nitrogen fixation into non-legume plants could foster crop productivity, by coaxing the roots of cereals to engage in symbiotic interaction with nitrogen-fixing bacteria and so creating a natural fertiliser effect.	
Underlying technologies or innovations	**Areas of application**
Engineered nitrogen fixation	Agriculture & Food
Source (Author | Year | Name)	
World Economic Forum | 2021 | Top 10 Emerging Technologies of 2021	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	2
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Soil Deal, Climate Change
EIC programme manager portfolios	
Food chain technologies and novel sustainable food	

55 Natural materials for 3D printing

Description	
3D printing of houses using local and natural materials could reduce construction complexity, cost and energy use. Building houses with 3D printers could help tackle the challenge of inadequate housing for 1.6 billion people worldwide, according to United Nations estimates. Several 3D printing housing projects have been successfully deployed. Materials such as concrete and various mixtures of sand, plastics, and binders are trucked to the building site and extruded through a massive 3D printer. As a simple and low-cost construction method, it could help mitigate housing shortage in remote and impoverished regions. However, the lack of infrastructure to transport materials has so far impeded its large-scale use.	
Underlying technologies or innovations	**Areas of application**
3D Building Printing	Building Construction
Source (Author | Year | Name)	
World Economic Forum | 2021 | Top 10 Emerging Technologies of 2021	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	2
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change, Climate-Neutral and Smart Cities
EIC programme manager portfolios	
Architecture, engineering and construction technologies	

56 Distributed energy generation and storage for increasing electric vehicle power consumption

Description	
Energy generation and storage systems located near the point of use could follow and leverage growing electricity demand and development of electric vehicle infrastructure. Enabling technologies include fuel cells, microturbines, reciprocating engines, load reduction, and electronic interfaces. These technologies are changing the way power is generated and transmitted, and increased demand for electricity, individual consumer control, and cleaner fuel is driving its development and uptake. Natural gas and renewable energies are currently used. Distributed energy resources may threaten power plants, and collaboration and partnerships will benefit suppliers and consumers alike. The integration of distributed energy resources into existing grids could address issues relating to reliability and predictability.	
Underlying technologies or innovations	**Areas of application**
Distributed Energy Resources, Distributed Ledger Technologies, Artificial Intelligence, Internet of Things	Energy, Logistics & Mobility
Source (Author | Year | Name)	
ITONICS | 2022 | Game-Changing Technologies for Energy	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	3
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change, Climate-Neutral and Smart Cities
EIC programme manager portfolios	
Advanced materials for energy and environmental sustainability, Energy systems and green technologies, Renewable energy conversion and alternative resource exploitation	

57 Perovskite photovoltaic cells for increased efficiency and as housing material

Description	
Next-generation photovoltaic cells (PVs) made of perovskite will increase panel efficiency, optimise payback time and could be used to design sophisticated housing materials such as high-transmittance windows. Perovskite, a material that has the same crystal structure as the mineral calcium titanium oxide, offers the potential for low-cost, low-temperature manufacturing of lightweight, ultrathin, flexible cells. 'Turning' perovskite enables different layers to absorb different wavelengths of light, meaning that layering perovskite over existing silicon panels enables them to absorb additional wavelengths and potentially boost their efficiency by 30%. PVs made of perovskite are useful in applications in fields ranging from automotive to consumer electronics to construction.	
Underlying technologies or innovations	**Areas of application**
Next-Generation Photovoltaic Cells	Energy, Building Construction, Consumer Electronics
Source (Author | Year | Name)	
ITONICS | 2022 | Game-Changing Technologies for Energy	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	1
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change, Climate-Neutral and Smart Cities
EIC programme manager portfolios	
Energy systems and green technologies, Advanced materials for energy and environmental sustainability, Renewable energy conversion and alternative resource exploitation	

58 Ionic liquids and molten salts to replace volatile organic compounds

Description	
Ionic liquids and other molten salts are seen as a promising, environmentally friendly and, above all, tailorable alternative to store and transport energy and also as a reaction medium in the production of bio-based chemicals, namely as a replacement to volatile organic solvents that the EU REACH Regulation wants replaced. Ionic liquids are highly concentrated, watery saline solutions or salts in liquid state; most maintain this liquid state in temperatures below 100°C and contain organic salts. Compared with conventional fluids, ionic liquids have a few key special properties: negligible vapour pressure; high thermal and electrotechnical stability; high ionic conductivity; and significant solvency for organic, inorganic and polymeric materials.	
Underlying technologies or innovations	**Areas of application**
Ionic Liquids	Energy, Industry & Manufacturing
Source (Author | Year | Name)	
Fraunhofer | 2022 | Fraunhofer Institute for Technological Trend Analysis - Trend News	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	1
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change
EIC programme manager portfolios	
Advanced materials for energy and environmental sustainability, Energy systems and green technologies, Renewable energy conversion and alternative resource exploitation	

59 Atmospheric water generation against water scarcity

Description	
Atmospheric water generation (AWG) based on the passive condensation of ambient humidity includes new approaches such as the use of hierarchically structured surfaces that different organisms already recur to; here, research on bionic approaches that emulate the condensation of dew and ambient humidity on surfaces and meshes are showing great promise. AWG can also be accomplished in an active capacity: active systems function in a similar way to air conditioners and thus mostly require a high energy input, rarely being economical, particularly when saltwater desalinisation is involved. Nevertheless, active AWG systems based on renewable energy can become quite interesting.	
Underlying technologies or innovations	**Areas of application**
Passive Atmospheric Water Generation	Environment & wildlife protection
Source (Author | Year | Name)	
Fraunhofer | 2022 | Fraunhofer Institute for Technological Trend Analysis - Trend News	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	1
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Restore our Ocean and Waters, Climate Change
EIC programme manager portfolios	
Advanced materials for energy and environmental sustainability, Architecture, engineering and construction technologies	

60 Ecosystem engineering for more efficiency and increased resilience

Description	
Ecosystem engineering, as the selection of plants, animals and microorganisms (all three themselves possibly genetically engineered) could enable more efficient production of food, materials and energy, namely by consuming fewer resources and being more resistant in hostile environments. Uses for ecological engineering can range from depleted farm fields to terraforming the surface of Mars (another signal identified in this report). Genetic modifications are already showing great promise in sites with saltwater incursion of historically unfarmable land. Although harmful applications of genetic modifications are possible, this biotech has already proven to be of use; nevertheless, risks include greater pressure on ecosystems as they become more exploitable, the displacement of native fauna and flora, and unintended impacts on consumer health.	
Underlying technologies or innovations	**Areas of application**
Gene-engineering	Agriculture & Food
Source (Author | Year | Name)	
National Intelligence Council - USA | 2021 | The Future of Biotech	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	1
Commission priorities	**Missions in Horizon Europe**
A European Green Deal, An economy that works for people	Climate Change, Soil Deal
EIC programme manager portfolios	
Food chain technologies and novel sustainable food	

61 Genetically modified organisms beyond productivity gains

Description	
Beyond the simple productivity gains, genetically modified organisms (GMOs) can help reduce the carbon footprint and promote the sustainability of farming through a better use of scarce resources such as water and land and reduced use of pesticides. Impacts on communities and habitats will vary depending on species, location, and culture. While unlikely to create political turmoil, transformed food and agriculture production has the potential to create both support and resistance in local communities. Some experts assess the integration of modern technologies in rural farming in Africa as having both increased output and engagement of tech-savvy youths in the community. Meanwhile, sporadic illness in USA factory-farmed fish and the perceived pernicious effects of herbicide-tolerant GMO crops has led to public opposition in the country.	
Underlying technologies or innovations	**Areas of application**
Gene-engineering	Agriculture & Food
Source (Author | Year | Name)	
National Intelligence Council - USA | 2021 | The Future of Biotech	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	3
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change, Soil Deal
EIC programme manager portfolios	
Food chain technologies and novel sustainable food	

62 Green funerals to reduce carbon footprint

Description	
Green funerals are being delivered through the use of alternative decomposition technologies. These include mushroom suits, alkaline hydrolysis, and burial in composting compounds, all of which promote natural decomposition of bodies, neutralise toxins generated by decay, and supposedly use fewer emissions than traditional methods such as casket burial or cremation. These technologies could help reduce the carbon footprint of the management of human remains and change the way society looks at death.	
Underlying technologies or innovations	**Areas of application**
Alternative decomposition	Deathcare
Source (Author | Year | Name)	
BBC Science Focus | 2022 | Future technology: 22 ideas about to change our world	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	2
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Soil Deal
EIC programme manager portfolios	
Advanced materials for energy and environmental sustainability, Health and biotechnology	

63 Red bricks as supercapacitors

Description	
Red bricks, a cheap and widely available building material, could be turned into supercapacitors, making Washington University in St Louis scientists claim that walls made of these bricks 'could store a substantial amount of energy' and can 'be recharged hundreds of thousands of times within an hour'. The method for this adaptation of the bricks involves coating brick samples in a conducting substance known as Pedot, which then seeps through the fired bricks' porous structure, converting them into 'energy storing electrodes'. Iron oxide, which gives the bricks their red colour, helps with the process. As of May 2023, this research is still in the proof-of-concept stage.	
Underlying technologies or innovations	**Areas of application**
Supercapacitor	Building Construction
Source (Author | Year | Name)	
BBC Science Focus | 2022 | Future technology: 22 ideas about to change our world	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	1
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change, Climate-Neutral and Smart Cities
EIC programme manager portfolios	
Advanced materials for energy and environmental sustainability, Energy systems and green technologies, Renewable energy conversion and alternative resource exploitation, Architecture, engineering and construction technologies	

64 Bio-concrete to heal its own cracks

Description	
Scientists at University of Colorado Boulder have created a sort of 'living concrete' made of sand, gel and bacteria, with a structural load-bearing function and the capacity to heal its own cracks. Furthermore, this material is also more environmentally friendly than traditional concrete, the second most consumed material on Earth after water. As this bio-concrete is capable of self-healing, the carbon impact of repair interventions in the future is also minimised. Additionally, the research team believes their work paves the way for future building structures that can 'heal its own cracks, suck up dangerous toxins from the air or even glow on command'.	
Underlying technologies or innovations	**Areas of application**
Bio-engineered Concrete	Building Construction
Source (Author | Year | Name)	
BBC Science Focus | 2022 | Future technology: 22 ideas about to change our world	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	1
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change, Climate-Neutral and Smart Cities
EIC programme manager portfolios	
Architecture, engineering and construction technologies	

65 Green hydrogen could help reduce carbon footprint in energy and agriculture

Description	
Green hydrogen produced by splitting water using renewable energy, and thus without the use of carbon-based fuels, will increasingly became an economically viable fuel, as renewable energy sources become more abundant. In addition to eliminating carbon emissions during hydrogen production, the process has a significantly purer end result. It is free of chemicals incorporated in fossil fuels, such as compounds containing sulphur and arsenic that can 'poison' the catalyst, thereby reducing reaction efficiency. Cleaner hydrogen also means that superior catalysts can be developed because they no longer need to tolerate the poisonous chemicals from fossil fuels. Additionally, the process could foster the production of green ammonia, reducing the CO2 footprint of fertiliser production.	
Underlying technologies or innovations	**Areas of application**
Green Hydrogen	Industry & Manufacturing, Agriculture & Food, Energy, Logistics & Mobility
Source (Author | Year | Name)	
World Economic Forum | 2021 | Top 10 Emerging Technologies of 2021	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	2
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change, Soil Deal
EIC programme manager portfolios	
Advanced materials for energy and environmental sustainability, Energy systems and green technologies, Renewable energy conversion and alternative resource exploitation, Food chain technologies and novel sustainable food	

66 Blue hydrogen obtained through carbon capture

Description	
Hydrogen's potential as a near-zero emission energy source could be unlocked through carbon capture and storage (known as blue hydrogen), preventing CO2 from entering the atmosphere and reducing emissions resulting from energy generation. As an alternative to storage and as a way to increase its economic viability, the captured CO2 could be further used as feedstock in the production of alternative synthetic fuels. While its true sustainability is debated, blue hydrogen is less carbon-intensive than grey hydrogen (a by-product of an industrial process) and more cost-effective than green hydrogen (produced entirely from renewable sources).	
Underlying technologies or innovations	**Areas of application**
Blue Hydrogen, Alternative Synthetic Fuels	Energy, Logistics & Mobility
Source (Author | Year | Name)	
ITONICS | 2022 | Game-Changing Technologies for Energy	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	2
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change
EIC programme manager portfolios	
Advanced materials for energy and environmental sustainability, Energy systems and green technologies, Renewable energy conversion and alternative resource exploitation	

67 Growth and diversification of artificial meat, dairy and oils

Description	
Market-share growth and diversification of artificial meat and dairy-based products could reduce the overall farming industry carbon footprint. Nevertheless, protein substitutes such as the Impossible Burger and Beyond Meat will need to take over a much greater share of the market to mitigate the massive levels of carbon and methane produced in raising livestock. New processes, such as precision fermentation through genome sequencing and gene editing, result in microbes engineered for a specific purpose, such as feeding them to a fermenter in order to create artificial dairy products (such as cheese), coconut oil or palm oil.	
Underlying technologies or innovations	**Areas of application**
Artificial Dairy Products, Artificial Meat, Artificial Oils	Agriculture & Food
Source (Author | Year | Name)	
World Economic Forum| 2021 | Top 10 Emerging Technologies of 2021	
BBC Science Focus | 2022 | Future technology: 22 ideas about to change our world	
Future Today Institute | 2022 | Synthetic Biology, Biotechnology & AgTech	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	3
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change, Soil Deal
EIC programme manager portfolios	
Food chain technologies and novel sustainable food	

68 Artificial leaves transform into organic fertilisers and enhance biosequestration

Description	
Artificial leaves, meant to emulate the natural process of CO2 absorption by biological trees, could come to perform biosequestration and even be turned into organic fertilisers. Scientists at Arizona State University have created one format of these leaves in plastic-like discs that absorb CO2 in the environment; when filled, the leaves drop down the trunk of the artificial tree and into pipes that collect the CO2 in liquid form, which can, in turn, be used in carbonated drinks. Another solution is to use the collected CO2 in carbon nanofibres to be used in consumer and industrial products such as wind turbine blades or airplanes. Another project out of Harvard University uses the leaves that collect solar energy and connects them to a strain of bacteria that makes them able to convert CO2 and nitrogen in the atmosphere into organic forms that can benefit living organisms such as plants and crops	
Underlying technologies or innovations	**Areas of application**
Carbon capture	Agriculture & Food, Environment & wildlife protection
Source (Author | Year | Name)	
Future Today Institute | 2022 | Synthetic Biology, Biotechnology & AgTech	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	2
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change, Soil Deal
EIC programme manager portfolios	
Energy systems and green technologies, Food chain technologies and novel sustainable food	

69 Greener fashion

Description	
The fashion industry contributes to 10% of global carbon emissions and is responsible for a significant consumption of water. Some fabrics (such as the ones made of polyester) are also responsible for polluting our oceans with microfibres, and the whole industry is depositing each year a significant amount of waste from unsold pieces of clothes. Several technologies are being developed that could help turn fashion into a greener industry such as microfibres grown in a biofoundry and engineered from natural materials (like spider DNA). Also, artificial leather (engineered from materials such as the ones that help fungi grow) could reduce the environmental impact of the farming industry, while addressing the ethical issues concerning animal use and accelerate the production of these materials. If fibres are designed and grown, rather than harvested and processed, further opportunities could be explored such as a more efficient use of bio-based pigments that demand less ink quantity and less water usage while being fully biodegradable.	
Underlying technologies or innovations	**Areas of application**
Synthetic Fabrics and Artificial Leather	Agriculture & Food, Fashion, Environment & wildlife protection
Source (Author | Year | Name)	
Future Today Institute | 2022 | Synthetic Biology, Biotechnology & AgTech	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	3
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change, Soil Deal
EIC programme manager portfolios	
Energy systems and green technologies	

70 Beer made from waste products

Description	
Waste from the food chain (such as peels) including expired products (namely fruit, vegetables and bread), and some other bio waste (like animal droppings) could be used to produce new beverages such as beer. The reuse of waste in the food chain is not something new, but this particular case opens new possibilities to reinforce this sector's circular economy approach. Paving the way is Finnish microbrewery Ant Brew, which has launched a range of craft beers called 'Wasted Potential' whose ingredients are taken from waste products from Lahti, the European Green Capital for 2021. The most unconventional beer from the edition is the Imperial Stout, which is made using goose droppings collected from parks and other public places in Lahti and used to smoke the malt.	
Underlying technologies or innovations	**Areas of application**
Food from waste	Agriculture & Food
Source (Author | Year | Name)	
Trend one | 2021 | The Trend Radar for the mid-sized sector - What trends matter in 2021+	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	3
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change, Climate-Neutral and Smart Cities, Soil Deal
EIC programme manager portfolios	
Food chain technologies and novel sustainable food	

71 Recycling wind turbines

Description	
Nearly 10GW of ageing turbines in Europe are expected to be repowered or decommissioned by 2025. Several companies are exploring the difficult process to recycle old wind turbines, turning them into new construction materials. Other firms are exploring how to produce fully recyclable blades from scratch, allowing them at the end of their life cycle to be broken down into reusable base components through novel chemcycling processes. This technology consists of a two-step process, in which thermoset composites (which are used in making wind turbine blades) are first disassembled into fibre and epoxy, and the epoxy is then further broken up into base components.	
Underlying technologies or innovations	**Areas of application**
Wind energy	Building Construction, Energy
Source (Author | Year | Name)	
Trend one | 2021 | The Trend Radar for the mid-sized sector - What trends matter in 2021+	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	2
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change
EIC programme manager portfolios	
Advanced materials for energy and environmental sustainability, Energy systems and green technologies, Architecture, engineering and construction technologies	

72 Bioplastic made of forest and farm waste

Description	
A new form of bioplastic that sequesters carbon, made out of biochar, has been developed in Berlin. Biochar is a form of charcoal produced by heating biomass, from forest and farm waste, to extremely high temperatures in an oxygen-free furnace. This new material remains stable for centuries and therefore - in contrast to decaying biomass - does not release its carbon into the atmosphere for a very long time. Biochar has several applications, from use in furniture to building facades.	
Underlying technologies or innovations	**Areas of application**
Bioplastic	Building Construction, Industry & Manufacturing, Environment & wildlife protection
Source (Author | Year | Name)	
Trend one | 2021 | The Trend Radar for the mid-sized sector - What trends matter in 2021+	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	3
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change, Climate-Neutral and Smart Cities, Soil Deal
EIC programme manager portfolios	
Architecture engineering construction technologies, Food chain technologies and novel sustainable food	

73 All-carbon recyclable printable transistor

Description	
Researchers have developed an all-carbon transistor that can be almost fully recycled. The transistor is made out of three carbon-based (known as nanocellulose) inks. Inks can be easily printed with the required semiconductor onto paper or other flexible, environmentally friendly surfaces. After use, this printed transistor could be recycled through a process involving baths and sound waves and later on reused almost up to 100%.	
Underlying technologies or innovations	**Areas of application**
Semiconductors	Consumer Electronics, Digital Products & Services, Industry & Manufacturing
Source (Author | Year | Name)	
Trend one | 2021 | The Trend Radar for the mid-sized sector - What trends matter in 2021+	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	2
Commission priorities	**Missions in Horizon Europe**
A European Green Deal, A Europe fit for the digital age	Climate Change
EIC programme manager portfolios	
Responsible electronics	

74 Terraforming for outer-Earth agriculture

Description	
Terraforming is the process of deliberately altering the environment of a planet or moon to make them more similar to that of Earth's, thus creating hospitable conditions. NASA distinguishes between three types of terraforming, ranging from full, to partial, to para-terraforming (in which large-scale pressurised habitats and agricultural zones exist on the surface without substantial atmospheric alterations). It has long been a hypothetical process, mentioned in various works of science fiction. However, as humans move towards outer space exploration and soon start off-planet settling, the need to develop agricultural practices that can thrive in these environments presents itself. Earth microbes that survive extreme conditions (such as those in the Atacama Desert) and new life forms developed via synthetic biology may be the way forward in this field, which will necessarily combine biology, botany, agriculture, robotics and physics.	
Underlying technologies or innovations	**Areas of application**
Terraforming	Space, Agriculture and Food
Source (Author | Year | Name)	
Future Today Institute | 2023 | 2023 Tech Trends Report	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	1
EC Priorities	**EU Missions**
A European Green Deal, A Europe fit for the digital age	n/a
EIC programme manager portfolios	
Space systems & technologies, Food chain technologies, novel & sustainable food	

75 Radiative cooling enables solar power to produce energy at night

Description	
Solar panels and wind turbines have thus far been the most pervasive forms of renewable energy solutions. Although wind farms work throughout the entire day, solar panels can only produce energy during daylight hours, and are subject to cloud coverage conditions as well. As an answer to this, new research and experiments at Stanford and the University of South Wales target 'radiative cooling', the process an object undergoes when cooling down at night, through which it radiates heat. This difference in temperature may be harnessed and turned into electricity, even being added to existing solar panels. The drawback of this technology is its effectiveness when compared with solar, as the energy produced is but a fraction of that of a solar cell (50 milliwatts per square metre compared with 200 watts per square metre).	
Underlying technologies or innovations	**Areas of application**
Radiative cooling	Energy
Source (Author | Year | Name)	
Future Today Institute | 2023 | 2023 Tech Trends Report	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	1
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change
EIC programme manager portfolios	
Energy systems and green technologies	

76 AI in wind farms improving energy output

Description	
AI applied to renewables, particularly wind farms, may help improve energy output in various formats. On the one hand, Michel Howland, an MIT professor, has developed an algorithm that can adjust the orientation of turbines and coordinate them so that their total energy output is maximised. This is due to the 'wake effect' in which the wind, upon hitting a turbine, reduces in speed and adds turbulence, creating a wake in the air much like a boat creates wakes in the water. By adjusting the orientation of turbines affected by the wake effect of other turbines, energy output can be consistent and maximised. On the other hand, a Google pilot programme has been launched in which AI is used to predict wind power output up to 36 hours in advance, helping to make this energy source more predictable.	
Underlying technologies or innovations	**Areas of application**
Artificial Intelligence, Wind Energy	Energy
Source (Author | Year | Name)	
Future Today Institute | 2023 | 2023 Tech Trends Report	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	2
Commission priorities	**Missions in Horizon Europe**
A European Green Deal, A Europe fit for the digital age	Climate Change
EIC programme manager portfolios	
Energy systems and green technologies	

77 CO2 storage and transformation into energy

Description	
The start-up Energy Dome, from Italy, has developed a battery that uses CO2 as its main component. The gas is used as a working fluid in a closed thermodynamic process. When CO2 is heated, it expands, causing a turbine inside the battery to start turning and electricity to be generated without emitting any of the CO2 inside. This breakthrough, coupled with direct carbon air capture (there are presently 19 such facilities operating around the world), could pave the way for a new generation of sustainable batteries. Furthermore, a group of researchers in the University of Basel discovered a bacterial enzyme that could store carbon dioxide and open new ways for depositing the gas.	
Underlying technologies or innovations	**Areas of application**
Carbon Capture, New types of batteries	Energy, Environment & wildlife protection
Source (Author | Year | Name)	
Future Today Institute | 2023 | 2023 Tech Trends Report	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	1
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change
EIC programme manager portfolios	
Energy systems and green technologies	

78 First 'supercritical' geothermal plant running within the next 6 years

Description	
Geothermal energy is available all over the world and is constant, renewable, and dispatchable (meaning, its output can be moderated according to demand). It has long played second fiddle to solar and wind power due to its extremely high implementation costs and significant operational risks. However, new breakthroughs in supercritical geothermal production (in which drilling is done 20 km or deeper into the earth to reach temperatures above 500 degrees Celsius) may revolutionise this energy source. Quaise, an enterprise originating from the Massachusetts Institute of Technology, has developed a non-mechanical drilling process that vaporises rocks to achieve supercritical temperatures and has announced its intention to have its first plant running within the next 6 years. Simultaneously, in Newberry (Oregon, USA), an existing well is being deepened to 4 500 metres to access temperatures of 400 degrees Celsius. This will enable testing of superhot temperatures in power production, and estimates point to the well providing for the energy needs of 3 million homes.	
Underlying technologies or innovations	**Areas of application**
Supercritical geothermal power	Energy
Source (Author | Year | Name)	
Future Today Institute | 2023 | 2023 Tech Trends Report	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	2
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change
EIC programme manager portfolios	
Energy systems and green technologies	

79 Biofuel development from hemp and algae

Description	
Biofuel initiatives have captured the attention of policymakers, with various governments offering support. Biofuel is produced over a short time span from biomass, which means it can be created from plants or from biowaste. The exploration of this fossil fuel alternative has resulted in a very promising crop for producing biofuel: hemp. Besides producing more biofuel per hectare than any other land-grown crop, it can be processed more quickly, as it does not need to be dried beforehand like other crops. Hemp can be processed into ethanol, methanol, biodiesel, and solid fuel. Another biomass that has been extensively tested is algae, as it does not compete with food crops for arable lands, and some strains have a high production of lipids that can be turned into fuel relatively easily. However, most of the funding for this research has been pulled, as growing algae for biofuel is particularly expensive, utilising large amounts of water and costly nutrients. Recently, coffee grounds were successfully used as feeding for microalgae, which may help to alleviate these costs.	
Underlying technologies or innovations	**Areas of application**
Biofuel	Energy
Source (Author | Year | Name)	
Future Today Institute | 2023 | 2023 Tech Trends Report	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	1
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change, Restore our Ocean and Waters
EIC programme manager portfolios	
Energy systems and green technologies	

80 Break-even in fusion power

Description	
Fusion power, a subset of nuclear energy, is obtained by fusing parts of atoms together. This could prove to be an effectively limitless power source, eco-friendly and safe, with only small amounts of radioactive waste. This seemed impossible to achieve for a long time, as the energy necessary to create fusion was higher than the output of the fusion itself, resulting in a net loss of energy for the experiments. However, at the end of 2022, it was announced that scientists at the National Ignition Facility of the Lawrence Livermore National Laboratory achieved break-even fusion power – in other words, the reaction produced slightly more energy than the energy necessary to create it. This could mean the technology is on its way to sustainable development and bigger, more powerful energy gains as it develops. Nevertheless, nuclear power is likely to continue to face resistance over concerns for possible accidents and fallout.	
Underlying technologies or innovations	**Areas of application**
Fusion nuclear power	Energy
Source (Author | Year | Name)	
Future Today Institute | 2023 | 2023 Tech Trends Report	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	1
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change
EIC programme manager portfolios	
Energy systems and green technologies	

81 Development of solar-enhanced vehicles

Description	
Electric vehicles with embedded solar panels may lessen their weight and charging needs, effectively increasing their efficiency and range. In 2022, the company Lightyear shipped its first solar-enhanced vehicle to a limited number of customers, but solar EVs have yet to reach critical mass in the market. However, advancements on the solar cells front may contribute to the development of this technology, as the difficulty of combining solar cells with the vehicles reduces. The company Exeger has developed compact and flexible solar cells, while Powerfoyle's cells are dye-sensitised and contain titanium dioxide, which enables the printing of cells to look like plastic, carbon fibre or steel.	
Underlying technologies or innovations	**Areas of application**
Solar-enhanced vehicles	Logistics & mobility, Environment & wildlife protection
Source (Author | Year | Name)	
Future Today Institute | 2023 | 2023 Tech Trends Report	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Green	2
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Climate Change
EIC programme manager portfolios	
n/a	

82 Regenerative ocean farming costs may be going down

Description	
Regenerative ocean farming, the practice of growing seaweed and shellfish in underwater gardens, has several obvious ecological benefits, such as requiring none of the inputs normally associated with farming, providing a habitat for other species, improving ocean quality, and capturing carbon dioxide. Besides this, it can become an important source of protein in the future of human food production. Now, this practice can be scalable and provide real economic returns, thanks to some advances and innovations in the supply chain, namely in hardware, software, and biology. Boats especially designed for multi-trophic aquaculture are being purposely built for new farms. Sensors and farm management software are enabling remote control over production, and maximisation of output. Researchers and breeders are working on the development of more productive and disease-resistant strains. Furthermore, expansion of the production itself has garnered economies of scale, leading to higher efficiencies.	
Underlying technologies or innovations	**Areas of application**
Ocean monitoring, bioengineering, boat engineering	Agriculture and Food, Environment & Wildlife protection
Source (Author | Year | Name)	
S2G Ventures | 2022 | 8 Trends Critical to a Vibrant Blue Economy	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	3
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Restore our Ocean and Waters
EIC programme manager portfolios	
Food chain technologies, novel & sustainable food	

83 Cell-cultivated seafood will take off

Description	
Cellular agriculture focuses on creating animal products without the use of the actual animals. Cell-cultivated food is identical to biological seafood at the cellular level, as it utilises the same biological process for tissue growth that occurs inside a living being. A combination of biotechnologies enables scientists to grow fish cells and structure them in a way that reproduces texture and bite. The opportunity resides in the future reduction of costs associated with the presently costly technology required, and cellular agriculture may one day be sustainable and increasingly affordable. This could be the starting point for a reduction in livestock consumption and ecosystem and fauna regeneration, as well as providing independence from weather conditions, diseases and antibiotics in the production of animal proteins.	
Underlying technologies or innovations	**Areas of application**
Cell-cultivated food	Agriculture and Food
Source (Author | Year | Name)	
S2G Ventures | 2022 | 8 Trends Critical to a Vibrant Blue Economy	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	1
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	Restore our Ocean and Waters
EIC programme manager portfolios	
Food chain technologies, novel & sustainable food	

Health

84 On-demand and remote drug manufacturing

Description	
Development of new solutions for on-demand manufacturing of drugs may revolutionise where, when and how they are made. Drugs could be made in remote locations or in field hospitals, requiring fewer resources to store and transport, and doses can be tailored to individual patients. Furthermore, drugs may be tailored to unique genetic profiles in the future: new diagnostic tests focused on recreational drugs such as marijuana show promise. Atai Life Sciences (Berlin) is developing research on repurposing psychedelics as therapies for depression and PTSD. MindMed (New York) is developing a platform to help patients determine which drugs to take – therapeutics based on MDMA and DMT – depending on genetic and other data.	
Underlying technologies or innovations	**Areas of application**
Continuous-flow Pharmaceutical Manufacturing	Pharma
Source (Author | Year | Name)	
World Economic Forum | 2021 | Top 10 Emerging Technologies of 2021	
Future Today Institute | 2023 | 2023 Tech Trends Report	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	3
Commission priorities	**Missions in Horizon Europe**
Economy that works for all, A Europe fit for the digital age, Promoting our European way of life	Cancer
EIC programme manager portfolios	
Health and biotechnology	

85 Breath sensors improving medical diagnostics

Description	
Improvement in accuracy of breath-sensor technology could streamline medical diagnostics by providing a non-invasive way to collect critical health data. Simultaneously, a series of new developments in existing technologies has enabled a new era for connectivity and internet of things, and unlocked new uses for industrial organisations by maximising geographic coverage, data throughput and spectrum efficiency, and minimising latency and energy consumption. These technologies include 5G/6G cellular, Wi-Fi 6, wireless low-power and wide-area (LPWA) networks, low-Earth orbit (LEO) satellites, and optical fibre wires. Connectivity will be a major boon in the treatment of chronic diseases, as AI-powered diagnostics can be conducted using data from patients while they are monitored at home using connected medical devices; this will improve patient access to healthcare while improving the overall digitisation of healthcare services.	
Underlying technologies or innovations	**Areas of application**
Artificial Intelligence, Portable Medical Devices	Healthcare
Source (Author | Year | Name)	
World Economic Forum | 2021 | Top 10 Emerging Technologies of 2021	
McKinsey & Company | 2022 | McKinsey Technology Trends Outlook 2022	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	3
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, A Europe fit for the digital age, Promoting our European way of life	Cancer
EIC programme manager portfolios	
Health and biotechnology, Medical technologies and medical devices	

86 Nanotech for personalised medicine

Description	
The application of nanotechnology in the field of medicine can enable a more personalised, predictive and regenerative healthcare system through applications such as smart pills, miniature surgeons and nano-enabled wearables. Although nanomedicine is still in its infancy, it is gaining traction in the treatment of cancer, Parkinson's disease, Alzheimer's, diabetes, orthopaedic diseases, and several other diseases related to blood, lungs, and the cardiovascular system. However, the high cost of nanoparticle-assisted medicine compared with its conventional counterparts and strict regulatory issues could impede the growth in this field for the foreseeable future.	
Underlying technologies or innovations	**Areas of application**
Nanotechnology	Healthcare, Pharma
Source (Author | Year | Name)	
ITONICS | 2021 | Game-Changing Technologies for Healthcare & Pharmaceutical	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	2
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, A Europe fit for the digital age, Promoting our European way of life	Cancer
EIC programme manager portfolios	
Health and biotechnology, Medical technologies and medical devices	

87 Intersection of biopharma and health-tech to enable faster treatments and cost reduction

Description	
The increasing intersection of biopharma & health-tech will produce a shift in the value system of care, faster development of treatments, and cost reduction. Traditionally, health-tech and biopharma have been two separate domains: health-tech sold software at zero marginal costs, while biopharma sold physical biochemical formulations. As such, everything was different, from buyers and investors to regulatory paths. However, many health-tech companies are starting to share characteristics with biopharma, for example, by getting clinical validation in randomised controlled trials that demonstrate efficacy in a way accepted by the system. This convergence will likely dictate the shift to value-based healthcare and reducing costs.	
Underlying technologies or innovations	**Areas of application**
Portable Medical Devices, Biopharma, Internet of the Body	Healthcare, Pharma
Source (Author | Year | Name)	
Dealroom | 2021 | Digital healthcare: patient-first?	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	3
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, A Europe fit for the digital age, Promoting our European way of life	Cancer
EIC programme manager portfolios	
Health and biotechnology, Medical technologies and medical devices	

88 Creation of synthetic organisms

Description	
The creation of never-before-seen living and reproducing synthetic organisms based on an expanded genetic code and amino acid repertoire could be common in research settings and some industrial sectors within the next 20 years. To be able to create these organisms would not only be a landmark in the human understanding of living processes but also enable a veritable boom in research, discovery and application of biotech and pharma. Synthetic organisms are also likely to trigger greater investment in biotech and further discussion on the direction of biosciences; concerns about the technology's broad availability to the public and its potential nefarious uses are inevitable.	
Underlying technologies or innovations	**Areas of application**
Gene-engineering, Bioengineering	Agriculture & Food, Healthcare
Source (Author | Year | Name)	
National Intelligence Council - USA | 2021 | The Future of Biotech	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	1
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, Promoting our European way of life	n/a
EIC programme manager portfolios	
Health and biotechnology, Food chain technologies and novel sustainable food	

89 Brain-reading robots for personalised medicine

Description	
Brain-reading robots, enhanced with a machine-learning algorithm that provides progressive personalisation to individual preferences and brain signals, could enable wheelchairs to be controlled by the brain or assistance machines for tetraplegic patients in the future. Researchers from the Swiss Federal Institute of Technology Lausanne (EPFL) have created a way for tetraplegic patients to interact with the world via a robot arm and a brain-computer interface, powered by a machine-learning algorithm. In the tests, the robot arm would perform tasks such as moving an object. The algorithm would then interpret the signs it received from the brain (through an electrode cap) and determine whether the movement was considered correct or incorrect. With time, the algorithm can adjust to individual brain signals.	
Underlying technologies or innovations	**Areas of application**
Robotics, Artificial Intelligence	Healthcare
Source (Author | Year | Name)	
BBC Science Focus | 2022 | Future technology: 22 ideas about to change our world	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	1
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, A Europe fit for the digital age, Promoting our European way of life	n/a
EIC programme manager portfolios	
Health and biotechnology, Medical technologies and medical devices	

94 Video games in medicine

Description	
Video games designed to treat mild to moderate mental health conditions may soon receive approval by competent authorities and help fight a rising epidemic. DeepWell, a video game publisher focused on creating games with therapeutic benefits, is paving the way. With its first game release set for 2023, it will be designed to treat mild to moderate depression, anxiety and hypertension. Besides this launch, DeepWell also aims to develop a framework to help other video game makers create medically therapeutic gaming experiences, and to get the U.S. Food and Drug Administration approval for them as over-the-counter treatments.	
Underlying technologies or innovations	**Areas of application**
Video games	Leisure & Entertainment, Consumer Electronics, Healthcare
Source (Author | Year | Name)	
Futures Platform | 2022 | Disruptor Alert	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	2
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, A Europe fit for the digital age, Promoting our European way of life	n/a
EIC programme manager portfolios	
Medical technologies and medical devices	

95 Gene-engineering could revolutionise medicine

Description	
Gene-engineering, including gene-editing solutions such as clustered regularly interspaced short palindromic repeats (CRISPR), could make health diagnostic testing more accessible, foster innovation and personalisation in healthcare and disease cures, and even eliminate insect-borne diseases. To combat the rising antibiotic resistance, CRISPR-based antibiotics are being explored, which work by killing bacteria that contain specific DNA. Xenotransplantation (the growing of genetically engineered organs in animals for transplantation into humans) shows great promise and may come to solve organ shortages and waiting lists. It can also expand beyond medical and agricultural applications, to include, for instance, the production of biofuels. This trend goes hand in hand with potential reproductive engineering in order to enhance human traits and performance, something that could be pursued by a growing number of people and societies as a means to advantage their children.	
Underlying technologies or innovations	**Areas of application**
Gene-engineering	Genomics, Healthcare, Agriculture & Food, Energy
Source (Author | Year | Name)	
National Intelligence Council - USA | 2021 | The Future of Biotech	
World Economic Forum | 2021 | Top 10 Emerging Technologies of 2021	
ITONICS | 2021 | Game-Changing Technologies for Healthcare & Pharmaceutical	
Dealroom | 2021 | Digital healthcare: patient-first?	
Future Today Institute | 2023 | 2023 Tech Trends Report	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	2
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, A Europe fit for the digital age, Promoting our European way of life	Cancer, Climate Change, Soil Deal
EIC programme manager portfolios	
Health and biotechnology, Food chain technologies and novel sustainable food	

96 Proactive and decentralised digital healthcare

Description	
Proactive, decentralised and patient-empowerment digital healthcare, together with continuous connectivity and monitoring, are game changers for prevention and healthcare provision. Wireless biomarker devices, for instance, can provide continuous, non-invasive monitoring of chronic diseases. Other portable medical devices provide rapid point-of-need diagnostics, live monitoring of biological processes in humans and animals and software-as-medical-device solutions. Low-latency networks and high density of connected devices and sensors make it possible to monitor patients at home in real time, which could be a major boon in the treatment of chronic diseases. AI-powered diagnostics can be conducted using data from patients while they are monitored at home using connected medical devices; this will improve patient access to healthcare while improving the overall digitisation of healthcare services.	
Underlying technologies or innovations	**Areas of application**
Internet of the Body, Internet of Things, Portable Medical Devices, Software-as-Medical-Device, Artificial Intelligence	Healthcare
Source (Author | Year | Name)	
World Economic Forum | 2021 | Top 10 Emerging Technologies of 2021	
ITONICS | 2021 | Game-Changing Technologies for Healthcare & Pharmaceutical	
Dealroom | 2021 | Digital healthcare: patient-first?	
McKinsey & Company | 2022 | McKinsey Technology Trends Outlook 2022	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	3
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, A Europe fit for the digital age, Promoting our European way of life	Cancer
EIC programme manager portfolios	
Medical technologies and medical devices	

97 3D bioprinting of tissues and bones to revolutionise medicine

Description	
3D bioprinting of living tissues addresses the demand for ethical pharmaceutical research & testing, regenerative medicine (e.g. printed skin used for replacing burned skin) and organ transplants, and represents a revolution in healthcare. Among the most recent signals are 3D-printed bones, designed to fit patient's needs and features and made from specific materials that enable full restoration of bone function. The potential creation of genetically tailored animals to produce human organs compatible for transplantation may reduce costs in treatments for chronic diseases, although it may raise ethical issues. Furthermore, synthetic and artificial wombs have already been used in science experiments: researchers of Northwestern University printed and implanted synthetic ovaries in mice that resulted in successful pregnancies. While synthetising and growing a full-size organic womb is still many years away, advancements like biobags (which successfully keep premature lambs alive and developing normally for 28 days) could help thousands of premature babies born before 25 weeks every year.	
Underlying technologies or innovations	**Areas of application**
3D Bioprinting	Healthcare, Biotechnology
Source (Author | Year | Name)	
ITONICS | 2021 | Game-Changing Technologies for Healthcare & Pharmaceutical	
Fraunhofer | 2022 | Fraunhofer Institute for Technological Trend Analysis - Trend News	
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Future Today Institute | 2023 | 2023 Tech Trends Report	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	2
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, A Europe fit for the digital age, Promoting our European way of life	Cancer
EIC programme manager portfolios	
Health and biotechnology, Medical technologies and medical devices	

98 Computer-aided drug discovery augmented by artificial intelligence and quantum computing

Description	
AI is making drug discovery faster and more effective by increasing the likelihood of success and shortening time-to-market of new drugs, changing the way scientists carry out research, for example by analysing and simulating countless scenarios. Additionally, quantum computers can provide the advanced computing power needed for complex computational workloads, also reducing significantly the time needed for research and development. Additionally, the use of algorithms and AI may be applied to understand tiny variations in DNA and make accurate gene-based predictions about an individual's future, enabling interventions at the DNA level that could one day contribute to eradicating diseases and resistance to viruses, or to protecting against degenerative conditions such as Alzheimer's.	
Underlying technologies or innovations	**Areas of application**
Computer-Aided Drug Discovery, Quantum computing, Artificial Intelligence	Scientific Research, Pharma
Source (Author | Year | Name)	
Deloitte | 2022 | Tech Trends 2022	
ITONICS | 2021 | Game-Changing Technologies for Healthcare & Pharmaceutical	
Dealroom | 2021 | Digital healthcare: patient-first?	
BBC Science Focus | 2022 | Future technology: 22 ideas about to change our world	
Future Today Institute | 2023 | 2023 Tech Trends Report	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	3
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, A Europe fit for the digital age, Promoting our European way of life	Cancer
EIC programme manager portfolios	
Quantum tech and electronics, Health and biotechnology	

99 Body-on-a-chip for testing new treatments

Description	
Different combinations of organoids (tiny blobs grown from human stem cells that could grow into tissues) could soon be integrated into a body-on-a-chip that could be used for research and testing. This body-on-a-chip could resemble a computer chip on a transparent circuit board, connected to a system pumping a blood substitute. Researchers could then induce diseases or intoxications to this circuit in order to understand how the body would react, and test potential treatments on living human tissue without the need for testing in animals or humans.	
Underlying technologies or innovations	**Areas of application**
Gene-engineering, Body-on-a-chip	Healthcare, Scientific Research, Pharma, Biotechnology
Source (Author | Year | Name)	
Future Today Institute | 2022 | Synthetic Biology, Biotechnology & AgTech	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	2
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, Promoting our European way of life	Cancer
EIC programme manager portfolios	
Health and biotechnology, Medical technologies and medical devices, Responsible electronics	

100 Molecular robotics

Description	
Scientists at Harvard University's Wyss Institute have discovered that our DNA, like a robot, can be programmed to perform tasks. DNA molecules can also self-assemble and react to the environment; scientists at Arizona State University and Harvard have created single-stranded DNA which can fold itself into origami-like shapes. RNA can be used as well, and other labs in the California Institute of Technology were able to create a DNA version of a game of tic-tac-toe. Molecular robotics could soon be used to provide advanced healthcare, such as targeted therapies or genetic augmentation, but could also provide new opportunities to advance agriculture.	
Underlying technologies or innovations	**Areas of application**
Molecular Robotics, Gene-engineering	Biotechnology, Pharma, Healthcare, Agriculture & Food, Genomics
Source (Author | Year | Name)	
Future Today Institute | 2022 | Synthetic Biology, Biotechnology & AgTech	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	1
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, Promoting our European way of life	Cancer
EIC programme manager portfolios	
Health and biotechnology, Food chain technologies and novel sustainable food	

101 Reversing ageing

Description	
Scientists at Columbia University have devised a way to record and store information about cells as they age, using the CRISPR-Cas system over a period of days, almost like a biological digital video-recorder. While DNA sequences do not change over a lifetime, chemical changes do occur in the strands. Observing, studying and quantifying these changes could hold the key to stopping or even reversing ageing. At the same time, another team at Harvard's Wyss Institute has combined three different therapies relating to cellular decay into one compound, designed to reverse obesity and diabetes while improving kidney and heart function; they were successful in their experiments with mice.	
Underlying technologies or innovations	**Areas of application**
Gene-engineering	Biotechnology, Pharma, Healthcare, Scientific Research, Genomics
Source (Author | Year | Name)	
Future Today Institute | 2022 | Synthetic Biology, Biotechnology & AgTech	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	1
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, Promoting our European way of life	Cancer
EIC programme manager portfolios	
Health and biotechnology	

102 On-demand molecules and microorganisms

Description	
New molecules and microorganisms with specific characteristics can be quickly discovered, designed and produced on an on-demand basis, using artificial intelligence and synthetic biology. The complexity of biological systems makes them highly adaptable and varied, suggesting there may be many ways to obtain desired outputs and consequently a high potential for customisation. Production systems could leverage this complexity in order to produce customised biological outputs; economies of scale may allow synthetic biology companies to produce hundreds of different organisms and outputs with similar processes. One example of this complexity is the human microbiome, which influences many areas of our health, from digestion to body odour. Biodigital therapies targeted at microbiomes are likely to be among the first to emerge, personalised for maximum efficiency.	
Underlying technologies or innovations	**Areas of application**
Gene-engineering, Artificial Intelligence	Healthcare, Agriculture & Food, Biotechnology, Pharma, Genomics
Source (Author | Year | Name)	
Future Today Institute | 2022 | Synthetic Biology, Biotechnology & AgTech	
Policy Horizons Canada | 2021 | Exploring Biodigital Convergence	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	2
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, A European Green Deal, Promoting our European way of life	Cancer
EIC programme manager portfolios	
Health and biotechnology, Food chain technologies and novel sustainable food	

103 Speeding up the design process for biological circuits

Description	
Researchers at the Federal University of Mato Grosso do Sul, in Brazil, are devising a way of building biological circuits made of synthetic DNA that can be operated, changed and commanded through software. A programme called DNAr simulates chemical reactions, while another, DNAr-Logic, powers the design of the circuits. The high-level design of a logical circuit is then translated into a chemical reaction network, which can be synthetised into DNA strands. This incredible shortening of the time it takes to design biological circuits could revolutionise and expedite the discovery of health treatments and new pharmaceuticals.	
Underlying technologies or innovations	**Areas of application**
Gene-engineering, Biological circuits	Biotechnology, Pharma, Healthcare, Scientific Research, Genomics
Source (Author | Year | Name)	
Future Today Institute | 2022 | Synthetic Biology, Biotechnology & AgTech	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	2
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, Promoting our European way of life	Cancer
EIC programme manager portfolios	
Health and biotechnology	

104 Biocomputers for diagnosing and treating diseases

Description	
Living organisms could be seen as computers already, considering that their cells act like logic gates, taking input from the outside world, processing it and responding with certain metabolic processes. Using a clustered regularly interspaced short palindromic repeats (CRISPR) gene-editing system, it is possible to build functional processors inside human cells. In the long term, billions of cells could build up these powerful biocomputers for diagnosing and treating disease. Cells would be looking for biomarkers and responding by creating different therapeutic molecules, depending on whether one, the other or both biomarkers are present.	
Underlying technologies or innovations	**Areas of application**
Gene-engineering	Biotechnology, Healthcare, Genomics
Source (Author | Year | Name)	
Policy Horizons Canada | 2019 | Exploring Biodigital Convergence	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	2
Commission priorities	**Missions in Horizon Europe**
An economy that works for people, A Europe fit for the digital age, Promoting our European way of life	Cancer
EIC programme manager portfolios	
Health and biotechnology	

105 Innovation in pharma and therapeutics could enable disease prevention in aquaculture

Description	
By 2050, global aquaculture is expected to at least double and, with global protein consumption on the rise, seafood is expected to become the fastest-growing animal protein consumed. However, aquatic animal diseases greatly impact not only profits but also output every year, with no consensual solutions to overcome the losses. However, recent breakthroughs in the production costs and delivery systems of therapeutics may help. Nucleic acid-based therapeutics, such as RNA and DNA developments, can be applied not only to human health. With the costs of these applications going down thanks to upstream and downstream advances, RNA has the potential to deliver targeted, safe and effective solutions to aquaculture.	
Underlying technologies or innovations	**Areas of application**
RNA therapeutics	Agriculture and Food
Source (Author | Year | Name)	
S2G Ventures | 2022 | 8 Trends Critical to a Vibrant Blue Economy	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	2
Commission priorities	**Missions in Horizon Europe**
A European Green Deal	n/a
EIC programme manager portfolios	
Food chain technologies, novel & sustainable food	

106 Alternative aquaculture feed combines nutritional benefits and environmental gains

Description	
Various developments in research into the future of feed are looking extremely promising, and circular feedstock production methods seem to produce nutrient-dense alternatives that are scalable. One of the possibilities for this technology involves farming insects at an industrial scale as aquaculture feed. These insect species provide a complete nutritional profile for the aquatic animals, as well as producing frass, a by-product that can be used as fertiliser. Single cell proteins such as yeast, bacteria and algae are another alternative which is also nutritionally compatible and has a rapid growth cycle. Another potential benefit is that some of these proteins can utilise CO2 as feedstock, thus combining the feeding of the planet with reducing greenhouse gases. The great barrier to both these solutions has been scale of operations, as both are dwarfed by the existing feedstock industry. Nevertheless, plans to open new facilities focusing on these technologies are starting to appear.	
Underlying technologies or innovations	**Areas of application**
Alternative feedstock	Agriculture and Food
Source (Author | Year | Name)	
S2G Ventures | 2022 | 8 Trends Critical to a Vibrant Blue Economy	
EIC macro-areas	**Trend consolidation level (from 3=high to 1=low)**
Health	2
Commission priorities	**Missions in Horizon Europe**
A Europe fit for the digital age	Climate Change, Restore our Ocean and Waters
EIC programme manager portfolios	
Food chain technologies, novel & sustainable food	

List of abbreviations

AI	Artificial Intelligence
ANTICIPINNOV	Anticipation and monitoring of emerging technologies and disruptive innovation
DG CNECT	European Commission's Directorate-General for Communications Networks, Content and Technology
DG GROW	European Commission's Directorate General for Internal Market, Industry, Entrepreneurship and SMEs
DG RTD	European Commission's Directorate-General for Research and Innovation
EC	European Commission
EIC	European Innovation Council
ERCEA	European Research Council Executive Agency
EU	European Union
IoT	Internet of Things
JRC	Joint Research Centre
ML	Machine Learning
PM	Programme Manager
STI	Science, Technology and Innovation
TRL	Technology Readiness Level

List of figures and tables

Figures:

Tables:

Appendix 1: List of sources

AUTHORS	YEAR	NAME	LINK [5]	INCLUSION IN THE REPORT
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Future Today Institute	2023	2023 Tech Trends Report	https://futuretodayinstitute.com/trends/	v1.0
McKinsey & Company	2022	McKinsey Technology Trends Outlook 2022	https://www.mckinsey.com/~/media/mckinsey/business%20functions/mckinsey%20digital/our%20insights/the%20top%20trends%20in%20tech%202022/mckinsey-tech-trends-outlook-2022-full-report.pdf	v1.0
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5 As available on 20/06/2023 -Links might become unavailable over time due to several reasons

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BCG	Continuous	Digital BCG	https://www.bcg.com/capabilities/digital-technology-data/overview	-
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Shell	2018	Sky - meeting the goals of the Paris agreement	https://www.shell.com/promos/business-customers-promos/download-latest-scenario-sky/_jcr_content.stream/1530643931055/eca19f7fc0d20adbe830d3b0b27bcc9ef72198f5/shell-scenario-sky.pdf	-
World Economic Forum	2018	Electric Vehicles for Smarter Cities: The Future of Energy and Mobility	http://www3.weforum.org/docs/WEF_2018_%20Electric_For_Smarter_Cities.pdf	-
World Economic Forum	2018	The Global Financial and Monetary System in 2030	https://www3.weforum.org/docs/WEF_Global_Future_Council_Financial_Monetary_Systems_report_2018.pdf	-

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