Deliverable

D3.2 Augmented SRA

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Short description of the content of the deliverable

This deliverable is the output of task T3.2 of the EXPRESS project. The main objective of this task is to analyse existing sector and technology roadmaps and construct an augmented Strategic Research Agenda (SRA) for the SSI (Smart Systems Integration) ecosystem in Europe using the EPoSS SRA as a basis and focal point and contrasting it with those of other networks, clusters and organisations.

This deliverable gathers the links between the EPoSS SRA and other platforms as opportunities to build bridges and to encourage collaboration. Two main issues were addressed to fulfil the objective of getting the Augmented SRA: identification of links between the EPoSS SRA and other relevant information sources from other ETPs, and analysis of the gathered information in order to identify the strengths, weaknesses, opportunities and threats that may act for or against the development of an ecosystem for Smart System Integration in Europe.

The central part of the deliverable, chapters 4 to 6, highlight the conclusions of the analysis of the links found in the 77 reviewed documents. These conclusions are organised in different chapters, each one devoted to the areas of ETP's classification in CORDIS, as shown in Figure 3. Each of these chapters is organised in accordance with the three types of links that were identified:

- *Application Opportunities for Smart Systems:* Introduction of Smart Systems in the specific application domains (e.g.: Transport & Mobility, Automotive, Energy, ICT...)
- Sector *drivers and barriers* to compel the use of new devices or techniques.
- *Technology challenges* (as hurdles that Smart Systems technologies should overcome) and research priorities (actions concerning research themes (priority, mid-term, long-term)).

Then, chapter 10 presents an integrated view of previous chapters transformed into SWOT components that will populate an overall SWOT analysis as input for a joint strategy and implementation plan. These contents are the inputs for task T3.3 (Strategy and implementation plan).

The deliverable has an initial part containing the executive summary, the objectives of the document and its organisation, and is completed with annexes including the methodology used to fulfil task 3.2, and references of all the analysed documents.

Table of contents:

1. Executive summary

1.1. Introduction

The augmented SRA of the European Smart Systems Integration Ecosystem takes as a basis the 2013 edition of the EPoSS roadmaps and SRA and the Smart Systems part of the ECSEL MASRIA, and consolidates these with roadmaps and SRAs of ETPs (European Technology Platforms), clusters and other networks. The outcome is an augmented SRA for the SSI ecosystem covering the application and sectoral view, the functional view, and the technological view.

The augmented SRA gathers the links between the basis SRA and SRAs of other platforms as opportunities to build bridges and to encourage collaboration. Two main issues were addressed to fulfil the objective of getting the Augmented SRA:

1. Identification of relevant information sources, and
2. links identification and analysis.

Regarding relevant information sources, diverse types of SRAs and roadmaps were analysed (see documents list in annexes). In a first round, 56 documents available from ETPs' SRAs were analysed. Then, in a second round analysis, additional 19 documents from regional clusters (SRA and roadmaps) were also analysed.

In this analysis, links were identified using the "SMART" filter. That way, any type of content that can affect Smart Systems was collected in these documents. **Three types of results** could be extracted for each of the analysed documents:

- **Opportunities for Smart Systems***:* in the specific applications domains of the ETPs (e.g.: Transport & Mobility, Automotive, Energy, ICT...).
- **Sector drivers and barriers** to the use of new devices or techniques.
- **Technology Challenges** (as hurdles that Smart Systems technologies should overcome) and **research priorities** (actions regarding coinciding research themes).

These were aggregated on the level of those sectors that the ETPs are grouped in, i.e. Production and Processes, Energy, Bio-based Economy, ICT, Transport, and Environment.

In an additional exercise, all drivers and barriers, application opportunities and technology challenges were analysed independently of the sector to provide an integrated view of Strengths, Weaknesses (or rather challenges), Opportunities and Threats.

As a general conclusion, there is a high degree of matching between the links identified in the analysed documents and the main aspects highlighted in the EPoSS SRA regarding drivers & barriers, technical research priorities and the benefits that SSI can bring to this sector.

1.2. Opportunities for Smart Systems Integration

ETPs seek to fulfil market and societal long-term needs and expectations related to their sectoral context. According to these needs, several application opportunities were identified where Smart Systems Integration can produce different types of benefits. These benefits that Smart Systems Integration can bring to the different types of ETPs guide the identification of research priorities. Some key benefits pursued in ETP SRAs are shown below and, even if they are mentioned in specific sectoral SRAs, they may be extended to other sectors:

– Implementing **trustworthy manufacturing process** while developing "design for manufacturing" "design for testing" and "**design for reliability**" with diversity of materials combined with increased system complexity.

– **ICT as key enablers to improve the quality of life for citizens** through

  - **Real world connectivity**
  - **Energy efficient ubiquitous interoperability**
  - **Secure access to various services** in different domains (digital economy, health systems, sustained energy and the protection of the environment, security and safety, life at home, in the cities, and in transportation systems)
- The *Waterborne* SRA pursues the **safe and efficient operation of increasingly complex vessels with a minimum of crew**, which requires new developments in process automation, computer technology, sensors, smart components and communication to be applied to the maritime industry.
- The *ERTRAC* SRA identifies **ICT as one of the key enablers for creating a safe, sustainable and efficient transport system**. And points to interoperability and harmonisation as well as roll out of those systems compared to the stand alone solutions as key factors to create economical sustainable solutions. **Additionally, Smart Systems are seen as components that enable new services and high performance infrastructures**
- Also automotive electronics and progressive **"smartification" of automotive systems have shown its benefits regarding some key issues** identified in transport ETPs such as:
  - **Safety and security related systems**.
  - **Improved product performance, and updatable/adaptable products.**
  - **New equipment with reduced emissions, enhanced comfort, and improved performance**.
  - **Management and control systems** addressing safety and security, equipment health monitoring, automated or self-assessed operation, and vehicle-infrastructure interaction.
  - **Smart Systems** Integration on equipments **allows key processes performance improvement**: supply chain, retrofitting, maintenance, and integrated transport system management.
- During the next decade the power network infrastructure must be upgraded to enable smart operation. Smart grids relate customer-side systems and provide opportunities to integrate Smart Systems products, services and businesses:
  - Smart appliances, routers, in-home display, building automation systems, thermal accumulators, smart thermostats.
  - Power conditioning equipment for bulk power and grid support, communication and control hardware for generation and enabling storage technology.
  - Electric vehicle charging infrastructure: Charging infrastructure, batteries, and inverters.
  - Home Energy Management Systems (HEMS) and Building Energy Management Systems (BEMS) in smart grids environments.
  - Energy-as-a-service is an innovative business model for energy utilities.

Priority and long term actions identified in the EPoSS SRA match with application opportunities identified in the links. But obviously, as the spectrum of analysed ETPs was very wide, more actions should be added, and prior collaboration between platforms is required as suggested in "drivers and barriers" section.

1.3. Driver and barriers and subsequent actions

The main drivers and barriers identified in the EPoSS SRA are also addressed in the analysed documents.

"Increased functionality" is addressed in the EPoSS SRA as the main driver for Smart Systems. This corresponds with the identified applications opportunities and technology challenges links identified in the Manufacturing / Factory Automation documents, which demand new functional materials, cognitive capabilities and human-worker interaction for Smart Systems.

Regarding the same driver, Energy sector documents specifically emphasize that new monitoring and control solutions are needed to address increased concerns that society is facing nowadays (drivers) on process safety and uncertainty reduction, and smart grid reliability and resilience.

Transport documents also provide evidence of requirements of advances on performance improvements such as: energy efficiency; market and societal needs such as: safety, security, comfort (e.g.: noise, vibration...) and so on. Other important drivers such as "reduced cost" and "increased reliability" from the EPoSS SRA are also identified by these ETPs.

This corresponds with the identified advances on performance improvements that ICT technologies can enable such as: energy efficiency, dependability, connectivity, manageability, and so. Additionally, ICT documents envisage that smartness will also be a key feature of future services.

Besides, "increased reliability" of machines and processes, product health assessment (it can be food or any manufactured product) drives the use of smart sensors or devices to reach new functionalities.

Additional drivers from an ecosystem perspective were identified. Key societal challenges and industrial leadership issues (Assisted Living, Intelligent Transport, Energy efficiency and Smart Grids, and Advanced and Intelligent Manufacturing) imply paradigm shifts that open attractive new opportunities due to both, the potential market size and the emergence of new services.

This potential is also based on two other driving foundations: On the one side, the existing capabilities, infrastructures, commercial scale demonstrators, and application arenas. On the other side, the aims of relevant leading economies, and the explicit public bodies' commitment and leadership on the above mentioned challenges and issues.

On the barriers side, "fragmented supply chain" which appears to be one of the most obstructive difficulties identified in the EPoSS SRA, is also a major barrier addressed in the analysed documents. This corresponds with what was found in the Manufacturing / Factory Automation documents, showing manufacturing capabilities and supply chains as missing capabilities for a reasonably priced mass production of diverse materials, and to manufacture the first batches of products.

In the same direction, transport documents emphasize on the supply chain, showing specifically that the increasing competitiveness and price pressures rail industry is facing lead to structural problems, and the need to consolidate some sectors of the rail supply industry. Innovative commercial approaches to large scale delivery are required.

In fact, we should talk about "fragmented ecosystem" because it was also identified that there is fragmented vision within some countries, and a fragmented and diverse offer of technology solutions. At the same time many assumptions are based on "unclear" future customer behaviour.

Linking "fragmented supply chain" to "skills shortage", it was found in ICT documents that further actions are required on collaboration, standards, and education and training.

“Untried techniques” appears to be the most obstructive difficulty in the Energy sector. In spite of lack of information about Smart Systems application, regulatory conditions, financial risk, and lack of technical standards are delaying the deployment of new technologies according to ETP revision.

Finally, according to Bio-based economy ETPs revision, “policy development needs improvement” in order to encourage emergent technologies’ implementation and new solution design.

These findings on drivers and barriers reinforce the actions claimed in the EPoSS SRA that should be complemented with additional actions on:

- **Push (needs) / Pull (success stories) forces**:
  - Recognizing safety, security and reliability as enablers of Smart Systems.
  - Migrating Smart Systems engagement in Automotive to other transport sectors.
- **Building application oriented collaboration streams**:
  - Building trans-ETP collaboration streams with other more application oriented (sectoral) ETPs, defining collaborative programs with user, societal, and advanced manufacturing needs as “pull” forces to foster innovation based on smartness of new technology.
  - The action claimed in the EPoSS SRA: “...better understanding of the Smart Systems supply chain to achieve a better match between research approaches and manufacturing capability” is reinforced. So, actions on building ecosystem collaboration streams between research resources, creating new industrial ecosystems, and promote industry-academia collaboration are required.
- **Interdisciplinary R&D&I**:
  - Encouraging inter-disciplinary R&D
  - This should be reinforced with holistic simulation tools to support the development process with coverage from concept, through manufacture to in-life service.
- **Enabling conditions and organisations**:
  - Building cohesiveness between the diverse actors of the ecosystem: shared vision, and longitudinal and transversal collaboration
  - Fostering the urgent action on open standards, regulations, and certification issues, specially on interoperability standards, protocols, and interfaces
  - Positioning EPoSS as a key actor for collaboration regarding Smart Systems Integration.

1.4. Technology challenges

To address these benefits, the following main technology challenges were identified:

- **Micro-nano technologies** looking for
  - **Miniaturisation** allowing both: higher integration level, and high performance computing Smart Systems.
  - **Advanced materials and smart structures**.
- **Sensors with advanced capabilities** (miniaturised, based on active multi-functional structures, reliable and maintenance free, perception oriented) for:
  - Analytical purposes and equipment.

    - Smart condition monitoring of processes, components and equipment with high signal-to-noise level sensors.
    - Industrial and sectors competitiveness: plant automation and process optimization, protection systems for machines, production and transportation processes.
    - Harsh environments: sensors dealing with difficult conditions, all weather operation, radiation detection, etc…
    - Context awareness: providing contextual information for different purposes (collective protection systems, fleet management, etc…).
    - Getting Information*:* New sensors for new data and meta-data, and access to sensor information will allow getting system level information. Then, multisensory networks and sensor data fusion will permit to advance on perception and content generation.
    - Wireless sensors with a life time of at least five years.
- **Control/Actuators** oriented to:
    - **Adaptive process control and automation** comprising self-organising production control, monitoring, metrology, perception/awareness and diagnosis.
    - Smart control enabled management systems are required for predictive engines, energy management for bus systems, multi-variable based control systems, and ship / shore systems integration and fast cargo handling
    - Precise, safe and secure mechanisms (e.g. medical devices that provide drug delivery).
    - Miniaturised control applications.
    - Ensure safety and security approach in sector on systems level (e.g. transport, food chain…).
- **Power technologies**
    - To enable **autonomous smarts systems**.
    - **Reduced energy consumption** at component level and energy management for overall system energy efficiency.
- **Interfaces and communications**
    - For interaction with users, **cooperative devices** and data gathering and exchange (obtain and develop information for fleet managers, drivers and in footpaths).
    - Looking for security and trust, interface standardisation and easy data exchange and interaction, grid awareness, turning devices into ubiquitous service enablers, adaptive HMI, connectivity and protocols for SatCom, and remote operation functionalities.
    - Enabling remote, smart and autonomous inspection and control. Interacting with Robots.
    - Interoperability*:* connectivity (interfaces and universal adaptors for diverse devices interconnection) and protocols (networking, data exchange and integrated model servers) require standardisation. Interoperability between systems and assets on the shop floor.

- **Cognition related challenges** oriented to **implement intelligent applications through**:
  - **Intelligent technologies for specific situations** such as hazardous situations. Safe and reliable human-machine/robot collaboration.
  - **Implement specific application functionality** like smart functions in medical devices (e.g. like ‘in vitro’ analysis of biological samples and parameters).
  - **Systems autonomy** and self- diagnosis integrating monitoring and fault prediction capabilities.
  - **Self-learning** to perform complex tasks and develop adaptive control strategies. Also, wellbeing perception oriented Smart Systems that mimic human behaviour.
  - **Content generation** from gathered information.
  - **Interaction** between devices and cognition based interaction with users and services as well.
- **Adaptability/Dependability** technologies for more robust, modular, configurable, easy to integrate, and adaptive systems
- **Modelling, simulation and design** tools for Smart Systems engineering, especially to develop intelligent systems based on risk perception and avoidance/protection, and for control strategies are required to balance different criteria.

1.5. Conclusions

A wealth of application opportunities were identified in different sectors to enhance products, equipment, processes, services, and facilities and infrastructures with improved performance based on increased functionality provided by Smart Systems Integration.

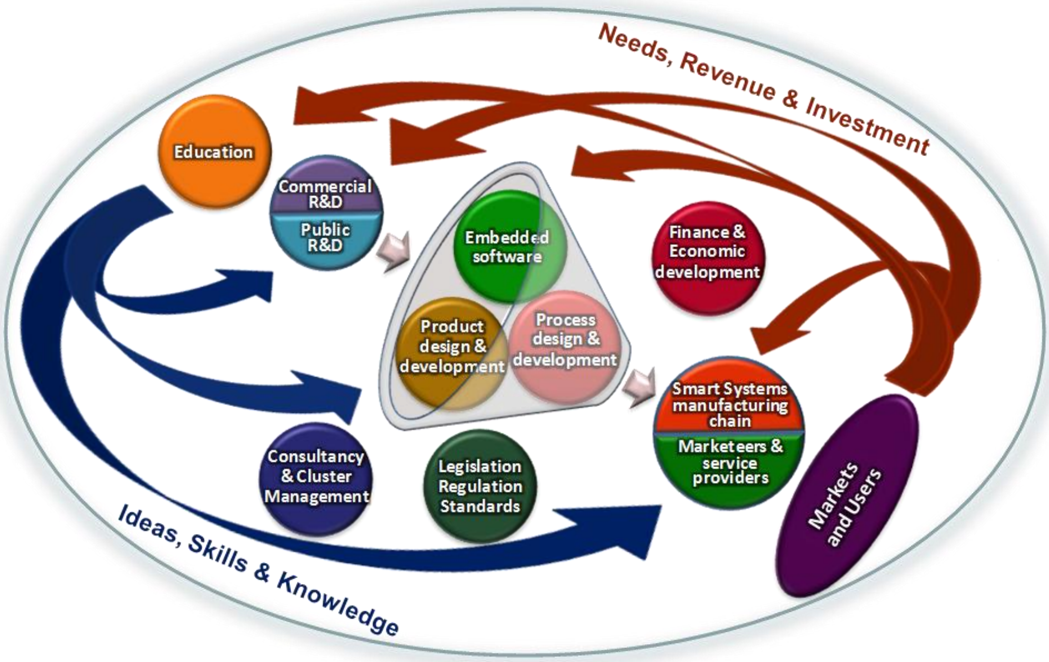


Figure 1: SSI Ecosystem

These links show a rich R&D and innovation potential and should form the concrete basis for actively engaging with the various actors in the value chains of these sectors; actors who up to now have not recognised the SSI community as a valuable partner and vice versa. Interacting and collaborating with them can further develop and grow the SSI Ecosystem.

This will offer solutions for critical requirements such as safety, security, reliability, energy efficiency, reduced emissions and comfort to these sectors, as well as drive innovation through new functionalities.

More specific conclusions are formulated in the different chapters devoted to each of the application sectors and in the transverse SWOT analysis. All of these conclusions provide valuable input for upcoming Horizon 2020 work programmes as well as for the Smart Systems objectives of the ECSEL MASRIA for 2015 and beyond.

2. Objectives of the Augmented SRA

This Augmented SRA is the output of task T3.2 of the EXPRESS project. The main objective of this task is to agree upon sector and technology roadmaps and a joint Strategic Research Agenda (SRA) for the SSI ecosystem in Europe.

The Augmented SRA takes as a basis the 2013 edition of the EPoSS SRA and the Smart Systems part of the ECSEL MASRIA, and consolidates these with roadmaps and SRAs of ETPs, clusters and other networks.

The outcome is an Augmented SRA for the SSI ecosystem covering the application and sectorial view, the functional view, and the technological view,

It's not a matter of adding new contents, but links with other SRAs and roadmaps. **The augmented SRA gathers the links between the EPoSS SRA and SRAs of other platforms as opportunities to build bridges and to encourage collaboration**.

"What elements of these SRAs are relevant for the SSI Ecosystem? "

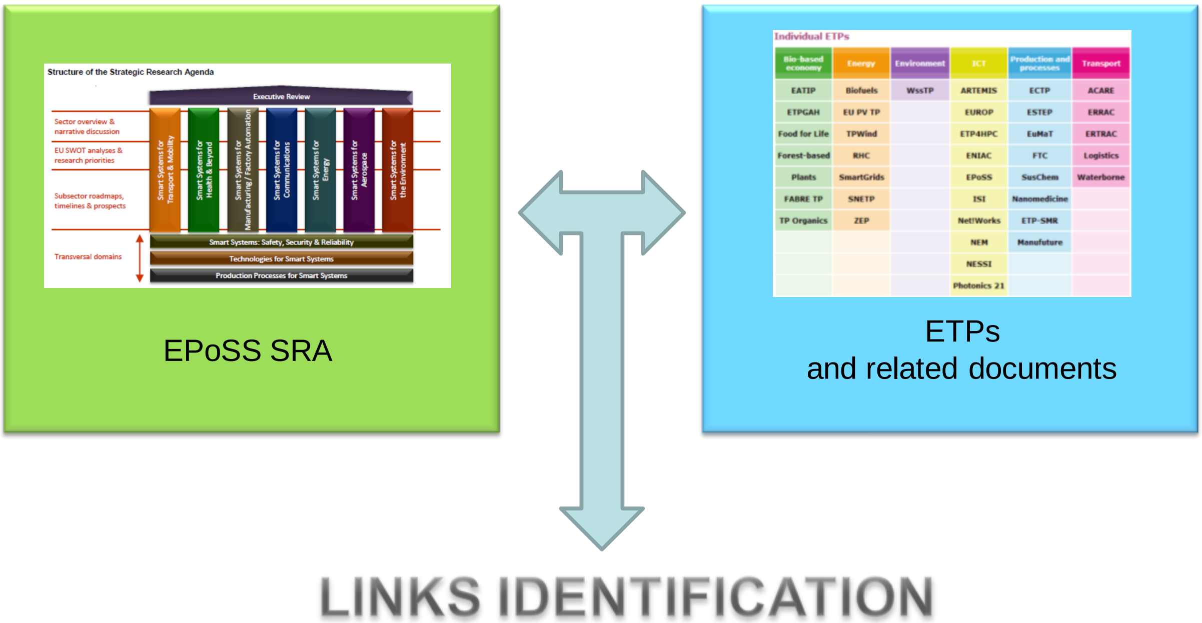


Figure 2: Links as base for Augmented SRA

Two main issues were addressed to fulfil the objective of getting the Augmented SRA:

1. Identification of relevant information sources, and
2. links identification and analysis.

Regarding relevant information sources, **two types of SRAs and roadmaps were analysed** (see documents list in annexes):

- **ETP (European Technology Platforms) SRAs**
- **Regional clusters SRAs and roadmaps**

Bio-based economy	Energy	Environment	ICT	Production and processes	Transport
EATIP	Biofuels	WssTP	ARTEMIS	ECTP	ACARE
ETPGAH	EU PV TP		EUROP	ESTEP	ERRAC
Food for Life	TPWind		ETP4HPC	EuMaT	ERTRAC
Forest-based	RHC		ENIAC	FTC	Logistics
Plants	SmartGrids		EPoSS	SusChem	Waterborne
FABRE TP	SNETP		ISI	Nanomedicine	
TP Organics	ZEP		Net!Works	ETP-SMR	
			NEM	Manufuture	
			NESSI		
			Photonics 21		

Cross ETP Initiatives
Nanofutures
Industrial Safety

Figure 3: European Technology Platforms (ETPs) in CORDIS

Regarding links identification and analysis **three types of links** were identified based **on three areas** extracted from the EPoSS SRA structure:

- ***Opportunities for Smart Systems***: Introduction of Smart Systems in the specific domain (e.g.: Transport & Mobility/Automotive)
  - *Applications and time horizon* (priority, mid-term, long-term)
  - *Application level (generations) of Smart Systems (required degree of smartness)*
- **Sector drivers and barriers** to compel the use of new devices or techniques:
  - Drivers for technological innovation
  - Benefits of (reasons for) “smartification”
- **Technology challenges** or *hurdles* that Smart Systems technologies *should overcome, and* **Research priorities**: actions regarding coinciding research themes (priority, mid-term, long-term)

Links were identified using the “SMART” filter: That way any type of content in these documents was collected that can affect Smart Systems as it is stated in the “Smart filter” definition. The “Smart” filter is a mental process to identify the connections between SRAs’ contents and Smart Systems (see page 10 of the EPoSS SRA):

Smart filter:

Smart Systems are self-sufficient intelligent technical systems or subsystems with advanced functionality, enabled by underlying micro- nano- and bio-systems and other components.

They are able to sense, diagnose, describe, qualify and manage a given situation. Their operation is further enhanced by their ability to mutually address, identify and work in consort with each other.

They are highly reliable, often miniaturised, networked, predictive and energy autonomous.

- Smart Systems are autonomous or collaborative systems.
- They bring together sensing, actuation and informatics / communications to help users or other systems perform a role.
- By their very nature these systems combine functionalities.
- They may extract multiple functionalities from a common set of parts, materials, or structures.

Smartness: "The concept of the Knowledge Base separates Smart Systems from systems which, although they may be automated, remain purely reactive".

3. Document organisation

The document is organised in four main parts. The first part, comprising chapter 1, 2 and 3, is devoted to the executive summary, the objectives of the task and the organisation of the document.

The second part of the document presents the results of the links analysis, and is organised in different chapters, according to the classification of ETPs in Cordis (Figure 3). Each chapter presents the results in three parts: application opportunities, drivers-barriers, and technology challenges.

The third part integrates all the partial analyses in one view ready to activate strategy and implementation plan activities. This integrated view shows the conclusions of the analysis as SWOT components.

Finally, the forth part presents annexes including: the methodology used to fulfil task 3.2, and the references of all the analysed documents.

4. Bio-based Economy

The main drivers and barriers identified in the EPoSS SRA are also addressed in the analysed documents.

- **Drivers**: “Increased functionality” is addressed in the EPoSS SRA as the main driver for Smart Systems. Besides, “increased reliability” of machines and processes, product health assessment (it can be food or any manufacturing product) drives the use of smart sensors or devices to reach new functionalities.
- **Barriers**: in the EPoSS SRA, “Untried techniques” appears to be the most obstructive difficulty. According to ETP revision “policy development needs improvement” in order to encourage emergent technological implementation and new solution design.

This reinforces the actions claimed in the EPoSS SRA that should be complemented with additional actions on:

- Positioning EPoSS as a key actor for collaboration regarding Smart Systems Integration
- Encouraging inter-disciplinary R&D

There is a match between the technology challenges derived from the links identified in the analysed documentation and the resulting benefits that can be obtained by meeting them.

According to SRA, and confirmed with ETP revision, a key issue is:

- Implementing **trustworthy manufacturing process** while developing “design for manufacturing”, “design for testing” and “**design for reliability**” with diversity of materials combined with increased system complexity.

This corresponds with main technology challenges derived from links regarding integration of complementary processes, sensors for food security and sustainability, and control systems oriented to ensure safety and security of the food chain.

4.1. Application Opportunities

Analysed documents emphasize application opportunities versus research opportunities, which highlight potential for collaboration guiding the implementation of Smart Systems. No opportunities were identified for Facilities, Equipment and New Business value streams.

The **greatest collaboration potential** appears to be developing as follows:

- New **Products** to solve current industry challenges:
  - **Chip technology/ DNA arrays**
  - **Biosensors and remote sensing**
  - **Sensor systems** give information about product, and connect customer domestic system
  - **Sensors** for monitoring and control
  - **Integrate sensor** and information systems in packaging materials
  - Chemical and biological analytical methods and sensors.
  - Monitoring tools, indicators and accompanying measures to reduce yield loss by promoting natural suppression of plant pathogens in soil.
  - Monitoring tools for soil, crops and animals should better support farmers’ observation.

- Developing trustworthy manufacturing **processes:**
  - **Processing control** for nutrient functionality and security
  - Control and **optimization of processes**
  - **Embedded intelligence** and communicating functions on products
  - **Smart electronic functions on packaging** include applications for monitoring and indicating product safety
- **Services:**
  - Intelligent systems to **advice consumers based on personal** way of life
  - Assuring **support of claims**
  - Intelligent sensors and actuators with improved **self-diagnosis properties**
  - **Inventory techniques**
  - Improve **database infrastructure**
  - Software tools for detecting **dangerous situations in industrial systems**

4.2. Drivers and Barriers

Some important drivers were identified. **ICT** is identified as an important driver for industry development, **and embedded devices** or ICT derived new applications are often mentioned.

- New customer-oriented services using ICT as a platform
- ICT to meet process and resource efficiency
- ICT for B2B and B2C models
- ETP challenge fits with the technology based challenges of Horizon 2020, which is identified as a driver.

Innovative and secure society, as well as the **concern about the opportunities emergent technologies offer to industry is identified** as a driver. This is aligned with the driver "increased functionality" identified in the EPoSS SRA.

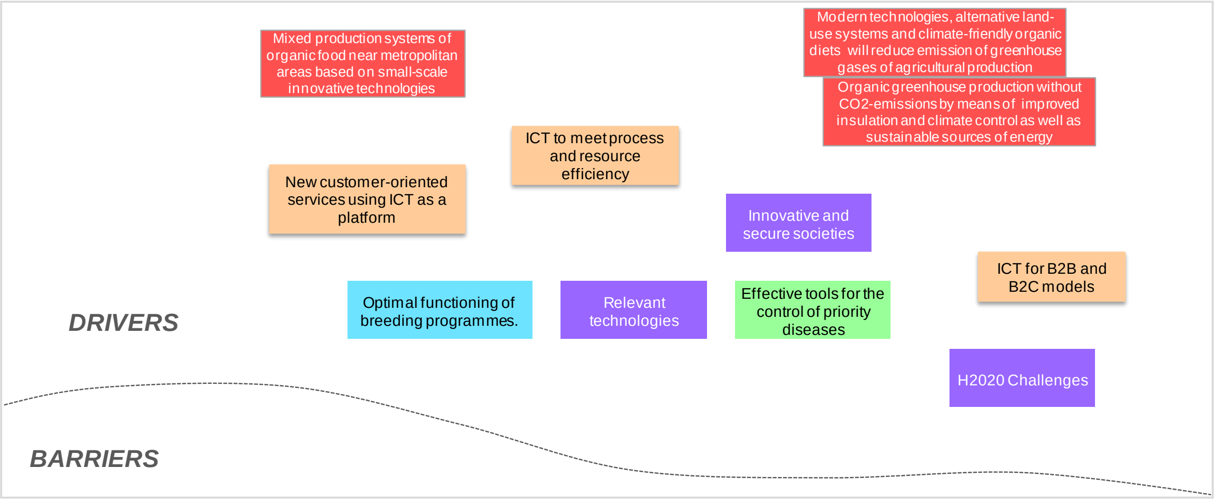


Figure 4: Drivers and barriers identified in Bio-based economy related SRAs

Climate-friendly technologies development and implementation will be **favoured by overall environmental awareness in Europe**.

Small-scale innovative technologies will allow new mixed production systems of organic food near metropolitan areas.

Smart Systems are not mentioned in most documents, enforcing the idea that **dissemination activities should be developed** in order to engage industrial community.

4.3. Technology Challenges

Technology challenges are identified in many of the base technologies regarding Smart Systems, such as:

- **Sensors**: Critical issues regarding food security and sustainability should be researched.
- **Interface and Comms**: Integration of complementary processes (food production and food processing, consumption and waste management …
- **Control/Actuators** oriented to ensure safety and security of the food chain:
  - Detection tools to ensure safety and security of the food chain
- **Adaptability**: Monitoring / models of dynamics of soil organic matter to improve soil quality

5. Energy

The main drivers and barriers identified in the EPoSS SRA are also addressed in the analysed documents.

- **Drivers**: “Increased functionality” is addressed in the EPoSS SRA as the main driver for Smart Systems. Specifically, new monitoring and control solutions are needed to answer several concerns society is facing nowadays (drivers) such as: Increase concern for the safety, increase the reliability and resilience of smart grid, reduce process uncertainty and so on.
- **Barriers**: in the EPoSS SRA, “Untried techniques” appears to be the most obstructive difficulty. In spite of lack of information about Smart Systems application, regulatory conditions and financial risk are delaying the deployment of new technologies according to ETP revision.

This reinforces the actions claimed in the EPoSS SRA that should be complemented with additional actions on:

- Encouraging inter-disciplinary R&D
- Supporting the development of holistic simulation tools with coverage from concept, through manufacture to in-life service.

According to SRA, **key issues in Energy** are:

- **Introducing Smart Systems into electricity generation/distribution**
- **Development of a new generation of Control/Actuators**
- **Improving the effectiveness of new energy resources**

Main technology challenges derived from links that will face key issues identified in the SRA:

- **Intelligent sensors** for control and condition monitoring.
- **Control/Actuators** focus on models, monitoring and impact assessment tools
- Power technologies to enable **autonomous smarts systems**.
- Interfaces and communications for interaction with users, **cooperative devices** and data exchange.
- **Cognition focus** on integration of condition monitoring and fault prediction capabilities.

5.1. Application Opportunities

Most of the analysed documents emphasize both research challenges and application opportunities, whereas SNETP, sustainable nuclear energy technology platform, emphasizes mostly application opportunities.

According to SNETP, there are numerous application opportunities, which show a clear potential for collaboration guiding the implementation of Smart Systems.

Fewer opportunities were identified for Facilities and New Business value streams (application opportunities) or Micro/Nano technologies (research challenges).

Six types of value streams appear to have greatest potential:

- **Product**
  - Smart meters with voltage and current transformers for Smart Grids
  - Monitoring devices for analysing the aging of the equipment for Smart Grids

- Electrical protection technology adapted to DER including new switch technologies and smart transformers; sensors capturing information about power flows, power quality (harmonics, etc), remaining capacity (dynamic rating) and other physical properties (temperature in cables, gas analysis in transformers, etc.)
- The integration of tracking control electronics and the inverter into one device, for EU PV TP
- Frequency-dependent power control for EU PV TP.
- To better characterise any natural events, like earthquakes, floods, etc., including methodologies to deal with rare events.
- Smart grids relate customer-side systems and provide opportunities to integrate Smart Systems products: Smart appliances, routers, in-home displays, building automation systems, thermal accumulators, smart thermostats

* **Equipment**
  - Development of control equipment and commissioning tools, ensuring that predicted results are actually obtained by the building system, for RHC.
  - The improvement of emergency response shall include: (i) availability of more sophisticated tools to provide to the operators with more reliable and quick indications/measurements of reactor status, to help in the implementation of an appropriate recovery strategy, (ii) availability of better environmental monitoring systems, models for contamination predictions, health effects of low doses, and effect of contamination on the environment (SNETP)
  - To develop wider and more robust lines of defence with respect to design basis aggressions and beyond design basis events, by defining additional measures to consider in the design and new or improved systems for mitigation of consequences. (SNETP platform)
  - Power conditioning equipment for bulk power and grid support, communication and control hardware for generation and enabling storage technology.
  - Electric vehicle charging infrastructure: Charging infrastructure, batteries, and inverters.
* **Process**
  - Small-scale power production with small-scale CCS could be a possibility for green power production for all small villages in developing countries that do not have electricity today. Key challenges to be addressed are small-scale transport and storage of CO2. (ZEP)
  - Integration of novel CO2 capture related technologies into power and other industrial processes (ZEP)
* **Services**
  - Decentralised load management systems (EU PV TP and Smart Grids)
    * Ability to remotely control levels of generation and demand along with other elements of network configuration.
    * Smart grid technologies provide an opportunity to maximise the use of existing infrastructure through better monitoring and management.
    * Real-time / Dynamic pricing infrastructure
    * Microgeneration management

- Higher controllability of PV systems and loads. (EU PV TP)
- Functionality to link smart inverters to electricity-consuming devices in homes or commercial premises must be developed. (EU PV TP)
- Home Energy Management Systems (HEMS) and Building Energy Management Systems (BEMS) in smart grids environments.

- **Facilities**
  - Ageing monitoring, prevention and mitigation, including topics on ageing monitoring of metallic components, R&D topics on concrete material, polymers and electrical equipment, and prevention and mitigation of ageing for metallic components and concrete (SNETP)
  - The modernization of the European meter infrastructure and the introduction of intelligent metering systems will have to happen. Smart meter communication infrastructure and technology. (Smart Grid)
  - Large scale demonstration of smart thermal grids
  - Small-scale transport and storage of CO2
  - Solutions need to be found for cost-effectively processing a wide range of sustainable feedstock.
  - It must be emphasized the role that smart grids can play in increasing electricity reliability: adequacy and security.
  - Power network infrastructure must be upgraded to enable smart operation
  - During 2015 – 2025 decade the power network needs to become fully automated and interconnected and this process must be driven by obliging the regulator to ensure that staged targets are met against a series of key indicators. A nationwide re-fit of the power network to create a fully network-connected system that identifies all aspects of the power grid and communicates its status and the impact of consumption decisions to automated decision-making systems on the network.
- **Businesses**
  - Energy-as-a-service is an innovative business model for energy utilities

5.2. Drivers and Barriers

More drivers than barriers were identified as shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**:

From the analysis of drivers and barriers identified in the different documents, it can be concluded that the **main drivers** are:

- **New monitoring and control solutions**, to answer several concerns society is facing nowadays (drivers) such as:
    - Increase the reliability and resilience of smart grid
    - Reduce uncertainty
    - Increase concern for the safety of nuclear power plants
- **Smart Systems provide “increased functionality”**:
    - ICT for better monitoring and metering
    - Implementation of digital technologies for improving operation while respecting safety margins

Additional **drivers** are:

- **Relevant general aims of leading economies act as pull forces for Smart Energy Management**:
    - A transition towards smart grid infrastructure is an essential element in the transition to a low carbon economy.
    - The development of smart grids is on the agenda of governments around the world (USA; EU).
    - Aging infrastructure, energy efficiency, growth in renewable energy, and the need to increase resilience
- Existing and projected **commercial-scale demonstrations**.
    - ESCoRTS is a joint project to foster progress towards cyber security of control and communication equipment in Europe.
    - The Telegestore project (ENEL – Smart grid) has demonstrated fewer service interruptions.
- **New services and paradigm shifts** in the energy sector:
    - Promote adoption of real-time energy usage information and pricing
    - Demand response in the electricity system can both reduce peak demand, but also provide system flexibility, enabling the deployment of variable generation technologies.
    - Cloud-based technology services are enablers for delivery of innovative services to both ends of the supply chain from utilities to consumers
- **Attractive potential market size around the globe**: An estimated global market size of $220 billion is forecast by 2020 for smart grid technology globally, whilst $500 billion will be spent globally on smart grid initiatives by 2030 (BRIC countries are expected to offer strong growth opportunities).

On the other hand, **the following main barriers** to Smart Systems implementation are delaying the deployment of new technologies:

- **Regulatory conditions**
- **Financial risk:** any project to upgrade a nationwide electricity system to ‘smart status’ will not be cheap and will require huge levels of capital investment.
- **Security**:
    - It is not feasible to accommodate significant embedded renewable and micro-generation on the network and **maintain system security** without moving towards a more dynamic approach to network operations
    - **Cyber security** must be considered as part of a larger smart grid deployment strategy
- **Technical standards**: the high probability that currently available technologies will become obsolete over relatively short timescales demands careful specification of technical standards. International organisations will need to confirm the technical standards that will underpin the smart grid system.
- It is, as yet, **unclear how changes in customer behaviour might emerge**.

    - In light of this uncertainty, the level of prescription and centralisation of customer facing aspects of a smart grid system -in particular, smart metering systems- is the subject of much debate.
    - Consumers do not currently view smart appliances as energy and cost saving
- Many of the new market sub-sectors created by smart technology **require the convergence of multiple industry members from different backgrounds**, sometimes from previously unrelated sectors.

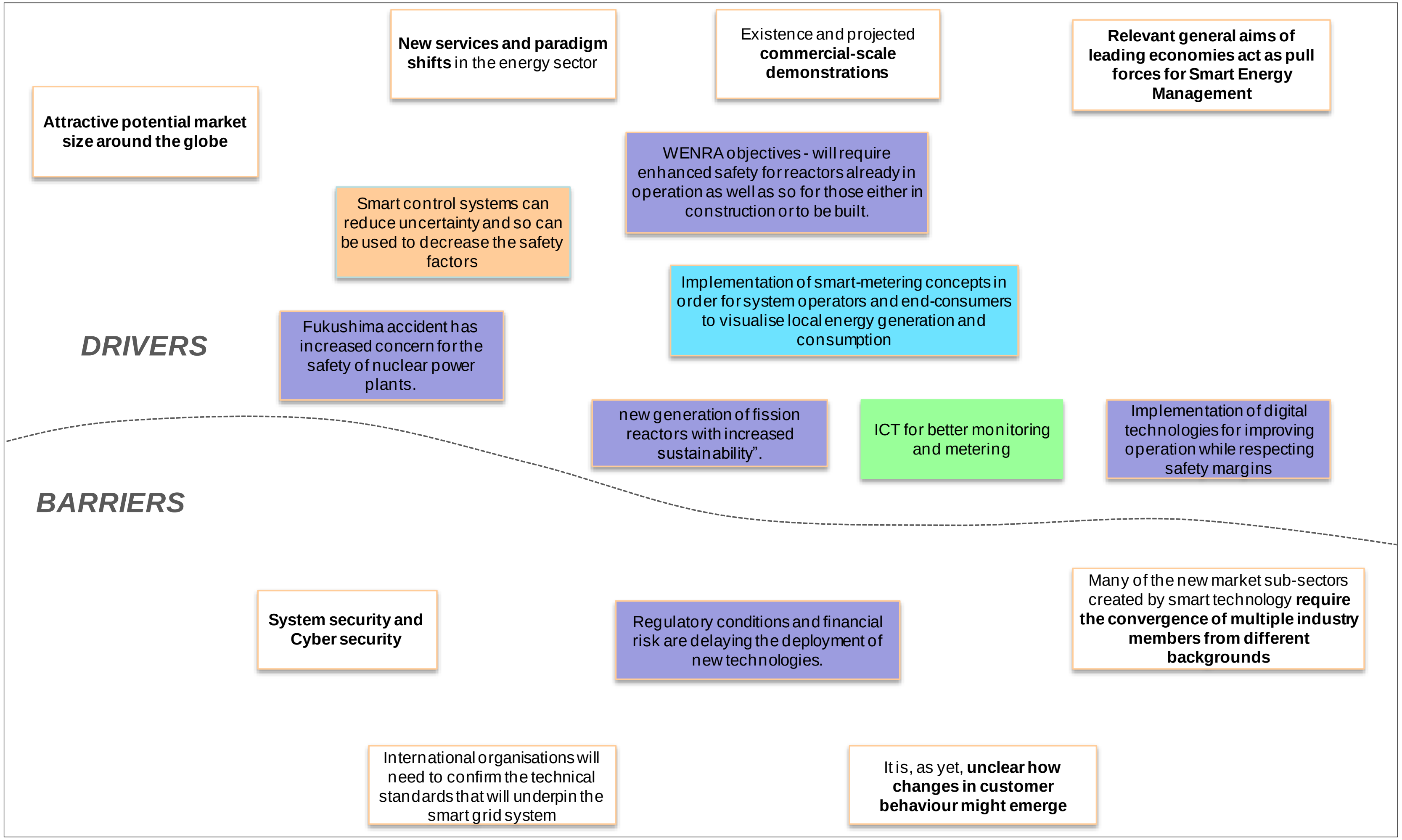


Figure 5: Drivers and barriers identified in Energy related SRAs

5.3. Technology Challenges

Technology challenges were identified in most of base technologies regarding Smart Systems such as:

- **Intelligent Sensors**:
  - Develop relevant sensors for control and condition monitoring
  - Devices for monitoring and controlling the network states
- **Control/Actuators** for:
  - Monitoring and modelling on biomass availability
  - Models, monitoring and impact assessment tools
  - Development of micro-inverters and DC/DC solar optimisers to be embedded in new smart PV modules
- **Power technologies** focus on:
  - New battery technologies for PV applications
  - Integration of monitoring and fault prediction capabilities into the wind turbine´s control system
- **Interfaces & Communications** for:
  - Smart meter communication infrastructure and technology
  - Interoperability of the smart grid solutions
  - Monitoring and managing energy consumption
  - Interfaces for the interconnection of different sensors and actuators
  - Communication protocols
- **Cognition** for:
  - Intelligent inverter functions and the way in which PV systems interact with other distributed generation technologies are relevant
  - Integration of condition monitoring and fault prediction capabilities into the wind turbine´s control system
  - Develop integral adaptive control strategies for varying external conditions
- **Modelling/Simulation** for:
  - Advances control strategies to optimise the balance between performance, loading and lifetime
  - Development of maintenance strategies
  - New protection criteria for inverters due to the high density of PV systems

6. Environment

The contents of this chapter are based on the links found in the strategic research agenda of WssTP, the European Technology Platform for Water. We also have included in this chapter the links found in the waste management chapter of the "*Smart Cities Market Opportunities for the UK document*"**.**

6.1. Application Opportunities

Application opportunities were identified in the following areas:

Urban Areas - Research and Technology Development

- For the **Public Health** challenges related to water services in urban environment, RTD needs will include sensors and monitoring systems to detect low levels of chemicals and microbiological contamination in river water or distribution systems
- For the **Safeguarding the Environment** challenges related to water services in urban environment, RTD needs will include methods to monitor and remove point source and diffuse chemical and biological pollutants, including emerging/priority contaminants.

Focus on cross-cutting issue Sensors and Monitoring

- The evolution of electronics, telecommunications and battery technologies is now changing this paradigm. This is a major evolution for water business which has to be handled carefully by water utilities and water companies for the benefit of the final consumers and a better protection of the Environment.
- A new revolution has already started and is leading water utilities and water companies to adapt their practices and organisations to get ready to develop and manage Networks of Sensors for appropriate applications.

Rehabilitation of degraded water zones (surface and groundwater) challenges

- Adaptation strategies to climate change:
  - Planning the creation of "potpolders" as buffer zones for floods.
  - Tuning with reclamation strategies.
  - For example phyto-remediation. (CO_2 capture).

Hydro Climatic Extremes

- Research and Technology Development
- For forecasting extremes: Drought forecasting and monitoring
- For long term planning/management of extremes: Exploiting new remote sensing (satellite, doppler radar, wireless sensor and other measurement) for forecasting and monitoring.

Waste Management

- **Smart public realm bins**:
  - Big Belly Solar UK is a company that produces a street waste collection bin that is a **self-contained compactor powered by the sun.** The bins can hold more waste than the average street bin due to the compaction feature. The smart angle is that **when these bins are 85% full they send an email or text message alerting the collection contractor**. This results in a **reduced number of collections which saves on collection costs and GHG**

emissions from collection vehicles. As an added feature each Big Belly bin **can transmit a Wi-Fi Platform providing local Council information and local retailer offers**

- **Automated waste collection systems:**
    - "**RFID tagging to track who deposits**"
    - **"RFID tagging to weight the waste"**

6.2. Drivers and Barriers

The **main drivers** identified are related to Agriculture - Research and Technology Development is **the requirement for improvement of water use efficiency** at different levels (local, regional, farm level). This requires a) the development of new water management tools, such as integrated models and decision support systems, improved monitoring and b) the improvement of water productivity while making use of improved irrigation technology and innovative production methods.

On the other hand, the **main barrier** to overcome is related to focusing on cross-cutting issue Sensors and Monitoring, because the **water industry is not yet ready to deploy those systems**, **and** another research need consists in **being able to understand their total environmental and economic cost of ownership** (impacts on operational and maintenance business processes and organisations).

Regarding waste management the main drivers and barriers were:

- **Drivers**:
    - **Regulation and directives:**
        - EU Directives which are aimed at reducing the volumes of land filled waste and increasing the levels of material recovery
        - China market: "China is now the largest generator of waste in the world". New regulations and policies were issued
    - **Advanced waste management solutions are being implemented**: Gulf States waste management industry has developed into a multi-billion dollar market. These countries are using advanced waste management solutions.
- **Barriers**:
    - **Government purchasing power is decreasing** (will waste management be a priority according to the decrease of public expenditure?)
    - **Slow adoption of new technologies**

6.3. Technology Challenges

The main technology challenges addressed in the analysed document regarding Smart Systems Integration are:

Rehabilitation of degraded water zones (surface and groundwater) challenges

- Development of integrated forecasting and Early Warning Systems using real-time data, integrating hydrological parameters, pollution loads, temperature, water quality (chemical, microbiological etc.).
- Lakes: Monitoring of eutrophication, restoration and management of water systems affected by toxic algal blooms (incl. cyanotoxins issue)

Focus on cross-cutting issue Sensors and Monitoring

- District metering, on-line leak detection, automated meter reading through fixed networks, all those new businesses are not far from being mature and lead the water industry to start evolving from lack drought of data to what we could call a new “flood of data”. This revolution will not stop and is rapidly moving forward due to new generations of on-line sensors. There is here a real research need for assessing how far micro and nano sensors will really fit the water industry requirements and how easy and economically feasible it is to massively deploy those new sensors in water and wastewater networks and facilities.

Sensors and waste management:

- **Monitoring sensors for smart bins and smart trucks**: "the GPS system report vehicle movements, tamper attempts, ….. , input/output ports that were used for **additional monitoring sensors**" mechanical separation of waste.
- **Smart sensors for following "size & shape, density, magnetism, electrical conductivity, optical properties**” **RFID tagging and GPS tracking**

7. Information and Communications Technologies

Taking into account that the EPoSS SRA analyses Smart Systems in the domain of Communications, and this is only a part of the issues considered in the diverse ETPs classified as ICT platforms, we have come to the following conclusions:

The main drivers and barriers identified in the EPoSS SRA are also addressed in the analysed documents.

- **Drivers**: “Increased functionality” is addressed in the EPoSS SRA as the main driver for Smart Systems. This corresponds with the identified advances on performance improvements such as: energy efficiency, dependability, connectivity, manageability, and so on. Additionally, smartness is also envisaged as a key feature of future services.
- **Barriers**: in the EPoSS SRA, “Fragmented supply chain” appears to be the most obstructive difficulty closely followed by “Skills shortage”. This corresponds with what was found in the analysed documents, showing that further actions are required on collaboration, standards, and education and training.

This reinforces the actions claimed in the EPoSS SRA: match research with commercial needs, and address skill shortages. That should be complemented with additional actions on:

- **Building collaboration streams** between research resources, creating new industrial eco-systems, and promote industry-academia collaboration.
- Fostering the urgent **action on open standards, regulations, and certification issues**.

There is a match between the technology challenges derived from the links regarding communications identified in the analysed documentation and the resulting benefits that can be obtained by meeting them.

The main benefit of Smart Systems for communications identified in the EPoSS SRA is that they act as key enablers to improve the quality of life for citizens through:

- Energy efficient ubiquitous interoperability
- Secure access to various services in different domains (digital economy, health systems, sustained energy and the protection of the environment, security and safety, life at home, in the cities, and in transportation systems)

This corresponds with the following technology challenges derived from links:

- **Reduced energy consumption** at component level and energy management for overall system energy efficiency
- **Adaptability/Dependability** technologies for more robust, reliable, secure, modular, configurable, usable, easy to integrate, tamper resistant and adaptive systems.
- **Interfaces and Communication technologies** looking for security and trust, interface standardisation and easy data exchange and interaction, grid awareness, turning devices as ubiquitous service enablers, system of systems, adaptive HMI, connectivity and protocols for SatCom, and remote operation functionalities

Regarding research priorities, both, **priority and long term actions identified in the EPoSS SRA match with some of those identified in the links**. So they are considered valid.

Obviously, as the spectrum of analysed ETPs was wider than the domain of communications, **additional technology challenges were identified:**

- **Cognition related challenges** oriented to:
    - **Implement specific functionality** like ‘In vitro’ analysis or ‘in-vivo’ monitoring of biological samples (blood, saliva, sweat, etc.) and parameters. New functions integrated in optical fibres.
    - **Systems autonomy**: self organising for automation and self-diagnosis.
    - **Self-X** (learning-monitoring-protecting) to perform complex tasks.
    - **Content generation** from gathered information and intelligent data aggregation techniques.
    - **Interaction** with users and services.
    - **Cognitive networks**: Ubiquitous and cloud based intelligence.
- Micro-nano **technologies looking for miniaturisation and reliability** allowing both: higher integration level, and high performance computing Smart Systems.
- **Modelling, simulation and design** tools for Smart Systems engineering and co-design.

This requires addressing collaboration as suggested in “Drivers and barriers”.

7.1. Application Opportunities

Most of the analysed documents emphasize application opportunities. This shows a high potential for collaboration guiding the implementation of Smart Systems into valued products, processes, services, equipment and infrastructures. While no opportunities were identified for new business value streams, five types of value streams appear to have greatest potential:

- Innovative **Products**
    - **High performance HW and SW components** allowed by advances in hardware integration and performance level.
    - Scale economies for High Performance Computing systems hardware components implemented in diverse Smart Systems based devices.
    - Evolution of driver and low-level interfaces at interconnect adapter level
    - **Smart cards** for “everything”, and smart packaging.
    - Driver assistance systems.
    - **Robotics applications** in the aerospace, automotive, manufacturing systems.
    - **SatCom featured Smart Systems** for diverse applications (transport and mobility, Energy, Security, Content, Health)
    - **Intuitive user interfaces** (including speech, tactile and multisensory interactions) H-M-Interaction
- New and improved **Processes**
    - Ubiquitous Broadband Access using **SatCom based processes**:
        - **On emergency** Bidirectional Communications and Backhauling
        - **On services** like telemedicine, e-learning, surveillance, etc.

  - **M2M platforms enabled “intelligence providing” processes**: intelligence extracted and added by a further processing of the gathered large amount of data stemming from each of the machines from within different environments
  - **Smart Systems as providers of content** and making available their knowledge base as content
  - The Future Internet will provide **access to things and their characteristics**, allowing interaction with them. In return, things become active and trigger actions over the Internet “of Things”
  - **Complex tasks execution enabled by NESSI Framework (“NESSI Core”)**: Software, ICT Architectures and ICT Infrastructures where data evolves into knowledge, and which helps humans to coordinate the execution of complex tasks
  - **Facilitating** cost-effective provisioning and seamless **composition of services**, supporting pervasive and ubiquitous application scenarios
  - **Nanophotonic devices** allowing the convergence of photonic and electronic technologies and **offering reductions in footprint, switching delay and power dissipation.**
- Enhanced and smart **Equipment**
  - **ICT technologies based rail transport system equipment**: in the rail infrastructure, rolling stock, control command and signalling equipment.
  - **Smart equipment for buildings** (sensors, actuators and control and communication systems will give new capacities to buildings)
  - **Electronic imaging** equipment
  - **Robots** will autonomously assist with the **protection of offices and homes**
  - **Robots will help secure borders or monitor the environment** in both routine and emergency operations
  - Reduction of **ground SatCom equipment** and devices costs
- New and enhanced **Services**
  - Smart Systems as **components of diverse service scenarios**
    - **Intermodal transportation**: convenient and optimised choice of transportation system by integrating data from different traffic information systems and from the ‘smart environment
    - Smart devices and systems enable home and **communities related services**
    - **Surveillance and environmental monitoring** and control
    - New services and applications based on hybridization of **Earth observation**
    - Ubiquitous Messaging Services allowed by **satellite M2M networking**
    - **E-government**
    - **Health, inclusion and assisted living.**
  - **Smart Systems as providers of content** and making available their knowledge base as content.
    - **Need to care** (e.g. including prevention and defence) for increasingly exhaustive **private and personal information**

        - Smart Systems as **enablers of tailored services: allowing** services' and electronic devices' seamless integration and to dynamically tailor services on the specific demands and conditions of the user.

- Enabling **Infrastructures**
    - **M2M communication enabled platforms:** M2M will be a core element of a wider generic, modular and flexible platform that makes "things-machines" available, searchable, accessible and usable by the set of multi-domain applications
    - **Service oriented utility infrastructure for Smart Cities scenario**:
        - Hardware which needs to be virtualised and able to be allocated flexibly, encouraging efficient hardware utilisation, in turn enabling energy efficiency
        - Infrastructures have to be architected and implemented to be robust, fault tolerant and secure.
        - From a user's perspective, infrastructures must be transparent, allowing a plug-and-play approach to infrastructure usage as well as to grid provisioning and operation of services.
        - The "Internet of Things" services will be embedded in the operation environment, and objects will become gateways to services
        - This scenario includes smart grids, energy efficiency, environment, ITS, public parking, and other infrastructures.
    - Fixed **mobile and broadcasting convergence**, which aims at integration and creation of a **unified communication infrastructure** from fixed and wireless mobile networks
    - **Home and building platforms**: future homes and offices networked with surrounding smart building facilities

7.2. Drivers and Barriers

The main identified **drivers** are of three types:

- **Advances on diverse base issues will favour Smart Systems**:
    - Advances on miniaturisation and integration level
    - Performance improvements: energy efficiency, dependability, connectivity, manageability, and so on.
    - Availability of communication networks and platforms.
    - Modelling and Simulation at system and environment level.
    - Photonic system-on-chip combining micro/nano-electro-mechanical systems (MEMS/NEMS) providing micro-fluidic and acoustic functions.
- **Services as pull forces** for Smart Systems development and implementation :
    - Customizable user demand focused services will be required.
    - Healthcare services requirements.
- **Smartness** is envisaged as a key feature **of future services and innovation.**
- **EPoSS SRA is referenced in several ETPs.**

On the other hand, also some **key barriers** or non-technical challenges were identified requiring to be addressed:

- **Standardisation** is an issue acting as a barrier, but becoming a driver once it is addressed.
- Further **actions are required to face challenges**:
  - Collaboration
  - Regulation and certification
  - Education and training

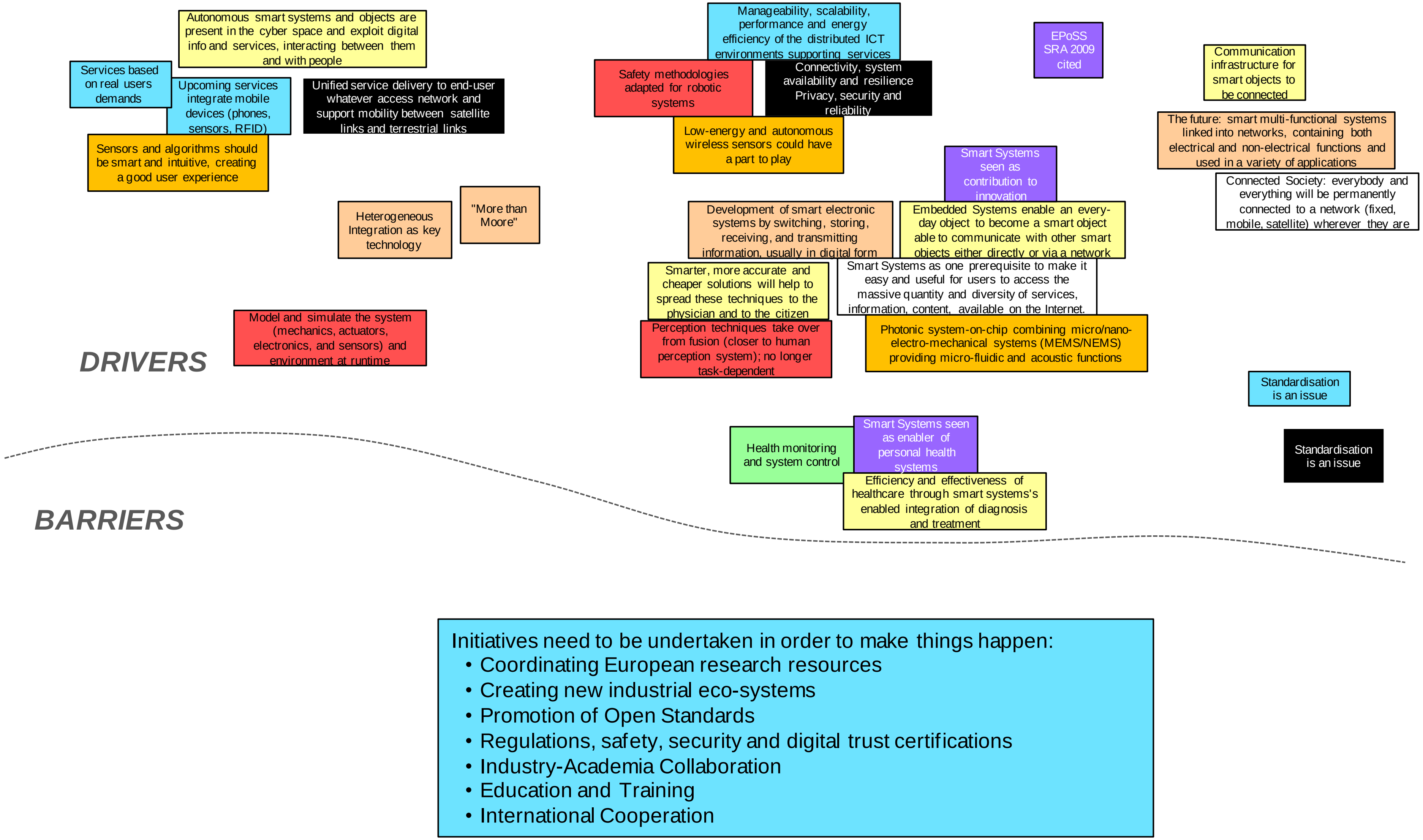


Figure 6: Drivers and barriers identified in ICT related SRAs

7.3. Technology Challenges

Technology challenges are identified in most of base technologies regarding Smart Systems, such as:

- **Micro-nano technologies** looking for miniaturisation and reliability allowing both: higher integration level, and high performance computing Smart Systems.
- **Sensor technologies:**
  - Access to sensor information and sensor networks.
  - Sensor fusion and content generation
  - Measurement performance (nanometre-scale) by increasing signal-to-noise levels and reduction of cross-sensitivity
  - New sensors for new data and meta-data: depth, motion of objects, scene environment, biosensors, smart meters.
- **Power: reduced consumption** at component level **and** energy management for **overall system energy efficiency**.
- **Adaptability/Dependability technologies** for more robust, reliable, secure, modular, configurable, usable, easy to integrate, tamper resistant, and adaptive systems
- **Modelling, simulation and design** tools for Smart Systems engineering and co-design
- **Interfaces and Communications technologies** looking for:
  - Security, encryption and trust.
  - Interface standardisation and easy real-time data exchange and interaction
  - Grid awareness
  - To turn devices as ubiquitous service enablers
  - Adaptive HMI
  - Connectivity and protocols for SatCom, convergence of wireless and optical networks.
  - Remote operation functionalities
  - System of systems: M2M and collaborative systems
  - Cost effective high-speed transport (40Gb/s – 100 Gb/s and beyond).
- **Cognition related technology challenges** are oriented to:
  - **Implement specific functionality** like ‘In vitro’ analysis or ‘in-vivo’ monitoring of biological samples (blood, saliva, sweat, etc.) and parameters. New functions integrated in optical fibres.
  - **Systems autonomy:** self organising for automation and self- diagnosis.
  - **Self-X (learning-monitoring-protecting)** to perform complex tasks.
  - **Content generation** from gathered information and intelligent data aggregation techniques.
  - **Interaction** with users and services.
  - **Cognitive networks**: Ubiquitous and cloud based intelligence.

8. Production and processes

As a general conclusion, there is a high degree of matching between the links identified in the analysed documents and the main aspects highlighted in the EPoSS SRA regarding drivers & barriers, technology research priorities and the benefits that SSI can bring to this sector.

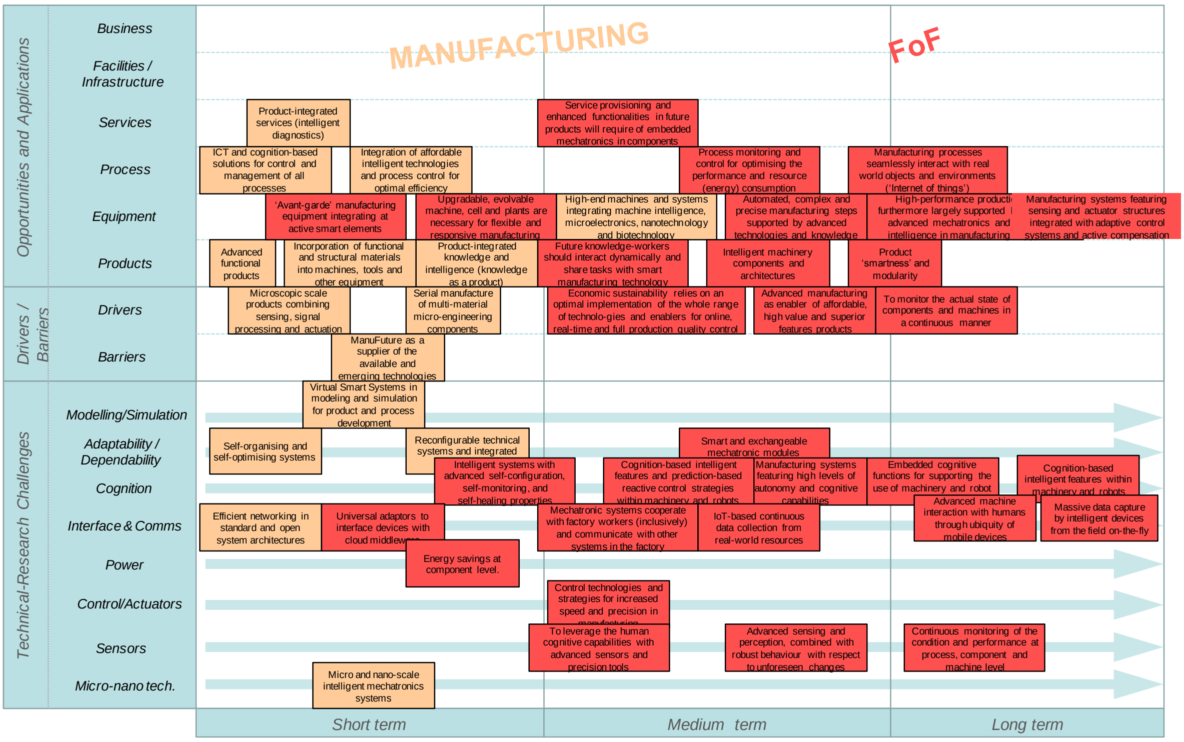


Figure 7: Main links identified in FoF (EFFRA) and Manufuture documents

The main drivers and barriers identified in the EPoSS SRA are also addressed in the analysed documents:

– **Drivers**: “Increased functionality” is addressed in the EPoSS SRA as the main driver for Smart Systems. This corresponds with the identified application opportunities and technology challenges links, which demand new functional materials, cognitive capabilities and human-worker interaction for Smart Systems.

– **Barriers**: in the EPoSS SRA, “fragmented supply chain” appears to be the most obstructive difficulty. This corresponds with what was found in the analysed documents, showing manufacturing capabilities and supply chains as missing capabilities for a reasonably priced mass production of diverse materials, and to manufacture the first batches of products.

This reinforces the actions claimed in the EPoSS SRA that should be complemented with additional actions on:

– **Positioning EPoSS** as a key actor for collaboration regarding Smart Systems Integration.

– **Building collaboration streams** with other more application oriented (sectoral) ETPs, defining collaborative programs with user, societal, and advanced manufacturing needs as “pull” forces to foster innovation based on smartness of new technology.

– Fostering the **urgent definition of interoperability standards**, protocols, and interfaces.

Regarding research priorities, **priority and long term actions identified in the EPoSS SRA match with the application opportunities identified in the links**. Obviously, as the spectrum of analysed ETPs was very wide, there would be **more actions that should be added**. Nevertheless, it would require a prior collaboration task between platforms as suggested in “Drivers and barriers”, in order to agree on common priorities. Additionally, **a new level of technology challenges was identified** that is closer to KETs. This new level set some more basic technology challenges. These should be aligned with application opportunities related actions, and an adequate time-phased prioritisation should be agreed in collaboration between the corresponding platforms.

There is also a match between the technology challenges derived from the links identified in the analysed documents and the resulting benefits that can be obtained by meeting them. Three main benefits were identified in the EPoSS SRA: **Miniaturised and networked sensors; Smart tooling; Smart processes and products**. This corresponds with the main technology challenges derived from links:

- **Micro-nano technologies looking for miniaturisation**.
- **Sensors** for analytical purposes and equipment condition monitoring.
- **Control/Actuators** oriented to medical devices and drug delivery mechanisms.
- Power technologies to enable **autonomous smarts systems**.
- Interfaces and communications for interaction with users, **cooperative devices** and data exchange.
- **Cognition to implement intelligent manufacturing**.

8.1. Applications opportunities

Most of the analysed documents emphasize application opportunities. This shows a high potential for collaboration guiding the implementation of Smart Systems into valued products, processes, services, equipment and so on.

Four main types of value streams appear to have greatest potential: innovative **Products**, new and improved **Processes**, enhanced and smart **Equipment**, and new and enhanced **Services.**

Fewer opportunities were identified for Facilities and New Business value streams:

- **Intelligent, safe, energy efficient, healthy, comfortable buildings and underground spaces**
- **Asset monitoring and tracking through Internet-of-Things middleware**
- **Advanced metering and monitoring of energy consumption in factories**

8.1.1. Innovative Products

- **Condition Monitoring (person, food, equipment)**: Monitoring, diagnostic and assistance devices and materials.
- **Automated, precise and personalised treatments**: Drug delivery devices products
- **The bionic person**:
  - Smart active implants or materials
  - Wearable and skin-contact devices using mobile and wireless technologies

    - Wearable robots (e.g., exoskeletons)
- **Smart Systems enabled energy efficient products**.
- **Mobile productivity tools and interactive devices**: for service support and dynamic interaction with workers. Intuitive user interfaces for C-level, plant managers, operators and workers at different operational levels, and provisioning monitoring and management data on mobile devices.
- **Radically-advanced new product concepts and functionalities** enabled by Smart Systems and materials
- **Intelligent products or modules/components**
- **Real-world connectivity:**
    - The trend is to seamlessly and bi-directionally interact with real-world objects and systems on a global scale, across a variety of application domains and stakeholders in a secure way, thus realising the Internet of Things.
    - Machine-to-machine connectivity in the cloud
    - Interoperable adapters between heterogeneous systems in the supply networks

8.1.2. New and improved Processes

- New **diagnostic tests and processes** allowed by Smart Systems
- **Automation** of processes
- **Development of new processes enabled by Smart Systems and related technologies**
    - New materials and micro-chemical reactions as enablers of new processes
    - New construction processes
    - New monitoring and predictive processes
    - Data privacy and inter-stakeholder access control
    - Experience and knowledge based processes:
        - People at the forefront: Future enterprises will not only be better equipped for transferring skills to a new generation of workers but also proficient in assisting older workers with better user interfaces, intuitive user-experience-driven workflows and other aids, such as mobile and service robots
        - Knowledge retention through eLearning tools (which capture knowledge from experienced workforces and help train inexperienced workers) and spread through semantic-knowledge ontologies (would be made accessible to workers – not only shopfloor but also knowledge workers – to aid in faster problem solving and process improvements)
- **Intelligent process control and optimisation**
    - Inventory/asset monitoring – Internet of Things – within the supply networks
    - Agile manufacturing systems and processes: real-world resources such as connected objects, devices and advanced robots would

leverage advances in the Internet-of-Things domain to communicate, collaborate and organise themselves autonomously

- Manufacturing Intelligence: Manufacturing enterprises will have a competitive advantage over their peers if they are able to perform real-time analysis over a large volume of data from processes, products and business systems
- Seamless factory lifecycle management: In Manufacturing 2.0 enterprises, assets and inventories together with assembly lines and machinery would be dynamically monitored, configured and maintained
- Real-time analysis on supply-chain data points, events and processes

8.1.3. Enhanced and smart Equipment

- **Diagnostic devices and equipment for** user friendly, non-invasive and telemedicine applications
- **Personalised and target focused therapeutic systems** or equipment
- **Smart and evolvable equipment**: equipment able to offer and add new functionality and intelligence by integrating Smart Systems as active components.
- **Methods and procedures** based on Smart Systems that allow new processes
- **Miniaturised equipment**
- **Automated-autonomous, high productive and adaptive equipment**
- **Humanoid and animal-like robots**
  - **Robotics,** emphasizing mechatronics, human assistance, cognition, and security**, will target automotive companies, rehabilitation/hospital structures, electronics and hardware companies.**
  - Core activity is the mechatronic (mechanical, electronic and control) development of systems for **future generations of humanoid robots**. This covers activities in actuation and power systems, mechanisms and structures, sensing, and locomotion and control
  - **Animal-like robots, at mm scale or bigger, will support humans** in exploration, services and low complexity operations, exploiting interactive capabilities and sensing networks**.**

8.1.4. New and enhanced Services

- **Monitoring services**:
  - Health-person and assisted living
    - The development of assisted living technologies (telehealth, telecare, and telehealthcare) and assisted living services can efficiently enhance the living conditions of older people and those who are physically impaired, playing a crucial role in helping them to live their lives safely and independently.
    - New ALT (Assisted Living Technologies) developments could:

        - Improve the management of chronic conditions, extend the range of conditions which are managed at home, and allow management while outside the home (mid-term)
        - Enable early home diagnosis of life threatening conditions and home monitoring of vital signs to be linked to real-time drug administration (long-term)
    - Buildings
    - Machinery and Equipment
- **Regenerative medicine**
- **Intelligent Services** based on:
    - Connected objects
    - Intelligent Products
    - Intelligent Buildings
    - Manufacturing and factory intelligence, KPIs, risk-performance indicators and sustainability-performance indicators
- **Quality assurance** services

8.2. Drivers and barriers

A joint analysis of the diverse drivers and barriers identified in the documents of the production and processes ETPs as shown in **Fehler! Verweisquelle konnte nicht gefunden werden.** confirms the synergies between sectors.

The **main drivers** are

- **Manufacturing capabilities and supply chains**
  - **As enablers** of
    - Affordable, high value and superior features products
    - Serial manufacture of multi-material micro-engineering components
    - The development of nanomedical materials for validation in clinical trials
- User, societal, and advanced manufacturing **needs as "pull" forces** to foster innovation based on smartness of new technology
  - The market is increasingly seeking more integrated solutions that are innovative, technologically advanced, and cost effective in order to maintain quality of care while coping with increasing demand and limited health and social care resources
  - Initiatives that have significant government backing such as the European Commission DG-CONNECT Ambient Assisted Living Joint Programme101 ("AAL") which is a scheme developed to enhance the quality of life for the elderly through effective use of information and communication technology
- **Smart Systems brand** (EPoSS) **requires to be reinforced**
  - A claim for collaboration among platforms is quite common, but EPoSS is not mentioned in several documents
- **Robotics becomes an arena for science and technology development and test**: Robots will have to perform a multitude of assistive roles for humanity thanks to their capabilities to act and interact, physically, socially and safely with humans, in an ubiquitous yet non-obtrusive, user-friendly and safe manner: So that robotics becomes an arena for science and an active technology provider to advance and validate natural principles and to translate them into synthetic ones: sensing and actuation, adaptation and maintenance, perception and cognition, and interaction

The **main barriers** are:

- **Manufacturing capabilities and supply chains**
  - **As missing capabilities**
    - For a reasonably priced mass production of diverse materials
    - To manufacture the first batches of the nanomedicine product
    - Industry players need to develop or collaborate to become capable of providing cost effective end-to-end system and service solutions to match the emergent commissioning requirements
    - Capitalise on existing world-leading skills and expertise around life sciences, bioengineering, service design and product design to deliver innovative products and services faster

- **Smart Systems technologies** are **recognised as KET for new advanced devices** required for future sectoral applications. In Europe, the High-Level Expert Group (HLG) on key enabling technologies proposed advanced manufacturing systems as one of the key pillars of growth and investment.
- **Interoperability standards**, protocols, interfaces and adequate software support **need to be addressed and developed**.
- Adopt **innovative commercial approaches to large scale delivery** to achieve in-year benefits for the NHS **through collaborative partnerships**, and develop a pricing model applicable to a consumer market
- **Technology solutions currently are still fragmented and diverse**, these will need to become more integrated at the location of care and fit for purpose
- **Robotics Barriers**:
  - The **difficulty** that current robots face **in tasks involving the manipulation of objects** beyond a simple reach-grasp-lift-and-hold task is a perfect illustration of the challenge. In this respect, **tactile sensing is one critical area that still remains unsolved** and will ultimately hamper developments.
  - **Actuators and Power sources are one of the primary "failure" areas for humanoid and mobile robots**. As they are **critical during interactions with people**, safety in Human-Robot interaction (HRI) is one of the biggest concerns for actuation.

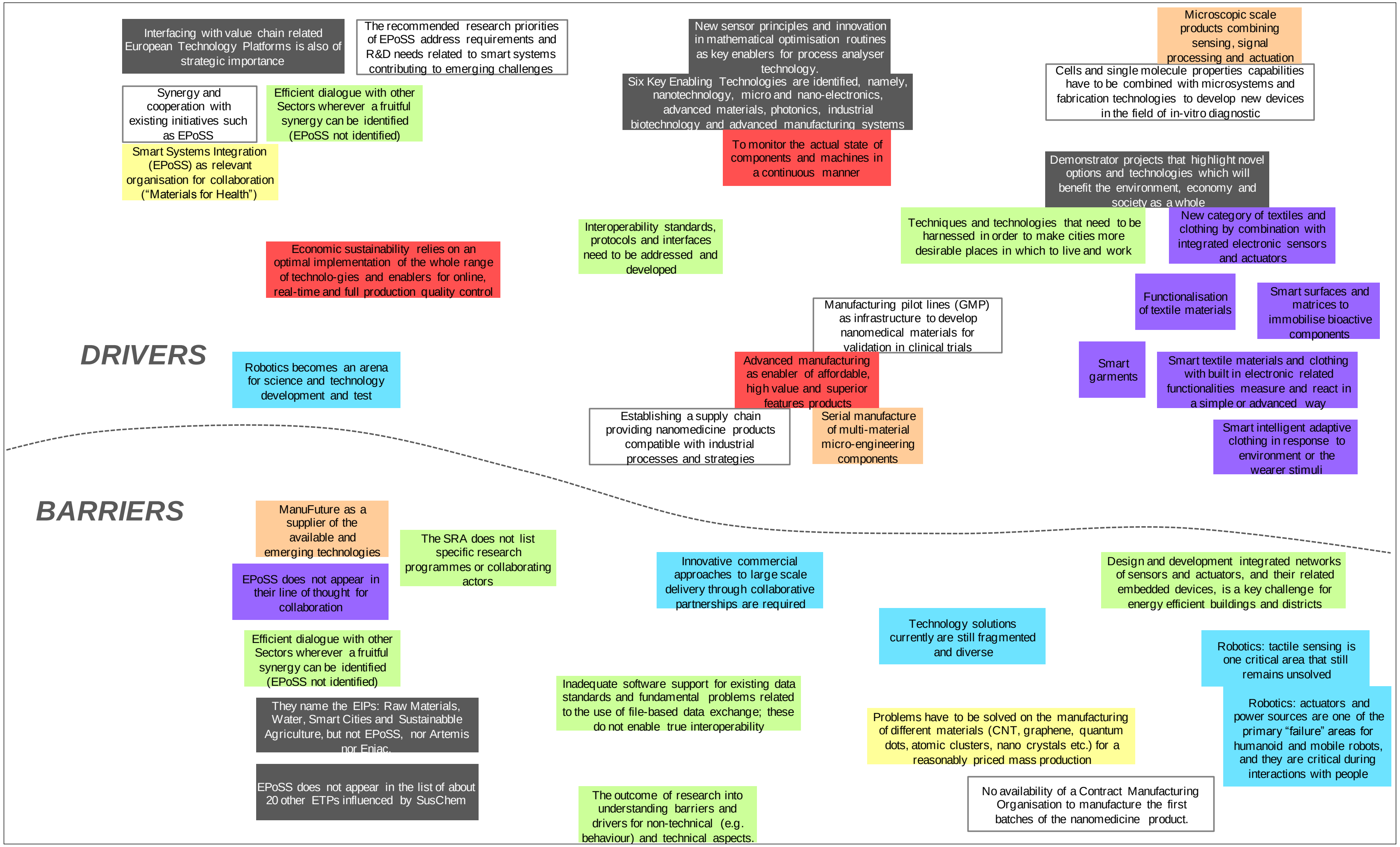


Figure 8: Drivers and barriers identified in Manufacturing / Factory Automation related SRAs

8.3. Technology challenges

Technology challenges were identified in most of the base technologies regarding Smart Systems:

- **Micro-nano technologies looking for miniaturisation**:
  - Nano-particles for therapeutic and diagnostic purposes.
  - Nano-structures based customized functional and smart materials.
  - Nano-technologies for therapeutic and diagnostics devices
  - Smart coatings
  - Optical materials for functional systems
  - New material structures for long term reliability
  - Materials with flexible physicochemical properties for flexible applications requests
  - Nano-scale mechatronic systems
- **Sensors for analytical purposes and equipment condition monitoring**:
  - Miniaturisation of sensors: nano-sensors.
  - Imaging sensors and methods
  - Advanced sensors based on active, multi-functional materials
  - Perception oriented sensors to leverage human capabilities
  - Condition monitoring sensors for processes, components and equipment
  - Sensors for harsh environments
  - Sensors for plant automation and process optimization
  - Technological and regulatory factors of this kind could also lead to **wireless sensors with a life of at least five years** (tele-health)
  - **Multisensory networks based perception**: In the future, problems will be encountered as the number of sensors in robots increases.
    - Integration of state-of-the-art multi-sensory networks, brain/cognitive models, biomimetic materials, etc. Here **the grand challenge is the integration of brain and body**, at the top of the architecture.
    - A promising approach for the successful hardware **implementation of a computational theory of multisensory perception on robotic platforms is the neuromorphic technology**
  - The failure to develop **a truly useful skin for the whole body and the fingertips in particular is perhaps the greatest failing** of researchers **in the "bodyware" aspect of robots** and without it there will always be a limitation to the learning capacity of any autonomous robot.
- **Control/Actuators oriented to medical devices and drug delivery mechanisms**:
  - Miniaturised control/actuator devices
  - Therapeutic devices
  - Diagnostic devices.
  - Non-invasive devices

- Control technologies for increased speed and precision
- **Adaptive process control and automation** comprising self-organising production control, monitoring, metrology, perception/awareness and diagnosis

- **Power technologies to enable autonomous Smart Systems**:
  - Built-in tiny energy supplies for sensors.
  - Miniaturised fuel cells
  - Energy saving strategies at component level
  - Mobile energy consumption and monitoring at the shop floor.
- **Interfaces and communications for interaction** with users, cooperative devices and data exchange:
  - Effective de-facto standards for networking, data exchange, object definitions, and integrated model servers.
  - Interfaces for user awareness and human-machine cooperation. Innovative and multimodal HMI interfaces.
  - Continuous and massive data gathering
  - Universal adaptors.
  - Interoperability between systems and assets on the shop-floor.
  - Interacting with robots:
    - The complex structures to be developed will need to be controlled in an "intelligent" manner. A preferred approach is to ensure human in the loop control whereby a human operator provides the overarching intelligence and hence the ability to solve unresolved and unexpected problems. The robot would be tele-operated. The robot would be able to complete the task controlled by the human and at the same time would "learn" the core actions needed to undertake the same or a similar task in the future.
    - The ability to interact meaningfully and safely with humans is a fundamental resource of our society and a strong requirement for future robots.
- **Cognition to implement intelligent manufacturing**:
  - Integration of smart functions in medical (nano) devices.
  - Materials that mimic physiological systems
  - Intelligent technologies for hazardous situations
  - Human behaviour based Smart Systems
  - Wellbeing perception oriented Smart Systems
  - Cognition-based intelligent machinery with advanced self-configuration, self-monitoring, and self-healing properties. This will enable self-learning manufacturing systems, and decision making at machine and workshop levels.
  - Safety and reliability in human-machine/robot collaboration
  - Service robotics at manufacturing-process level

9. Transport

The main drivers and barriers identified in the EPoSS SRA are also addressed in the analysed documents.

- **Drivers**: "Increased functionality" is addressed in the EPoSS SRA as the main driver for Smart Systems. This corresponds with the identified advances on performance improvements such as: energy efficiency; market and societal needs such as: safety, security, comfort (e.g.: noise, vibration...) and so. Other important drivers such as "reduced cost" and "increased reliability" in the EPoSS SRA are also identified by these ETPs.
- **Barriers**: in the EPoSS SRA, "Fragmented supply chain" appears to be the most obstructive difficulty closely followed by "Skills shortage". This corresponds with what was found in the analysed documents, showing that rail industry is facing increasing competitiveness and price pressures resulting in structural problems and the need to consolidate some sectors of the rail supply industry.

So, the action claimed in the EPoSS SRA: "...better understanding of the Smart Systems supply chain to achieve a better match between research approaches and manufacturing capability" is reinforced. That should be complemented with additional actions on:

- **Migrating Smart Systems engagement in automotive to other transport sectors**.
- Fostering the urgent **action on open standards, regulations, and certification issues**.

The Waterborne SRA identifies as a priority that "New developments in process automation, computer technology, sensors, smart components and communication must be applied to the maritime industry to enable the safe and efficient operation of increasingly complex vessels with a minimum of crew".

The ERTRAC SRA identifies as a priority that "ICT is one of the key enablers for creating a safe, sustainable and efficient transport system. To create economically sustainable solutions some of the main challenges for ICT are interoperability and harmonisation as well as roll out of those systems compared to the stand alone solutions."

Automotive electronics and progressive "smartification" of automotive systems have shown its benefits regarding some key issues identified in transport ETPs such as:

- Experiences gained in energy efficiency with ICE and Hybrid and Fully Electric vehicles should be transferred to other sectors.
- Distributed architectures, network and communication efficiency, interconnection, plug and play...

This corresponds with the following application streams derived from links:

- **Safety and security related systems**.
- **Improved product performance, and updatable/adaptable products**
- **New equipment with reduced emissions, enhanced comfort and improved performance**
- **Management and control systems** addressing safety and security, equipment health monitoring, automated or self-assessed operation, and vehicle-infrastructure interaction
- **Smart Systems Integration** on equipment **allows key processes performance improvement**: Supply chain, Retrofitting, Maintenance, and Integrated transport system management.

- **Smart Systems as:**
    - **Components of diverse service scenarios**
    - **Enablers of new services and high performance rail infrastructures**

Regarding research priorities, both, **priority and long term actions identified in the EPoSS SRA match with some of those identified in the links**.

Smart Systems have a lot to research and develop, focusing on:

- Security approach
- Get and develop information for fleet managers, drivers, and in pedestrian paths
- Remote, smart and autonomous inspection
- Smart monitoring

According to research challenges, Sensors and control/actuators offer an important research potential.

9.1. Application Opportunities

Most of the analysed documents emphasize application opportunities. This shows a high potential for collaboration guiding the implementation of Smart Systems into valued products, processes, services, equipment and infrastructure. No opportunities were identified for New Business value stream.

Five types of value streams appear to have greatest potential:

- Innovative **Products**
    - **Safety and security related systems for**:
        - Protecting (motor) cyclists from collisions
        - Detecting explosives
        - Packaging solutions for home delivery of fresh food
    - **Improved product performance** enabled by:
        - Energy efficient technologies
        - New control technologies
        - Noise attenuation techniques
        - Sensor technologies that monitor environmental conditions
    - **Updatable/adaptable products based on:**
        - Interchangeable components
        - Intelligent control techniques
- Enhanced and smart **Equipment**
    - **Advanced mechatronics and materials enable new equipment with the following characteristics:**
        - **Reduced emissions:** by electric and sustainable bio-fuels based traction, improved diesel and hybrid engines.
        - **Enhanced Comfort**: reduced noise and vibration, new cooling concepts
        - **Improved performance**

- **Management and control systems** addressing:
    - **Safety and security** from both, traffic and personal perspectives
    - **Equipment health monitoring**
    - **Automated or self-assessed operation**
    - **Vehicle-infrastructure interaction**

- New and improved **Processes**
  - Introduction of **Smart Systems** on components or equipment **allows processes performance improvement** regarding:
    - **Productivity**
    - **Improved capacity and availability**
    - **Reduced human errors**
    - **Tracking-tracing and navigation**
    - **Integrated intelligence and automated control**
    - **Passengers' comfort**
  - **Special emphasis is on the following processes**
    - **Supply chain**
    - **Retrofitting**
    - **Maintenance**
    - **Integrated transport system management**
- New and enhanced **Services**
  - Smart Systems as **components of diverse service scenarios**
    - **Equipment health monitoring**
    - **Authentication**
    - **Ticketing**
    - **Traffic management and punctuality**
  - Smart Systems as enablers of **new services**
    - **Crisis management**
    - **Traffic/journey information**
    - **Key assets protection**
    - **Intelligent mobility**
  - The existing traffic systems do not provide sufficient information to enable cities to manage traffic flow more effectively
- Enabling **Infrastructures**
  - **High performance rail infrastructures:** Many performance attributes should be improved
    - **Reliability and availability**
    - **Energy-efficient railroad**
    - **Punctuality**

        - **Safety and security**
        - **Cost effectiveness**
        - **Noise reduction**
    - **Predictive infrastructure,** monitoring capabilities, and intelligence that enable new maintenance services
    - Manchester has recently issued a request for a Dynamic Road Network Efficiency and Travel Information System Solution.

9.2. Drivers and Barriers

9.2.1. Drivers

The main drivers identified are:

- **European aim for industrial leadership and competitiveness** will foster the application of Smart Mobility Innovation (SMI) in transport related sectors.
- **This leadership is oriented to solve market and societal needs** such as: safety, security, comfort (e.g.: noise, vibration...) and so. Several objectives and challenges linked to these needs act as drivers:
    - The **mitigation of congestion** is the main priority of a number of cities and governments in the EU
    - A **reduction in travel time** on the roads
    - **Improve Safety**: Loss of life expectancy, deaths brought forward, increased hospital admissions, soiling of buildings and damage to forests and other ecosystems. Smart transport solutions aim to reduce all of the above to improve quality of life
    - Transport systems have significant **impacts on the environment**: energy use and carbon emissions
    - **Shift to Sustainable Transport** and Optimisation of Transportation: Cities and Governments have to find more effective methods of changing commuters' reliance on cars (expected increase in car use) to encourage mass transport usage.
- **A multimodal European network connecting** rail, air, road and waterborne will ensure efficient **transport of passengers and freight.**
- A **cost efficient multimodal network** will be based on **overall energy consumption efficiency,** and **reduced maintenance expenditures** thanks to advanced inspection and maintenance techniques.
- **Specific research drivers address these challenges**
    - Reducing weight and noise emissions of rolling stock and infrastructure
    - Rail traction and energy supply; energy regeneration braking systems
    - New methods for measuring the toxicity of fumes in fires
- **Additional technology challenges related with SSI are formulated:** :
    - Safe and efficient operation.
    - "Smartification" of automotive systems
    - ITS applications for mobility services

- **Commitment of public and private bodies**:
  - The EPSRC have recognised the ever-increasing demand on our transport infrastructure.
  - Transport Catapult should help bring about a more cohesive voice and approach to transport related issues in the UK
  - The Industry Doctoral Training Centre (IDTC) in Transport and the Environment at the University of Southampton combines masters-level technical courses and MBA management courses with PhD-level research.
  - The Transportation Research Group (TRG) based at the University of Southampton has research links with other groups in the UK and overseas.
- **Existing capabilities and infrastructures are solid foundations**:
  - Education sector is highly regarded around the globe for provision of world leading research, and development of innovative technologies for the smart transport sector.
  - The basic infrastructure is in place for development of a strong smart transport market within the UK
  - The nation has strong capability in traffic management services through the experience gained during the 2012 Olympics.
  - The UK (London Underground) has extensive experience in designing, managing and retrofitting underground transport systems.
  - UK consultancies are highly regarded internationally and are well placed to help bridge the gap between Universities and industry, enabling faster development of research ideas.
  - UK based SMEs and expert companies spoken to, noted that there was sufficient technology in the marketplace to deploy smart transport systems in the UK

9.2.2. Barriers

On the other hand, relevant barriers to overcome are:

- **Fragmented vision within some countries**
  - Little agreement between cities on requirements and standards for basic infrastructure
  - There are over 300 different authorities in the UK responsible for making decision on roads and transport
  - There is no strategic, holistic vision set out by the UK Government for Intelligent Transport System (ITS).
- **High cost of the required infrastructure:**
  - Funding gaps in deployment of ITS for City councils
  - Cities are also reluctant to spend scarce funding on untested solutions
- **Cities are slow to adopt new ITS.**
- **Apart from some technology challenges that are mentioned, no specific developments are detailed**.

- Some **telemetric and telecommunications gaps** may also act as barriers to meet future transport objectives.
- There **is a need for harmonised standardisation and certification**.
    - No British Standards for the development and deployment of Smart Transport Systems or ITS
- The need to **fix the safety problems that automation can potentially cause**.
- **Rail industry is facing increasing competitiveness and price pressures:** structural problems arise and the need to consolidate some sectors of the rail supply industry.
- **Fragmented market**
    - Industry experts noted that UKTI are looking for large opportunities, therefore there are fewer opportunities for small players operating in the market
    - Collaboration and behavioural change is required from operators and end users in order to provide more efficient and cost effective transport services
    - Some countries are lacking tier one manufacturing capability
    - UK SME companies find it difficult to access financing for development projects to becoming actors in this market.
- In the public perception there is **misconception of what 'Smart Transport' represents** which stakeholders need to educate.

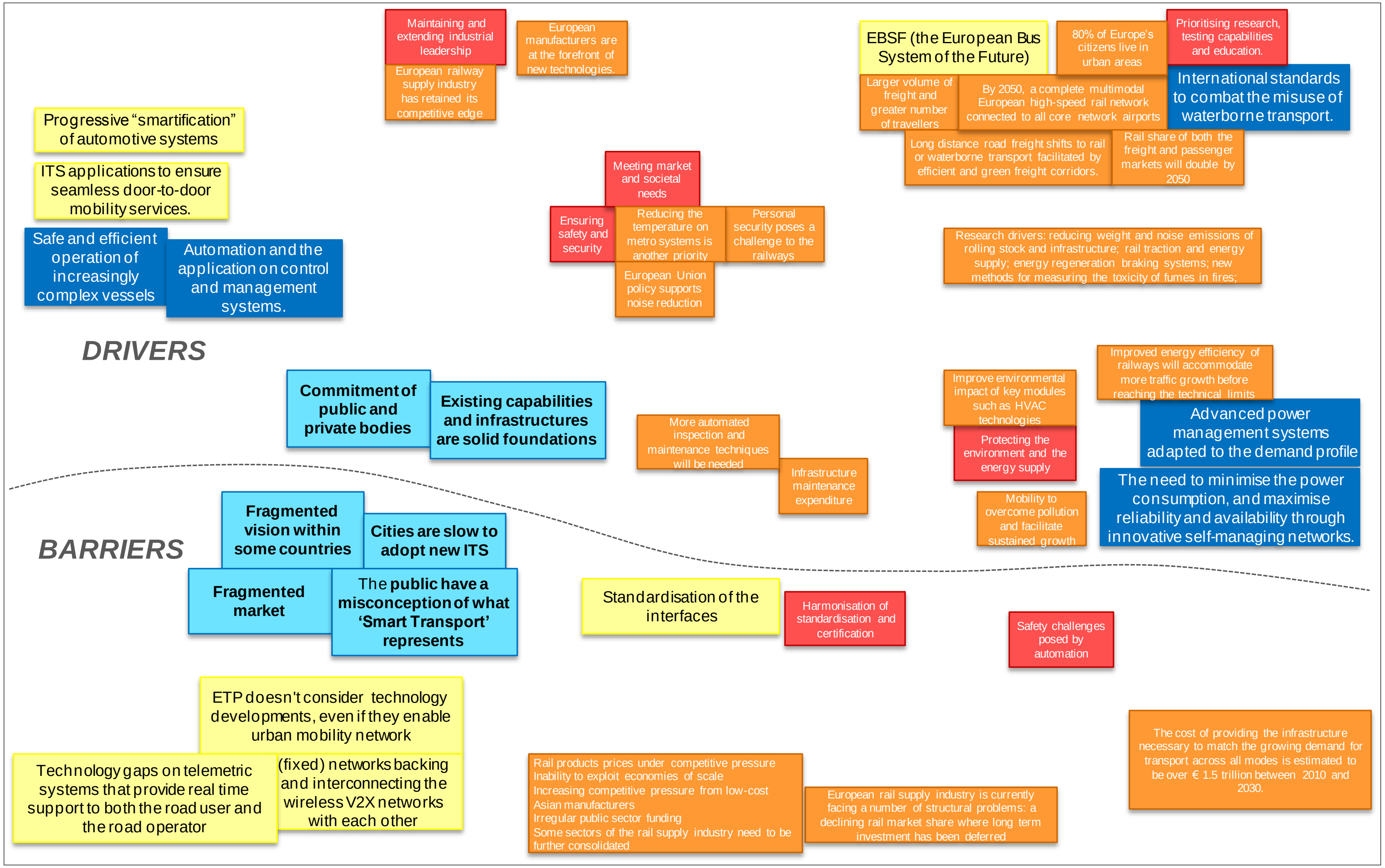


Figure 9: Drivers and barriers identified in TRANSPORT related SRAs

9.3. *Technology Challenges*

The main technology challenges identified in the analysed documents are:

Micro-Nano Tech

- **Remote and autonomous operation:** New concepts and requirements for remote and autonomous operation of ships
- **Smart structures and materials:**
  - New structural materials technologies for vehicle structures and components and new performance standards
  - Airframe technologies based on advanced materials deliver improved flow and load control
  - Smart structures combined with drag reduction techniques
  - Motion stabilized work platforms

Sensors

- **Reliable and maintenance free** sensors/actuators
- **Security approach**:
  - Smart Systems communications with security and train staff will optimize passenger safety
  - Sensor technologies to enable all weather operations and avoid atmospheric hazards
- **Get information**
  - To help drivers and fleet managers improve fuel consumption
  - In pedestrian paths
- **Autonomous inspection**:
  - Remote condition monitoring to create intelligent infrastructure that can monitor and inspect itself
  - Sensors on air vehicles and information on global atmospheric conditions, capturing safety and security events, on-board sensors for surveillance and situational awareness

Control and actuators

- **Management systems such as:**
  - Predictive engine
  - Multivariable model-based control systems
  - Energy management solutions for bus systems
- **Smart monitoring for:**
  - Smart self-monitoring and self-repairing materials
  - Ship/Shore systems integration and fast cargo handling
  - Sensors and intelligent monitoring, prediction and control systems

Interfaces & Communications/Cognition/Adaptability

- **Interfaces & Communications focus on Communications networks, such as:**

    - New generation on-board trackside communications networks
    - Remote monitoring of the integrity of bridges and tunnels
    - To look after passengers through their journey
- **Cognition for Safe road transport and security, such as:**
    - Safety systems which make intelligent decisions and take preventive actions under dangerous conditions
    - Safe mobility management
- **Adaptability for:** Advanced field measurement techniques

Modelling/simulation

- **Related to safety conditions**, such as:
    - Control systems for motion compensation in extreme conditions
    - Remote operation of system in cold climate
    - Power-train management concepts

10. Cross ETP Initiatives

This analysis covered the two cross-ETP initiatives that were included in the CORDIS ETP map in February 2014: Industrial Safety and Nanofutures.

Due to the transversal nature of these initiatives, the results of the analysis are presented in accordance with the integrated view structure that is presented in the next chapter.

10.1. Industrial Safety

The main drivers and barriers identified in the EPoSS SRA are also addressed in the analysed documents.

- **Drivers**: “Increased functionality” followed by “increased reliability” are addressed in the EPoSS SRA as the main driver for Smart Systems according the results of 47 Smart Systems providers to the Safety & Security sector.
- **Barriers**: in the EPoSS SRA, “untried techniques” appears to be the most obstructive difficulty. This is stated as instructive, as the “increased functionality” will most likely be satisfied by “untried techniques”.

This reinforces the actions claimed in the EPoSS SRA that should be complemented with additional actions on recognizing safety, security and reliability as enablers of Smart Systems.

The main technology challenges derived from links on **sensors: sensors** for industrial safety focusing on environmental condition control and machines, production and transportation process analytical purposes. This corresponds with the key issue in safety and security identified in EPoSS SRA:

- Implementing **trustworthy manufacturing processes** while developing “design for manufacturing”, “design for testing” and “**design for reliability**” with diversity of materials combined with increased system complexity.

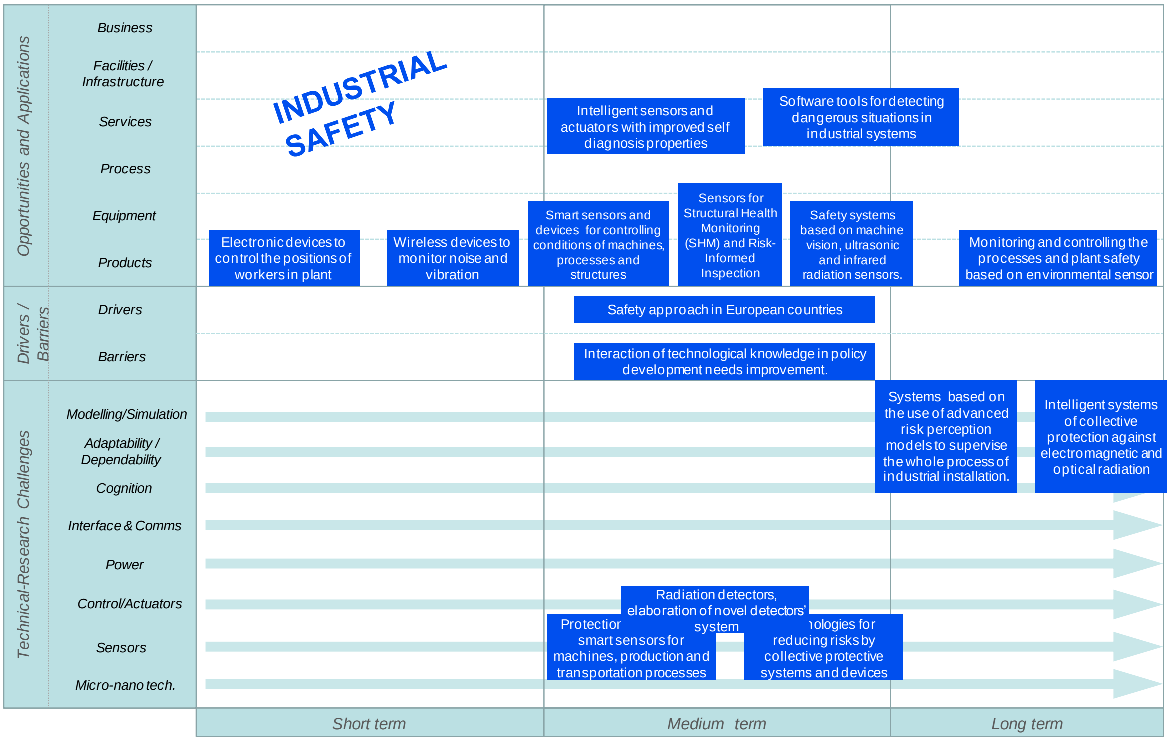


Figure 10: Industrial Safety smart links

10.1.1. Application Opportunities

The main application opportunities appear in the “Products” value stream regarding:

- **Electronic devices** to control the positions of workers in plants
- **Wireless devices** to monitor noise and vibration
- **Smart sensors and devices** for controlling conditions of machines, processes and structures
- **Sensors for Structural Health Monitoring (SHM) and Risk-Informed Inspection**
- **Safety systems** based on machine vision, ultrasonic and infrared sensors
- Monitoring and controlling the processes and plant safety based on **environmental sensors**

10.1.2. Drivers and Barriers

Few drivers and barriers have been identified. On the driver’s side, **innovative and secure society,** the need for **a consistent approach to Safety and that this approach is also maintained consistently across the various industries and transportation facilities** appear to be the most prominent. This is aligned with the driver “increased reliability” identified in the EPoSS SRA.

On the other hand, the **main barrier** is the **interaction of technological knowledge in policy development which needs improvement**.

10.1.3. Technology Challenges

Technology challenges are identified in two of the base technologies regarding Smart Systems, such as:

- **Sensors** for industrial safety focusing on environmental condition control and machines, production and transportation process analytical purposes:
  - Protection systems and smart sensors for machines, production and transportation processes.
  - Radiation detectors, elaboration of novel detectors’ systems.
  - Technologies for reducing risks by collective protective systems and devices.
- **Modelling/Simulation** to develop risk perception models and intelligent systems of collective protection:
  - Systems based on the use of advanced risk perception models to supervise the whole process of industrial installation.
  - Intelligent systems of collective protection against electromagnetic and optical radiation.

10.2. Nanofutures

NANOfutures integrated Industrial and Research Roadmap shows a set of actions that respond to the analysed ETP needs, based on common horizontal issues from industry to safety, from research to communication.

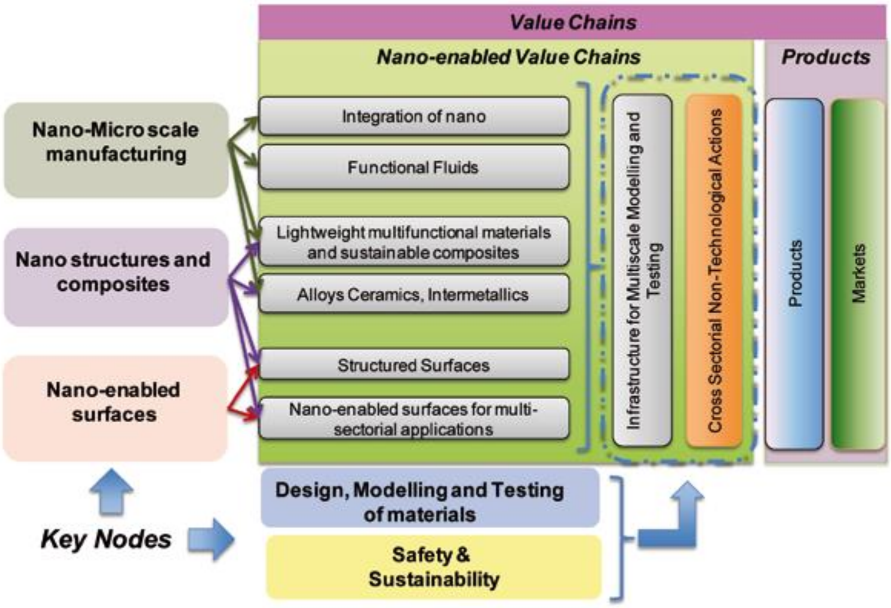


Figure 11: From Keynode groups to NANOfutures Value Chains (Source: Nanofutures Industrial and Research Roadmap)

The figure above shows the main components of this cross-sectoral initiative. Two types of components can be highlighted:

- **5 Key Nodes**:
  - Design, Modelling and Testing of Materials
  - Nano-Micro Scale Manufacturing
  - Safety and Sustainability
  - Nanostructures and Composites
  - Nano-Enabled Surfaces
- **7 Nano-enabled Value Chains (VC)** constitute the backbone of the roadmap:
  - VC1 - Lightweight Multifunctional Materials and Sustainable Composites
  - VC2 - Nano-Enabled Surfaces for multisectorial applications
  - VC3 - Structured Surfaces
  - VC4 - Functional Alloys, Ceramics and Intermetallics
  - VC5 - Functional Fluids
  - VC6 - Integration of Nano
  - VC7 - Infrastructure for Multiscale Modelling and Testing

The actions recommended by the Nanofutures roadmap focus on new or enhanced nano-materials (getting new nanomaterials, multifunctional materials, innovative or improved functionality of these materials, active materials, and the interfaces between materials), new fabrication processes to synthesise and cost efficiently produce these materials, methods and tools for new nano-materials development, etc...

Most of the actions proposed in the Nanofutures roadmap will potentially impact Smart Systems Integration due to the KET nature of these technologies. These impacts will affect both perspectives: technological challenges and applications opportunities.

Due to the KET nature of the roadmap’s actions, not many direct smart-links have been identified pointing to specific opportunities or technology challenges regarding Smart Systems Integration. The following table show the few specific smart-links identified.

Action code	Action	Contribution to integrated view
VC3-008-short	2D – Metrology tools for printing, HE, NIL, Laser, Litho…	Design of faster analytical tools for monitoring materials synthesis, the development of robust and reproducible measurement techniques and sensors and fast online sensing during manufacture
VC6-001-short	Overall materials and product design system architecture Unified methodologies for design of nanoenabled materials and products	An effective and efficient nanomaterial development must rely on the appropriate design of a computational architecture as well. The computational architecture, together with the algorithms for hierarchical computations, can facilitate design automation with a high computational efficiency: a similar result is achieved with the adoption of unified and internationally recognized methodologies
VC6-004-short	Unified methodologies for design of nanoenabled materials and products	Development of methods for measuring properties
VC7-001-short	Connect simulation tools and programs to test and demonstrate capabilities and create reliable benchmarks	Software tools give the possibility to simulate new devices without physically building them
VC3-002-medium	2D & 3D - Metrology for process and functional properties analysis	Surface texture could be evaluated through automated 2D or 3D Measurement System that offer true colour analysis and imaging of complicated surface in less than 1 min for each site
VC5-005-medium	In vivo studies: effective testing and monitoring of material behaviour in use	The safety assessment should include consideration of the toxicity of both the ingredients and their impurities; dosimeter for in vitro and especially in vivo toxicology studies, if needed; and clinical testing, if warranted.
VC6-005-medium	3D manufacturing control, Process control, analytical control, Material interfaces, Extrusion	Here automation is increasing and process control is becoming increasingly complex and meaningful.
VC1-010-long	Materials modelling, thermal simulation and process design	Nanotechnologies (such as nanoparticles, nanofibres etc.) a way to improve the energy density of a type of battery known as lithium-air (or lithium-oxygen) batteries, producing a device that could potentially pack several times more energy per pound than the lithium-ion batteries that now dominate the market for rechargeable devices in everything from cellphones to cars
VC6-002-long	Precision large scale nano/ micromanufcaturing of 3D structures	The development of precision and large scale manufacturing processes by encompassing a wider range of innovative materials and geometric shapes, satisfying functional and technical requirements, allowing the emerging of new microproducts in many technological fields is a key aspect of 3D structures

Table 1: Nanofuture roadmap smart-links

11. Integrated view for strategy and implementation plan

WP2 Ecosystem SWOT and WP3 Augmented SRA, both provide specific input components that will populate an overall SWOT analysis as input for a joint strategy and implementation plan.

So first, Augmented SRA contents require to be seen as SWOT components:

- Drivers and barriers aspects should be transformed into Strengths, Opportunities, Threats or Weaknesses components.
- Opportunities and Applications are candidates for Opportunities type components of the SWOT.
- Technical-Research Challenges can be seen as either Weaknesses or Opportunities

Previous chapters' contents show that there are similarities and complementarities between the components identified within each main subject stream. As the Augmented SRA is a key input for a joint strategy and implementation plan, an integrated view of these SWOT components is required.

11.1. Strengths

The main Strengths identified from the Augmented SRA are:

- **Smart Systems as performance enablers**: Smart Systems enable increased functionality and improved performance, allowing the development of new advanced smart and cost-efficient devices and new production paradigms.

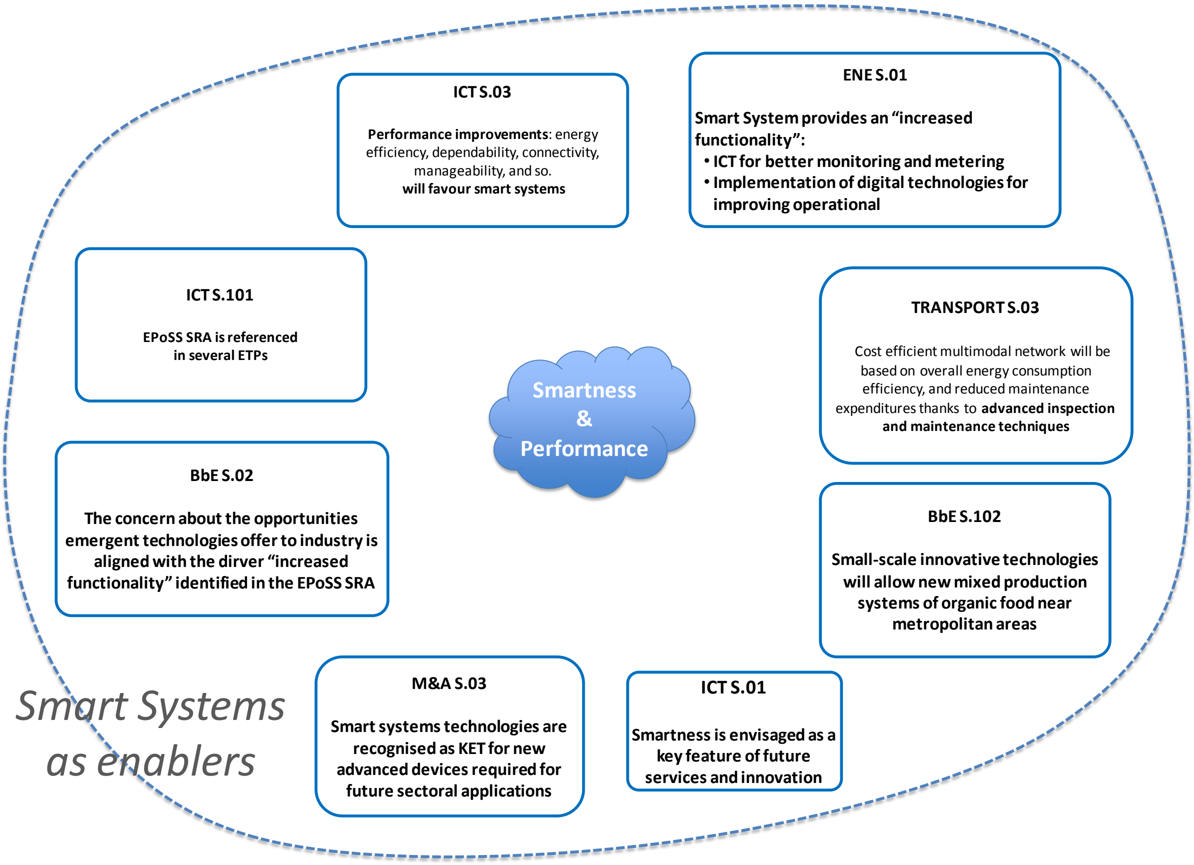


Figure 12: Smartness & Performance type strengths

- **Capabilities**: powerful capabilities exist to provide solutions based on Smart Systems Integration.
  - Engineering skills at system and environment level.
  - Availability of communication networks and platforms.
  - Smart Systems manufacturing capabilities and supply chain.
  - Existing capabilities and infrastructures are solid foundations for smart transport.

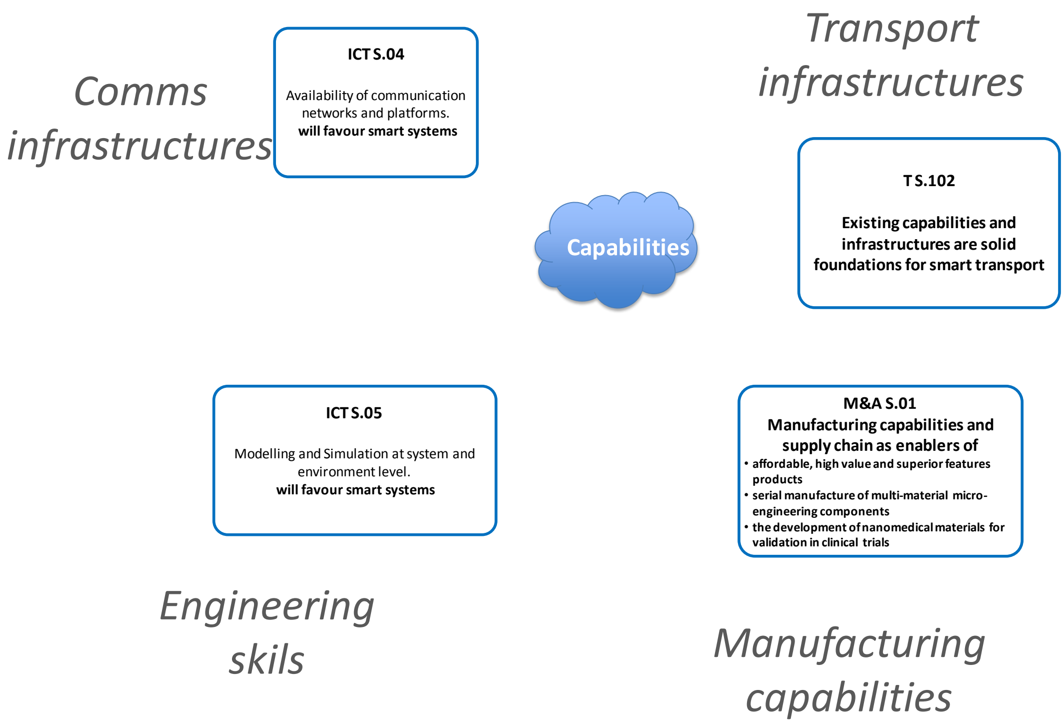


Figure 13: Capabilities type strengths

- **Needs at different levels acting as pull forces**:
  - Driving infrastructure & themes consciousness at EU level:
    - **Big structural infrastructures** like multimodal European network connecting rail, air, road and waterborne; and European aim for industrial leadership oriented to solve market and societal needs such as: safety, security, comfort.
    - **Commitment on specific issues:**
      - Relevant general aims of leading economies act as pull forces for **Smart Energy Management.**
      - Commitment of public and private bodies on **smart transport infrastructure requirements**.
      - Overall **environmental awareness** in Europe **will favour climate-friendly technologies** development and implementation.
    - **New services and paradigm shifts** in the energy sector
  - Lead Users needs as "pull" forces to foster innovation: users, society, and advanced manufacturing act as lead users with their needs as "pull" forces to

foster innovation based on smartness of new technology. For example, robots will have to perform a multitude of assistive roles for humanity.

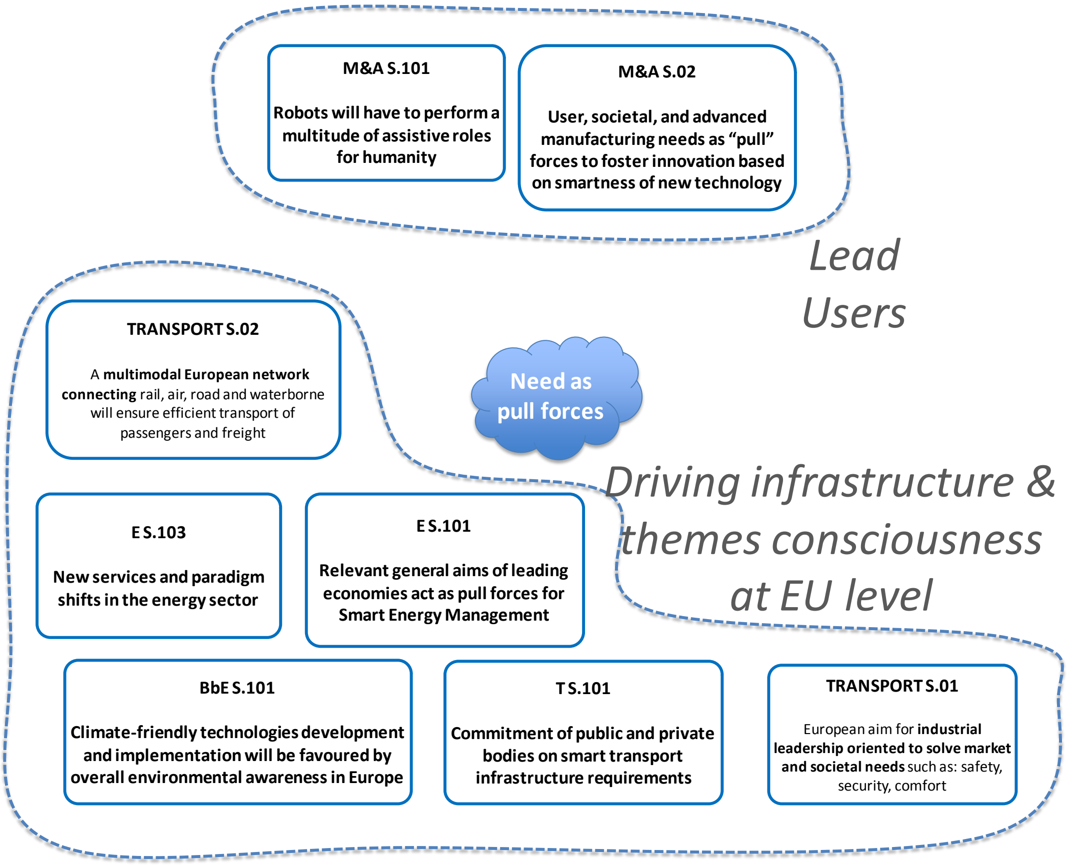


Figure 14: Needs as pull forces type strengths

- **Market size and large demonstrators:** There is an attractive potential market size around the globe on relevant issues as smart grids and intelligent transport. Also there are on-going and projected commercial-scale demonstrations in these areas.
- **Technology**: Advances on miniaturisation and integration will favour Smart Systems. Also, ICT is identified as an important driver for industry development.

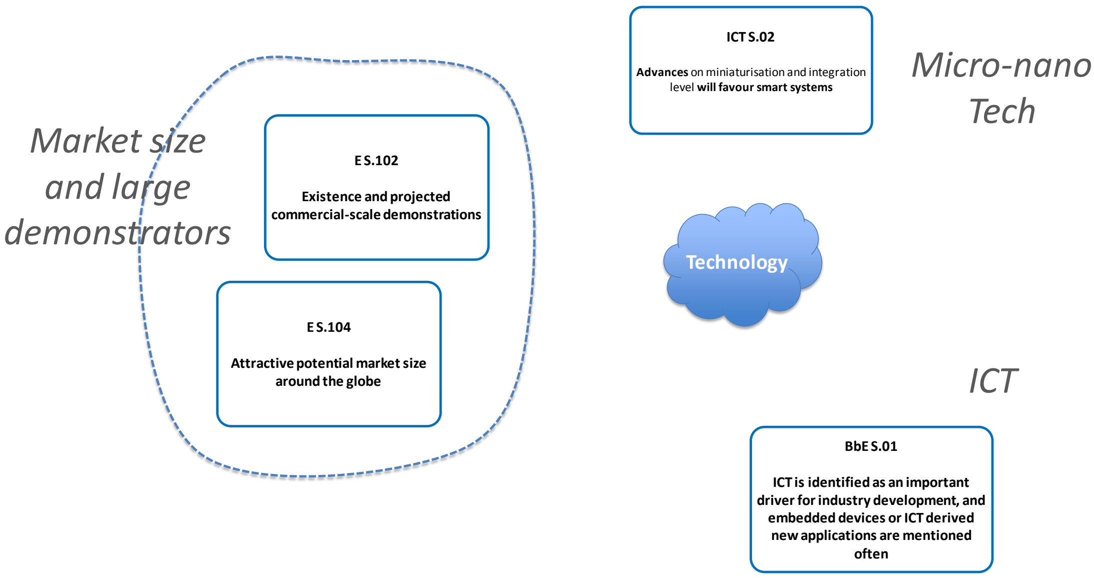


Figure 15: Technology and Market type strengths

11.2. Weaknesses (Technology challenges)

Most weaknesses are technology challenges. These challenges were classified as weaknesses because we interpret that they are capabilities not available yet. So, we are in a weak position to address related opportunities.

The main Weaknesses identified from the Augmented SRA were classified within the main technological areas of Smart Systems:

11.2.1. Modelling and simulation

***System Control**:* Advances in control strategies are required to balance different criteria (Energy: performance, loading and lifetime), or to implement new protection criteria in PV systems, or to compensate extreme conditions (transport), or remote operation or power-train management.

***Maintenance strategies**:* Development of maintenance strategies involving preventative, risk-based inspection using condition monitoring.

***System modelling/simulation**:* for Smart Systems engineering and co-design, especially to develop intelligent systems based on risk perception and avoidance/protection.

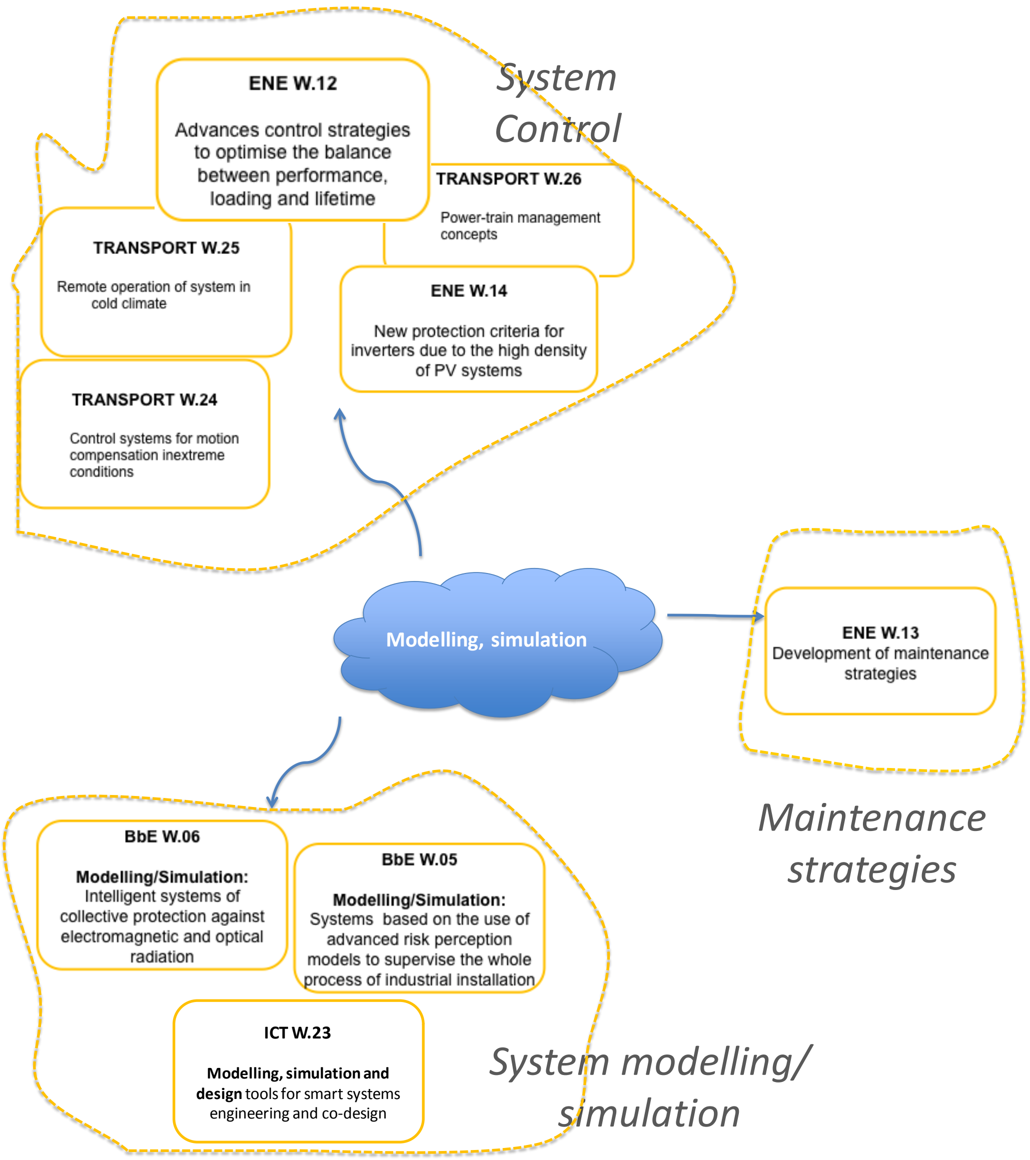


Figure 16: Weaknesses on Modelling and Simulation

11.2.2. Control and actuators

Monitoring*:* monitoring and assessment tools to manage biomass issues and decisions; and advanced self-monitoring materials, intelligent sensors and prediction to enable ship / shore systems integration and fast cargo handling.

Control technologies for increased speed and precision are required, as well as for adaptive process control and automation.

Tools and devices*:* control technologies that provide safe and secure drug delivery mechanisms and enable safe food chain.

Micro strategies*:* miniaturized control/actuator devices for micro-inverter solar PV applications and non-invasive devices.

Management systems*:* smart control enabled management systems are required for predictive engines, energy management for bus systems, multi-variable based control systems, and ship / shore systems integration and fast cargo handling.

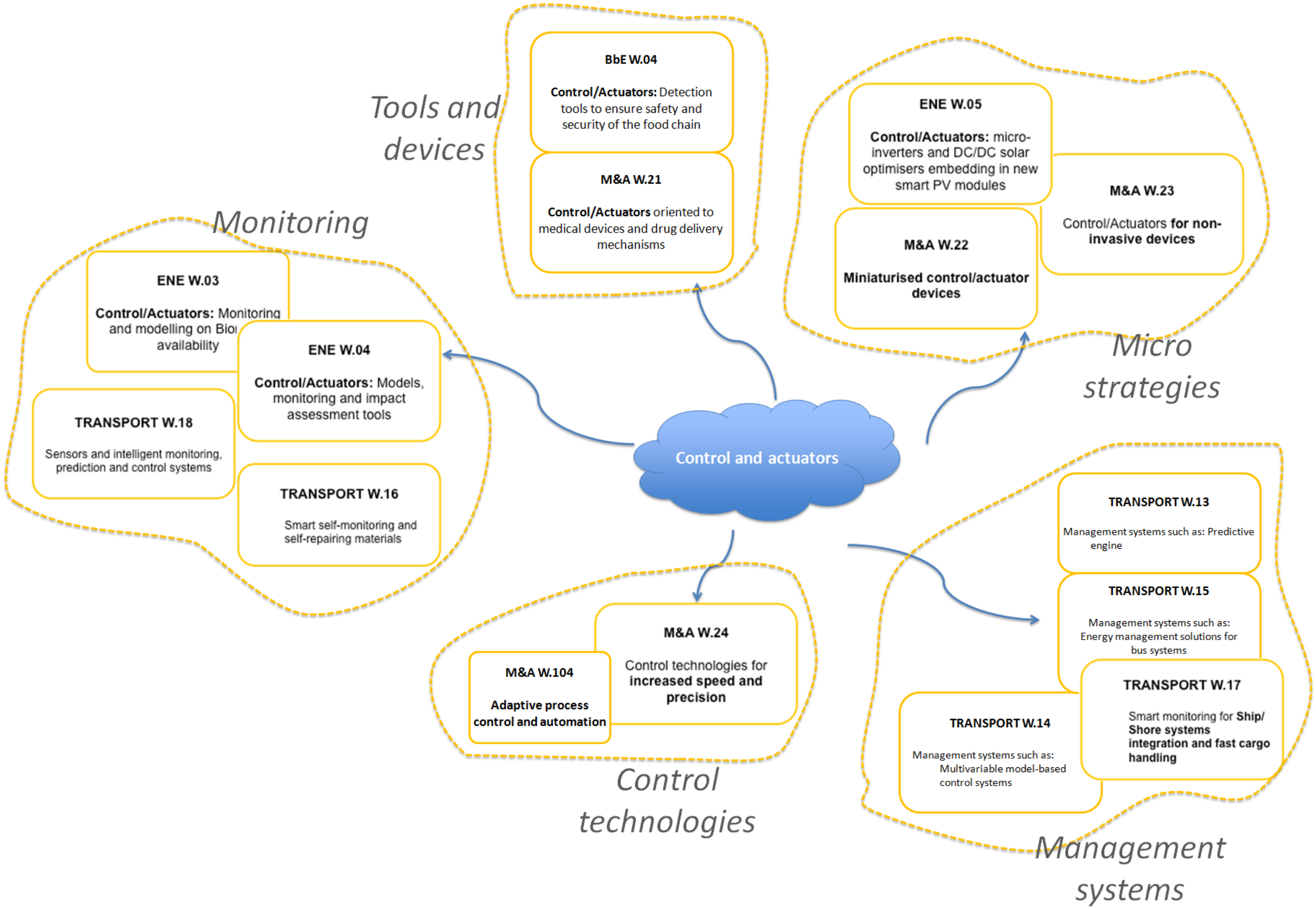


Figure 17: Weaknesses on Control/Actuators

11.2.3. Interfaces & Communications technologies

Data Gathering*:* continuous and massive data gathering from advanced field measurement techniques require grid-aware network-oriented operating systems

Communication infrastructure*:* cost-effective high-speed communications networks infrastructure at on-board level, and transport systems level, together with adaptive HMI for safe journeys need to be developed.

Security, encryption and trust*:* Point-to-point "Dynamic Trust" is an emerging future model for a highly networked world.

Interoperability*:* connectivity (interfaces and universal adaptors for diverse devices interconnection), convergence of wireless and optical networks, and protocols (networking, data exchange and integrated model servers) require standardisation to assure interoperability between systems and assets on the shop floor (System of systems).

Remote control*:* devices turned on ubiquitous service enabler and remote monitoring and operation for critical infrastructures

Interaction and interface: the complex structures to be developed require to be controlled in an "intelligent" manner ensuring human in the loop control. The ability to interact meaningfully and safely with humans is a fundamental resource of our society and a strong requirement for future robots. Adaptive HMIs are also required. An additional challenge is inter-process interaction to enable the integration of complementary processes.

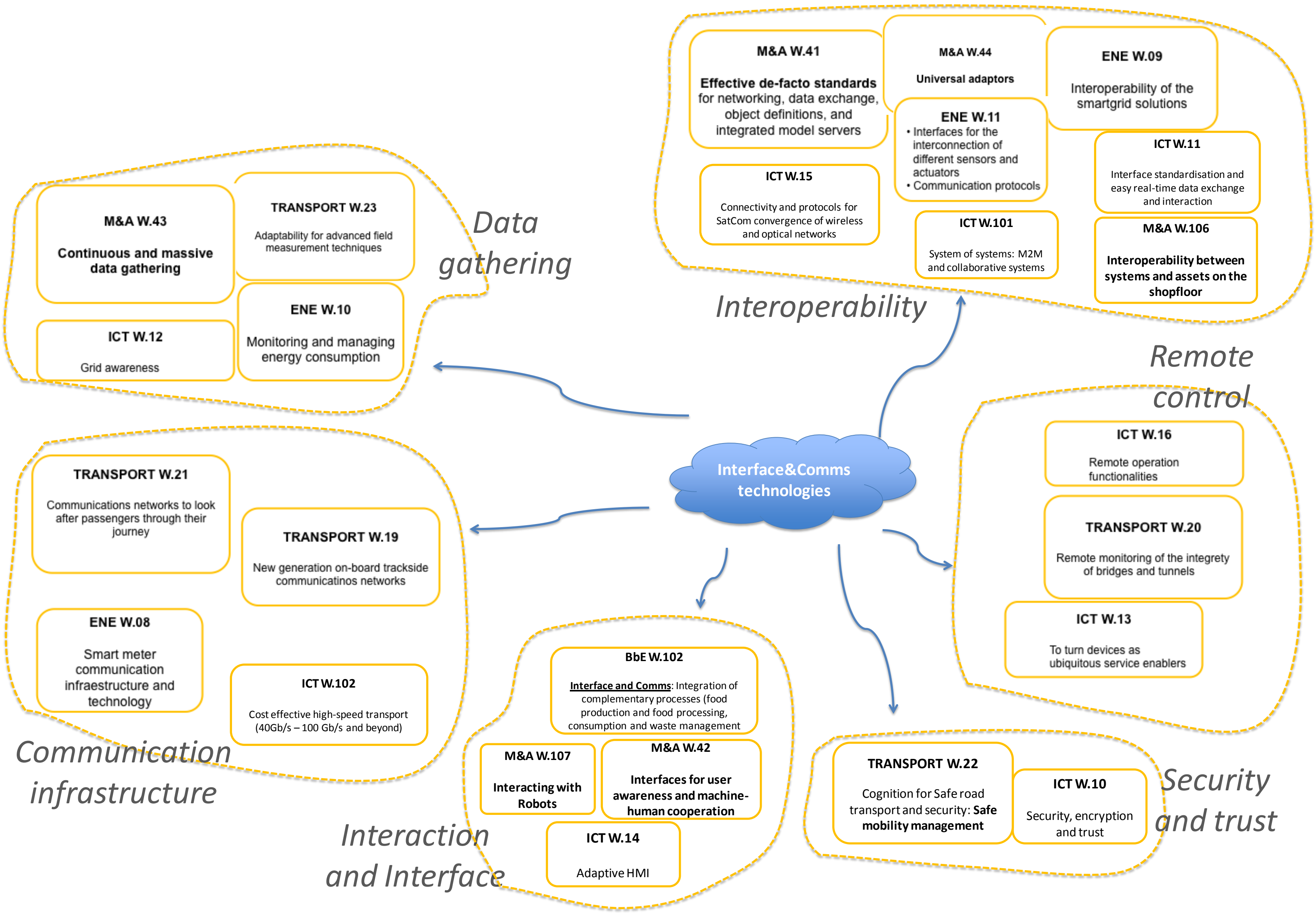


Figure 18: Weaknesses on Interfaces & Communications technologies

11.2.4. Micro-Nano technologies

***Miniaturisation**:* Smart Systems need to achieve higher integration level. Also, miniaturisation for sensors (monolithic integration, larger number of dedicated imagers per system in electronic imaging technology, etc…), reliability, and high performance computing Smart Systems is required.

***Materials/Structures**:* Advanced materials and smart structures for vehicle structures and components, airframe technologies to deliver improved flow and load control, and for drag reduction techniques.

11.2.5. Adaptability

***Technologies for adaptive systems**:* Technologies for more robust, reliable, secure, modular, configurable, usable, easy to integrate, tamper resistant, and adaptive systems.

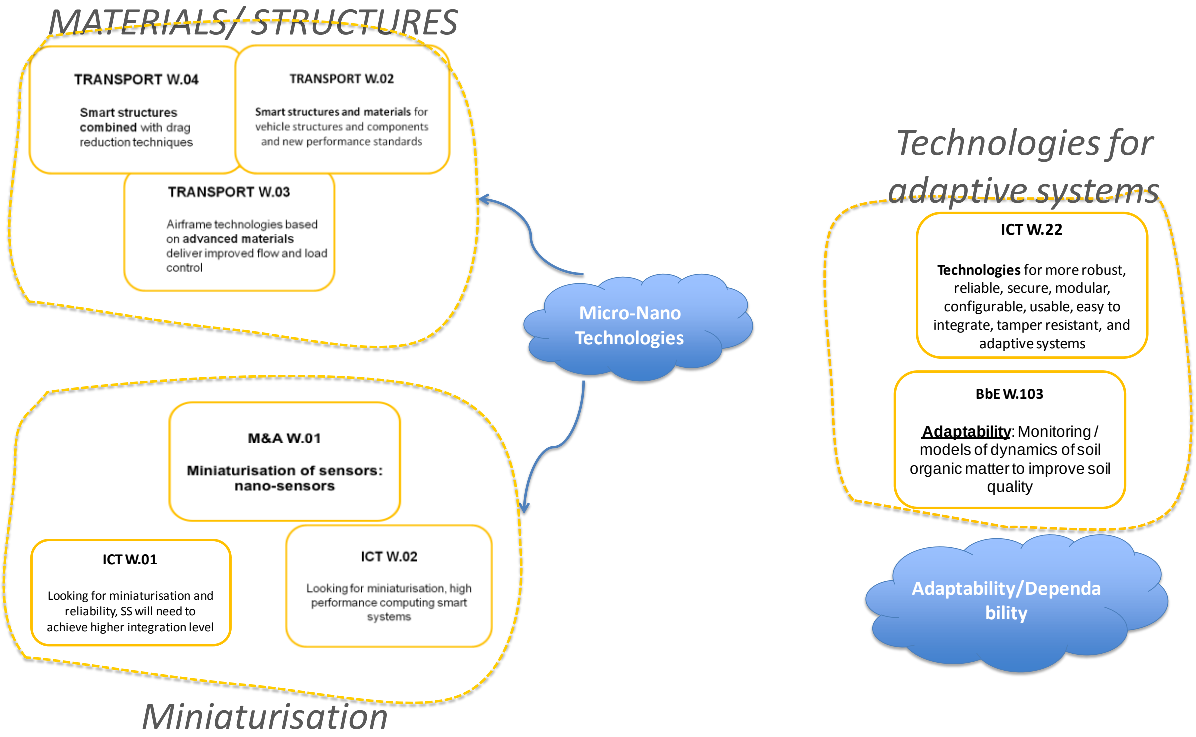


Figure 19: Weaknesses on Micro-Nano technologies & Adaptability

11.2.6. Cognition

Power technologies for Wind turbines’ control system*:* Integration of monitoring and fault prediction capabilities into the wind turbines control system

Develop integral adaptive control strategies: Integration of monitoring and fault prediction capabilities, adaptive control strategies for varying external conditions, and cognition capabilities for inter-device interaction.

Human behaviour based Smart Systems: intelligent data aggregation techniques and cognition based interaction with users and services. Also, wellbeing perception oriented Smart Systems that mimic human behaviour including content generation. They can be based on materials that mimic physiological systems.

Intelligent technologies for specific situations/functions: such as hazardous situations or the implementation of smart functions in medical devices. New functions can even be integrated in optical fibres.

Self-learning: Smart Systems cognitive autonomy through self-diagnosis, self-learning of complex tasks, self-configuration, and self-healing will enable cognition-based intelligent machinery.

Safe human-machine collaboration*:* Increasing human-machine/robot collaboration requires considering safety and reliability as major issues.

Networked intelligence: Ubiquitous and cloud based intelligence.

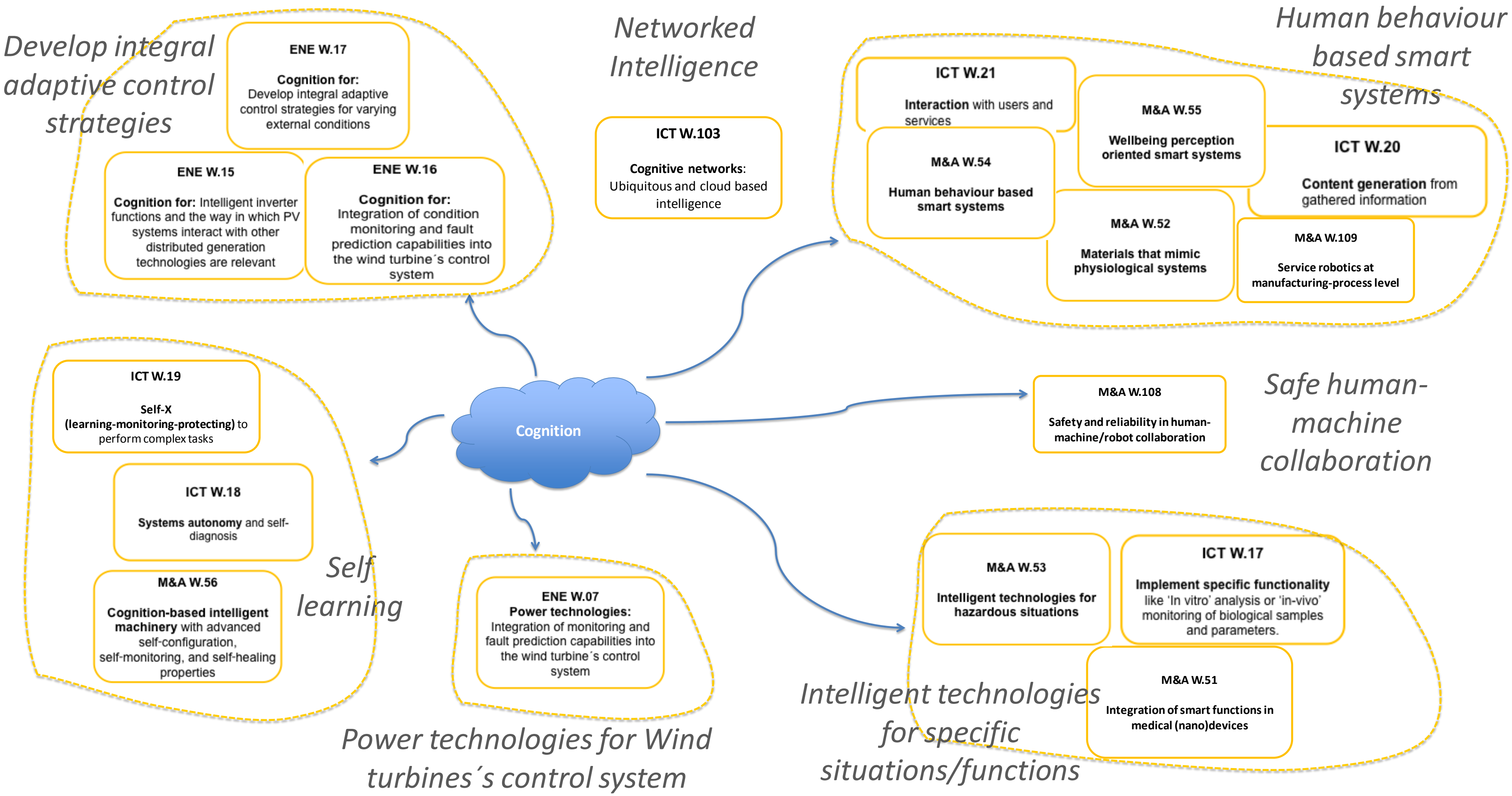


Figure 20: Weaknesses on Cognition technologies

11.2.7. Sensors

Monitoring*:* Condition monitoring of processes, components and equipment with high signal-to-noise level sensors will allow high performance measurement (nanometre-scale) and building intelligent infrastructures that will reach to autonomous inspection (monitor and inspect themselves, and their context as well)

Smart sensors for production*:* Sensor are required for plant automation and process optimization, and for protection systems for machines, production and transportation processes.

Advanced capabilities for sensors such as: miniaturised, based on active multi-functional structures, reliable and maintenance free, perception oriented, and imaging sensors and methods.

Environment: On the one hand, sensors dealing with difficult conditions such as harsh environments, all weather operation, radiation detection. On the other hand, providing contextual information for different purposes (collective protection systems, fleet management, etc…)

Get Information*:* New sensors for new data and meta-data, and access to sensor information and sensor networks will allow getting system level information. Then, sensor data fusion will permit to advance to content generation.

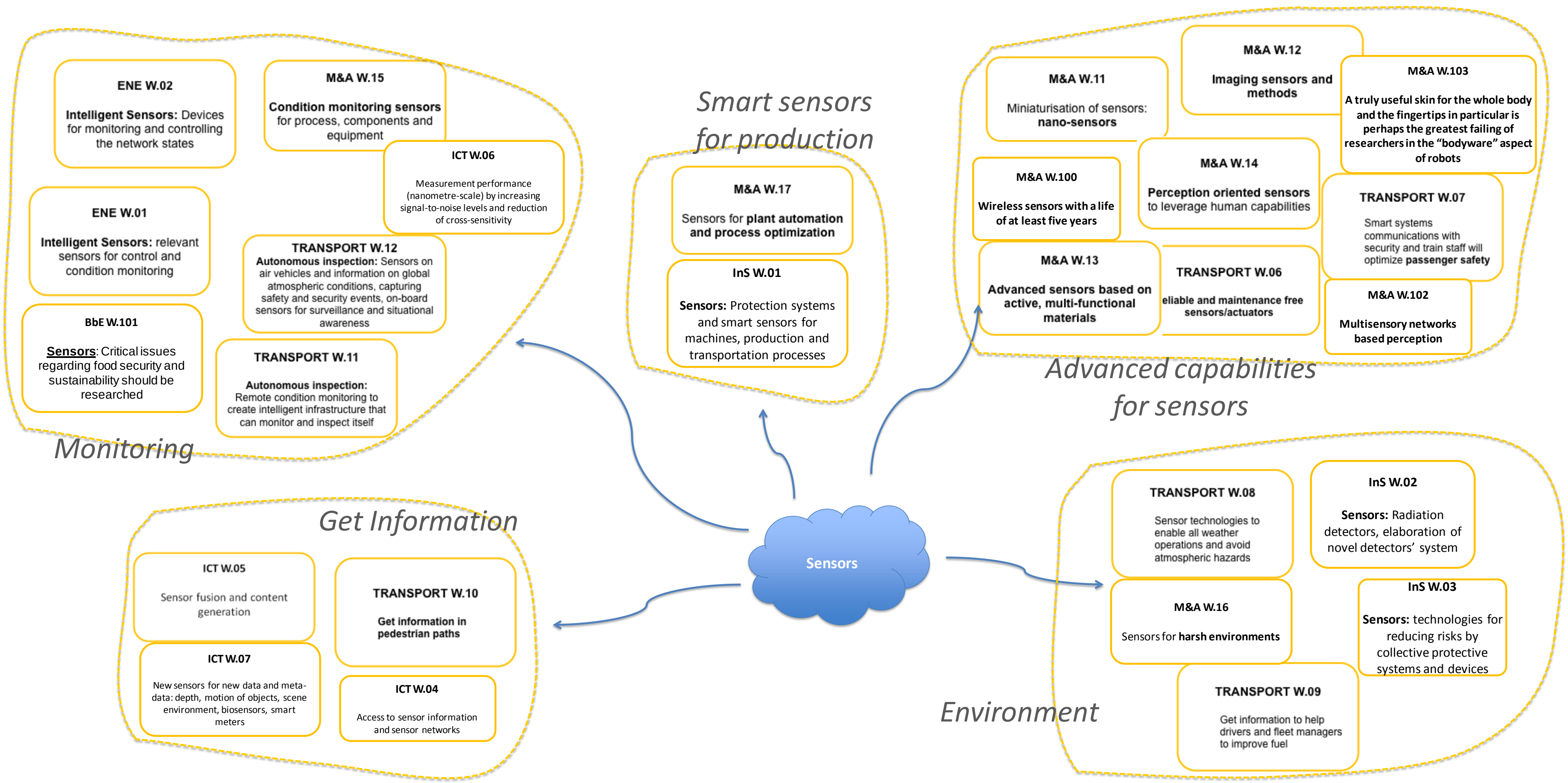


Figure 21: Weaknesses on Sensor technologies

11.2.8. Power

Energy consumption efficiency: Advances in energy consumption and energy saving strategies at component level must be combined with energy management for overall system energy efficiency, enhanced by mobile energy consumption and monitoring at the shop floor.

Power technologies for Smart Systems (Sensors…)*:* built-in tiny energy supplies for sensors and power technologies (miniaturized fuel cells) for autonomous Smart Systems are required. Additionally new battery technologies are required for PV applications.

11.2.9. Other types of weaknesses

Ships Operation: New concepts and requirements for remote and autonomous operation of ships, and further development of motion stabilized work platforms are required

Education*: Education and training initiatives need to be undertaken in order to make things happen.*

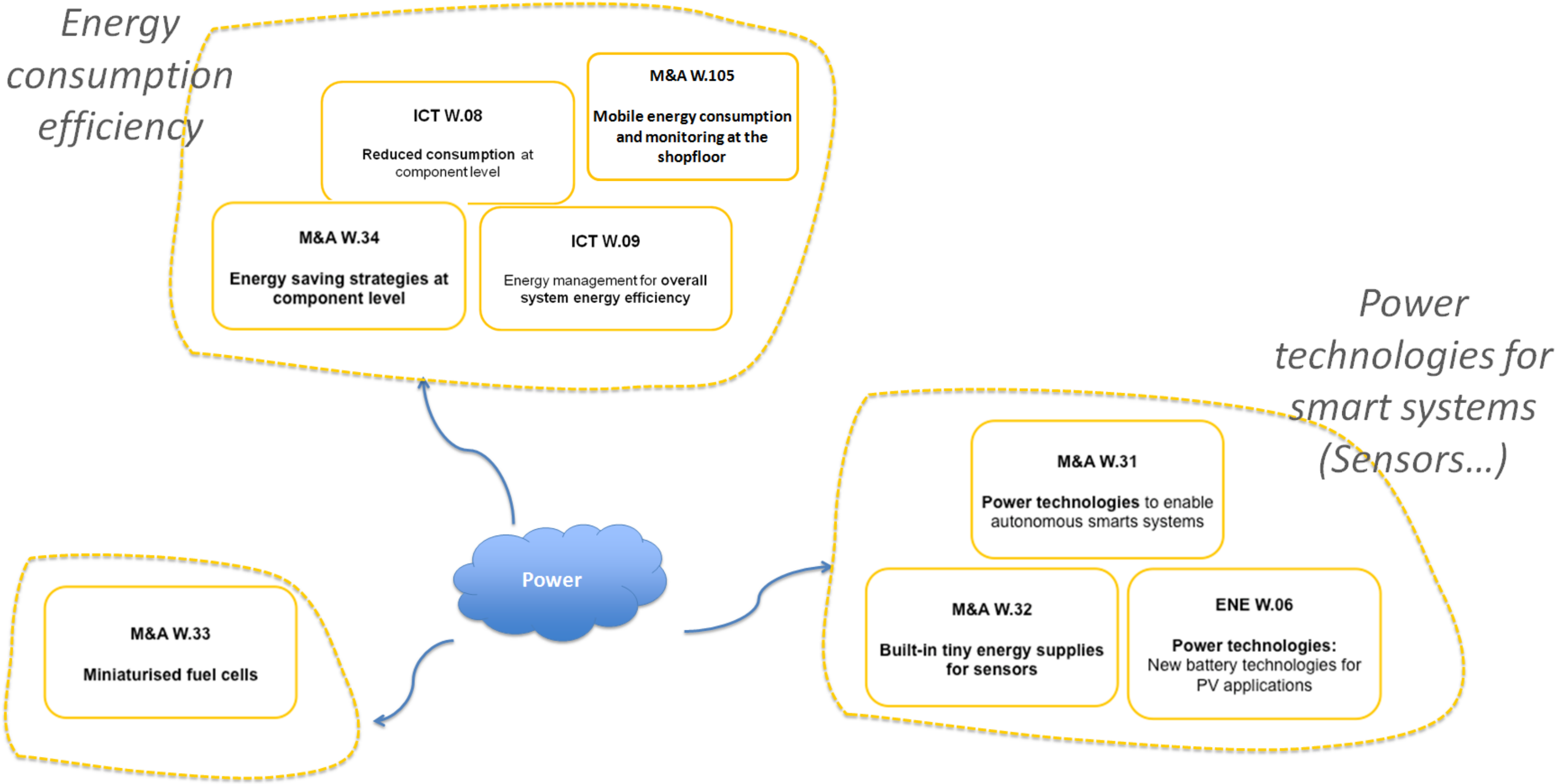


Figure 22: Weaknesses on Power technologies

11.3. Opportunities

Many inputs gathered from the analysed documents answer the following question:

What types of value opportunities or applications can be built from smart systems capabilities?

Most opportunities represent contexts where Smart Systems have a high potential to provide new value. Opportunities were classified in terms of the type of “value stream” they stress on: product, equipment, process, service, facility or infrastructure.

11.3.1. Products

These types of opportunities show that new products or a relevant improvement in existing products is enabled by Smart Systems Integration.

***High performing products**:* Advances in hardware integration and performance level, noise attenuation techniques, and intelligence integrated components/products will enable radically-advanced new product concepts and functionalities based on Smart Systems and materials. Some examples are: integrate sensor and information systems in packaging materials; smart cards for “everything” and smart packaging; robotics applications in the aerospace, automotive, manufacturing systems; updatable/adaptable products based on interchangeable components and intelligent control techniques.

***Health devices and products**:* Chip technology/DNA arrays together with chemical and biological analytical methods and sensors (biosensors and remote sensing) will enable automated, precise and personalized treatments: drug delivery devices products, and even smart active implants or materials

***Monitoring ready products**:* Monitoring, diagnostic and assistance devices and materials; monitoring and controlling the processes and plant safety based on environmental sensors; sensors for Structural Health Monitoring (SHM) and risk-informed inspection; wireless devices to monitor noise and vibration

***Monitoring Sensors**:* Smart sensors for monitoring conditions of machines, processes and structures; sensor technologies that monitor environmental conditions

***Monitoring Devices**:* Smart meters with voltage and current transformers for Smart Grids; monitoring devices for analysing the aging of the equipment for Smart Grids. Monitoring tools for soil, crops and animals should better support farmers’ observation.

***Intelligent products**:* Smart Systems enabled energy efficient products; products incorporating sensors capturing information about power flows, power quality (harmonics, etc), remaining capacity (dynamic rating) and other physical properties; frequency-dependent power control. Contexts like Smart Grids relate customer-side systems and provide opportunities to integrate Smart Systems products.

“Controlled” products: Integration of new control technologies into products such as tracking control electronics and the inverter into one device.

***Safety products**:* Safety systems based on machine vision, ultrasonic and infrared radiation sensors and other electronic devices to control the positions of workers in plant; electrical protection technology adapted to DER including new switch technologies and smart transformers (temperature in cables, gas analysis in transformers, etc.); safety and security related systems for diverse applications such as: protecting cyclists, detecting explosives, packaging solutions for fresh food, etc…

***Ubiquitous user interfacing**:* Sensor systems give information about product, and connect customer domestic system; intuitive user interfaces (including speech, tactile and multisensory interactions) facilitate Human-Machine-Interaction; mobile productivity tools and interactive devices for service support and dynamic interaction with workers; SatCom featured Smart Systems for diverse applications (transport and mobility, energy, security, content, health) enable ubiquity. That allows diverse applications like drivers assistance systems (car), and permits to better characterise any natural events, like earthquakes, floods, etc.

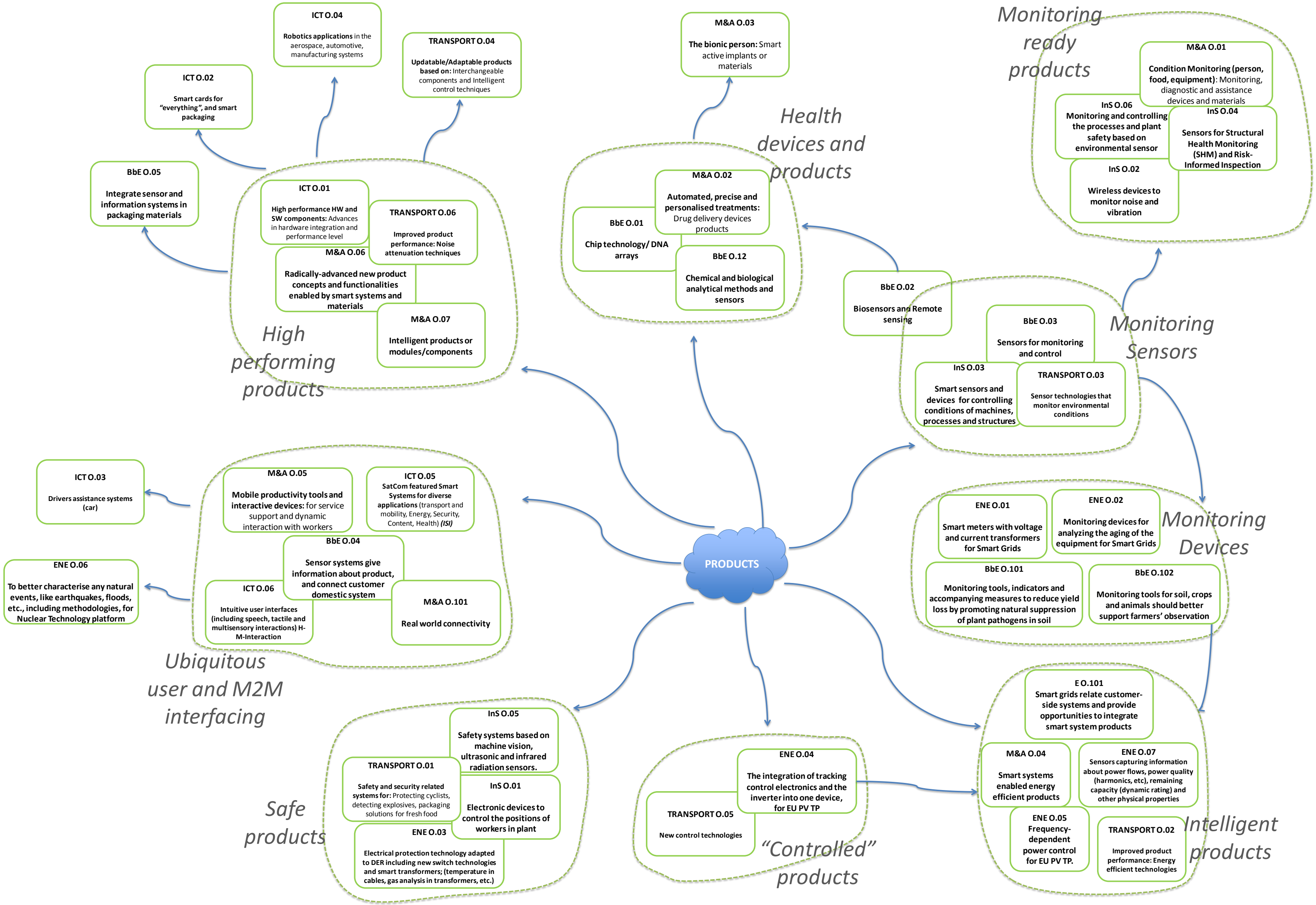


Figure 23: Opportunities on Products

11.3.2. Equipment

Equipment is also a product but its nature and types of markets brought us to consider this type of opportunities in a separate group. These types of opportunities show that new equipment or a relevant improvement in existing equipment is enabled by Smart Systems Integration.

Equipment for automation: Automation of processes is an overall opportunity for Smart Systems Integration due to their potential contribution to automated-autonomous, high productive and adaptive equipment, making also possible management and control systems for automated or self-assessed operation, and intelligent process control and optimization.

New processes enabling: Equipment enabled by Smart Systems and related technologies will make possible the development of new processes.

Miniaturised Equipment: Developing smaller, more efficient and cheaper equipment, especially for medical applications.

High performing: Advanced mechatronics and materials enable new equipment with improved performance:

- *Enhanced Comfort*: reduced noise and vibration
- *Reduced emissions*: by electric and sustainable bio-fuels based traction, Smart Systems driven improved diesel and hybrid engines
- *Smart equipment*: for example in buildings (sensors, actuators, control and communication systems will give new capacities)
- *ICT technologies based infrastructures* like rail transport system equipment
- Same or *improved functionality at lower cost*

Robots: Robots will autonomously assist protecting offices and homes, and also will help secure borders or monitor the environment in both routine and emergency operations. In the long term, humanoid and animal-like robots will perform specialised tasks.

Advanced equipment control: Equipment with advanced management and control systems for

- Vehicle-infrastructure interaction,
- Equipment health monitoring
- Safety and security.

More sophisticated tools to provide to the operators with more reliable and quick indications/measurements of equipment status, to help in the implementation of an appropriate recovery strategy. Following this thread, new monitoring and control solutions are needed, to answer several concerns society is facing nowadays (drivers) such as:

- Increase the reliability and resilience of smart grid
- Reduce uncertainty
- Increase concern for the safety of nuclear power plants

Environmental awareness: Equipment for better environmental monitoring systems, models for contamination predictions, health effects of low radiation doses, and effect of contamination on the environment.

Advanced design and simulation tools: Development of control equipment and commissioning tools that ensure that predicted results are actually obtained by equipment. Tools allowing the design of wider and more robust lines of defence with respect to design basis aggressions and beyond design basis events, by defining additional measures to consider in the design and new or improved systems for mitigation of consequences.

Diagnostics in medicine: Diagnostic devices and equipment for user friendly, non-invasive and telemedicine applications.

Electric power equipment: Specific applications as power conditioning equipment for bulk power and grid support, and electric vehicle charging infrastructure.

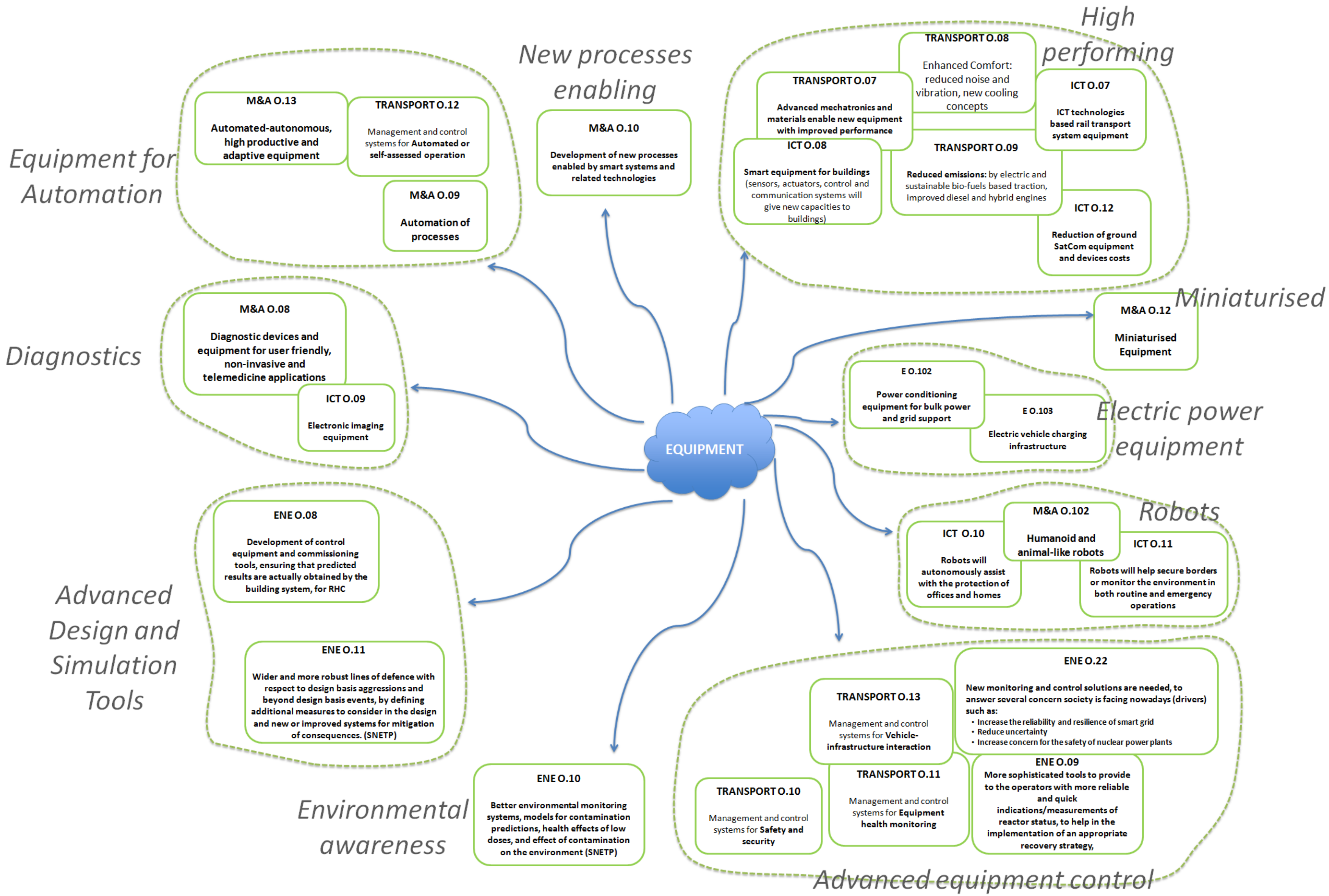


Figure 24: Opportunities on Equipment

11.3.3. Processes

Processes type opportunities show that new processes or a relevant improvement in existing ones is enabled by Smart Systems Integration.

Process Automation: Smart Systems will enable automation of processes and, in consequence, performance improvement regarding reduced human errors.

Process Performance Improvement: Control and optimization of manufacturing processes is required. Also support processes require performance improvement: supply chain, maintenance, retrofitting. Nanophotonic devices will enable reductions in footprint, switching delay and power dissipation.

Process Innovation: Embedded intelligence and communicating functions on products and equipment will enable process innovation: small-scale power production with small-scale CCS could be a possibility for green power production for all small villages in developing countries that do not have electricity today; key challenges to be addressed are small-scale transport and storage of CO2; integration of novel CO2 capture related technologies into power and other industrial processes; smart and evolvable equipment: equipment able to offer and add new functionality and intelligence by integrating Smart Systems as active components.

Intelligent complex processes: From complex tasks execution enabled by NESSI Framework ("NESSI Core"), through implementing intelligent processes (performance improvement regarding integrated intelligence and automated control and M2M platforms enabled "intelligence providing" processes), till generating content (Smart Systems as providers of content make available their knowledge base as content).

New Processes: Methods and procedures based on Smart Systems will allow new processes:

- Smart electronic functions on packaging include applications for monitoring and indicating product safety
- New diagnostic tests and processes allowed by Smart Systems
- Processing control for nutrient functionality and security

Perceived Value: Process performance improvement enabled by Smart Systems will be oriented to improve perceived value by users regarding comfort and other perception aspects.

Process Management: Performance improvement regarding basic functions (tracking-tracing and navigation) will enable improvement in integrated process management (transport system management).

System availability & productivity: Processes improvement, together with improved process management will boost the required systems availability and productivity, by means of improved capacity, availability and productivity.

Ubiquitous Customization: Smart Systems will facilitate cost-effective provisioning and seamless composition of processes and services (understanding that providing a service implies to execute a process), supporting pervasive and ubiquitous application scenarios using SatCom Broadband Access based processes.

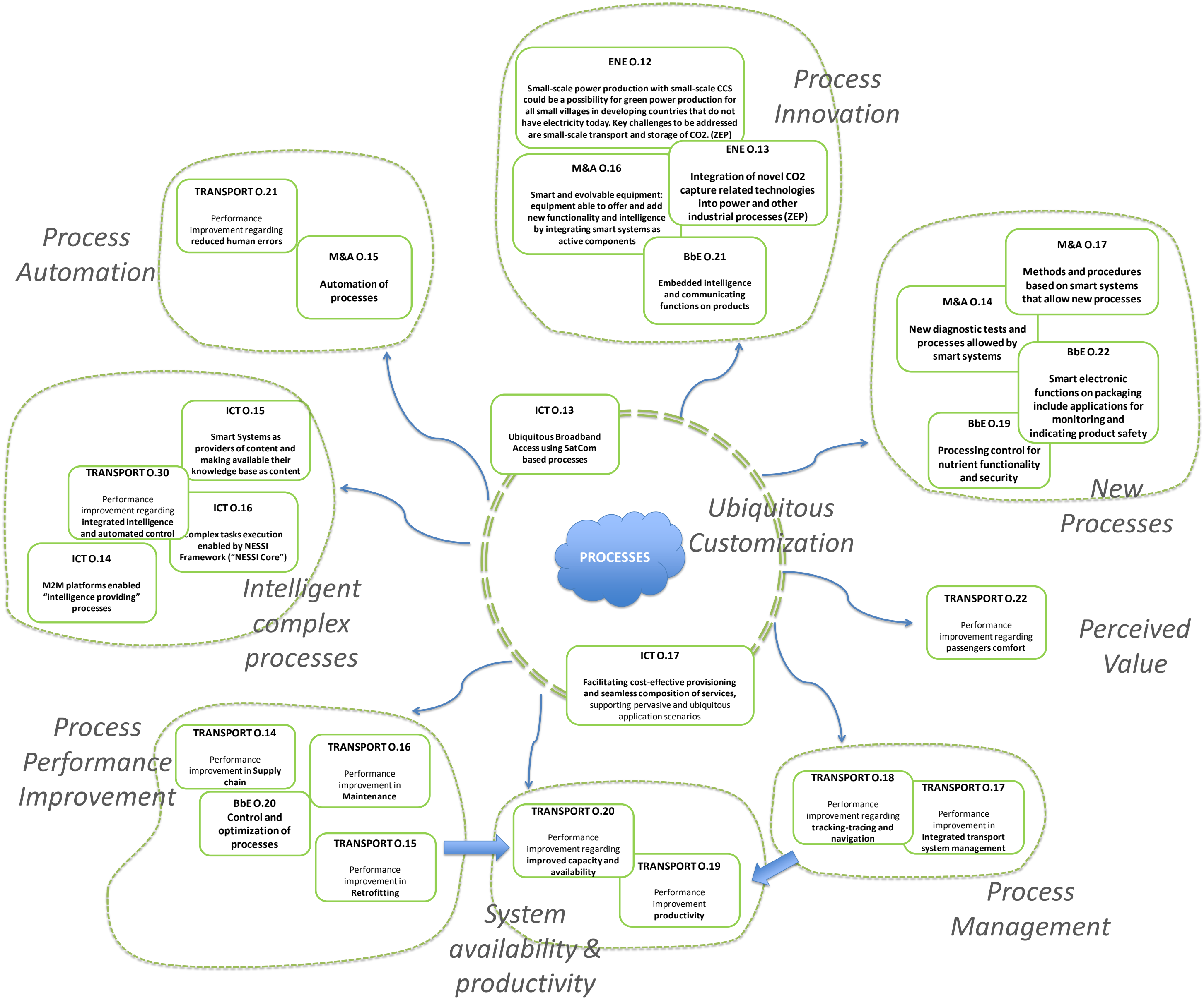


Figure 25: Opportunities on Processes

11.3.4. Services

Services type opportunities show that new services or a relevant improvement in existing ones is enabled by Smart Systems Integration.

Service enabler components: Smart Systems are seen as components that enable services in different ways:

- As providers of content and making available their knowledge base as content
- As enablers of tailored services
- Intelligent sensors and actuators with improved self-diagnosis properties
- As connected intelligent components of a system

So, Smart Systems, as components, enable services in diverse scenarios: Equipment health monitoring, authentication, ticketing, traffic management and punctuality.

Data availability: Database infrastructure must be improved to tackle the accessibility and data traffic that will be required by Smart Systems intervening in services.

Cognitive components are required in diverse scenarios: Intelligent systems to advise consumers based on personal way of life, inventory techniques for forest industries, software tools for detecting dangerous situations in industrial systems; and so on.

Intelligent Services: Intelligence services based on connected objects, intelligent components, products, equipment and infrastructures, and manufacturing and factory intelligence are required:

- *Intermodal transportation* based on intelligent mobility and traffic/journey information
- *Monitoring services including surveillance and environmental monitoring and control*
- *Key assets protection*
- *Quality assurance services*
- *Ubiquitous Messaging Services* allowed by satellite M2M networking
- Higher *controllability of PV systems and loads*
- *Home Energy Management Systems (HEMS) and Building Energy Management Systems (BEMS) in smart grids*
- *Regenerative medicine*
- *Support of claims*
- *Crisis management*
- *E-government*
- *Health, inclusion, and assisted living*
- *e*tc…

Service Businesses: These intelligence services are seeds for new businesses like *"energy-as-a-service"*, an innovative business model for energy utilities

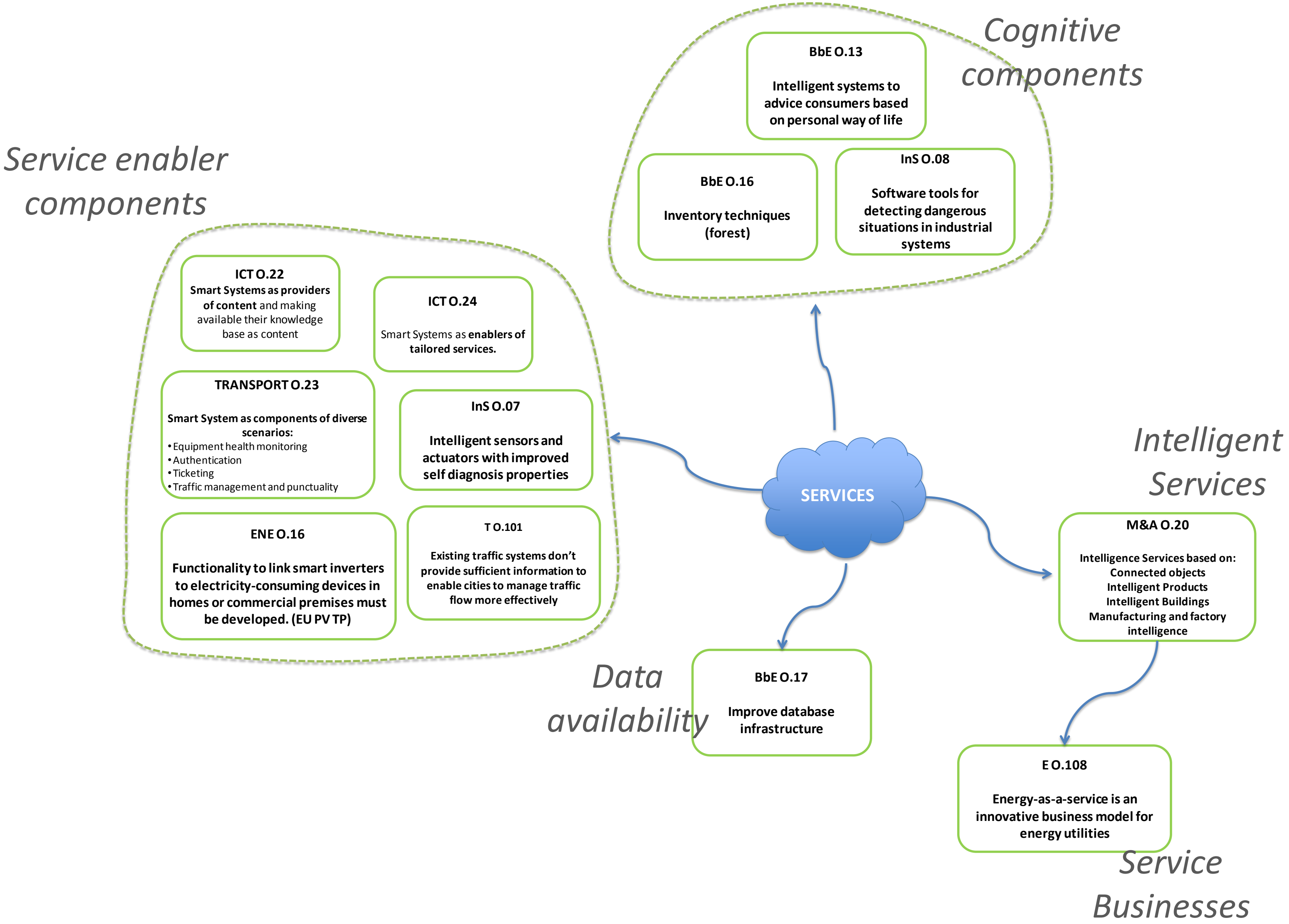


Figure 26: Opportunities on Services

11.3.5. Facilities/Infrastructures

Facilities/Infrastructures types of opportunities show that new services or a relevant improvement in existing ones is enabled by Smart Systems Integration

Rail & Road: High performance rail and road infrastructures should be improved in many performance attributes such as reliability and availability, energy-efficiency, safety. Public bodies' requests, as that issued by Manchester for a Dynamic Road Network Efficiency and Travel Information System Solution, are opportunities to implement advanced solutions based on Smart Systems Integration...

Buildings: Intelligent, safe, energy efficient, healthy, comfortable buildings and underground spaces are foreseen in near future. These future homes and offices will be networked with surrounding smart building facilities up to whole cities and regions. So, large scale demonstration of smart thermal grids will be in place.

Healthy infrastructures: Predictive infrastructure, monitoring capabilities, and intelligence that enable new maintenance services that will enable healthy buildings and infrastructures. So, ageing monitoring, prevention and effect mitigation on metallic components, on concrete material, polymers and electrical equipment are required. For these purposes, asset monitoring and tracking through Internet-of-Things middleware is required.

Communications: Fixed mobile and broadcasting convergence, which aims at integration and creation of a unified communication infrastructure from fixed and wireless mobile networks, is required for M2M communication enabled platforms.

Utilities: Service oriented utility infrastructure for Smart Cities scenario is required. During 2015 – 2025 decade the power network needs to be upgraded to become fully automated and interconnected and to enable smart operation. In consequence, smart grids can play a relevant role in increasing electricity reliability (adequacy and security).

Sustainable feedstock: Solutions need to be found for cost-effectively processing a wide range of sustainable feedstock.

CO2 infrastructure: Small-scale transport and storage of CO2 should be developed.

Metering: Modernization of the European meter infrastructure and the introduction of intelligent metering systems will have to happen. Smart meter communication infrastructure and technology is required. Advanced metering and monitoring of energy consumption in factories is a short term application opportunity.

11.3.6. Other types of Opportunities

Fit with challenges: ETPs' challenges fit with the technology based challenges of Horizon 2020. Also some sectoral challenges demand Smart Systems performances, like being an innovative and secure society regarding food and consumers.

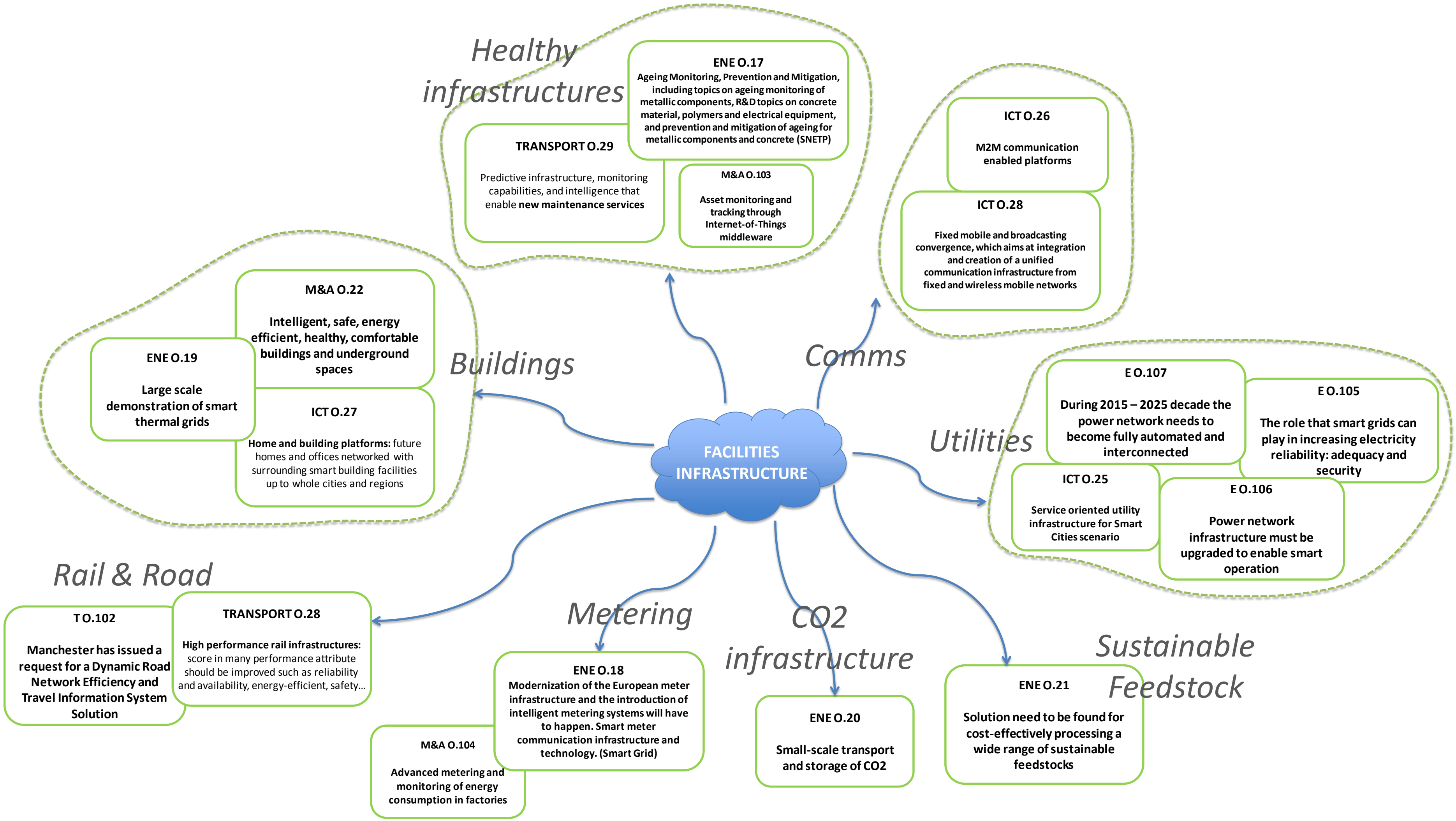


Figure 27: Opportunities on Facilities/Infrastructures

11.4. Threats

The main Threats identified from the Augmented SRA are:

- **Policy makers' priorities**: The weak collaboration between platforms delays Smart Systems implementation and makes difficult education and training in this field. At the same time the fragmented vision on big issues such as transport infrastructure requirements within some countries may compromise SSI implementation.
- **Regulatory conditions**: the slow pace of regulation issues delays the deployment of new technologies
- **Need for a harmonised standardisation and certification**: standards, regulation and certification harmonisation requires to be addressed. Special attention should be put on the lack of technical standards that will underpin the smart grid system.
- **High cost of required infrastructure**: the high cost of new big infrastructures, such as transport, may delay their construction and, in consequence, scenarios for SSI will not be implemented.
- **Safety problems automation can cause**: automation promoted by SSI requires a balance with safety issues. Humanoid and mobile robots where actuators and power sources are one of the primary "failure" areas during interactions with people, is a specific issue.
- **Industry technological requirements**: technologic gaps in different sectors act as barriers to meet future objectives (telemetric and telecommunications in transport; current robot's difficulties facing tasks involving the manipulation of objects beyond a simple reach-grasp-lift-and-hold task). Moreover, current technology solutions are still fragmented and diverse. An additional issue is on maintaining system security and cyber security.
- **Customizable user demand focused services will be required**: It is unclear how changes in customer behaviour might emerge (the public has a misconception of what 'Smart Transport' represents). Customisation poses an additional difficulty for SSI implementation. It's an additional issue to address.
- **Value chains actors' collaboration is required:** Market and value chains are fragmented and sometimes slow-paced (Cities are slow to adopt new ITS). The convergence of multiple industry members from different backgrounds is required, and the adoption of innovative commercial approaches to large scale delivery through collaborative partnerships.

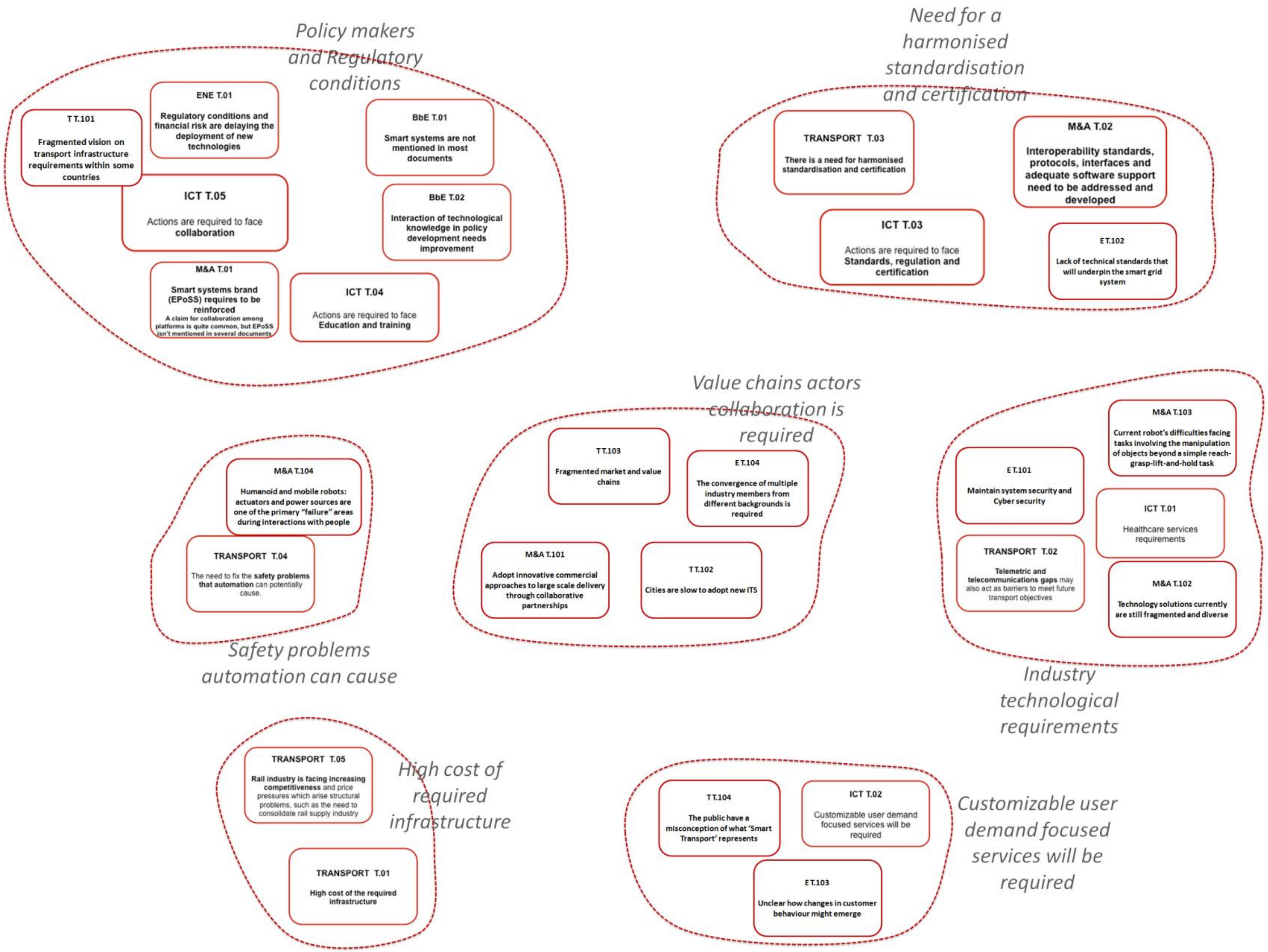


Figure 28: Threats

12. Annexes

12.1. Methodology

As it was explained in chapter 2, the Augmented SRA takes as a basis the 2013 edition of the EPoSS roadmaps and SRA and consolidates these with roadmaps and SRAs gathered in WP2, with a priority set on those available at the level of consortium and associated partners. The outcome is an Augmented SRA for the SSI ecosystem covering the application and sectorial view, the functional view, and the technological view. The augmented SRA gathers the links between the EPoSS SRA and other platforms as opportunities to build bridges and to encourage collaboration.

This objective required designing a specific methodology to fulfil such ambitious task. The objectives of the methodology are:

- To ease relevant contents identification.
- To anticipate the homogeneity of gathered information formats in order to ease consolidation of all the information.
- To assure a homogeneous analysis tasks execution by means of a specific procedure and associated tools.

The methodology is based on three Pillars:

- **EPoSS SRA as a basis and focal point**.
- WE NEED LINKS: **We look for links between the EPoSS SRA and documents of other platforms as opportunities to build bridges and to encourage collaboration**.
- **LINKS are**
    - **based on contents of official ETPs' documents** (SRAs or roadmaps)
    - are **selected with the "SMART" filter**

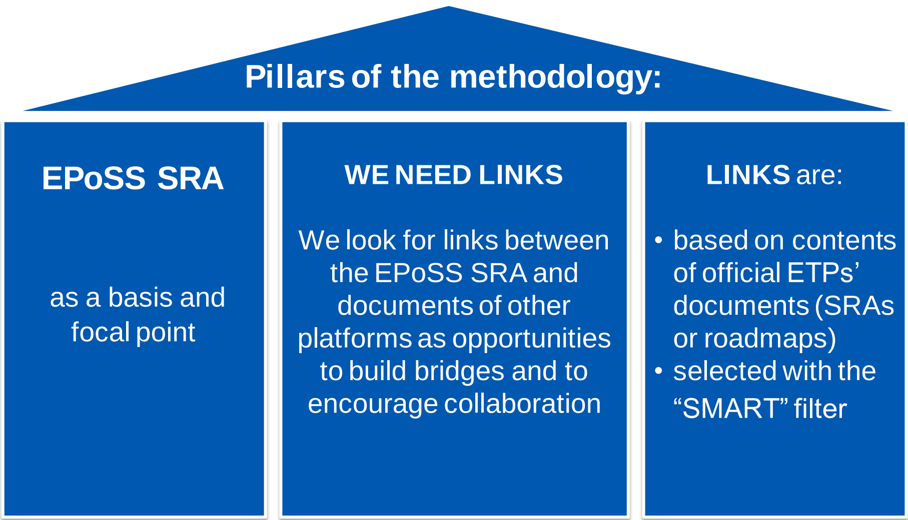


Figure 29: Pillars of the methodology

Smart filter:

Smart Systems are self-sufficient intelligent technical systems or subsystems with advanced functionality, enabled by underlying micro- nano- and bio-systems and other components.

They are able to sense, diagnose, describe, qualify and manage a given situation. Their operation is further enhanced by their ability to mutually address, identify and work in consort with each other.

They are highly reliable, often miniaturised, networked, predictive and energy autonomous.

- Smart Systems are autonomous or collaborative systems.
- They bring together sensing, actuation and informatics / communications to help users or other systems perform a role.
- By their very nature these systems combine functionalities.
- They may extract multiple functionalities from a common set of parts, materials, or structures.

Smartness: “The concept of the Knowledge Base separates Smart Systems from systems which, although they may be automated, remain purely reactive”.

As an example, the “automatic” camera of a decade ago would simply measure light intensity and adjust the shutter speed and lens aperture so that the photograph is properly exposed.

The typically “Smart” digital camera of today, by comparison, not only measures light intensity, but analyses the subject for signs of motion, for colour balance (including also the detection and optimisation of flesh tones), for facial expressions (smiles, closed eyes) and for contrast, to ensure that the focus is set for critical sharpness.

All these parameters are compared with a Knowledge Base inside the camera, which essentially distils the skills and experience of over 150 years of photography and applies it to the camera settings to produce a high quality image whilst being very simple to use

Smartness levels:

- ***1st-generation****-Smart Systems include sensing and/or actuation as well as signal processing to enable actions.*
- ***2nd-generation****-Smart Systems are predictive and self-learning.*
- ***3rd-generation****-Smart Systems simulate human perception/cognition.*

The methodology has the following phases:

1. Analysis framework design
2. Links identification
3. Links analysis
4. Integrated view

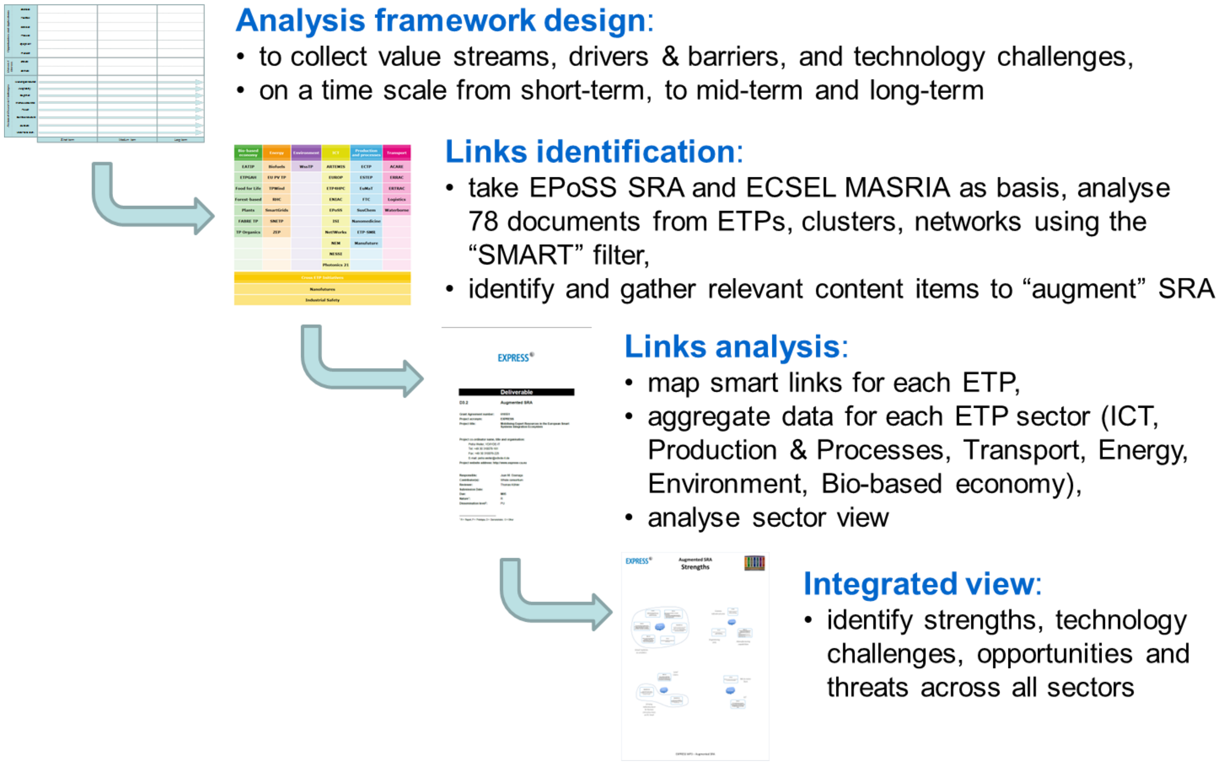


Figure 30: Methodology phases

12.1.1. *Analysis framework design*

One of the most important issues of the methodology is to assure a homogeneous analysis of the gathered information by means of a specific procedure and associated tools.

Most of the analysed documents are SRAs from ETPs, and these documents have two main types of contents:

- Applications and types of solutions that address key sector and societal needs.
- Technology challenges that require to be solved in order to implement these applications and solutions.

In addition to that, other valuable information can be found that give clues of the main drivers and barriers that can act for or against the plans that are shown in these documents.

These types of contents match the overall structure of roadmapping techniques used in technology valuation processes, specifically the Value Roadmapping (VRM) techniques proposed by Dissel [1].

Three main types of layers were defined to show the links:

- **Application Opportunities layer**: these are ideas or proposals of applications, mentioned in or derived from the ETP document, where Smart Systems can play a relevant role or induce a breakthrough innovation. This layer was partitioned in the following types of opportunities:
    - Products: new products or relevant product innovation.
    - Equipment: new equipment of relevant equipment innovation.
    - Process: new processes or relevant process innovation.
    - Service: new services or relevant service innovation.
    - Facility or Infrastructure: new facility or infrastructure or relevant innovation on them.
    - Business: new businesses.
- **Divers and Barriers layer**: these are non-technological issues or trends that act in favour or against the use of new devices or techniques in the analysed sector/subsector (the ETP focus).
- **Technology challenges layer**: these are generic sector/subsector level “functionality” performance improvement challenges that foster technological innovation (e.g.: “energy efficiency and fuel economy” in “Transport & Mobility” sector).

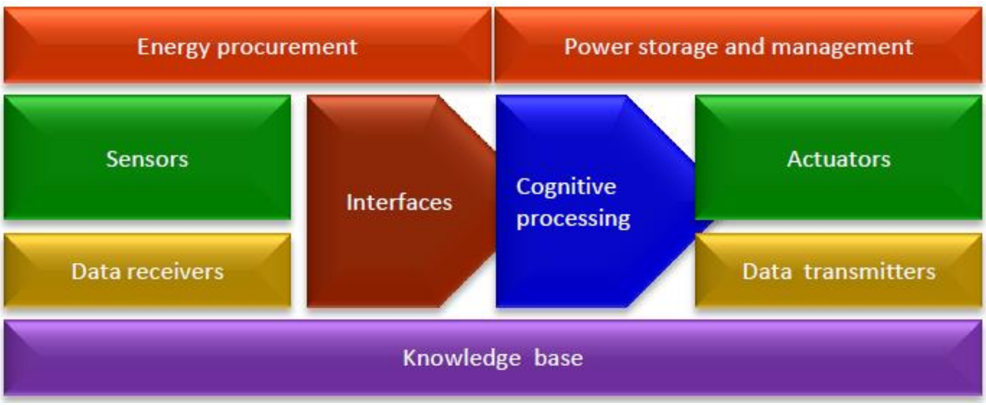


Figure 31: Smart Systems' main technology layers

This layer was partitioned mostly according to the main technology layers of Smart Systems as shown in the EPoSS SRA. Other sublayers were added: micro and nano technologies as KET; adaptability as a Smart Systems design issue to address customization and dependability of such systems; modelling and simulation technology challenges on design and development tools. The resulting sublayers are the following:

- Micro-nano technologies
- Sensors
- Control/Actuators
- Power
- Interfaces & Communications
- Cognition
- Adaptability
- Modelling/Simulation

The resulting analysis framework is shown in Figure 32.

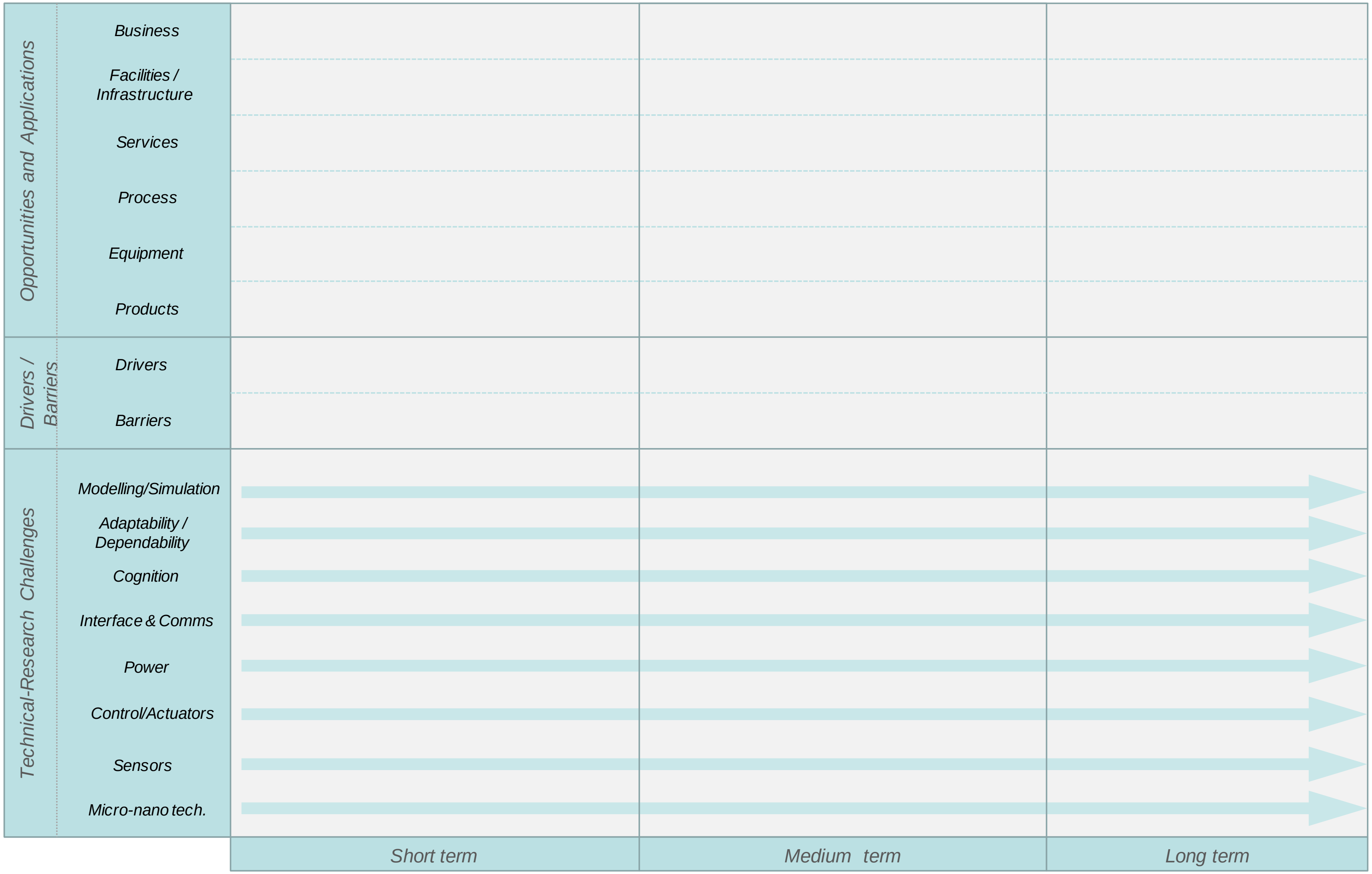


Figure 32: Analysis framework

12.1.2. Links identification

We look for links between the EPoSS SRA and other platforms as opportunities to build bridges and to encourage collaboration. Links are based on contents of official ETPs' documents (SRAs or roadmaps). The contents of official documents were considered as "evidences".

Bio-based economy	Energy	Environment	ICT	Production and processes	Transport
EATIP	Biofuels	WssTP	ARTEMIS	ECTP	ACARE
ETPGAH	EU PV TP		EUROP	ESTEP	ERRAC
Food for Life	TPWind		ETP4HPC	EuMaT	ERTRAC
Forest-based	RHC		ENIAC	FTC	Logistics
Plants	SmartGrids		EPoSS	SusChem	Waterborne
FABRE TP	SNETP		ISI	Nanomedicine	
TP Organics	ZEP		Net!Works	ETP-SMR	
			NEM	Manufuture	
			NESSI		
			Photonics 21		
Cross ETP Initiatives					
Nanofutures					
Industrial Safety					

Figure 33: ETPs considered in links identification

The link identification includes the following steps:

Step 1. **Read ETP document**: all documents were previously uploaded to EXPRESS website and each partner was assigned to a set of them.

Step 2. **Detect the links**: identify a paragraph where an application opportunity, technology challenge or driver/barrier for Smart Systems is devised. For that purpose a "Smart Filter" definition was provided (see chapter 2).

Step 3. **Record the link**: copy and paste the exact content in the provided "Excel" sheet.

Step 4. **Reference the link**: Specify ETP and associated document as link's source and indicate the page number where it is located.

Step 5. **Classify the link** by filling the following columns:

- Type: Driver, Barrier, Application Opportunity, Tech/Research Challenge
- Horizon: Priority, Mid-term, Long-term, Not specified
- Generation (of Smart Systems): First, Second, Third

Step 6. **Add a comment** (if required)

ETP	Sector	Document	Link content (original text from ETP document)	Page	Type	Horizon	Generation	Comments
Forest Technology Platform	Forest	SRA	The sector would benefit in particular from investment that supports the development of open platforms and technologies such as the systematic use of radio frequency identifica¬tion (RFID), embedded components and systems, process control as well as robotics, micro- and nano-electronics. Working together in new applications, these technologies can minimise waste in the produc¬tion process, prevent illegal logging, facilitate product recovery for recycling, or make it almost impossible to counterfeit important documents	9	Application Opportunity	Not specified	Second	
Forest Technology Platform	Forest	SRA	ICT has reduced production costs both in forestry and the forest-based industries. Mobile ICT solutions will continue to revolutionise the monitoring and management of forest resources. Light Detection And Ranging technology (LIDAR), an optical remote sensing technology, and other augmented reality and glo¬bal tracking systems will play a crucial role in the whole value chain, from forest management and harves¬ting operations to transportation and logistics, manufacturing and processing, product development and resource management.	9	Application Opportunity	Not specified	Second	
Forest Technology Platform	Forest	SRA	The generation of smart materials that react in an engineered way to stimuli such as electrical current, temperature fluctuations, or chemical compounds would be useful in a broad range of domains, such as wood preservation, healthcare, packaging and the media. Advanced wood-based materials with innovative self-healing properties will reduce maintenance needs significantly. The sector is increasingly developing new wood-based advanced materials aimed at enhancing efficient product reuse, recycling and end-of-life use (cradle to cradle), paving the way to a low-carbon economy. New materials and their functionalities will have to be characterised using suitable new methods and mea-suring techniques, which have yet to be developed	11	Tech/Research Challenge	Not specified	First	
Forest Technology Platform	Forest	SRA	New sensor systems give information about the origin, shelf life and safety of the product. Integrated information systems provide information about the product or connect the client to the manufacturer's website for further instructions. The same information system can also connect to a consumer's domestic system (for ins¬tance, internet-connected fridges) and manage sto¬rage and purchases based on best-before dates.	34	Application Opportunity	Long-term	Second	
Forest Technology Platform	Forest	SRA	Integrate sensor and information systems in packaging materials – printing applications using functional inks and tags carrying anti-counterfeiting information	34	Tech/Research Challenge	Mid-term	Second	

Figure 34: Example of link recording tool

12.1.3. Links analysis

First, each link identified from each platform was tagged, classified and placed in the analysis framework in accordance to its sublayer and expected impact horizon. Figure 35 shows the links identified from construction ETP documents placed in the analysis framework.

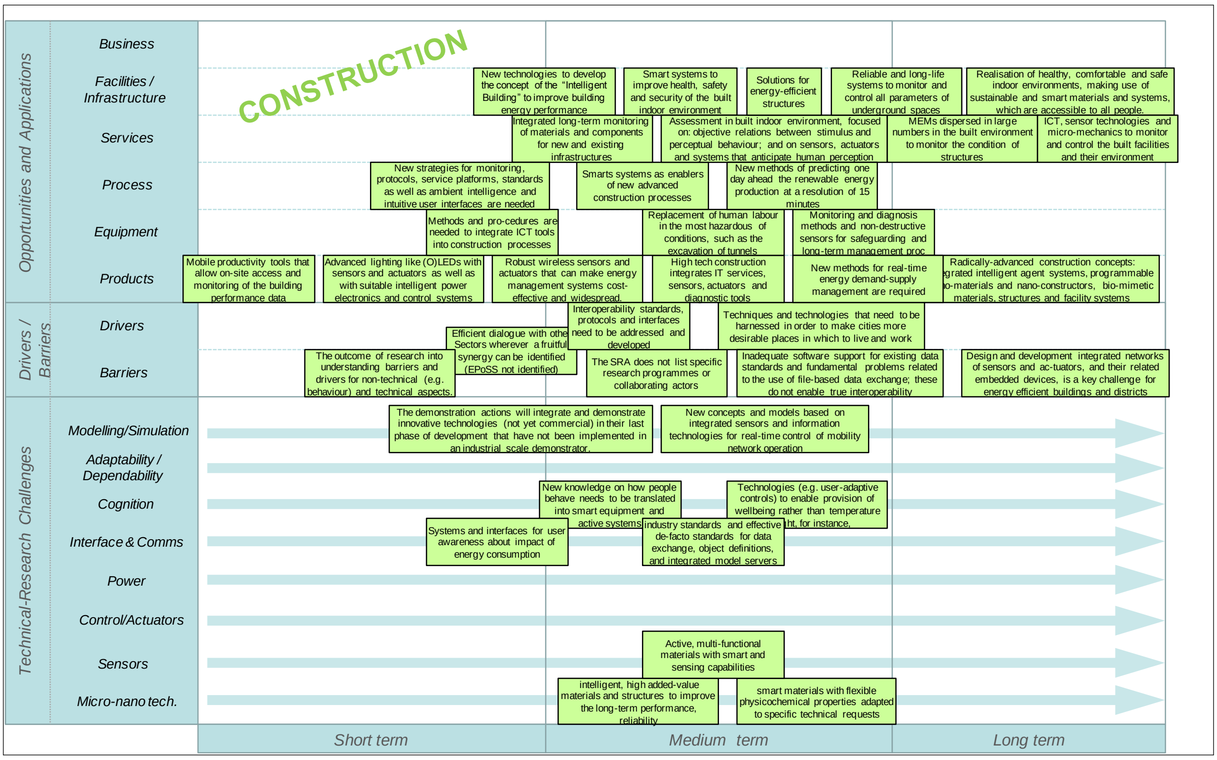


Figure 35: Links from construction ETP placed in the analysis framework.

The second step was the joint analysis of each platform's links diagram

Finally, data was aggregated for each ETP sector (ICT, Production & Processes, Transport, Energy, Environment, Bio-based economy) leading to the augmented view of the EPoSS SRA as detailed in chapters 4 to 9.

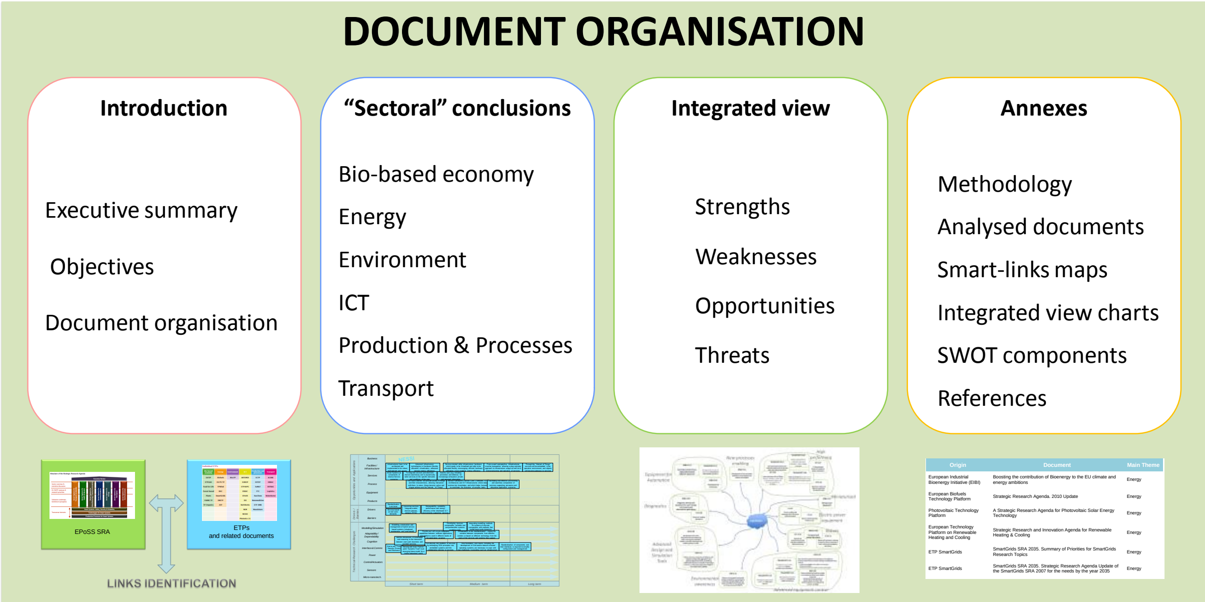


Figure 36: Augmented SRA contents

12.1.4. *Integrated view*

This final phase of the methodology consisted of producing an integrated concluding view of all the links analysis independent of the sector and in such a way that they activate the strategy and implementation plan activities that are to be fulfilled in task T3.3 of the EXPRESS project.

As the components of a SWOT analysis are key inputs for a strategy, the approach of this phase of the methodology was to transform the links into SWOT components. This complements the SWOT components gathered in WP2, and both together will activate task T3.3 (Strategy and implementation plan).

The criteria used to transform the analysis of each chapter into SWOT components are:

- Drivers and barriers aspects should be transformed into Strengths, Opportunities, Threats or Weaknesses components.
- Opportunities and Applications are candidates for Opportunities type components of the SWOT.
- Technical-Research Challenges can be seen as either Weaknesses or Opportunities

Once all SWOT components were identified and defined, they were clustered in order to clarify the integrated view. The results are detailed in chapter 10.

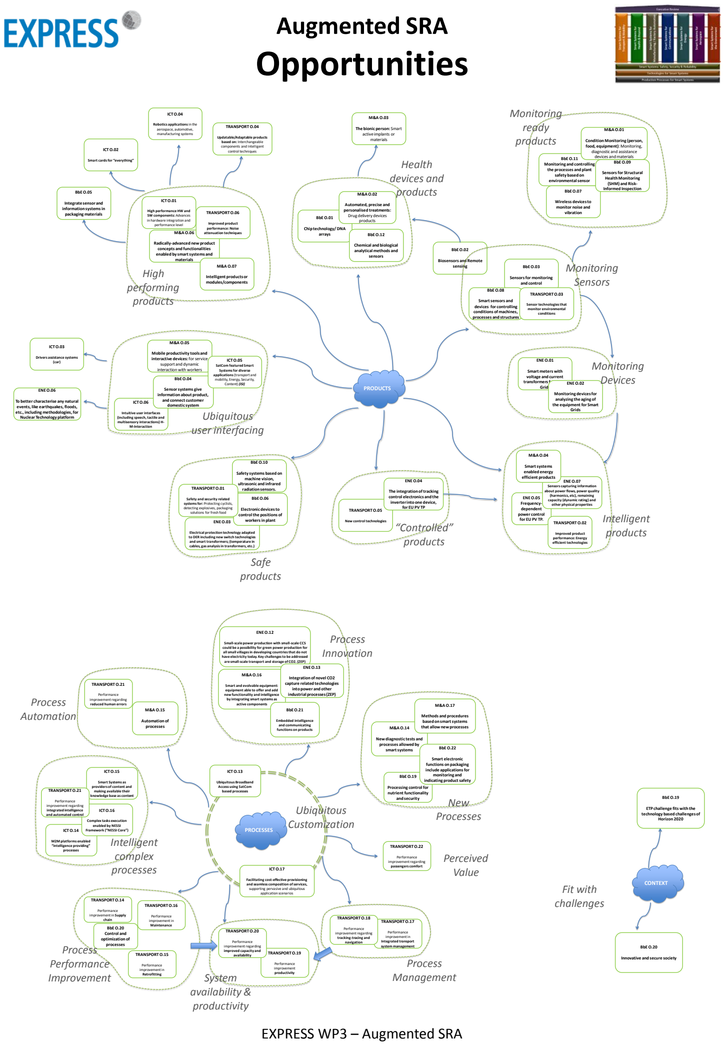


Figure 37: Partial view of SWOT opportunities chart

12.2. Analysed documents

ETP documents

Origin	Document	Main Theme
European Industrial Bioenergy Initiative (EIBI)	Boosting the contribution of Bioenergy to the EU climate and energy ambitions	Energy
European Biofuels Technology Platform	Strategic Research Agenda. 2010 Update	Energy
Photovoltaic Technology Platform	A Strategic Research Agenda for Photovoltaic Solar Energy Technology	Energy
European Technology Platform on Renewable Heating and Cooling	Strategic Research and Innovation Agenda for Renewable Heating & Cooling	Energy
ETP SmartGrids	SmartGrids SRA 2035. Summary of Priorities for SmartGrids Research Topics	Energy
ETP SmartGrids	SmartGrids SRA 2035. Strategic Research Agenda Update of the SmartGrids SRA 2007 for the needs by the year 2035	Energy
SNEPT	SNEPT SRIA 2013	Energy
European Technology Platform on Renewable Heating and Cooling	Strategic Research Priorities for Solar Thermal Technology	Energy
European Wind Energy Technology Platform (TPWind)	Strategic Research Agenda Market Deployment Strategy from 2008 to 2030	Energy
European Wind Energy Technology Platform (TPWind)	Strategic Research Agenda Market Deployment Strategy from 2008 to 2030. Annex A: Detailed research Actions	Energy
Zero Emissions Platform (ZEP)	Recommendations for research to support CCS deployment in Europe beyond 2020	Energy
WssTP	Strategic Research Agenda. WssTP a common vision for water innovation	Environment
European Aquaculture Technology and Innovation Platform	Aquaculture in 2030. Our vision for the future	Bio-based economy
European Technology Platform for Global Animal Health	European Technology Platform for Global Animal Health Action Plan	Bio-based economy
European Technology Platform for Global Animal Health	European Technology Platform for Global Animal Health Strategic Research Agenda	Bio-based economy
FABRE TP	FABRE TP Strategic Research Agenda	Bio-based economy

Origin	Document	Main Theme
Forest-based Sector Technology Platform (FTP)	Strategic Research and Innovation Agenda for 2020	Bio-based economy
Forest-based Sector Technology Platform (FTP)	Annex to the Strategic Research and Innovation Agenda	Bio-based economy
European Technology Platform “Food for Life”	Strategic Research and Innovation Agenda	Bio-based economy
TPOrganics Technology Platform	Strategic Research Agenda for organic food and farming	Bio-based economy
ARTEMIS	ARTEMIS Strategic Research Agenda 2011	ICT
ENIAC	Multi Annual Strategic Programme	ICT
EPoSS	EPoSS SRA	ICT
European Technology Platform for High Performance Computing	ETP4HPC Strategic Research Agenda Achieving HPC leadership in Europe	ICT
EUROP	Robotics Vision	ICT
Integral SatCom Initiative European Technology Platform	Integral SatCom Initiative European Technology Platform Strategic Research and Innovation Agenda	ICT
NEM (Networked and Electronic Media)	Position Paper on Future Research Directions. Opportunities for an Innovative Europe	ICT
NESSI	NESSI Strategic Research Agenda. Vol I	ICT
NESSI	NESSI Strategic Research Agenda. Vol II	ICT
NESSI	NESSI Strategic Research Agenda. Vol III	ICT
Net!Works	Strategic Research Agenda. eMobility NetWorld. A Strategy for Innovation in Future Networks in Europe	ICT
Photonics21	Second Strategic Research Agenda in Photonics. Lighting the way ahead	ICT
ENERGY-EFFICIENT BUILDINGS PPP	MULTI-ANNUAL ROADMAP AND LONGER TERM STRATEGY	Production & Processes
European Construction Technology Platform (ECTP)	Strategic Research Agenda for the European Construction Sector	Production & Processes
European Steel Technology Platform	A vision for the future of the steel sector	Production & Processes
ETP SMR	Strategic Research and Innovation Agenda (Strategic Innovation and Technology Roadmap)	Production & Processes
EuMaT	Strategic Research Agenda	Production & Processes

Origin	Document	Main Theme
EURATEX	Strategic Research Agenda	Production & Processes
ManuTex	Research Road Map	Production & Processes
BioTex	A Joint Research Roadmap for the European Industrial Biotechnology and Textile & Clothing Sectors	Production & Processes
Footweat P&P ETP	Towards a Strategic Roadmap for Research and Innovation in the European Design-based Consumer Goods Sectors	Production & Processes
Factories of the Future	MULTI-ANNUAL ROADMAP FOR THE CONTRACTUAL PPP UNDER HORIZON 2020	Production & Processes
Manufuture	STRATEGIC RESEARCH AGENDA assuring the future of manufacturing in Europe	Production & Processes
ETP Nanomedicine	Roadmaps in Nanomedicine. Towards 2020	Production & Processes
ETP Nanomedicine	NANOMEDICINE 2020. Contribution of Nanomedicine to Horizon 2020	Production & Processes
SusChem ETP	Meeting the Challenges of Europe 2020. An Enhanced Strategy for SusChem	Production & Processes
SusChem ETP	Sustainable Chemistry Strategic Research Agenda 2005	Production & Processes
ACARE	Strategic Research and Innovation Agenda. Vol 1	Production & Processes
ACARE Report of the High Level Group on Aviation Research	Flightpath 2050. Europe's Vision for Aviation	Production & Processes
ACARE	2008 Addendum to the Strategic Research Agenda	Production & Processes
ACARE	Strategic Research & Innovation Agenda Executive Summary	Production & Processes
ERRAC	Rail route 2050: The Sustainable Backbone of the Single European Transport Area	Production & Processes
ERRAC	Strategic Rail Research Agenda 2020	Production & Processes
ERRAC	ERRAC Roadmap: WP 01 - The Greening of Surface Transport	Production & Processes
ERRAC	ERRAC Roadmap: WP 02 - Encouraging Long-distance Modal Shift & De-congesting Transport Corridors	Production & Processes
ERRAC	ERRAC Roadmap: WP 02 - Encouraging modal shift (long distance) and decongesting transport corridors	Production & Processes
ERRAC	ERRAC Roadmap: WP 03 - Metro, light rail and tram systems in Europe	Production & Processes

Origin	Document	Main Theme
ERRAC	ERRAC Roadmap: WP 03 - Urban Mobility Research Roadmap	Production & Processes
ERRAC	ERRAC Roadmap: WP 03 - Urban, Suburban and Regional Rail Research Roadmap	Production & Processes
ERRAC	ERRAC Roadmap: WP 04 - IMPROVING SAFETY & SECURITY ROADMAP	Production & Processes
ERTRAC	VDA Position "Automated Driving"	Production & Processes
ERTRAC	Roadmap EV Infrastructure	Production & Processes
ERTRAC	ERTRAC Multi-Annual Implementation Plan for Horizon 2020	Production & Processes
European Technology Platform on Logistics	European Technology Platform on Logistics input for the first calls of the HORIZON 2020 (DRAFT)	Production & Processes
WATERBORNE	Strategic Research Agenda. OVERVIEW - ISSUE II - May 2011	Production & Processes
WATERBORNE	Strategic Research Agenda. Implementation	Production & Processes

Second round analysis of additional documents

Origin	Document	Main Theme
VINNOVA	Smarter electronic systems for Sweden	ICT
Clean Sky JU	Clean Sky 2	Transport
Basque Government	Agenda Digital de Euskadi 2015	ICT
ERTRAC, EPoSS, SmartGrids	Multiannual Roadmap for the Contractual Public Private Partnership European Green Vehicles Initiative	Transport
MINAM	MINAM roadmap 2012	Production & Processes
IMS	IMS 2020	Production & Processes
EeB PPP	MULTI-ANNUAL ROADMAP AND LONGER TERM STRATEGY	Energy
ActionPlanT	The ActionPlanT Roadmap for Manufacturing 2.0	ICT / Manufacturing
ITS	Intelligent Transport Systems in action	Transport
David Topham	Collation of SRA recommendations relevant to Smart Systems	ICT
RO-cKET	RO-cKETs_Roadmap brochure	Cross KET
RO-cKET	Complete List of Innovation Fields	Cross KET
Department of Energy and Climate Change	UK Renewable Energy Roadmap	Energy
Simon Skillings, Green Alliance	A Road Map to Deliver Smart Grid in the UK	Energy
Aerospace, Aviation and Defence KTN	Autonomous Systems Report	Transport
International Energy Agency	Smart Grids Technology Roadmap	Energy
Department for Business Innovation and Skills	The Smart City Market: Opportunities for the UK	Miscellaneous
IfM and Technology Strategy Board	UK Future Manufacturing Landscape MedTech Sector Roadmap	Production & Processes
Italian Institute of Technology	IIT strategic plan 2012 2014	Production & Processes

12.3. Links maps

This annex sections collect the links maps for each analysed ETP. These maps were produced in the "Links Analysis" phase of the methodology (see 12.1.3). The maps are grouped according to the classification in Cordis.

The following figure shows the colour codes used in the maps. Note that there are no maps for EATIP and Plants due to the lack of found links.

Bio-based economy	Energy	Environment	ICT	Production and processes	Transport
EATIP	Biofuels	WssTP	ARTEMIS	ECTP	ACARE
ETPGAH	EU PV TP		EUROP	ESTEP	ERRAC
Food for Life	TPWind		ETP4HPC	EuMaT	ERTRAC
Forest-based	RHC		ENIAC	FTC	Logistics
Plants	SmartGrids		EPoSS	SusChem	Waterborne
FABRE TP	SNETP		ISI	Nanomedicine	
TP Organics	ZEP		Net!Works	ETP-SMR	
			NEM	Manufuture	
			NESSI		
			Photonics 21		

Cross ETP Initiatives
Nanofutures
Industrial Safety

Figure 38: Links colour codes

12.3.1. Bio-based Economy

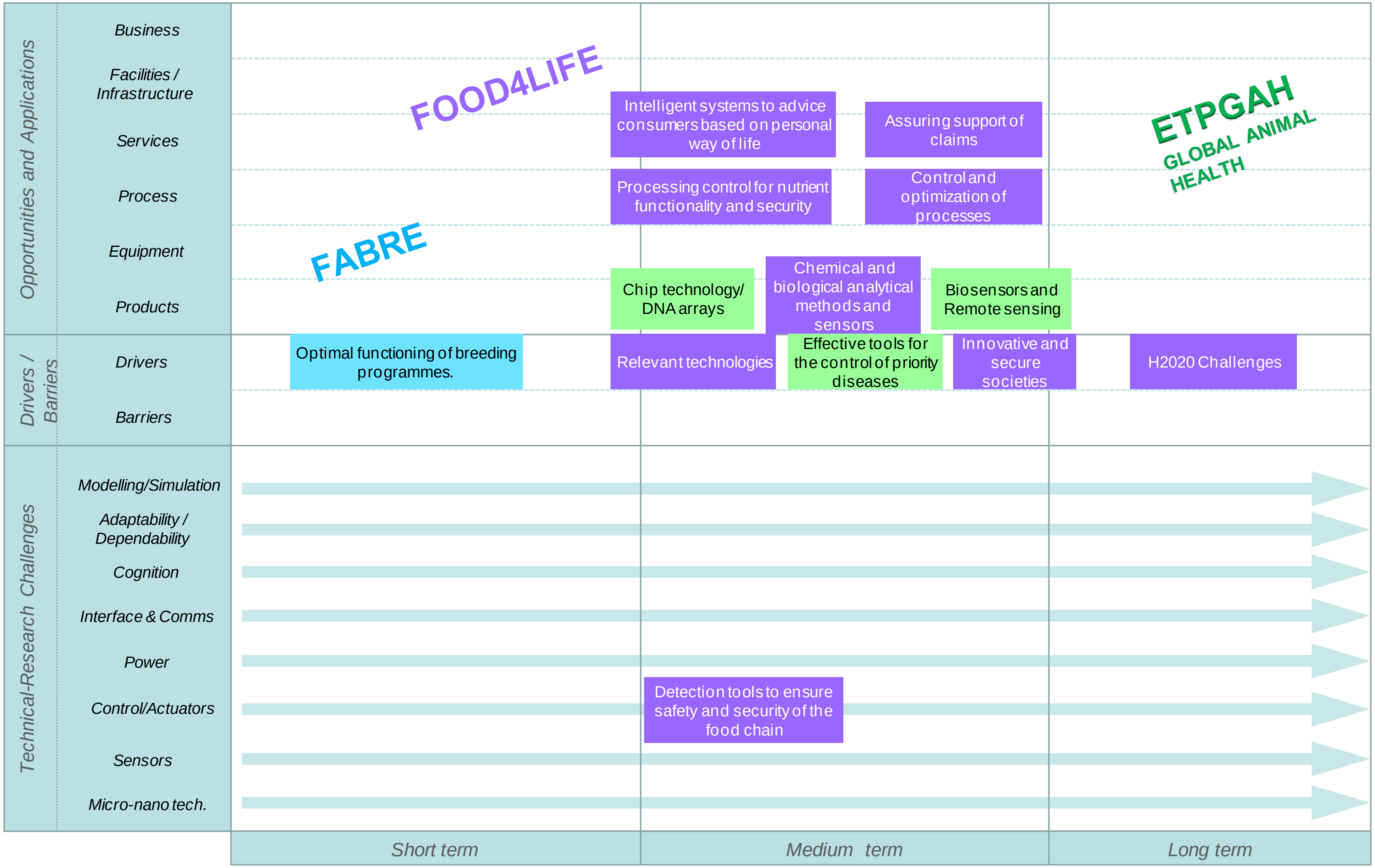


Figure 39: FABRE, FOOD4LIFE and ETPGAH links

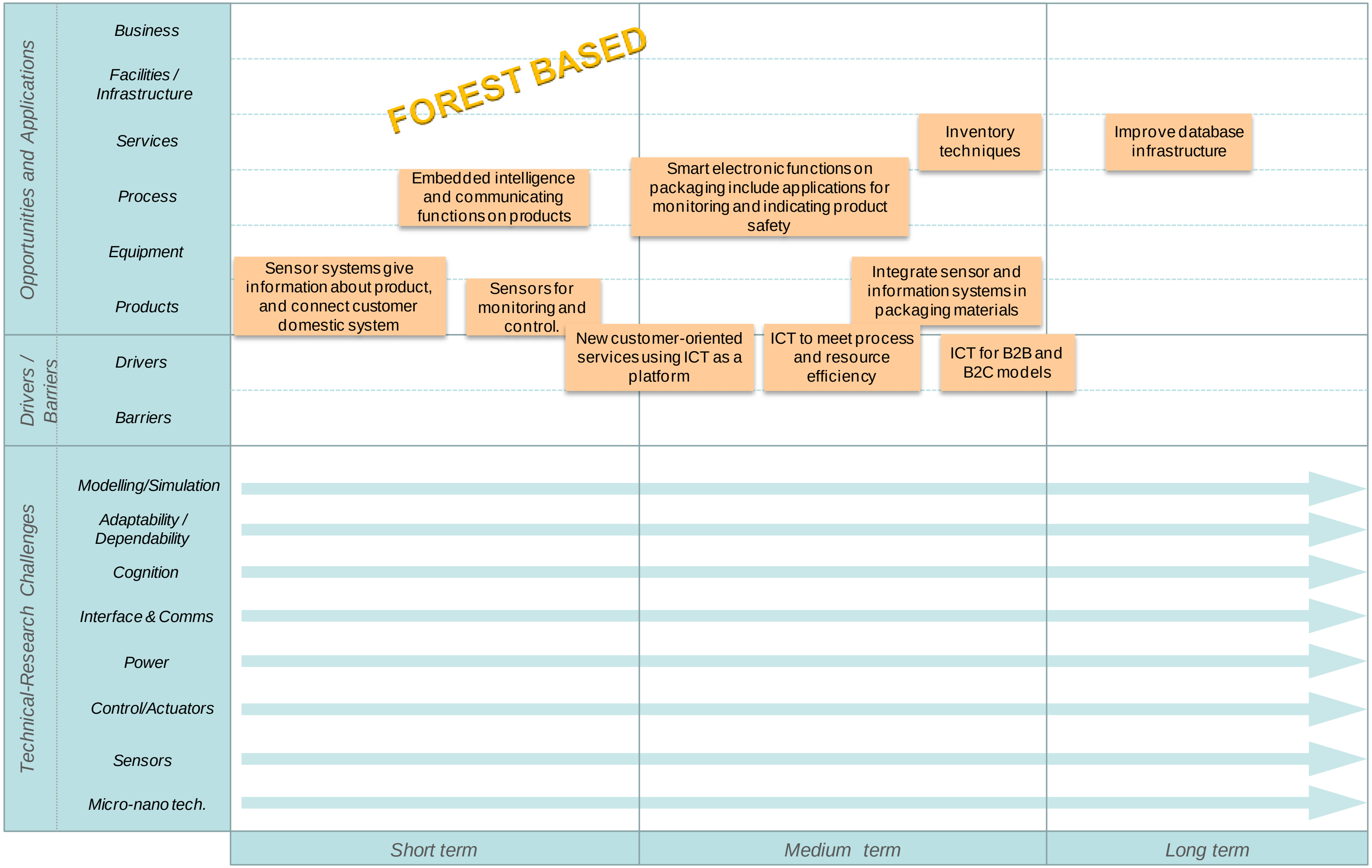


Figure 40: FOREST BASED links

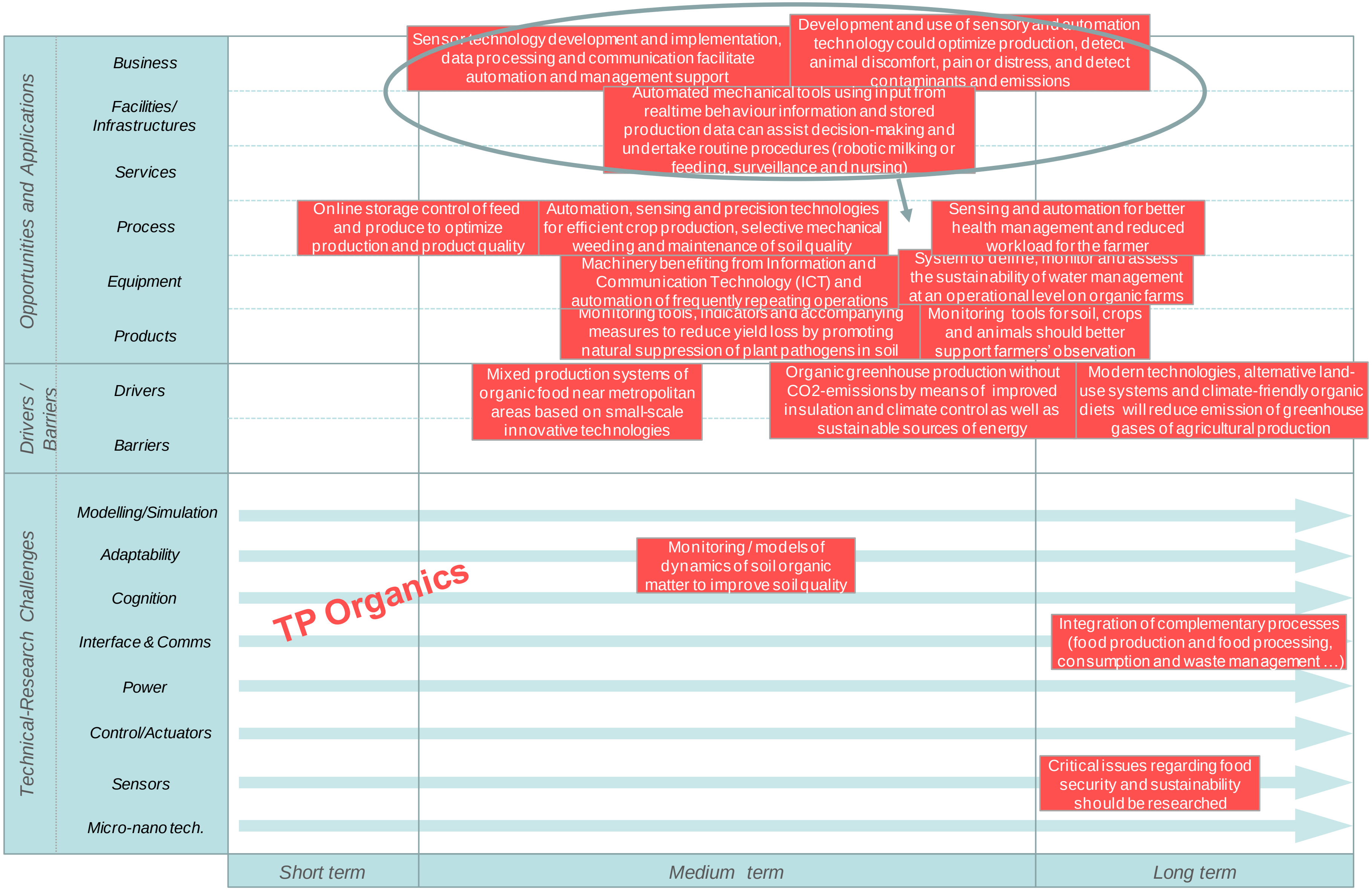


Figure 41: TP Organics links

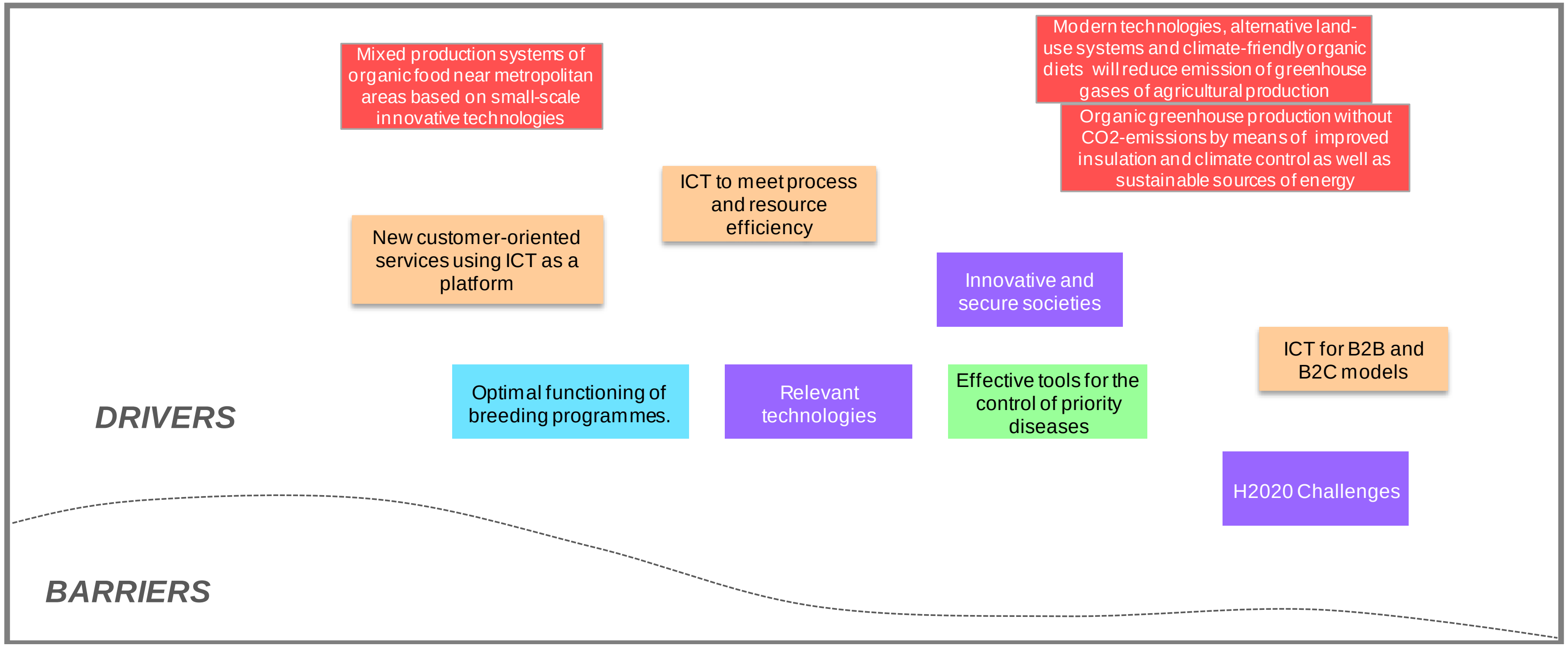


Figure 42: Bio-based economy drivers and barriers links

12.3.2. Energy

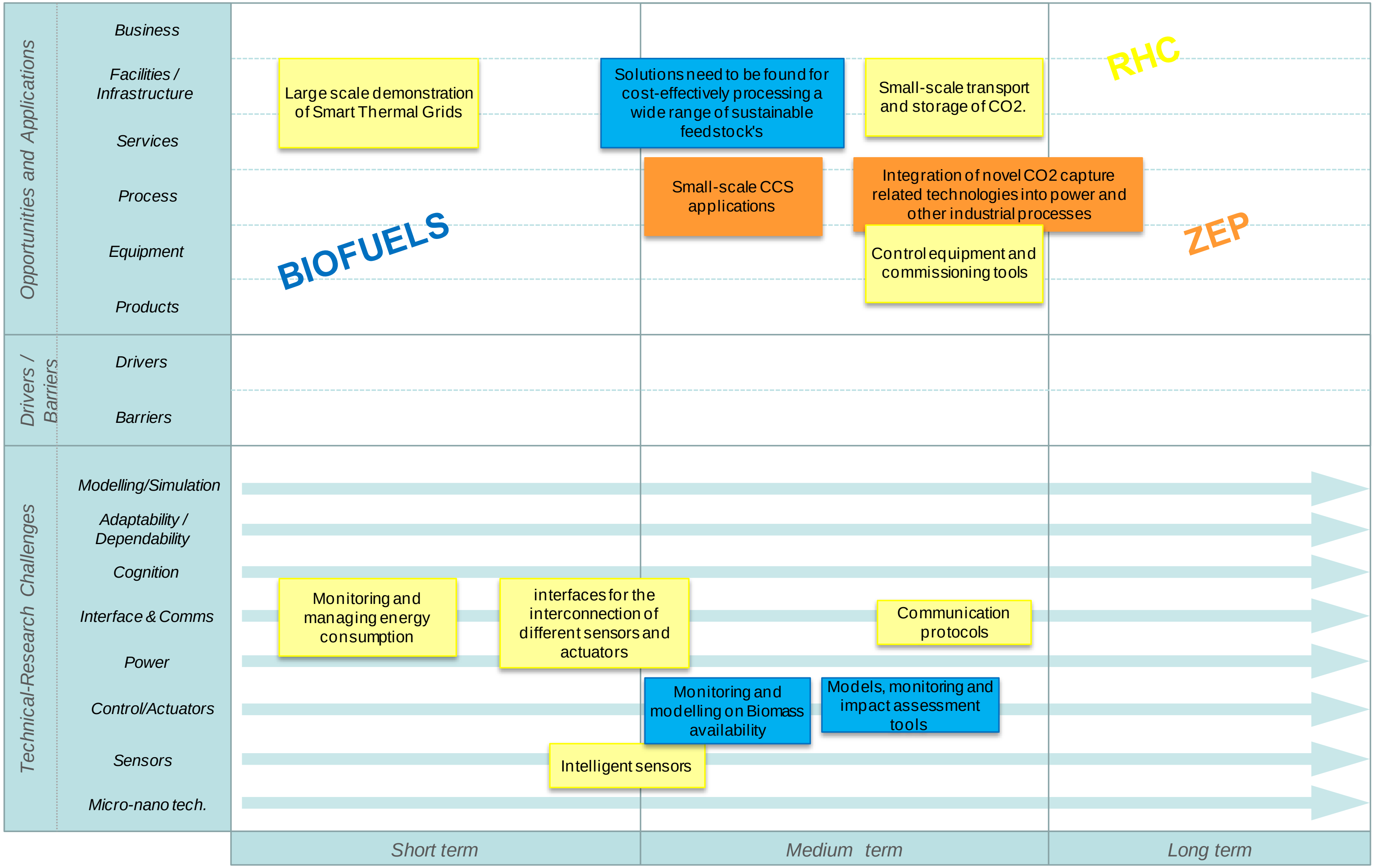


Figure 43: BIOFUELS, RHC and ZEP links

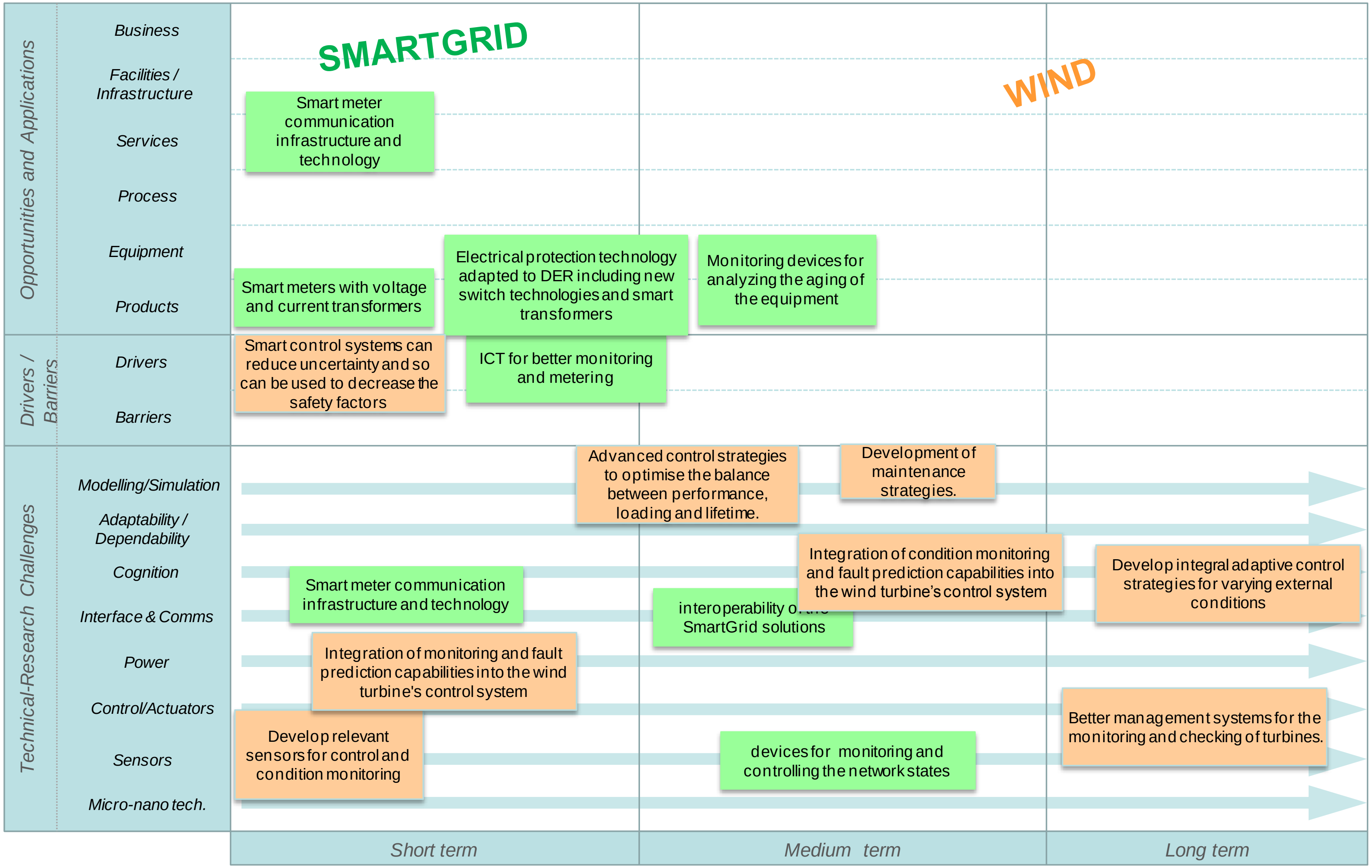


Figure 44: SMARTGRIDS and TPWind links

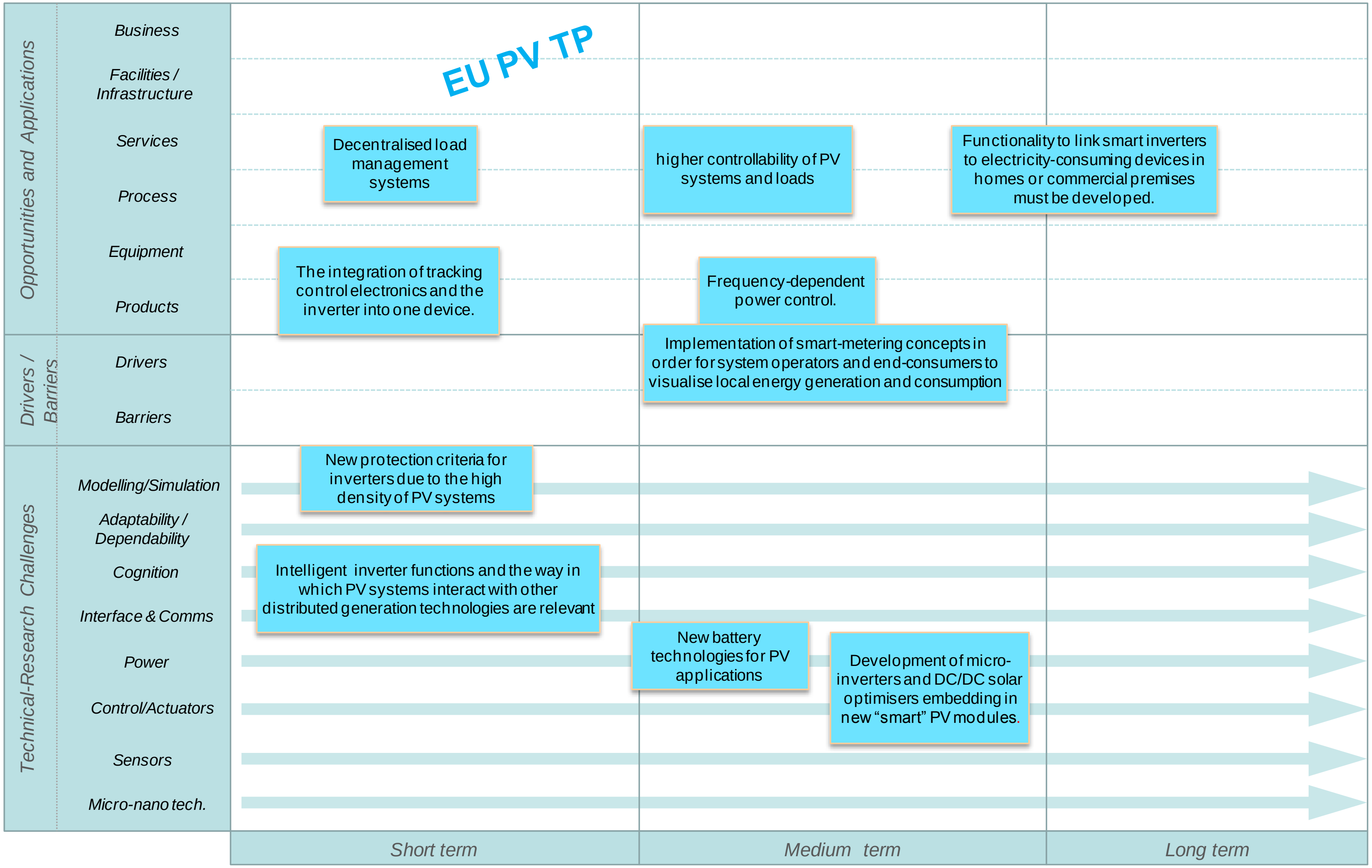


Figure 45: EU PV TP links

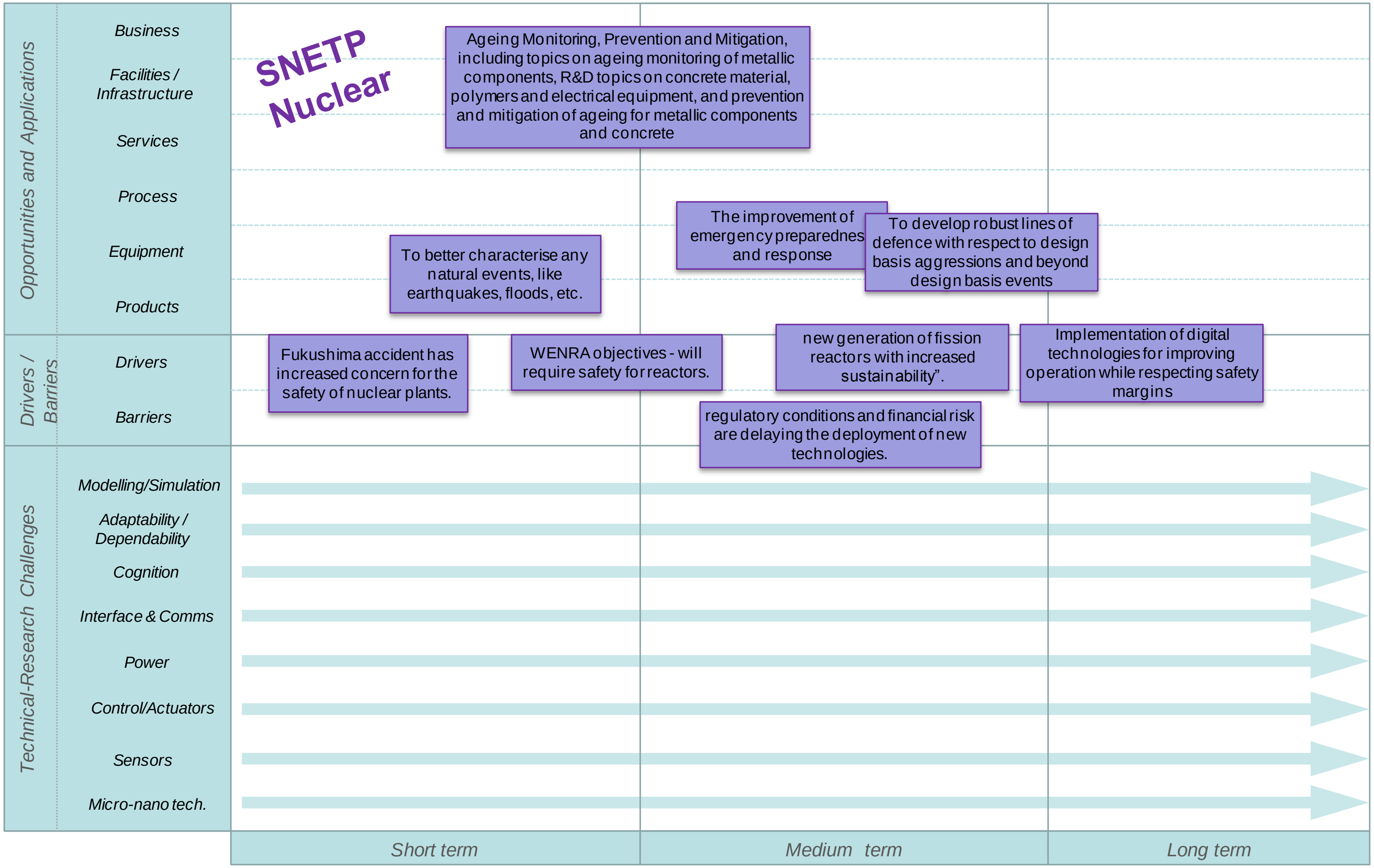


Figure 46: SNETP links

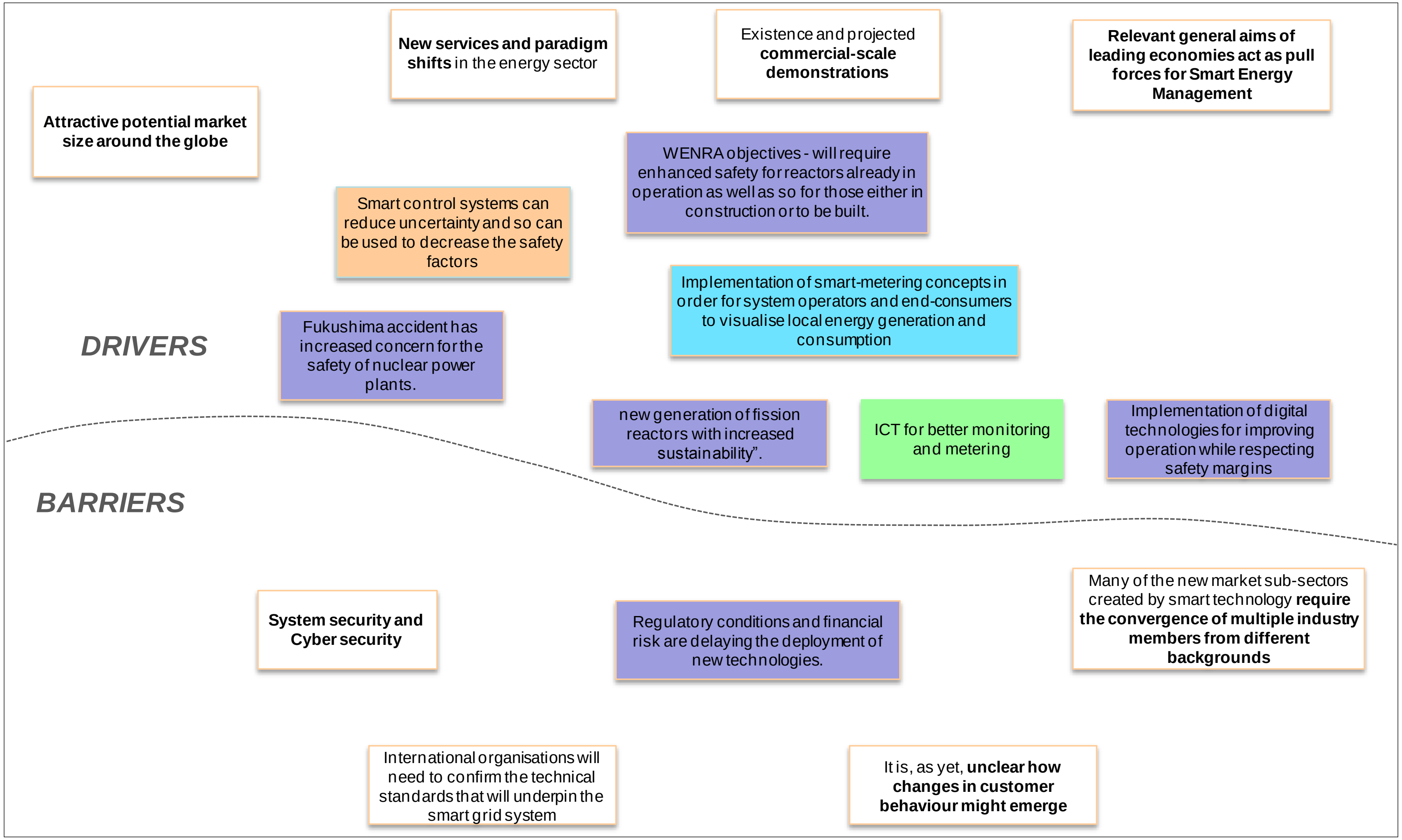


Figure 47: Energy drivers and barriers links

12.3.3. Environment

Figure 48: WssT links

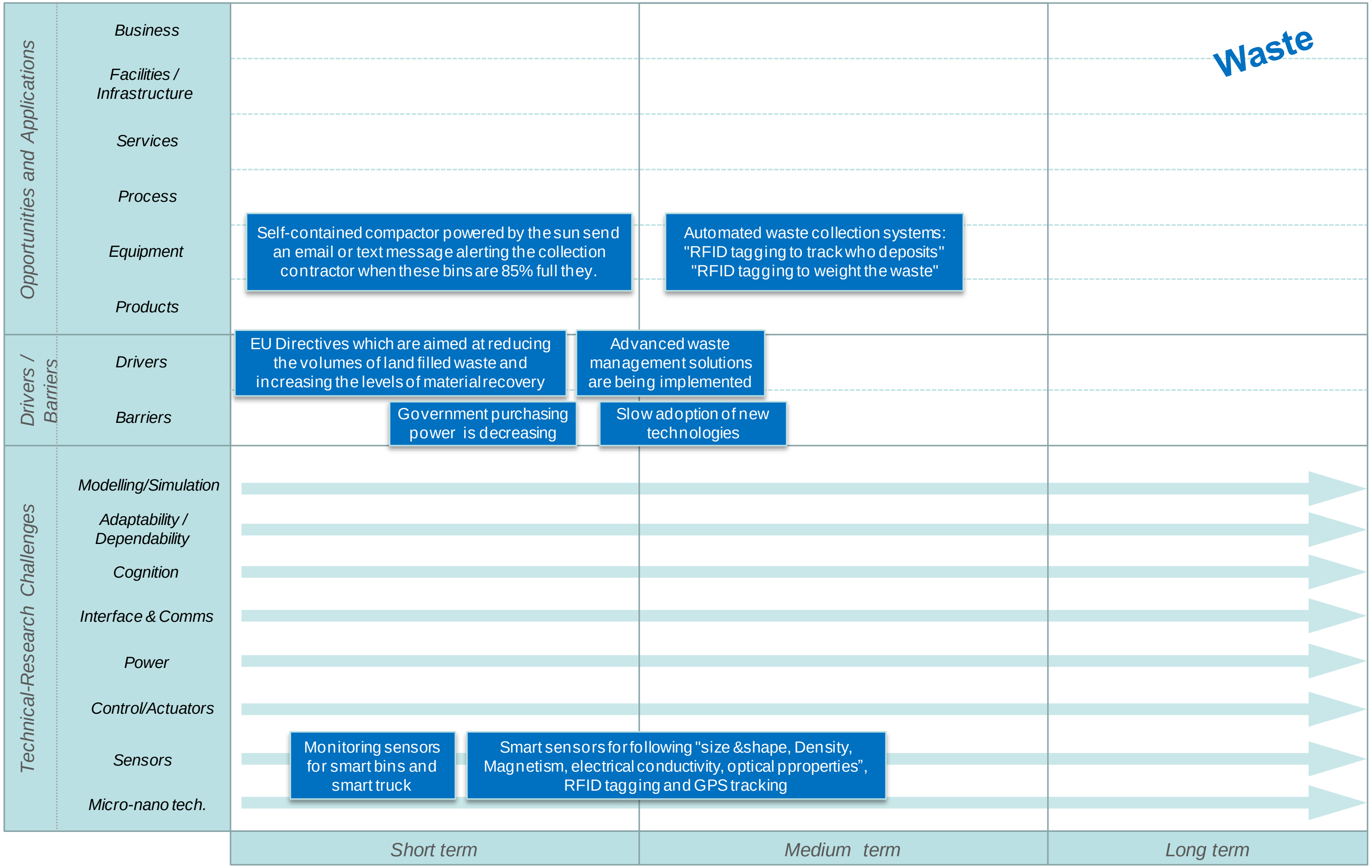


Figure 49: Waste links

12.3.4. ICT

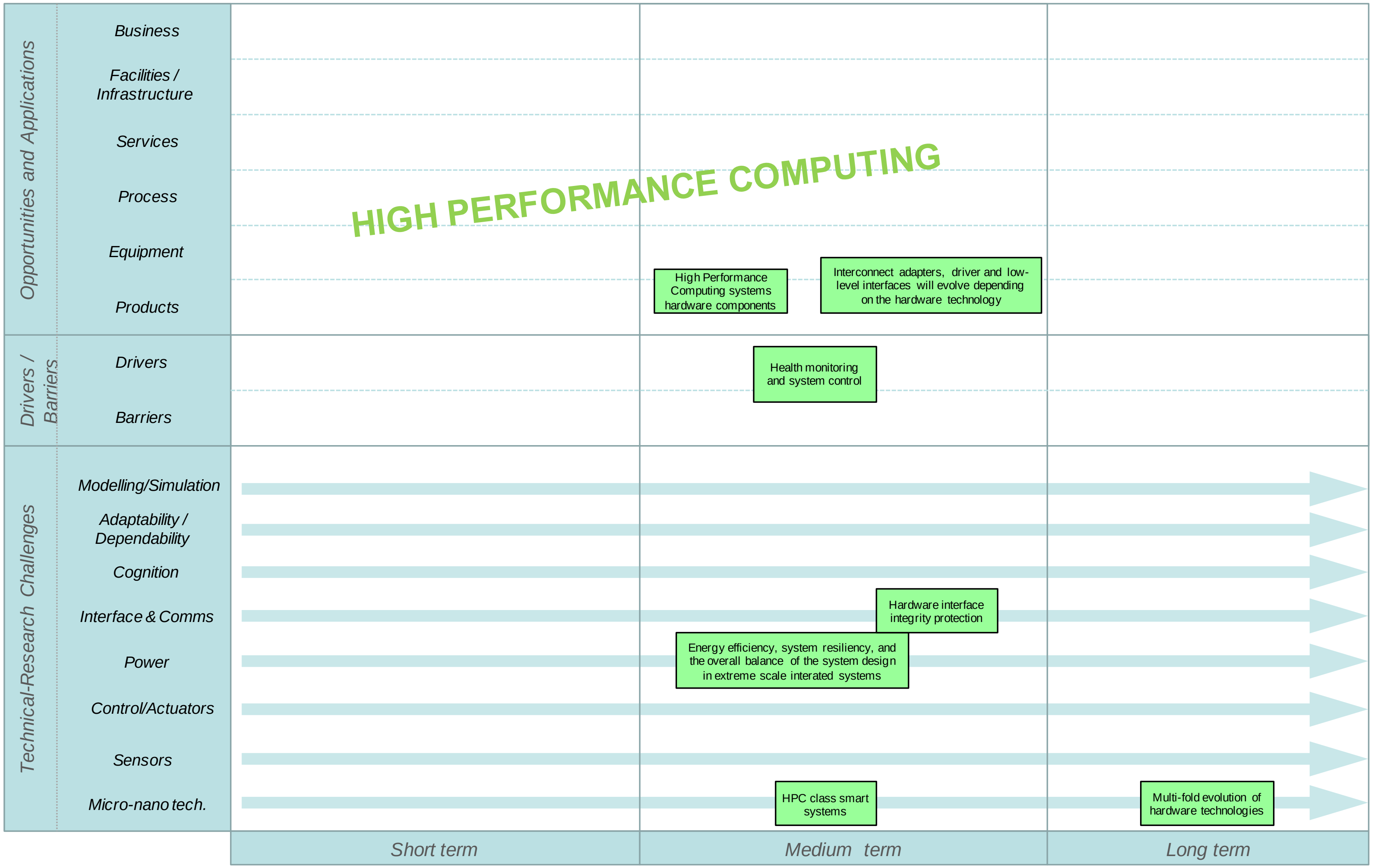


Figure 50: High Performance Computing links

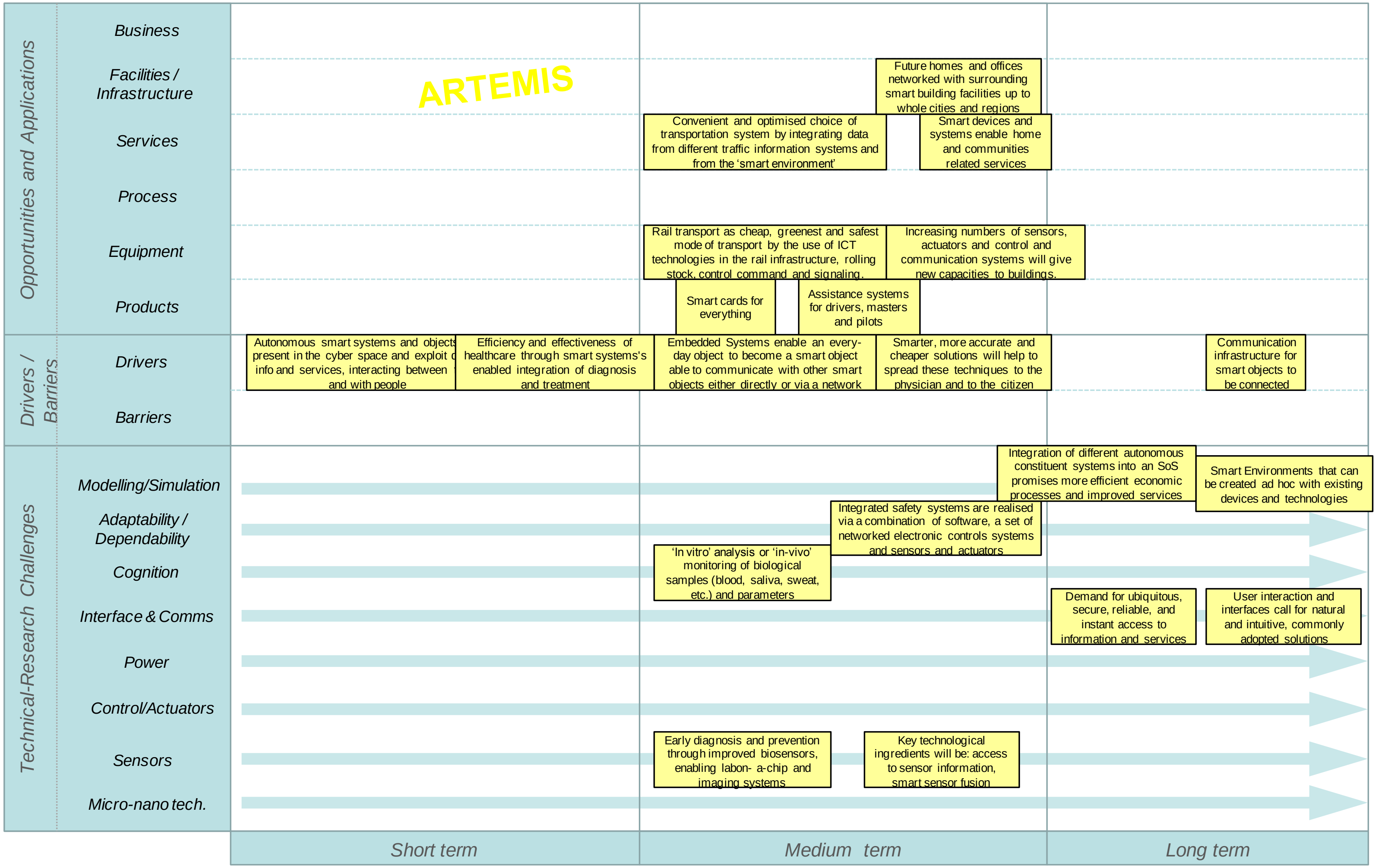


Figure 51: Artemis links

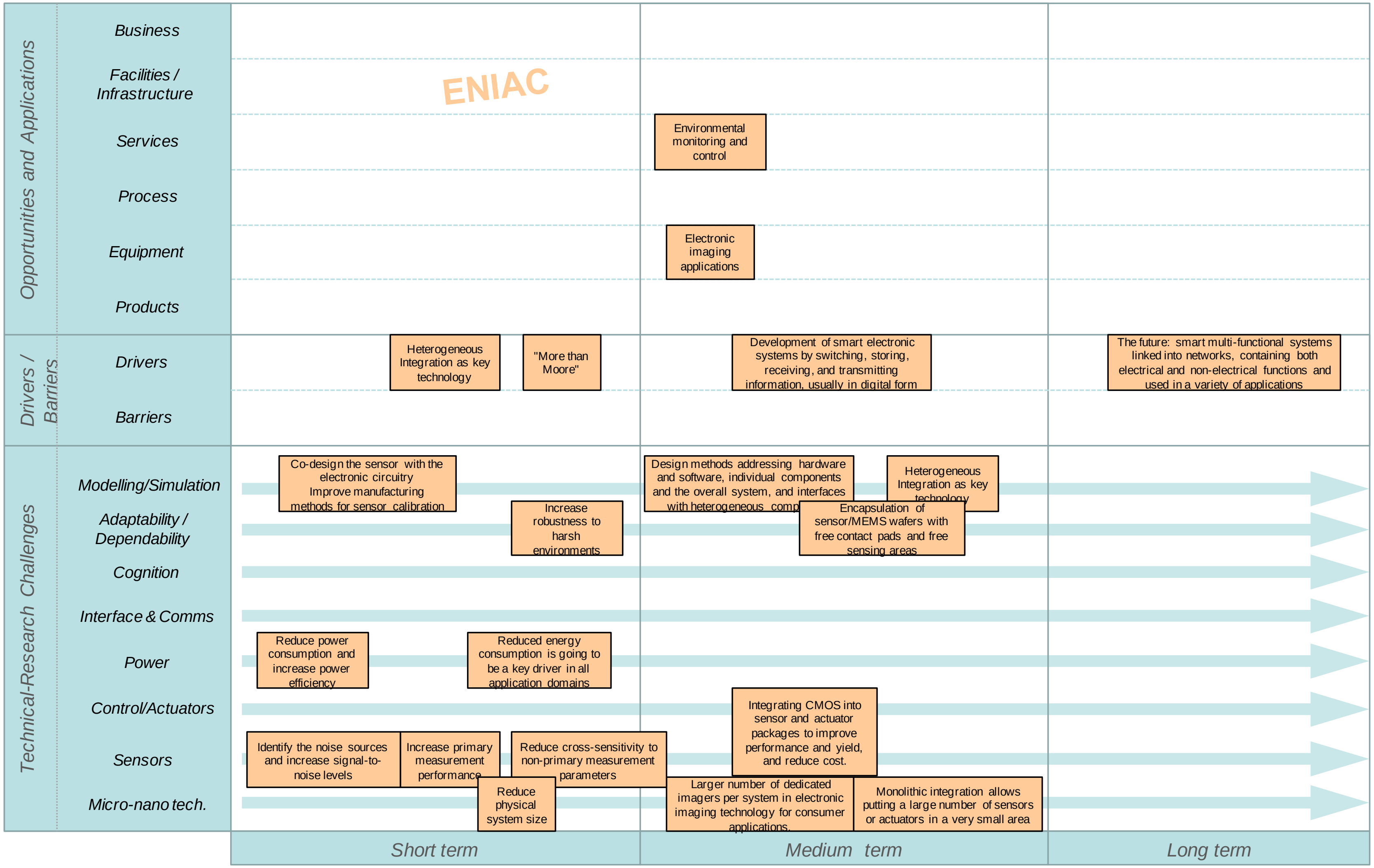


Figure 52: ENIAC links

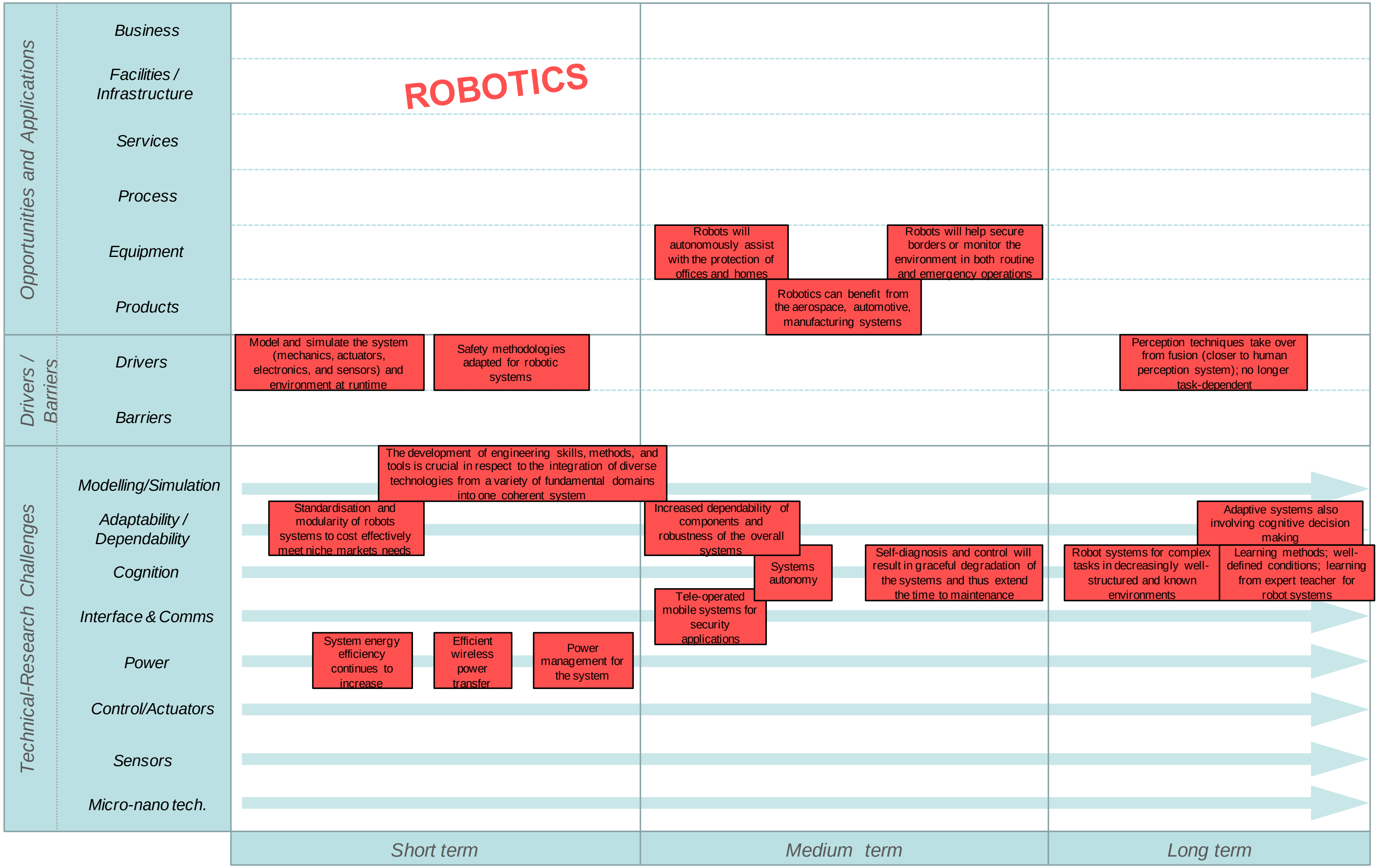


Figure 53: Robotics links

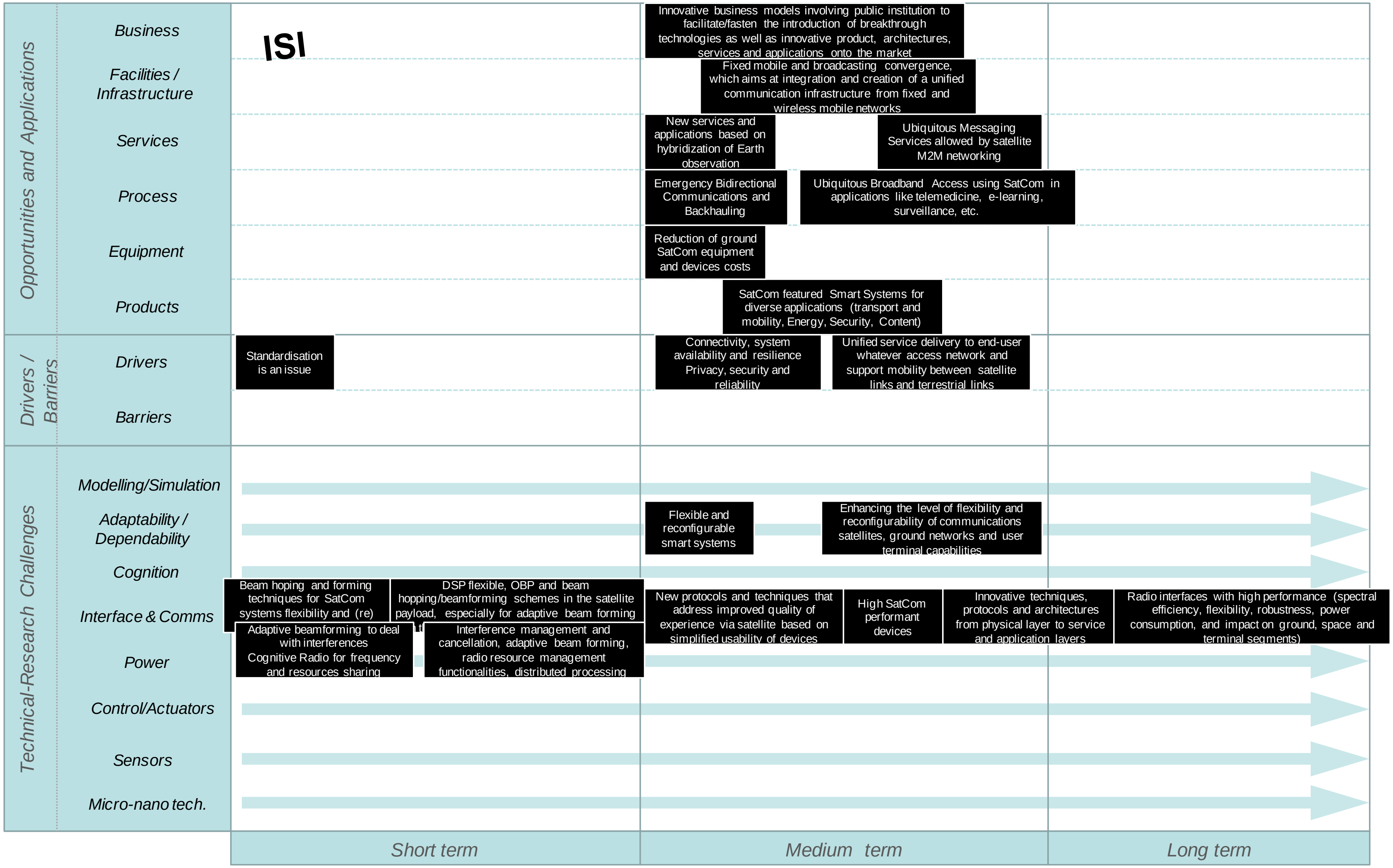


Figure 54: ISI links

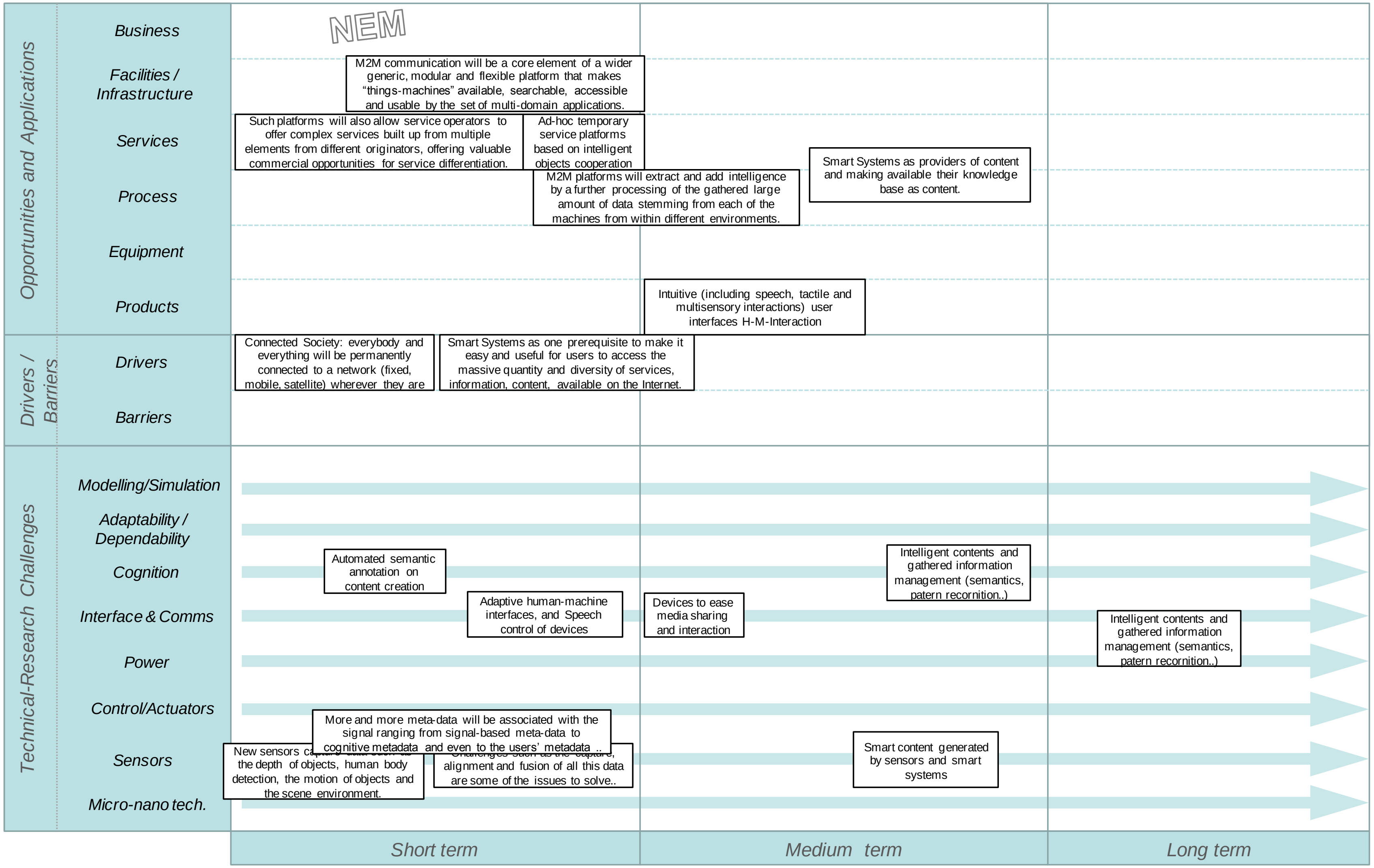


Figure 55: NEM links

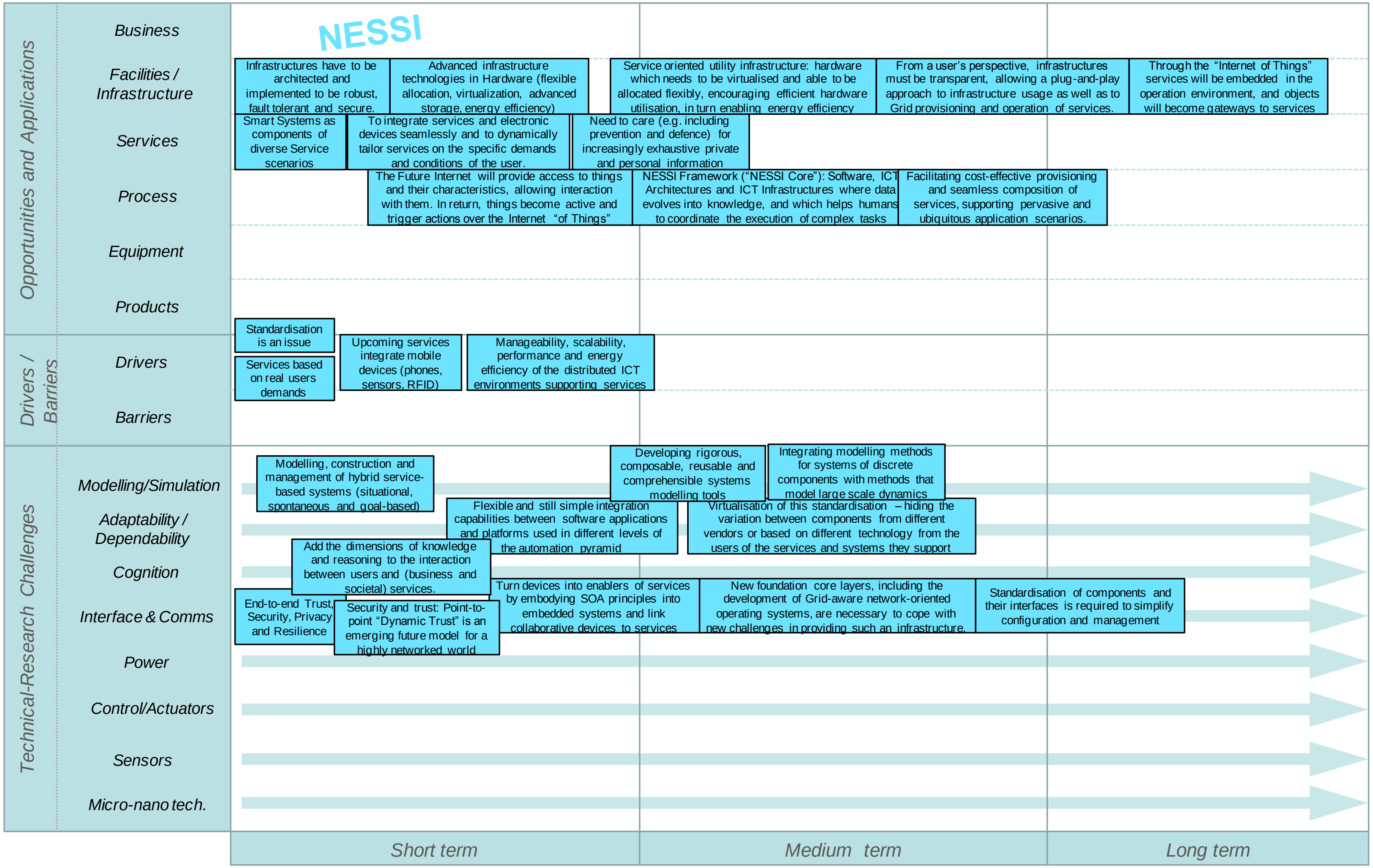


Figure 56: NESSI links

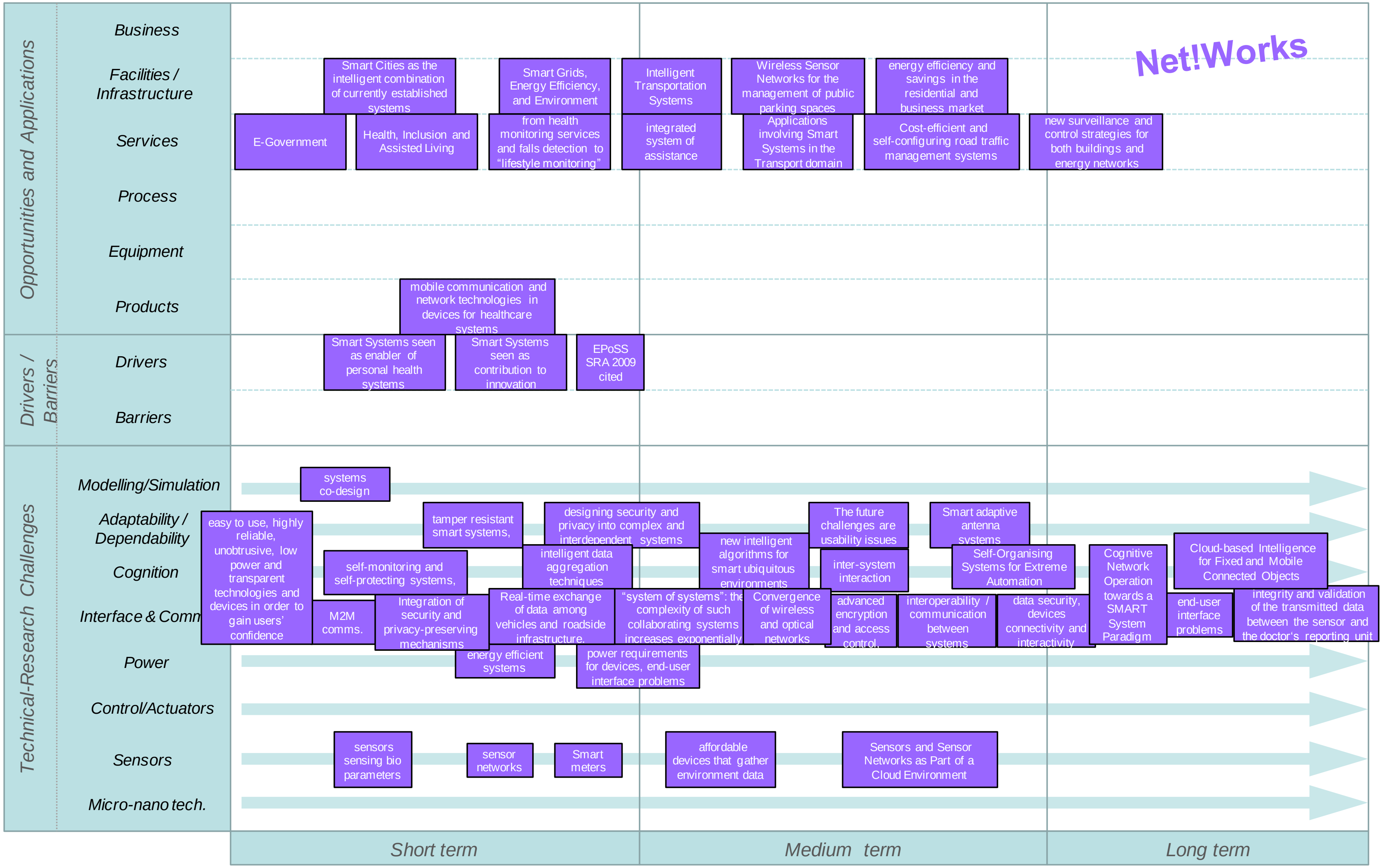


Figure 57:Net!Works links

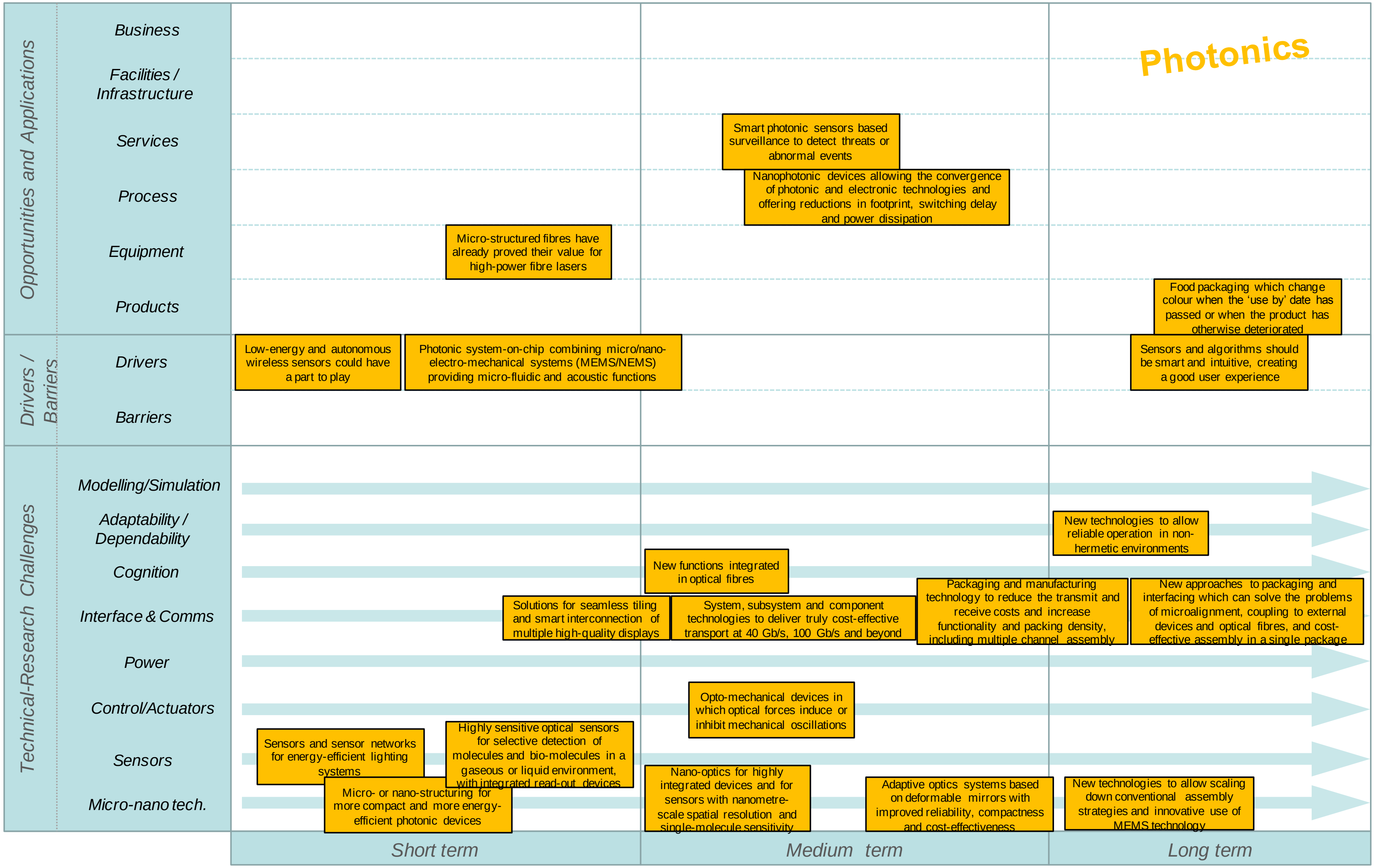


Figure 58: Photonics links

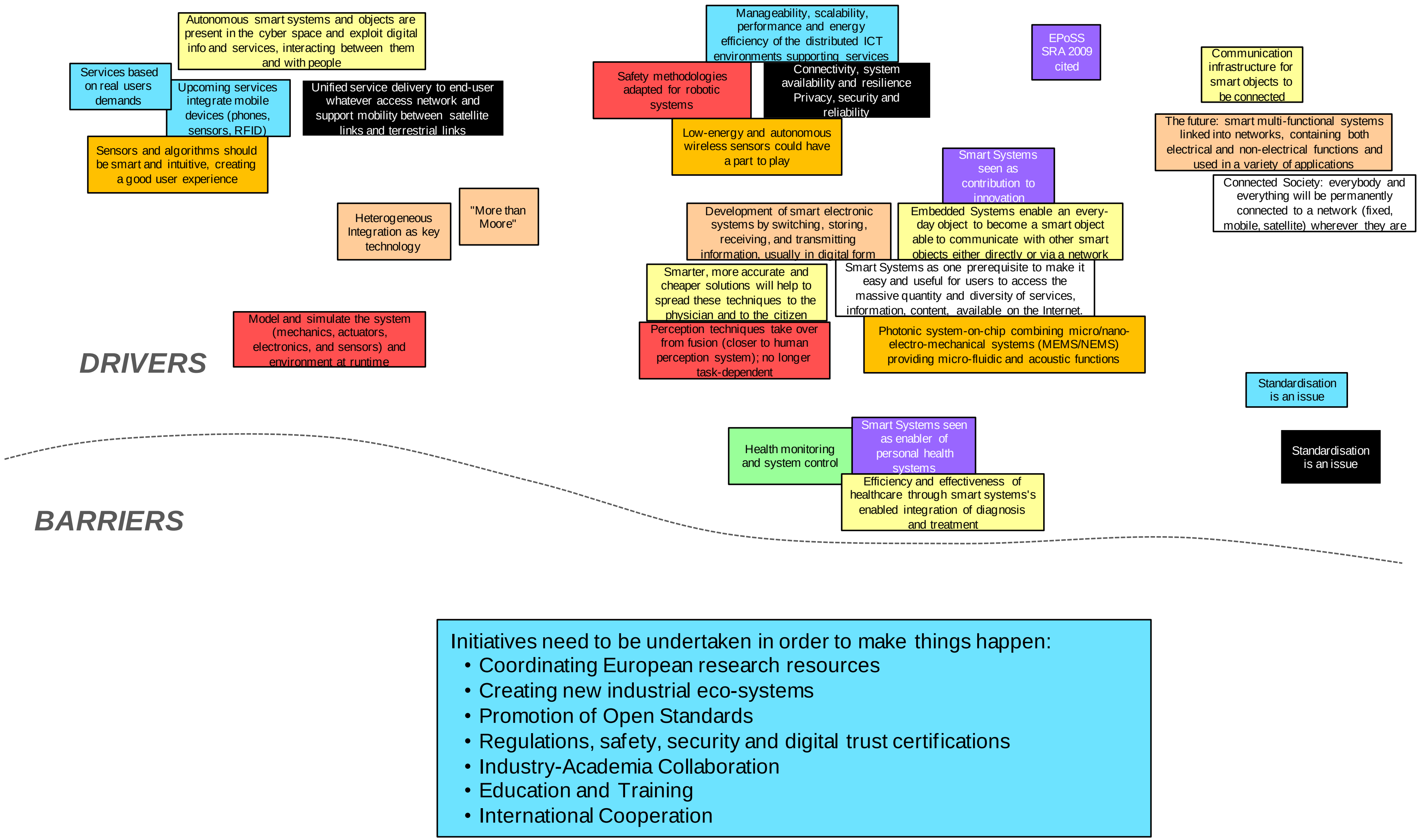


Figure 59: ICT drivers and barriers links

12.3.5. Production and processes

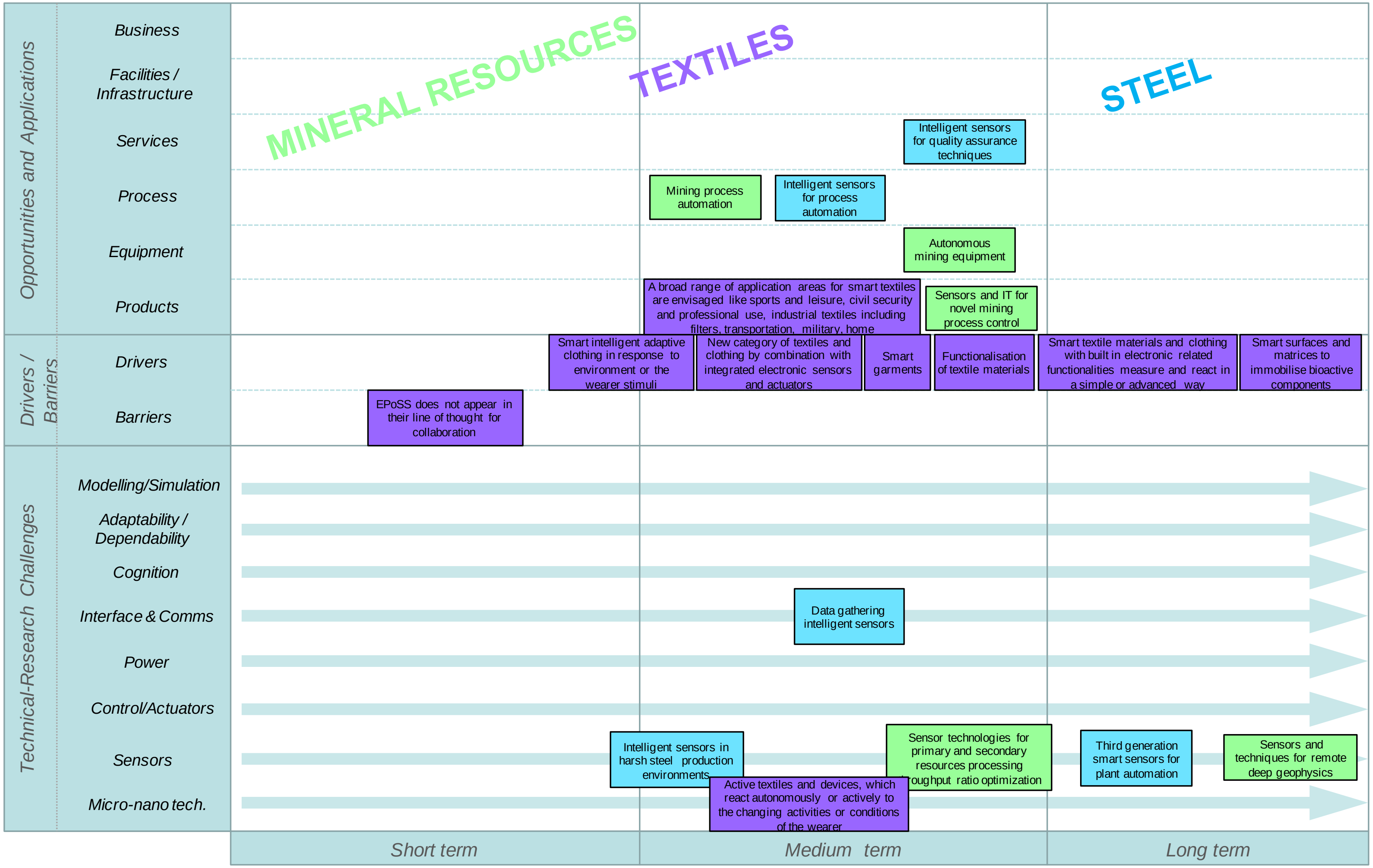


Figure 60: Mineral, Textiles and Steel links

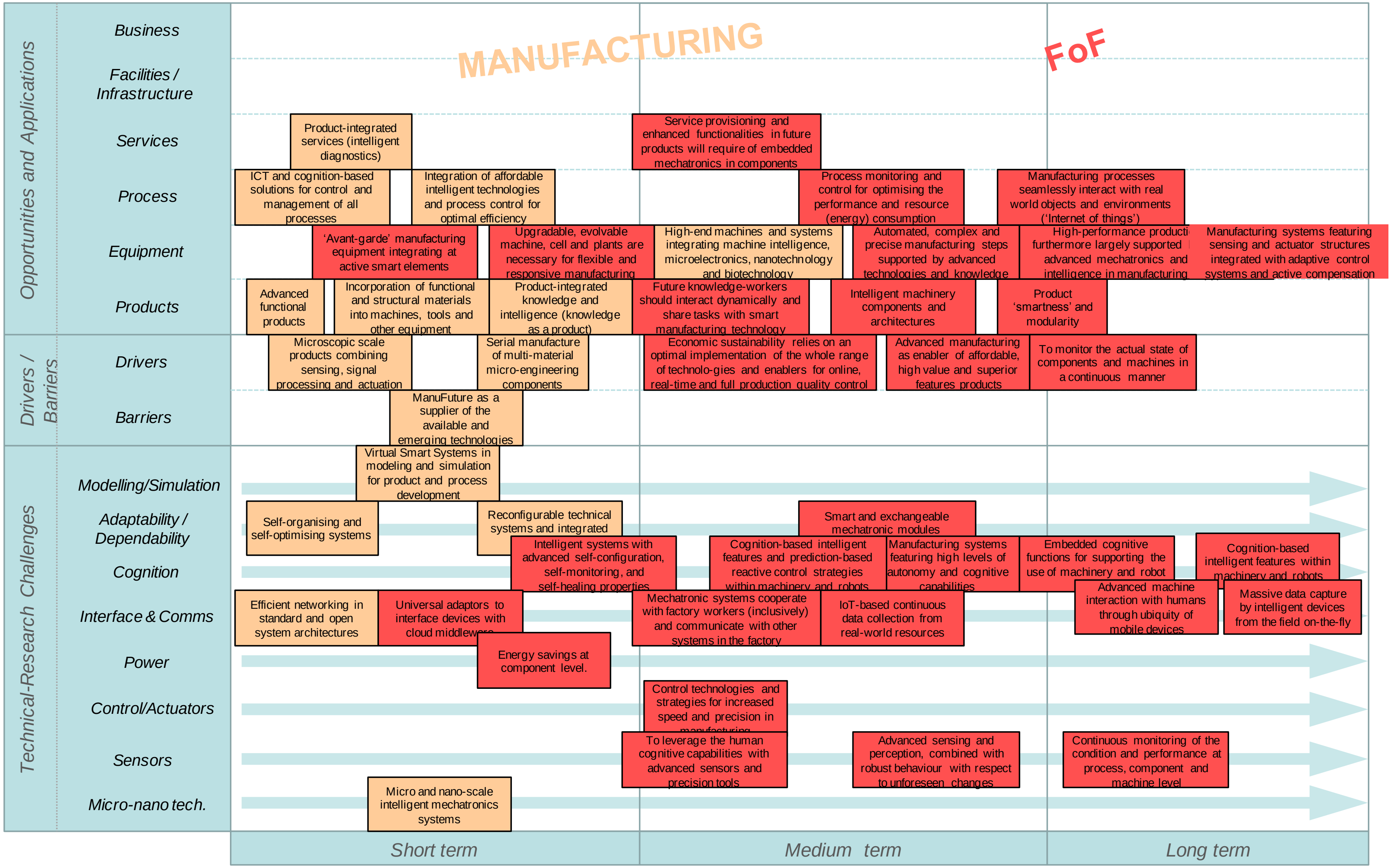


Figure 61: Manufuture and FoF links

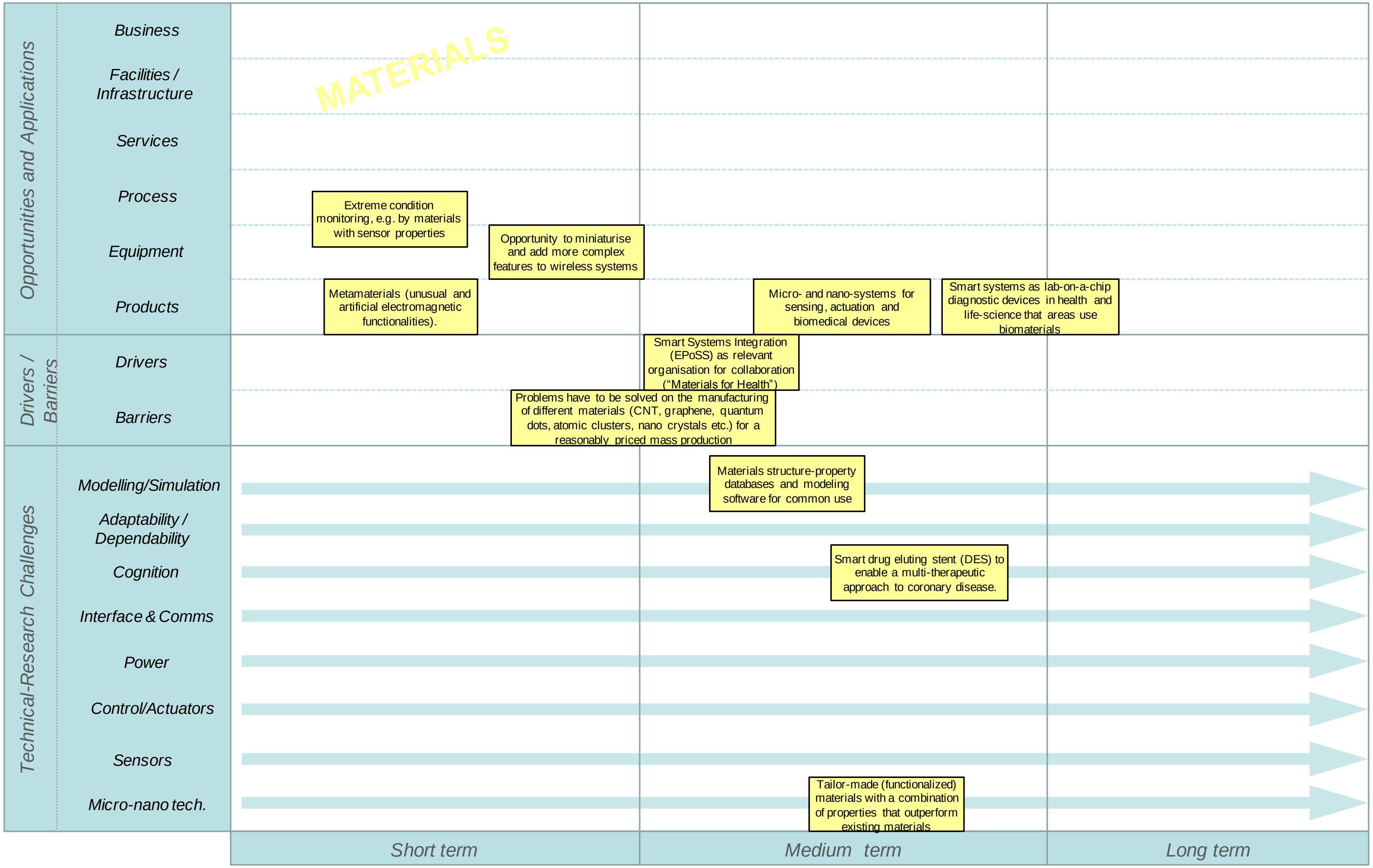


Figure 62: Materials links

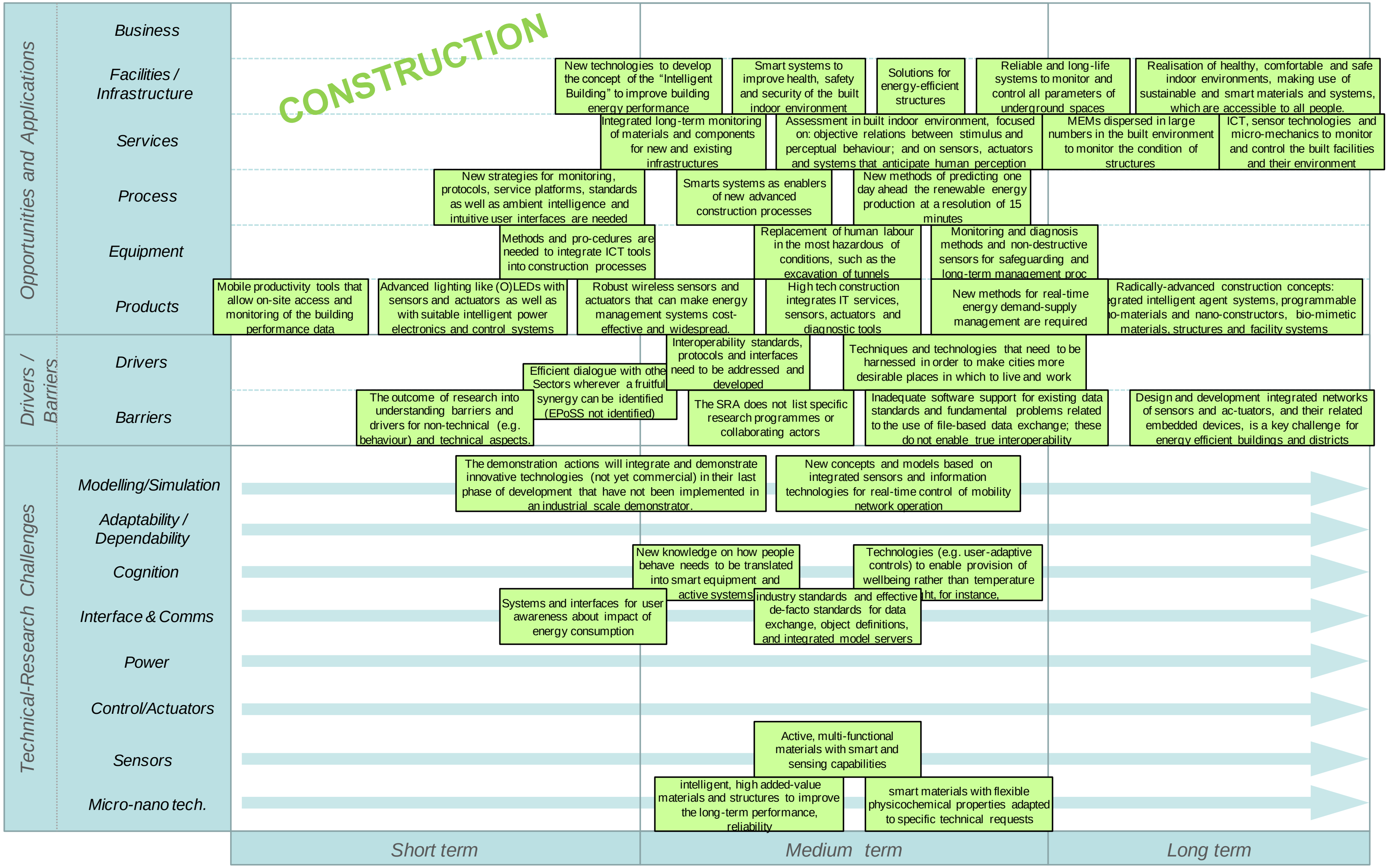


Figure 63: Construction links

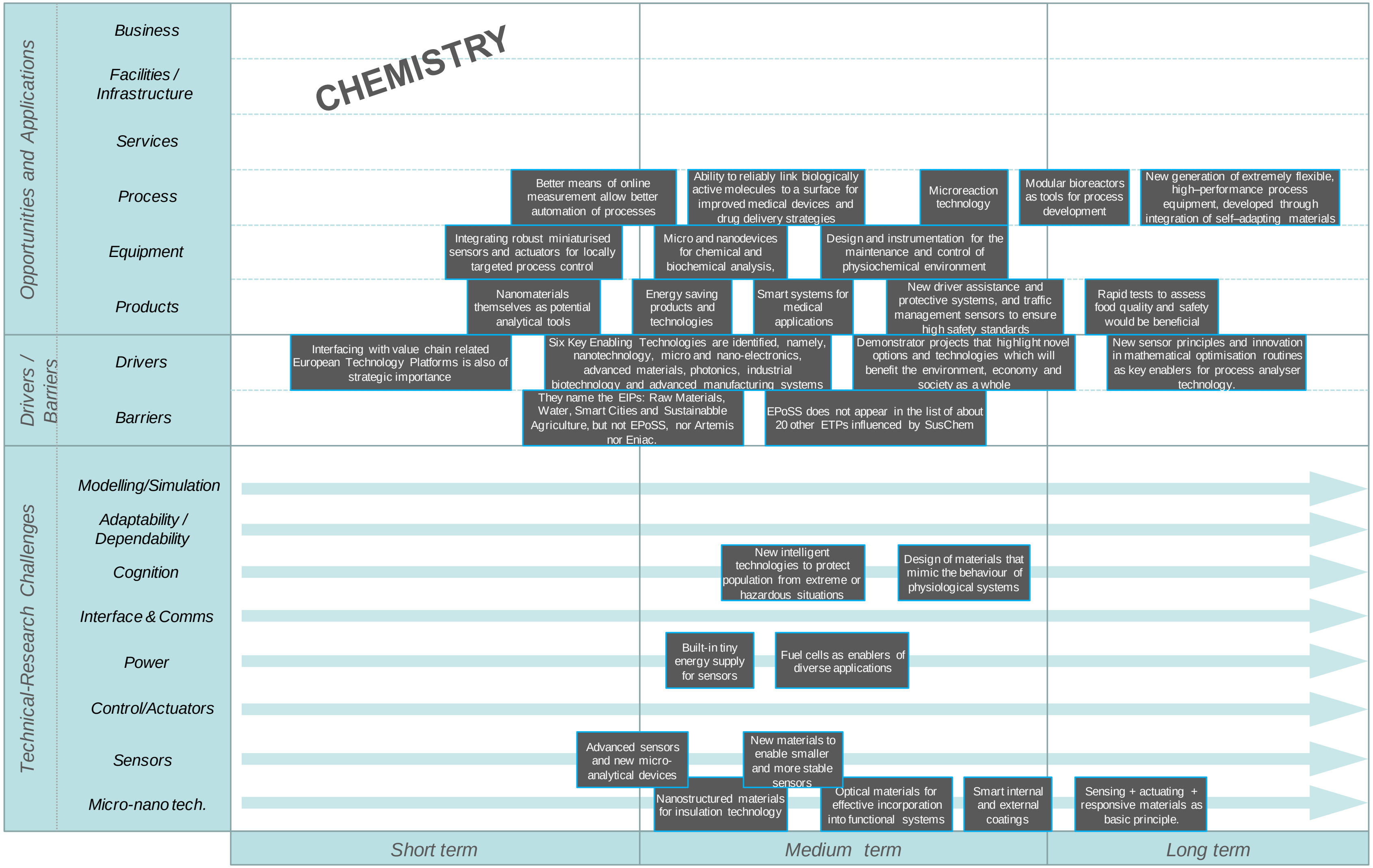


Figure 64: Chemistry links

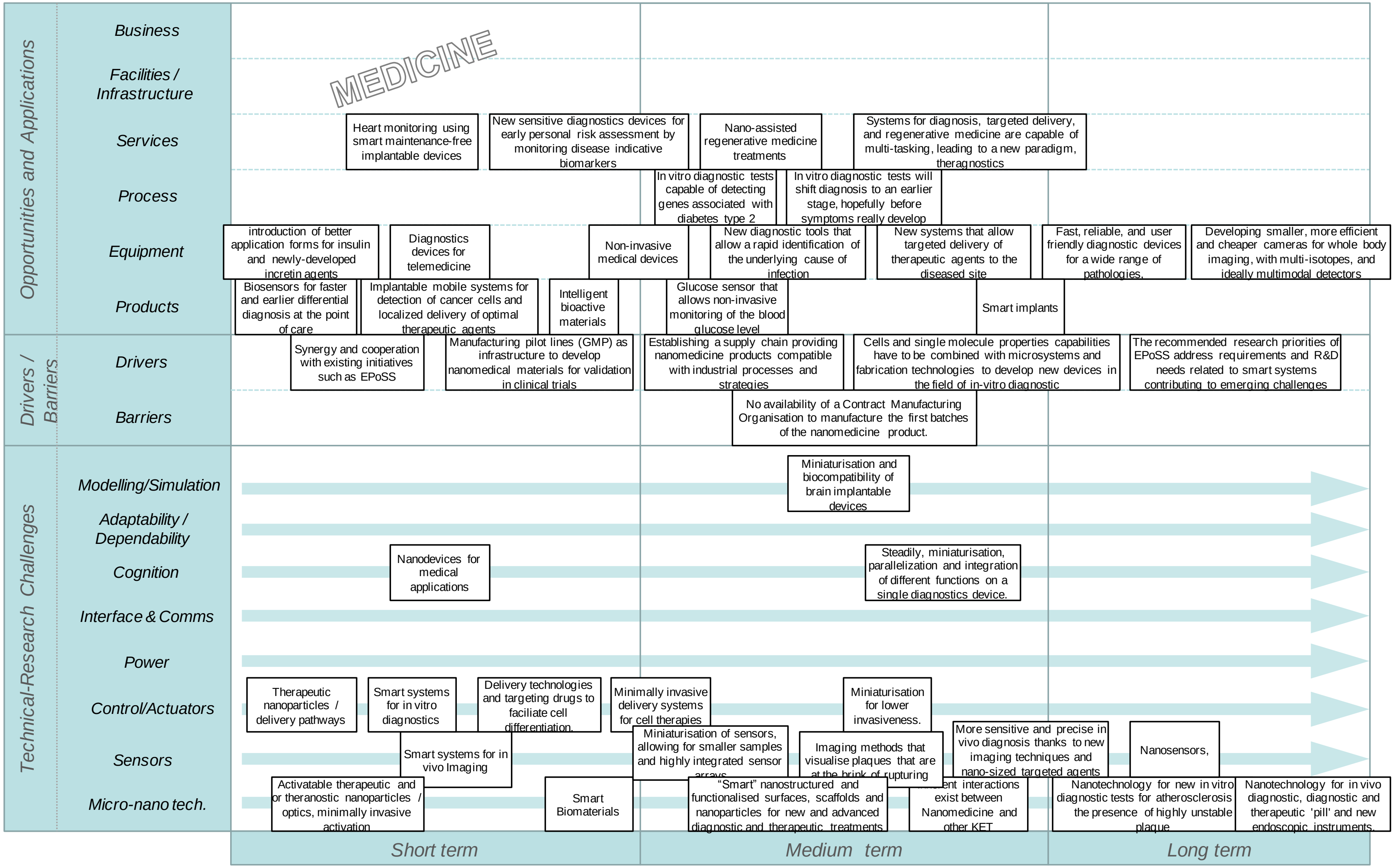


Figure 65: Medicine links

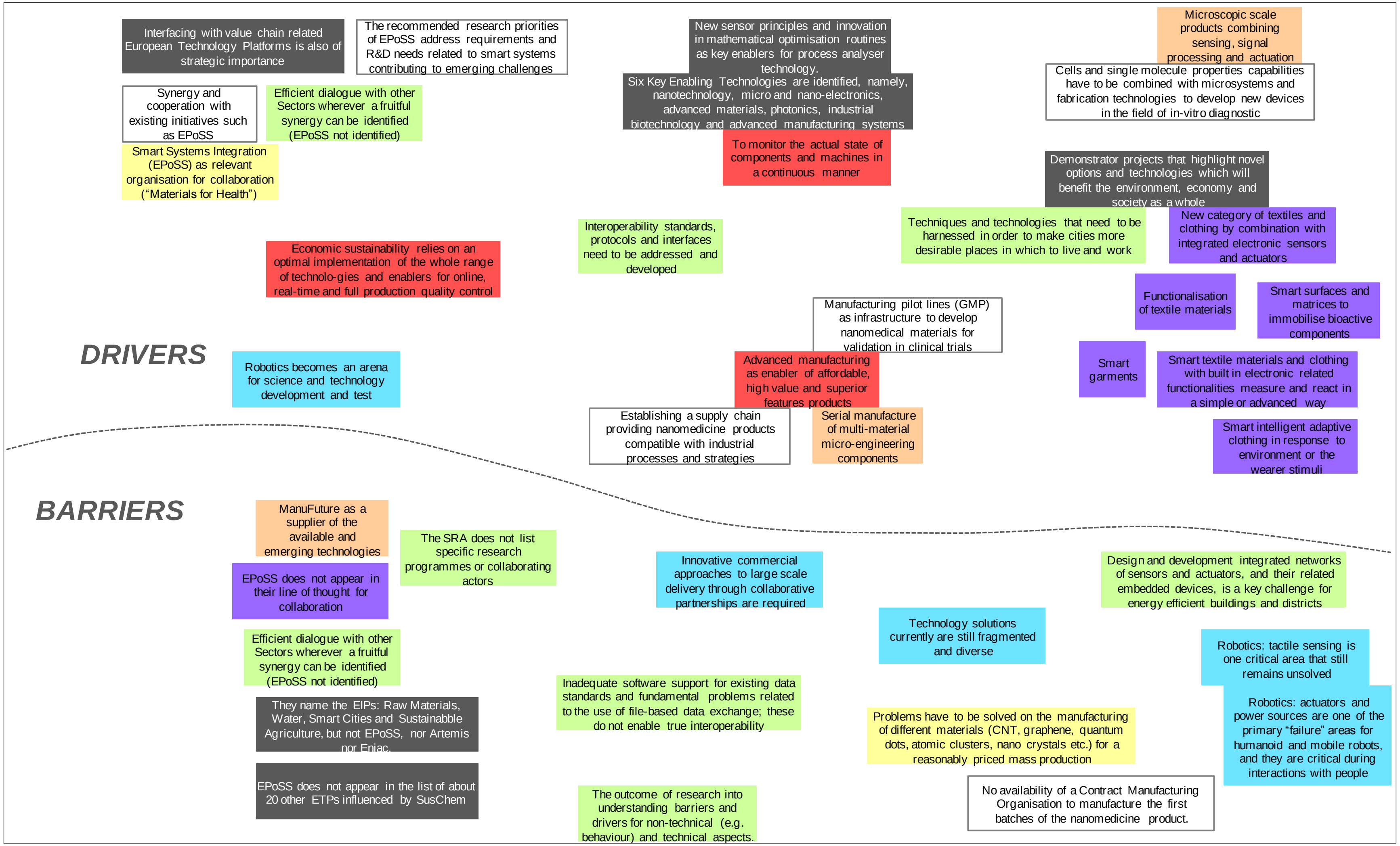


Figure 66: Production and processes drivers and barriers links

12.3.6. Transport

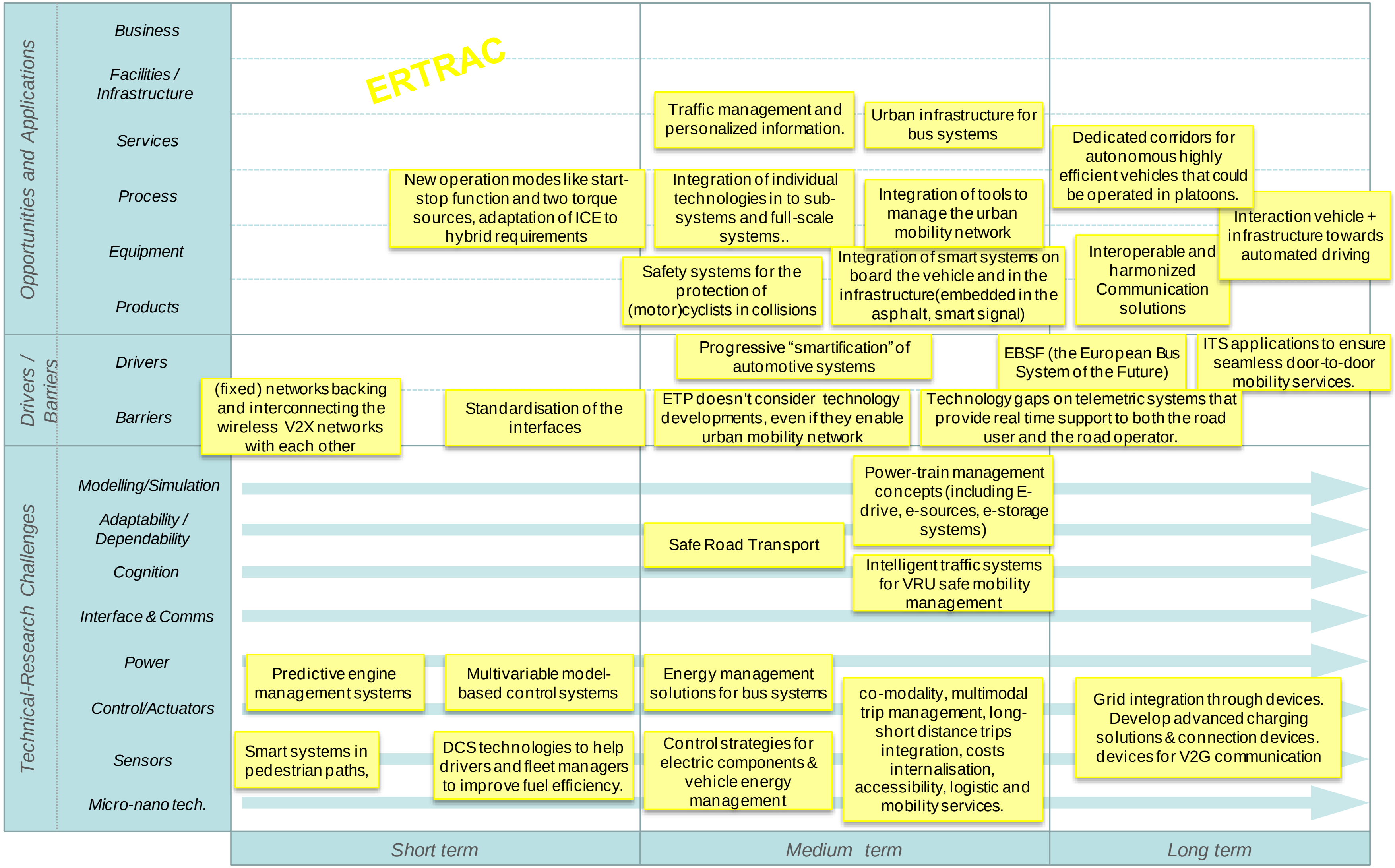


Figure 67: ERTRAC links

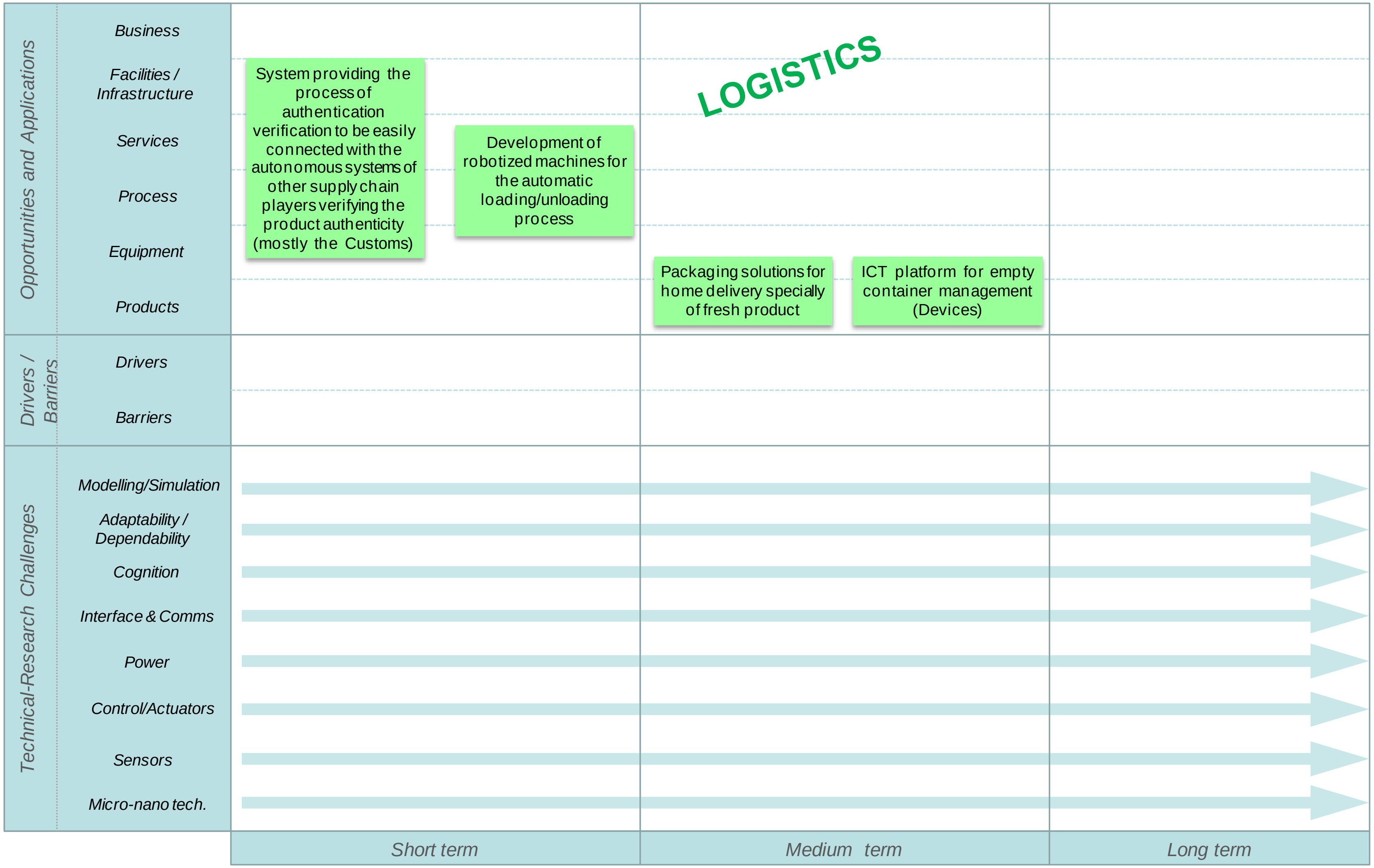


Figure 68: Logistics links

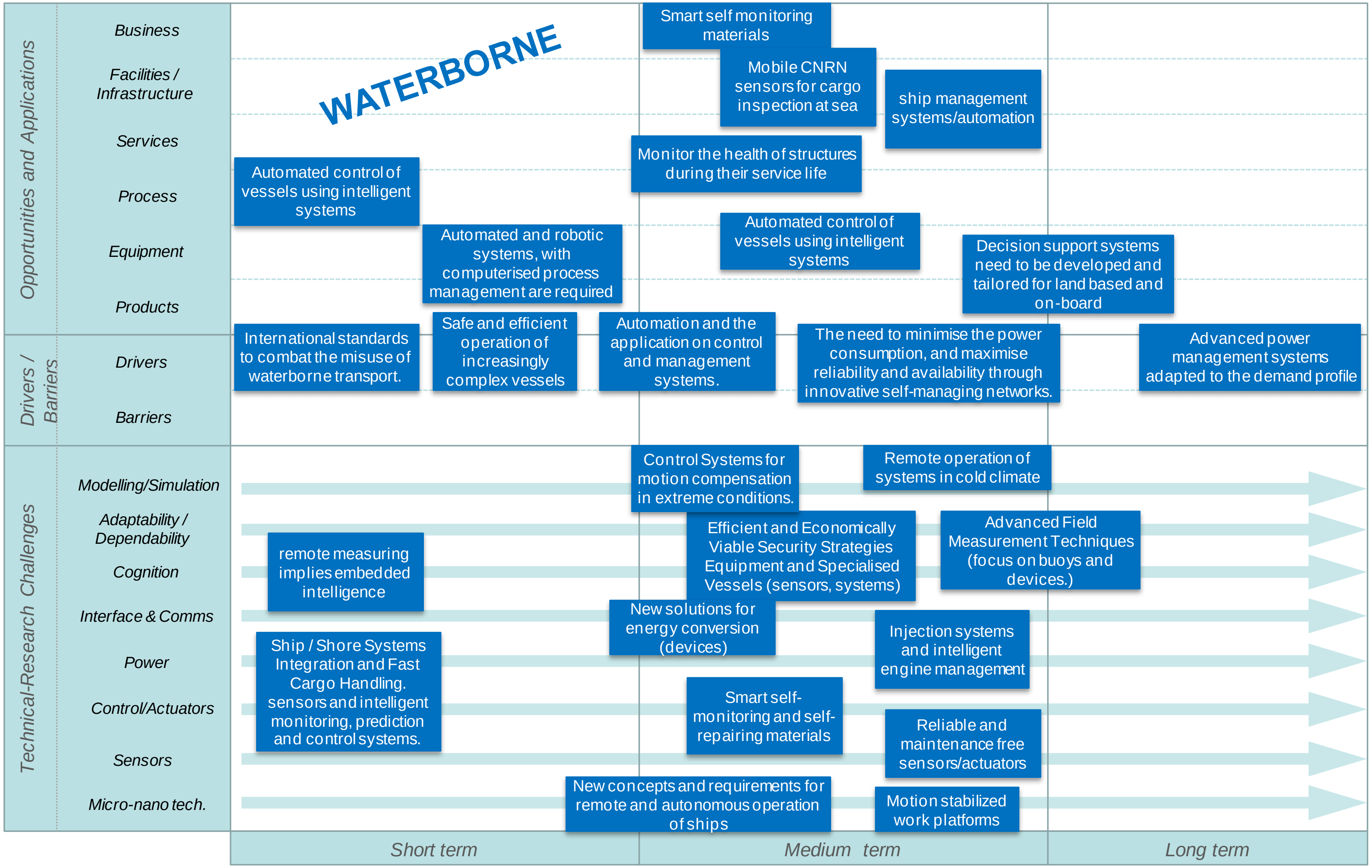


Figure 69: Waterborne links

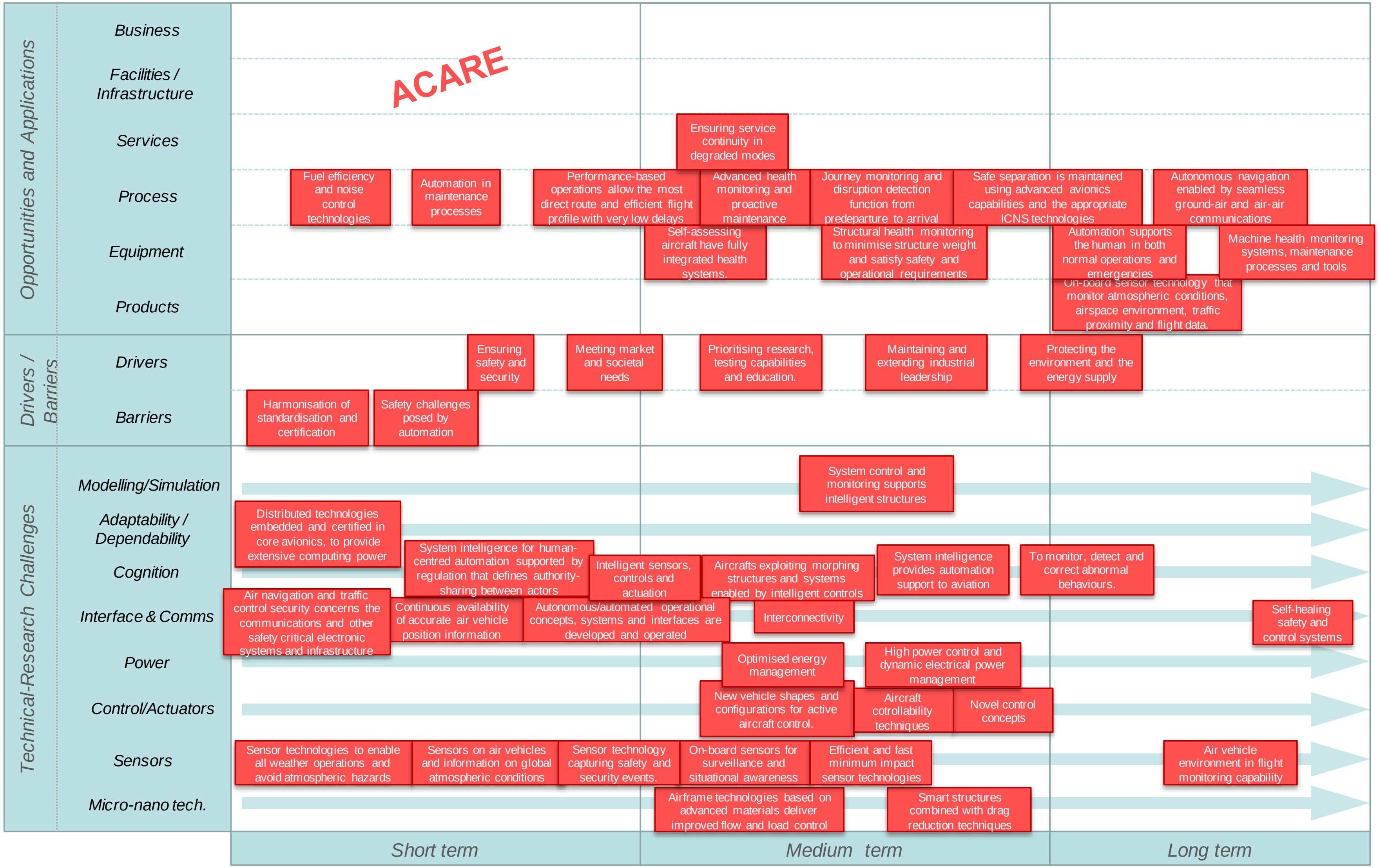


Figure 70: ACARE links

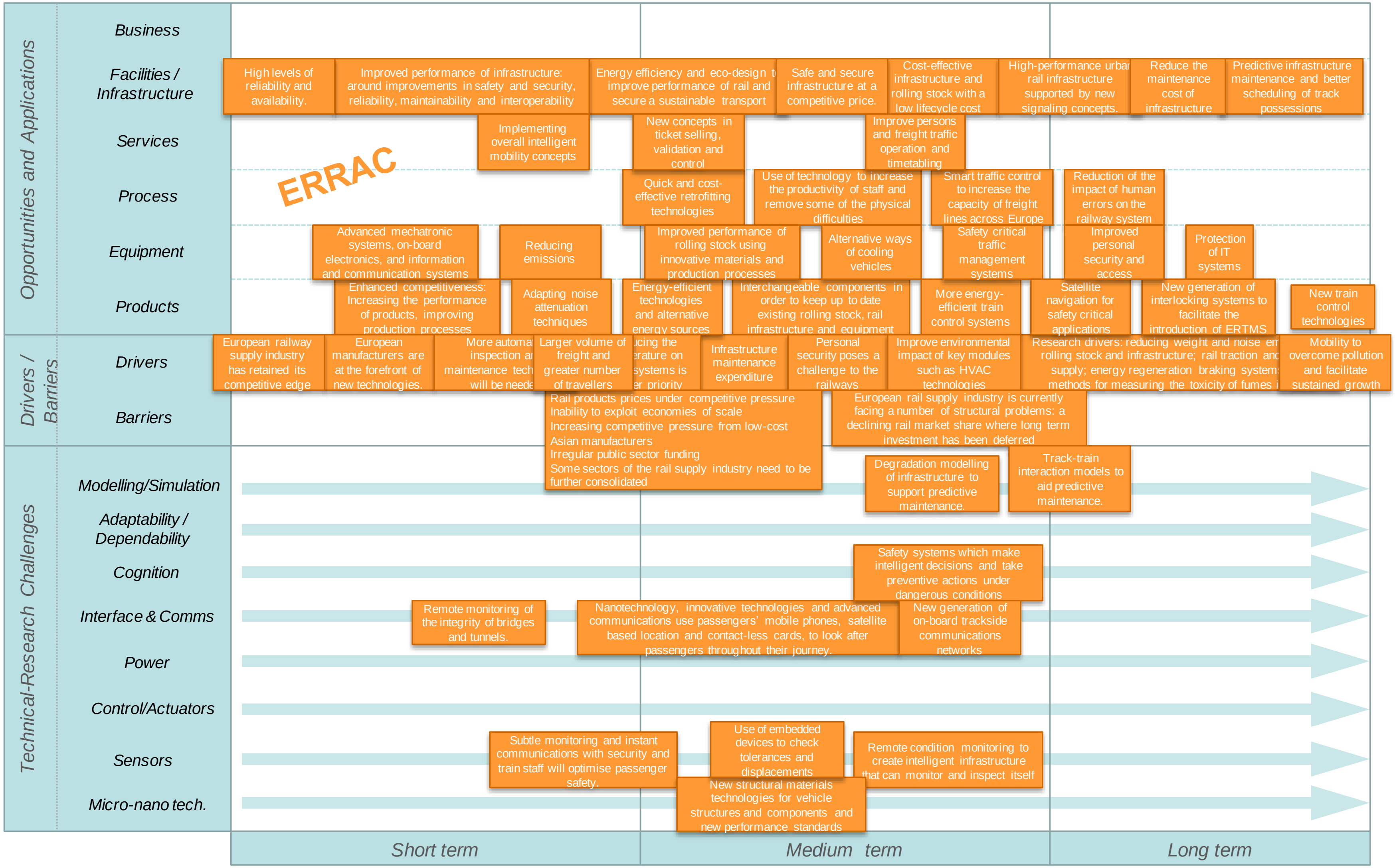


Figure 71: ERRAC links (I)

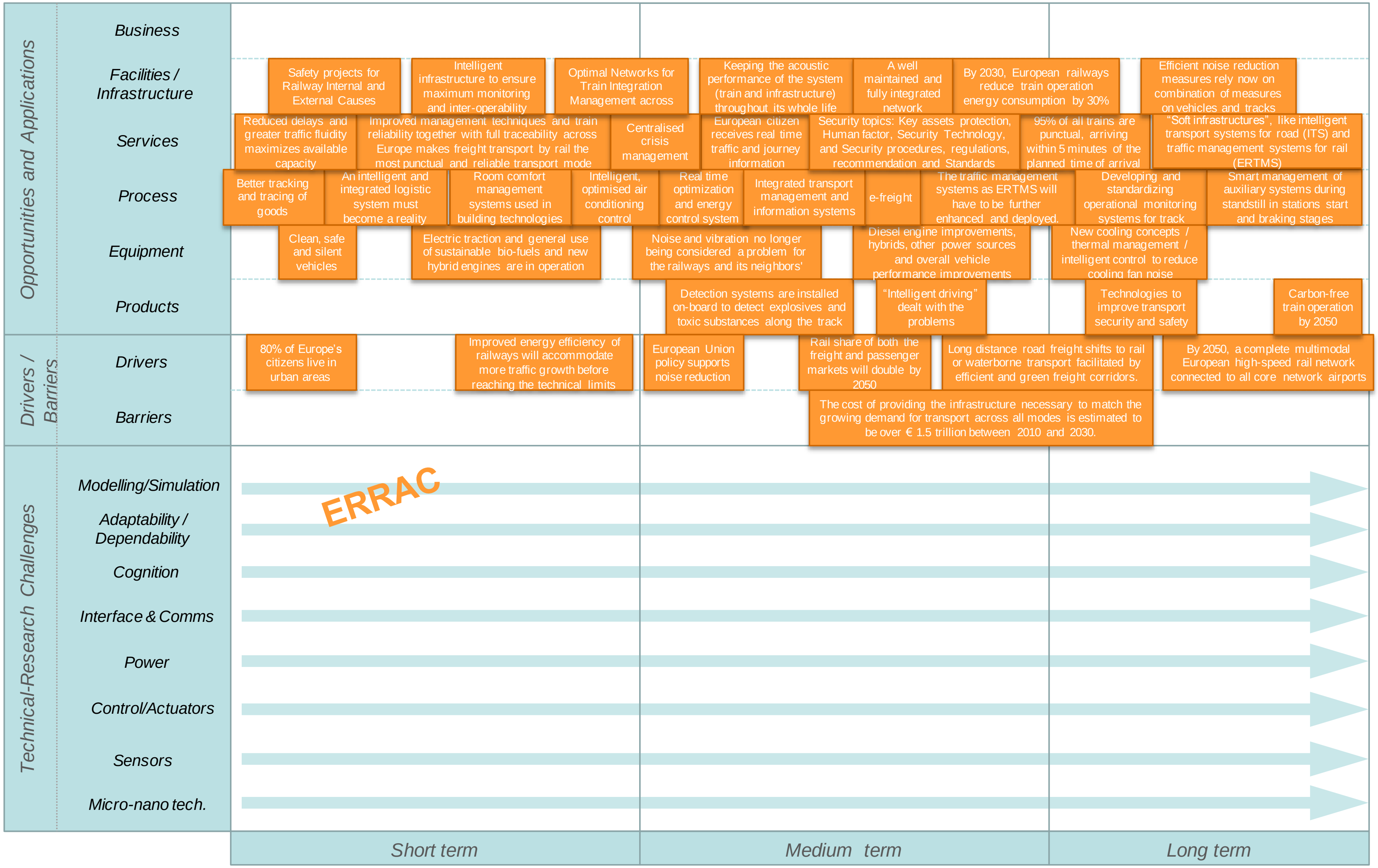


Figure 72: ERRAC links (II)

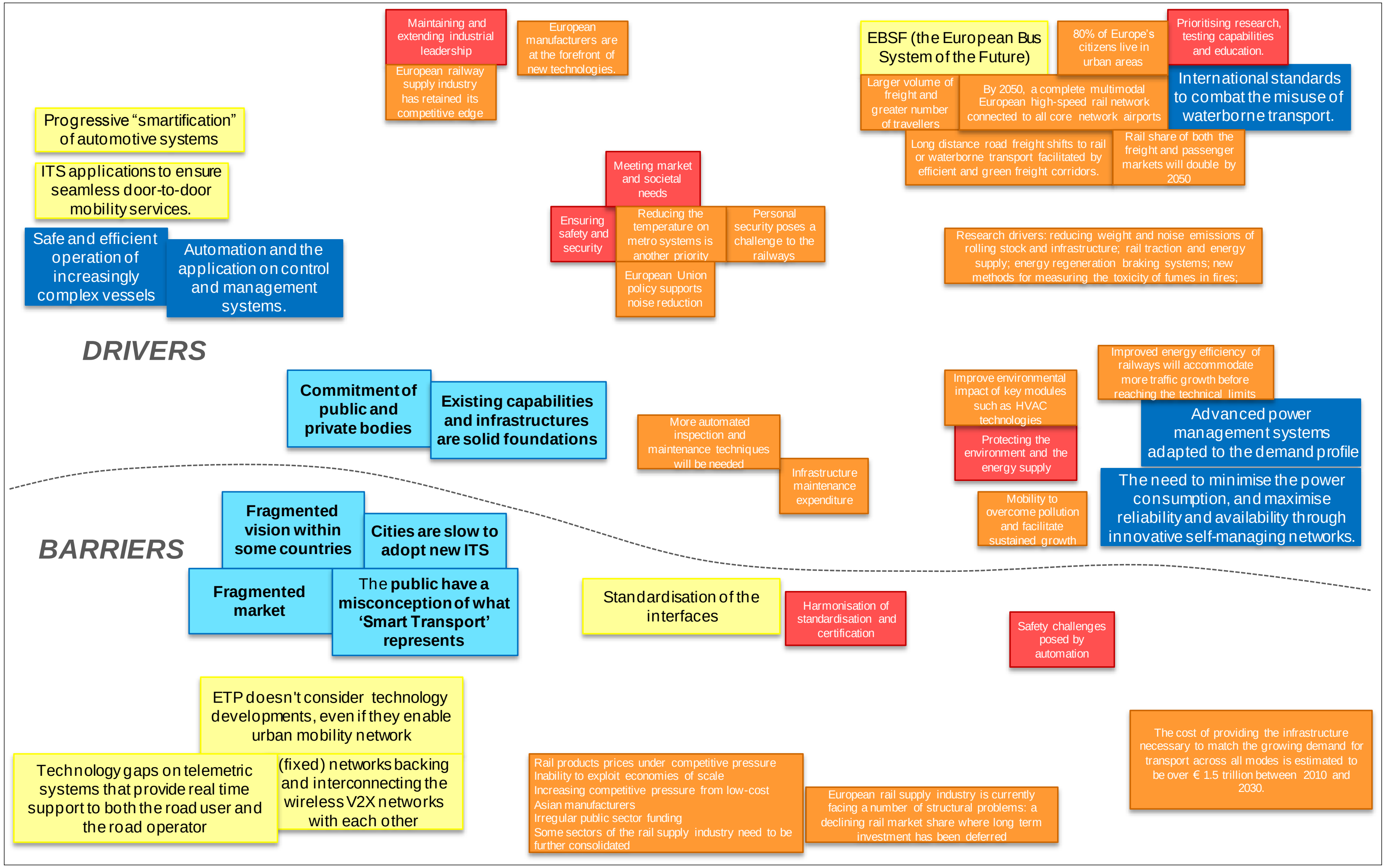


Figure 73: Transport drivers and barriers links

12.3.7. Cross ETP Initiatives

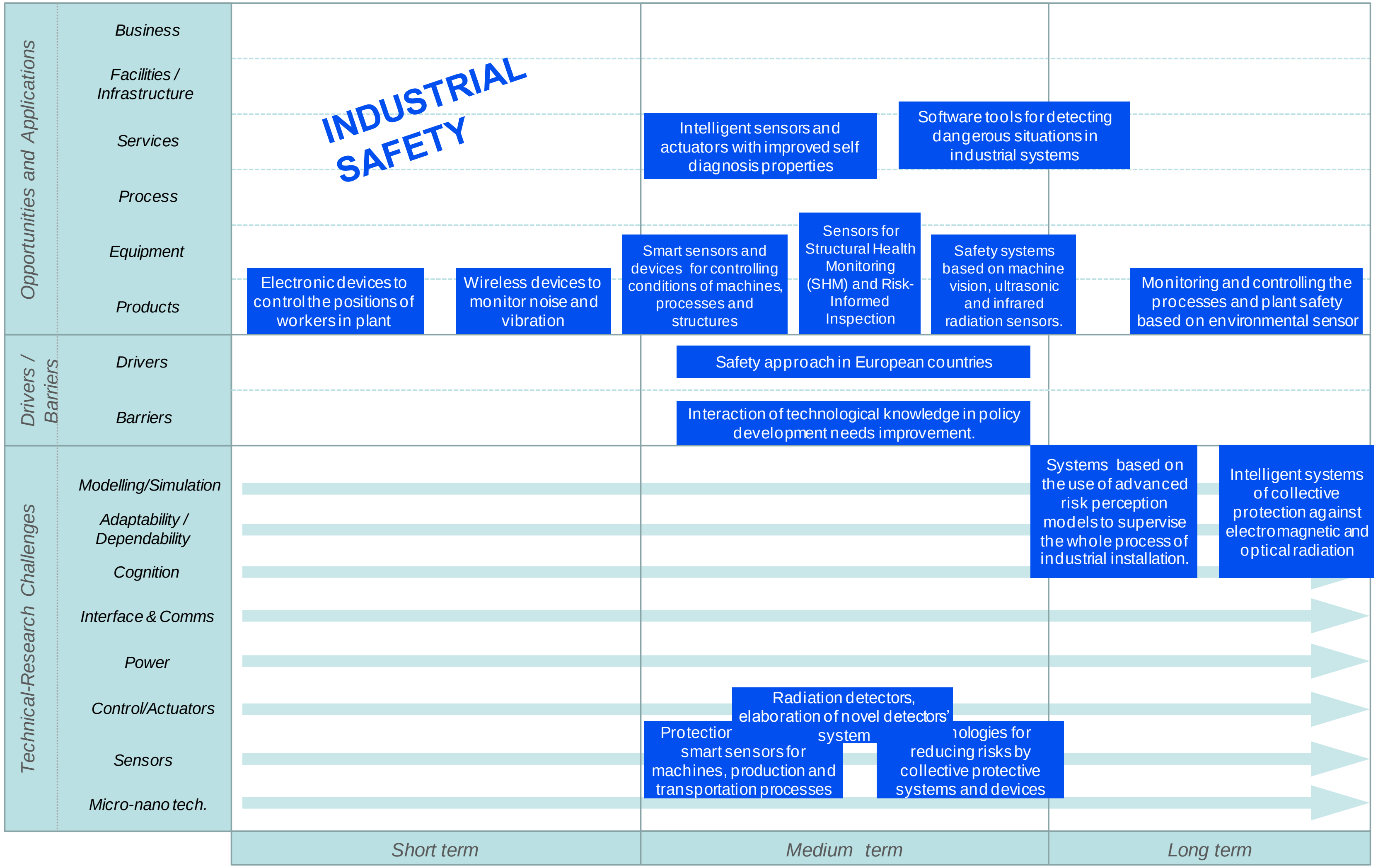


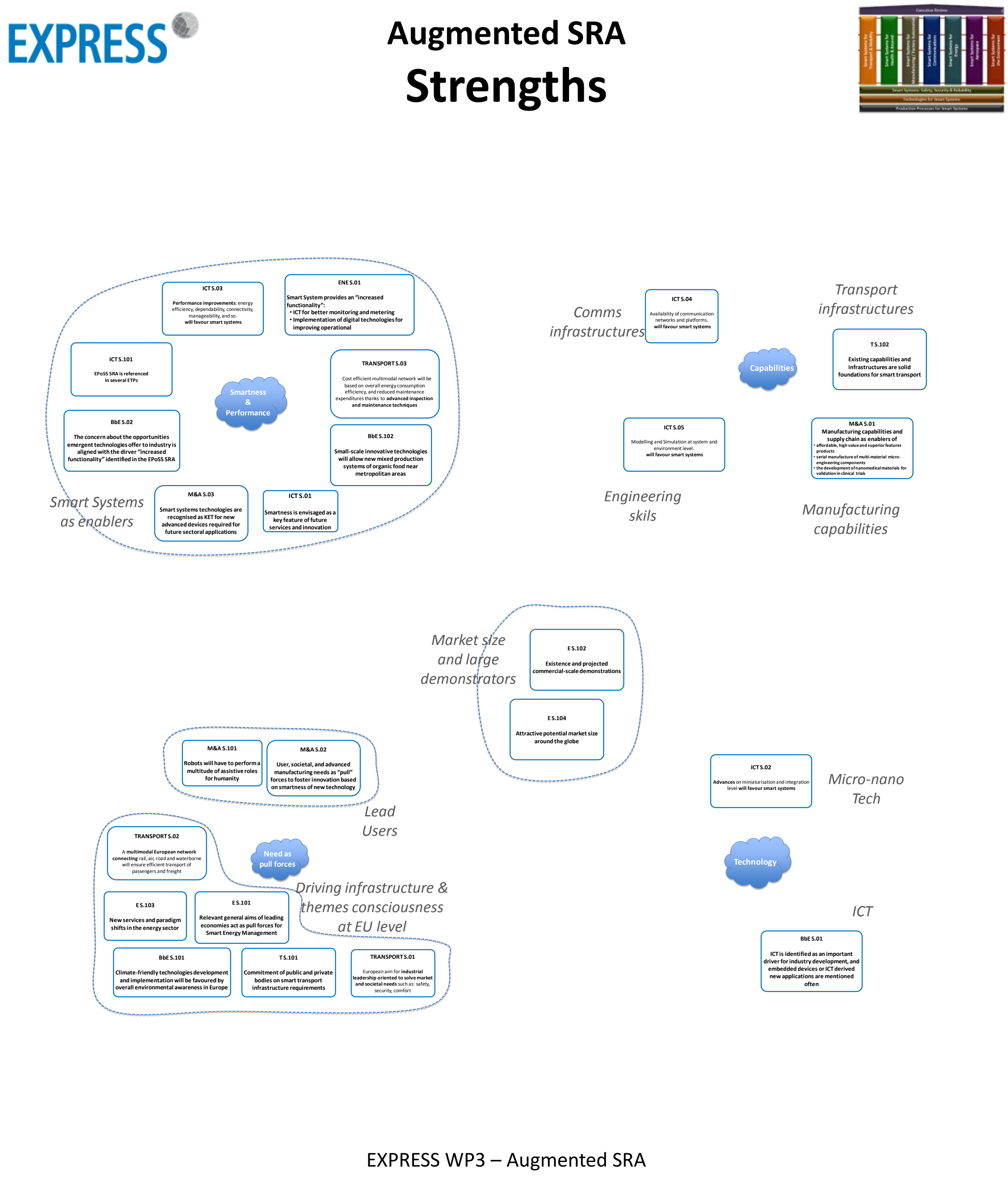
Figure 74: Industrial Safety links

Action code	Action	Contribution to integrated view
VC3-008-short	2D – Metrology tools for printing, HE, NIL, Laser, Litho…	Design of faster analytical tools for monitoring materials synthesis, the development of robust and reproducible measurement techniques and sensors and fast online sensing during manufacture
VC6-001-short	Overall materials and product design system architecture Unified methodologies for design of nanoenabled materials and products	An effective and efficient nanomaterial development must rely on the appropriate design of a computational architecture as well. The computational architecture, together with the algorithms for hierarchical computations, can facilitate design automation with a high computational efficiency: a similar result is achieved with the adoption of unified and internationally recognized methodologies
VC6-004-short	Unified methodologies for design of nanoenabled materials and products	Development of methods for measuring properties
VC7-001-short	Connect simulation tools and programs to test and demonstrate capabilities and create reliable benchmarks	Software tools give the possibility to simulate new devices without physically building them
VC3-002-medium	2D & 3D - Metrology for process and functional properties analysis	Surface texture could be evaluated through automated 2D or 3D Measurement System that offer true colour analysis and imaging of complicated surface in less than 1 min for each site
VC5-005-medium	In vivo studies: effective testing and monitoring of material behaviour in use	The safety assessment should include consideration of the toxicity of both the ingredients and their impurities; dosimeter for in vitro and especially in vivo toxicology studies, if needed; and clinical testing, if warranted.
VC6-005-medium	3D manufacturing control, Process control, analytical control, Material interfaces, Extrusion	Here automation is increasing and process control is becoming increasingly complex and meaningful.
VC1-010-long	Materials modelling, thermal simulation and process design	Nanotechnologies (such as nanoparticles, nanofibres etc.) a way to improve the energy density of a type of battery known as lithium-air (or lithium-oxygen) batteries, producing a device that could potentially pack several times more energy per pound than the lithium-ion batteries that now dominate the market for rechargeable devices in everything from cellphones to cars
VC6-002-long	Precision large scale nano/ micromanufcaturing of 3D structures	The development of precision and large scale manufacturing processes by encompassing a wider range of innovative materials and geometric shapes, satisfying functional and technical requirements, allowing the emerging of new microproducts in many technological fields is a key aspect of 3D structures

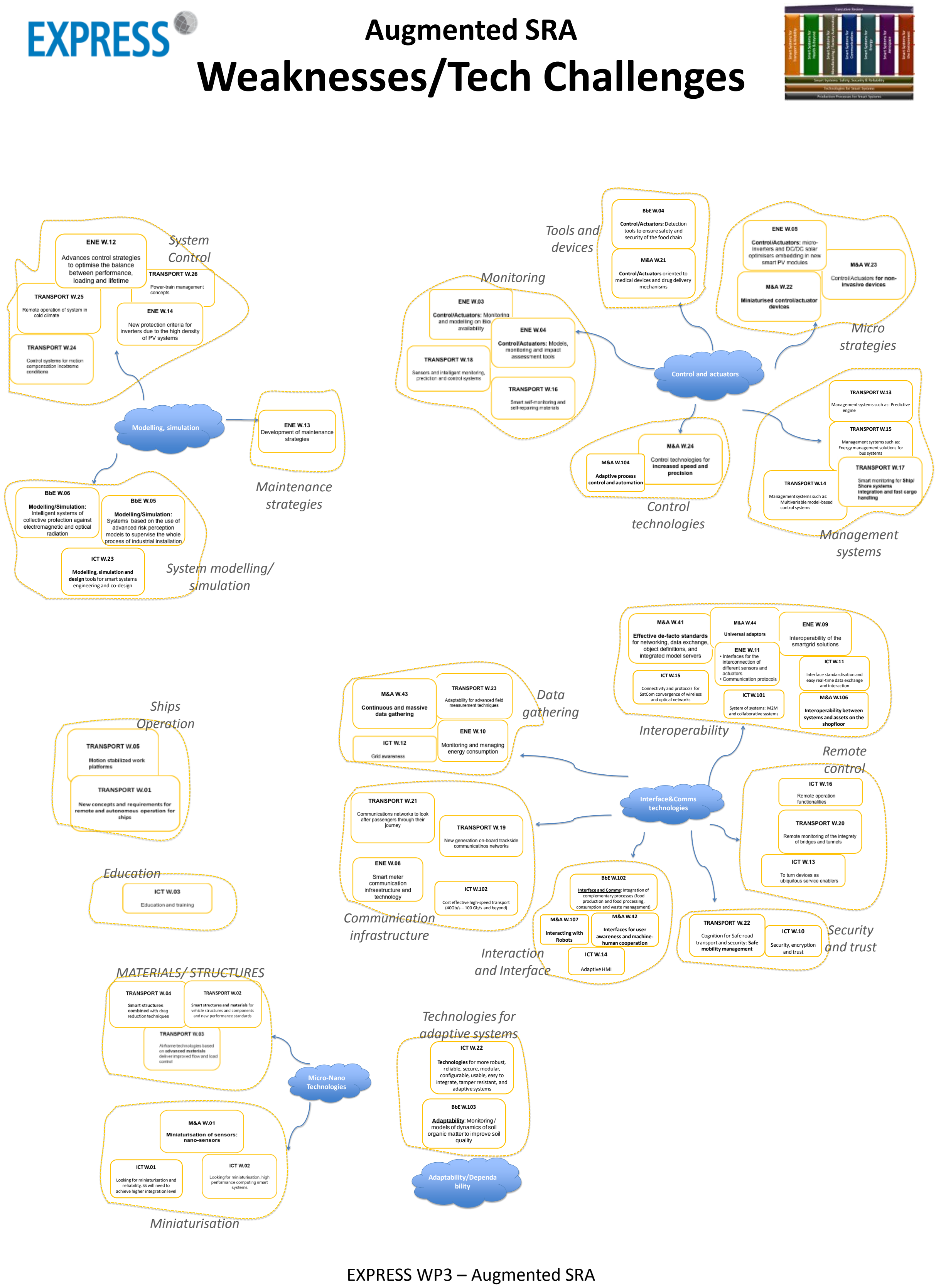
Table 2: Nanofutures roadmap smart links

12.4. Integrated view charts

12.4.1. Strengths

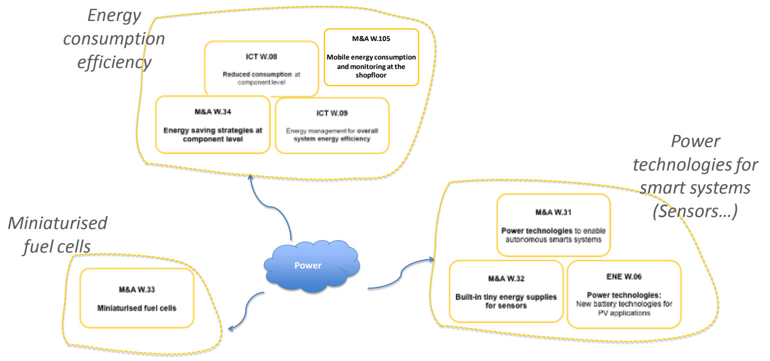


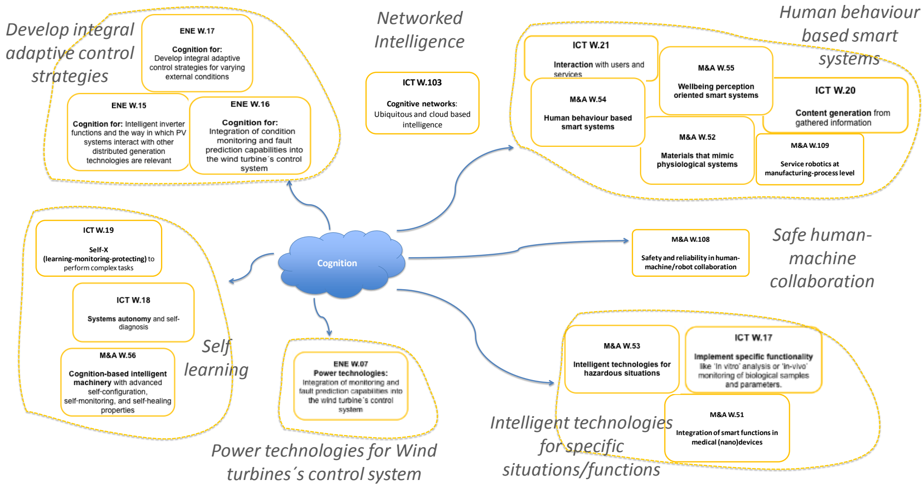
12.4.2. Weaknesses

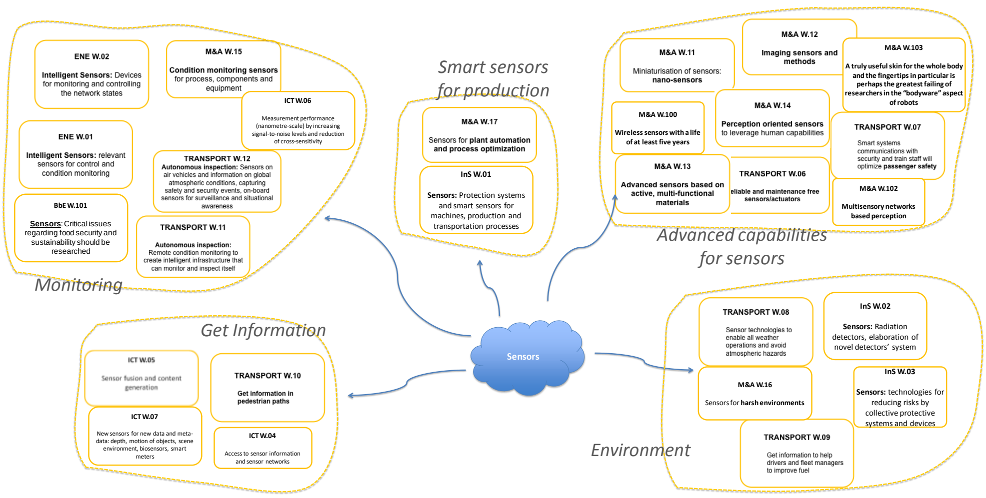


Augmented SRA

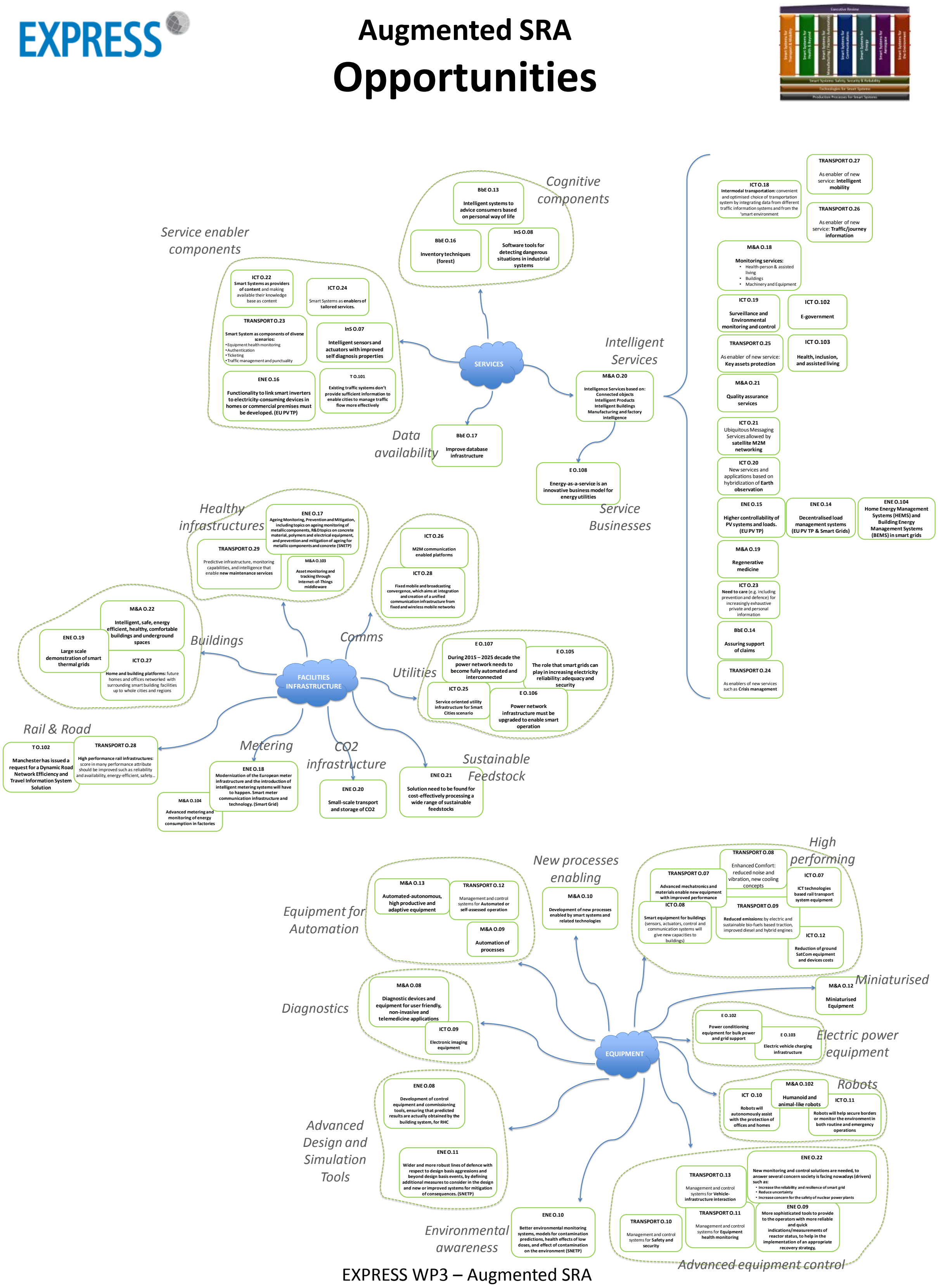
Weaknesses/Tech Challenges



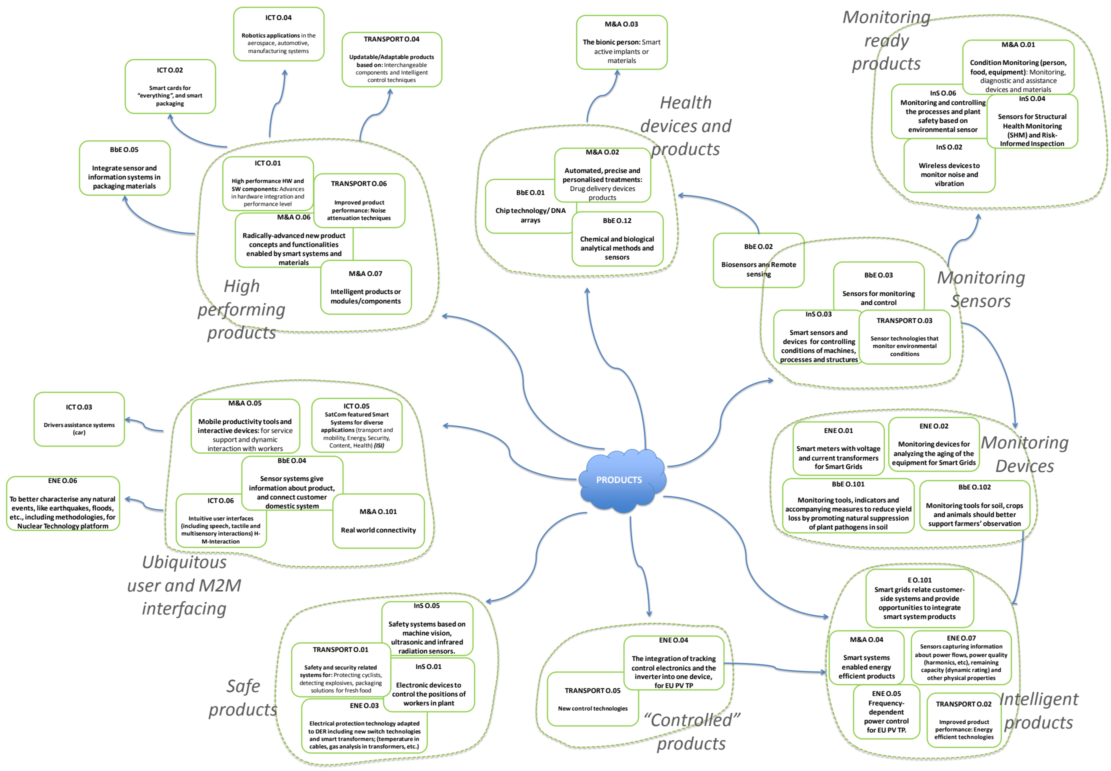


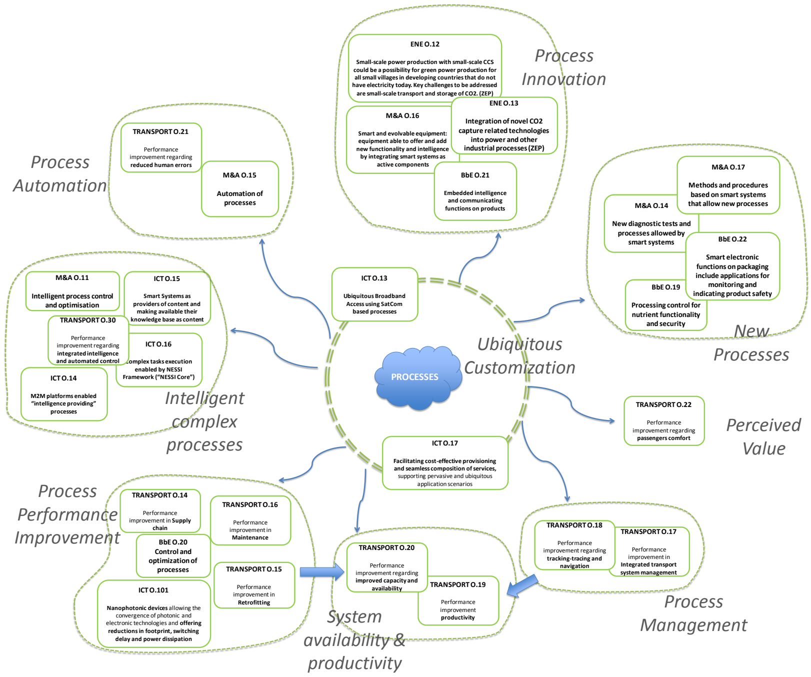


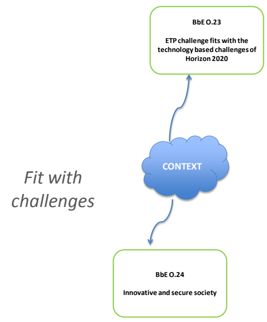
12.4.3. Opportunities



Augmented SRA
Opportunities



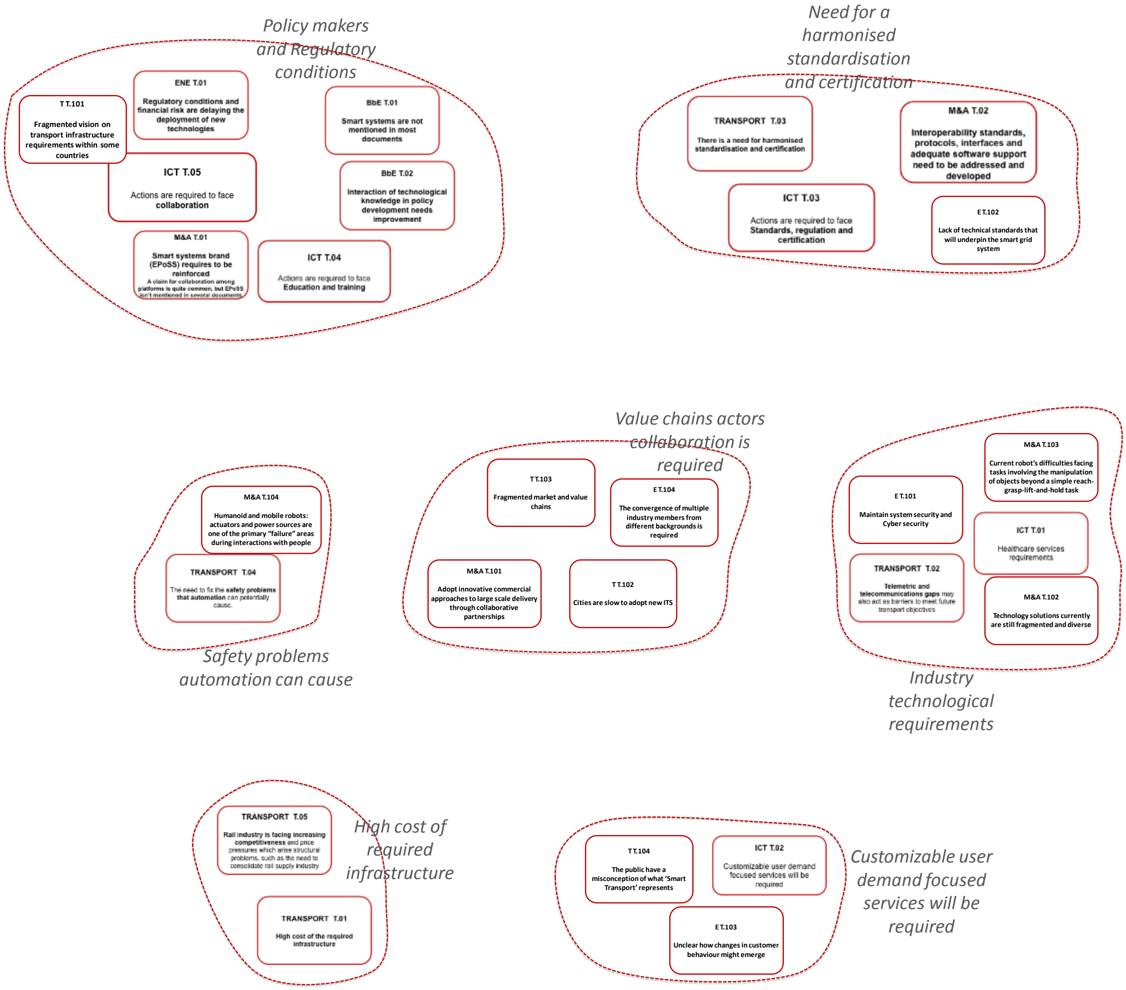




EXPRESS WP3 – Augmented SRA

12.4.4. Threats

Augmented SRA
Threats



12.5. SWOT components

12.5.1. Strengths

ETP Cluster	SWOT ID	Type	Class	Description
Bio-based Economy	BbE S.01	Strength	Strength	ICT is identified as an important driver for industry development, and embedded devices or ICT derived new applications are mentioned often
Bio-based Economy	BbE S.02	Strength	Strength	The concern about the opportunities emergent technologies offer to industry is aligned with the dirver "increased functionality" identified in the EPoSS SRA
Bio-based Economy	BbE S.101	Strength	Strength	Climate-friendly technologies development and implementation will be favoured by overall environmental awareness in Europe.
Bio-based Economy	BbE S.102	Strength	Strength	Small-scale innovative technologies will allow new mixed production systems of organic food near metropolitan areas
Energy	ENE S.01	Strength	Strength	Smart System provides an "increased functionality": - ICT for better monitoring and metering - Implementation of digital technologies for improving operational
Energy	ENE S.101	Strength	Strength	Relevant general aims of leading economies act as pull forces for Smart Energy Management
Energy	ENE S.102	Strength	Strength	Existence and projected commercial-scale demonstrations
Energy	ENE S.103	Strength	Strength	New services and paradigm shifts in the energy sector
Energy	ENE S.104	Strength	Strength	Attractive potential market size around the globe
ICT	ICT S.01	Strength	Strength	Smartness is envisaged as a key feature of future services and innovation
ICT	ICT S.02	Strength	Strength	Advances on miniaturisation and integration level will favour smart systems
ICT	ICT S.03	Strength	Strength	Performance improvements: energy efficiency, dependability, connectivity, manageability, and so.
ICT	ICT S.04	Strength	Strength	Availability of communication networks and platforms.
ICT	ICT S.05	Strength	Strength	Modelling and Simulation at system and environment level.
ICT	ICT S.101	Strength	Strength	EPoSS SRA is referenced in several ETPs

ETP Cluster	SWOT ID	Type	Class	Description
Production&Processes	M&A S.01	Strength	Strength	Manufacturing capabilities and supply chain as enablers of: - affordable, high value and superior features products - serial manufacture of multi-material micro-engineering components - the development of nanomedical materials for validation in clinical trials
Production&Processes	M&A S.02	Strength	Strength	User, societal, and advanced manufacturing needs as “pull” forces to foster innovation based on smartness of new technology
Production&Processes	M&A S.03	Strength	Strength	Smart systems technologies are recognised as KET for new advanced devices required for future sectoral applications
Production&Processes	M&A S.101	Strength	Strength	Robots will have to perform a multitude of assistive roles for humanity
Transport	TRANSPORT S.01	Strength	Strength	European aim for industrial leadership oriented to solve market and societal needs such as: safety, security, comfort
Transport	TRANSPORT S.02	Strength	Strength	A multimodal European network connecting rail, air, road and waterborne will ensure efficient transport of passengers and freight
Transport	TRANSPORT S.03	Strength	Strength	A Cost efficient multimodal network will be based on overall energy consumption efficiency, and reduced maintenance expenditures thanks to advanced inspection and maintenance techniques
Transport	TRANSPORT S.101	Strength	Strength	Commitment of public and private bodies on smart transport infrastructure requirements
Transport	TRANSPORT S.102	Strength	Strength	Existing capabilities and infrastructures are solid foundations for smart transport

12.5.2. Weaknesses

ETP Cluster	SWOT ID	Type	Class	Description
Energy	ENE W.06	Weakness	Power	Power technologies: New battery technologies for PV applications
Energy	ENE W.07	Weakness	Power	Power technologies: Integration of monitoring and fault prediction capabilities into the wind turbine´s control system
ICT	ICT W.08	Weakness	Power	Reduced consumption at component level
ICT	ICT W.09	Weakness	Power	Energy management for overall system energy efficiency
Production&Processes	M&A W.105	Weakness	Power	Mobile energy consumption and monitoring at the shopfloor
Production&Processes	M&A W.31	Weakness	Power	Power technologies to enable autonomous smarts systems
Production&Processes	M&A W.32	Weakness	Power	Built-in tiny energy supplies for sensors
Production&Processes	M&A W.33	Weakness	Power	Miniaturised fuel cells
Production&Processes	M&A W.34	Weakness	Power	Energy saving strategies at component level

ETP Cluster	SWOT ID	Type	Class	Description
Bio-based Economy	BbE W.101	Weakness	Sensors	Sensors: Critical issues regarding food security and sustainability should be researched
Cross Initiatives	InS W.01	Weakness	Sensors	Sensors: Protection systems and smart sensors for machines, production and transportation processes
Cross Initiatives	InS W.02	Weakness	Sensors	Sensors: Radiation detectors, elaboration of novel detectors' system
Cross Initiatives	InS W.03	Weakness	Sensors	Sensors: technologies for reducing risks by collective protective systems and devices
Energy	ENE W.01	Weakness	Sensors	Intelligent Sensors: relevant sensors for control and condition monitoring
Energy	ENE W.02	Weakness	Sensors	Intelligent Sensors: Devices for monitoring and controlling the network states
ICT	ICT W.04	Weakness	Sensors	Access to sensor information and sensor networks
ICT	ICT W.05	Weakness	Sensors	Sensor fusion and content generation
ICT	ICT W.06	Weakness	Sensors	Measurement performance (nanometre-scale) by increasing signal-to-noise levels and reduction of cross-sensitivity
ICT	ICT W.07	Weakness	Sensors	New sensors for new data and meta-data: depth, motion of objects, scene environment, biosensors, smart meters
Production&Processes	M&A W.100	Weakness	Sensors	Wireless sensors with a life of at least five years
Production&Processes	M&A W.102	Weakness	Sensors	Multisensory networks based perception
Production&Processes	M&A W.103	Weakness	Sensors	A truly useful skin for the whole body and the fingertips in particular is perhaps the greatest failing of researchers in the "bodyware" aspect of robots
Production&Processes	M&A W.11	Weakness	Sensors	Miniaturisation of sensors: nano-sensors
Production&Processes	M&A W.12	Weakness	Sensors	Imaging sensors and methods
Production&Processes	M&A W.13	Weakness	Sensors	Advanced sensors based on active, multi-functional materials
Production&Processes	M&A W.14	Weakness	Sensors	Perception oriented sensors to leverage human capabilities
Production&Processes	M&A W.15	Weakness	Sensors	Condition monitoring sensors for process, components and equipment
Production&Processes	M&A W.16	Weakness	Sensors	Sensors for harsh environments
Production&Processes	M&A W.17	Weakness	Sensors	Sensors for plant automation and process optimization
Transport	TRANSPORT W.06	Weakness	Sensors	Reliable and maintenance free sensors/actuators
Transport	TRANSPORT W.07	Weakness	Sensors	Smart systems communications with security and train staff will optimize passenger safety
Transport	TRANSPORT W.08	Weakness	Sensors	Sensor technologies to enable all weather operations and avoid atmospheric hazards
Transport	TRANSPORT W.09	Weakness	Sensors	Get information to help drivers and fleet managers to improve fuel
Transport	TRANSPORT W.10	Weakness	Sensors	Get information in pedestrian paths
Transport	TRANSPORT W.11	Weakness	Sensors	Autonomous inspection: Remote condition monitoring to create intelligent infrastructure that can monitor and inspect itself
Transport	TRANSPORT W.12	Weakness	Sensors	Autonomous inspection: Sensors on air vehicles and information on global atmospheric conditions, capturing safety and security events, on-board sensors for surveillance and situational awareness

ETP Cluster	SWOT ID	Type	Class	Description
Bio-based Economy	BbE W.102	Weakness	Interface & Comms	Interface and Comms: Integration of complementary processes (food production and food processing, consumption and waste management
Energy	ENE W.08	Weakness	Interface & Comms	Interface & Comms for: Smart meter communication infraestructure and technology
Energy	ENE W.09	Weakness	Interface & Comms	Interface & Comms for: Interoperability of the smartgrid solutions
Energy	ENE W.10	Weakness	Interface & Comms	Interface & Comms for: Monitoring and managing energy consumption
Energy	ENE W.11	Weakness	Interface & Comms	Interface & Comms for: - Interfaces for the interconnection of different sensors and actuators - Communication protocols
ICT	ICT W.10	Weakness	Interface & Comms	Security, encryption and trust
ICT	ICT W.11	Weakness	Interface & Comms	Interface standardisation and easy real-time data exchange and interaction
ICT	ICT W.12	Weakness	Interface & Comms	Grid awareness
ICT	ICT W.13	Weakness	Interface & Comms	To turn devices as ubiquitous service enablers
ICT	ICT W.14	Weakness	Interface & Comms	Adaptive HMI
ICT	ICT W.15	Weakness	Interface & Comms	Connectivity and protocols for SatCom convergence of wireless and optical networks
ICT	ICT W.16	Weakness	Interface & Comms	Remote operation functionalities
ICT	ICT W.101	Weakness	Interface & Comms	System of systems: M2M and collaborative systems
ICT	ICT W.102	Weakness	Interface & Comms	Cost effective high-speed transport (40Gb/s – 100 Gb/s and beyond)

ETP Cluster	SWOT ID	Type	Class	Description
Production&Processes	M&A W.106	Weakness	Interface & Comms	Interoperability between systems and assets on the shopfloor
Production&Processes	M&A W.107	Weakness	Interface & Comms	Interacting with Robots
Production&Processes	M&A W.41	Weakness	Interface & Comms	Effective de-facto standards for networking, data exchange, object definitions, and integrated model servers
Production&Processes	M&A W.42	Weakness	Interface & Comms	Interfaces for user awareness and machine-human cooperation
Production&Processes	M&A W.43	Weakness	Interface & Comms	Continuous and massive data gathering
Production&Processes	M&A W.44	Weakness	Interface & Comms	Universal adaptors
Transport	TRANSPORT W.19	Weakness	Interface & Comms	New generation on-board trackside communicatinos networks
Transport	TRANSPORT W.20	Weakness	Interface & Comms	Remote monitoring of the integrety of bridges and tunnels
Transport	TRANSPORT W.21	Weakness	Interface & Comms	Communications networks to look after passengers through their journey
Transport	TRANSPORT W.22	Weakness	Interface & Comms	Cognition for Safe road transport and security: Safe mobility management
Transport	TRANSPORT W.23	Weakness	Interface & Comms	Adaptability for advanced field measurement techniques

ETP Cluster	SWOT ID	Type	Class	Description
ICT	ICT W.01	Weakness	Micro-nano technologies	Looking for miniaturisation and reliability, SS will need to achieve higher integration level
ICT	ICT W.02	Weakness	Micro-nano technologies	Looking for miniaturisation, high performance computing smart systems
ICT	ICT W.03	Weakness	Micro-nano technologies	Education and training
Production&Processes	M&A W.01	Weakness	Micro-nano technologies	Miniaturisation of sensors: nano-sensors
Transport	TRANSPORT W.01	Weakness	Micro-nano technologies	New concepts and requirements for remote and autonomous operation for ships
Transport	TRANSPORT W.02	Weakness	Micro-nano technologies	Smart structures and materials for vehicle structures and components and new performance standards
Transport	TRANSPORT W.03	Weakness	Micro-nano technologies	Airframe technologies based on advanced materials deliver improved flow and load control
Transport	TRANSPORT W.04	Weakness	Micro-nano technologies	Smart structures combined with drag reduction techniques
Transport	TRANSPORT W.05	Weakness	Micro-nano technologies	Motion stabilized work platforms

ETP Cluster	SWOT ID	Type	Class	Description
Bio-based Economy	BbE W.05	Weakness	Modelling/Simulation	Modelling/Simulation: Systems based on the use of advanced risk perception models to supervise the whole process of industrial installation
Bio-based Economy	BbE W.06	Weakness	Modelling/Simulation	Modelling/Simulation: Intelligent systems of collective protection against electromagnetic and optical radiation
Energy	ENE W.12	Weakness	Modelling/Simulation	Modelling/ Simulation for: Advances control strategies to optimise the balance between performance, loading and lifetime
Energy	ENE W.13	Weakness	Modelling/Simulation	Modelling/ Simulation for: Development of maintenance strategies
Energy	ENE W.14	Weakness	Modelling/Simulation	Modelling/ Simulation for: New protection criteria for inverters due to the high density of PV systems
ICT	ICT W.23	Weakness	Modelling/Simulation	Modelling, simulation and design tools for smart systems engineering and co-design
Transport	TRANSPORT W.24	Weakness	Modelling/Simulation	Control systems for motion compensation inextreme conditions
Transport	TRANSPORT W.25	Weakness	Modelling/Simulation	Remote operation of system in cold climate
Transport	TRANSPORT W.26	Weakness	Modelling/Simulation	Power-train management concepts

ETP Cluster	SWOT ID	Type	Class	Description
Bio-based Economy	BbE W.103	Weakness	Adaptability/ Dependability	Adaptability: Monitoring / models of dynamics of soil organic matter to improve soil quality
ICT	ICT W.22	Weakness	Adaptability/ Dependability	Technologies for more robust, reliable, secure, modular, configurable, usable, easy to integrate, tamper resistant, and adaptive systems
Energy	ENE W.15	Weakness	Cognition	Cognition for: Intelligent inverter functions and the way in which PV systems interact with other distributed generation technologies are relevant
Energy	ENE W.16	Weakness	Cognition	Cognition for: Integration of condition monitoring and fault prediction capabilities into the wind turbine´s control system
Energy	ENE W.17	Weakness	Cognition	Cognition for: Develop integral adaptive control strategies for varying external conditions
ICT	ICT W.17	Weakness	Cognition	Implement specific functionality like 'In vitro' analysis or 'in-vivo' monitoring of biological samples and parameters.
ICT	ICT W.18	Weakness	Cognition	Systems autonomy and self- diagnosis
ICT	ICT W.19	Weakness	Cognition	Self-X (learning-monitoring-protecting) to perform complex tasks
ICT	ICT W.20	Weakness	Cognition	Content generation from gathered information
ICT	ICT W.21	Weakness	Cognition	Interaction with users and services
ICT	ICT W.103	Weakness	Cognition	Cognitive networks: Ubiquitous and cloud based intelligence
Production&Processes	M&A W.102	Weakness	Cognition	Multisensory networks based perception
Production&Processes	M&A W.108	Weakness	Cognition	Safety and reliability in human-machine/robot collaboration
Production&Processes	M&A W.109	Weakness	Cognition	Service robotics at manufacturing-process level
Production&Processes	M&A W.51	Weakness	Cognition	Integration of smart functions in medical (nano)devices
Production&Processes	M&A W.52	Weakness	Cognition	Materials that mimic physiological systems
Production&Processes	M&A W.53	Weakness	Cognition	Intelligent technologies for hazardous situations
Production&Processes	M&A W.54	Weakness	Cognition	Human behaviour based smart systems
Production&Processes	M&A W.55	Weakness	Cognition	Wellbeing perception oriented smart systems
Production&Processes	M&A W.56	Weakness	Cognition	Cognition-based intelligent machinery with advanced self-configuration, self-monitoring, and self-healing properties

ETP Cluster	SWOT ID	Type	Class	Description
Bio-based Economy	BbE W.04	Weakness	Control/Actuators	Control/Actuators: Detection tools to ensure safety and security of the food chain
Energy	ENE W.03	Weakness	Control/Actuators	Control/Actuators: Monitoring and modelling on Biomass availability
Energy	ENE W.04	Weakness	Control/Actuators	Control/Actuators: Models, monitoring and impact assessment tools
Energy	ENE W.05	Weakness	Control/Actuators	Control/Actuators: micro-inverters and DC/DC solar optimisers embedding in new smart PV modules
Production&Processes	M&A W.104	Weakness	Control/Actuators	Adaptive process control and automation
Production&Processes	M&A W.21	Weakness	Control/Actuators	Control/Actuators oriented to medical devices and drug delivery mechanisms
Production&Processes	M&A W.22	Weakness	Control/Actuators	Miniaturised control/actuator devices
Production&Processes	M&A W.23	Weakness	Control/Actuators	Control/Actuators for non-invasive devices
Production&Processes	M&A W.24	Weakness	Control/Actuators	Control technologies for increased speed and precision
Transport	TRANSPORT W.13	Weakness	Control/Actuators	Management systems such as: Predictive engine
Transport	TRANSPORT W.14	Weakness	Control/Actuators	Management systems such as: Multivariable model-based control systems
Transport	TRANSPORT W.15	Weakness	Control/Actuators	Management systems such as: Energy management solutions for bus systems
Transport	TRANSPORT W.16	Weakness	Control/Actuators	Smart self-monitoring and self-repairing materials
Transport	TRANSPORT W.17	Weakness	Control/Actuators	Smart monitoring for Ship/Shore systems integration and fast cargo handling
Transport	TRANSPORT W.18	Weakness	Control/Actuators	Sensors and intelligent monitoring, prediction and control systems
Production&Processes	M&A W.00	Weakness	General	Manufacturing capabilities and supply chain as missing capabilities: - for a reasonably priced mass production of diverse materials - to manufacture the first batches of the nanomedicine product

12.5.3. Opportunities

ETP Cluster	SWOT ID	Type	Class	Description
Bio-based Economy	BbE O.01	Opportunity	Product	Chip technology/ DNA arrays
Bio-based Economy	BbE O.02	Opportunity	Product	Biosensors and Remote sensing
Bio-based Economy	BbE O.03	Opportunity	Product	Sensors for monitoring and control
Bio-based Economy	BbE O.04	Opportunity	Product	Sensor systems give information about product, and connect customer domestic system
Bio-based Economy	BbE O.05	Opportunity	Product	Integrate sensor and information systems in packaging materials
Bio-based Economy	BbE O.10	Opportunity	Product	Safety systems based on machine vision, ultrasonic and infrared radiation sensors
Bio-based Economy	BbE O.101	Opportunity	Product	Chemical and biological analytical methods and sensors
Bio-based Economy	BbE O.102	Opportunity	Product	Monitoring tools, indicators and accompanying measures to reduce yield loss by promoting natural suppression of plant pathogens in soil
Bio-based Economy	BbE O.12	Opportunity	Product	Monitoring tools for soil, crops and animals should better support farmers' observation
Cross Initiatives	InS O.01	Opportunity	Product	Electronic devices to control the positions of workers in plant
Cross Initiatives	InS O.02	Opportunity	Product	Wireless devices to monitor noise and vibration
Cross Initiatives	InS O.03	Opportunity	Product	Smart sensors and devices for controlling conditions of machines, processes and structures
Cross Initiatives	InS O.04	Opportunity	Product	Sensors for Structural Health Monitoring (SHM) and Risk-Informed Inspection
Cross Initiatives	InS O.05	Opportunity	Product	Safety systems based on machine vision, ultrasonic and infrared radiation sensors
Cross Initiatives	InS O.06	Opportunity	Product	Monitoring and controlling the processes and plant safety based on environmental sensor
Energy	ENE O.01	Opportunity	Product	Smart meters with voltage and current transformers for Smart Grids
Energy	ENE O.02	Opportunity	Product	Monitoring devices for analyzing the aging of the equipment for Smart Grids
Energy	ENE O.03	Opportunity	Product	Electrical protection technology adapted to DER including new switch technologies and smart transformers; (temperature in cables, gas analysis in transformers, etc.)
Energy	ENE O.04	Opportunity	Product	The integration of tracking control electronics and the inverter into one device, for EU PV TP
Energy	ENE O.05	Opportunity	Product	Frequency-dependent power control for EU PV TP
Energy	ENE O.06	Opportunity	Product	To better characterise any natural events, like earthquakes, floods, etc., including methodologies, for Nuclear Technology platform
Energy	ENE O.07	Opportunity	Product	Sensors capturing information about power flows, power quality (harmonics, etc), remaining capacity (dynamic rating) and other physical properties
Energy	ENE O.101	Opportunity	Product	Smart grids relate customer-side systems and provide opportunities to integrate smart system products

ETP Cluster	SWOT ID	Type	Class	Description
ICT	ICT O.01	Opportunity	Product	High performance HW and SW components: Advances in hardware integration and performance level
ICT	ICT O.02	Opportunity	Product	Smart cards for “everything”, and smart packaging
ICT	ICT O.03	Opportunity	Product	Drivers assistance systems (car)
ICT	ICT O.04	Opportunity	Product	Robotics applications in the aerospace, automotive, manufacturing systems
ICT	ICT O.05	Opportunity	Product	SatCom featured Smart Systems for diverse applications (transport and mobility, Energy, Security, Content, Health) (ISI)
ICT	ICT O.06	Opportunity	Product	Intuitive user interfaces (including speech, tactile and multisensory interactions) H-M-Interaction
Production&Processes	M&A O.01	Opportunity	Product	Condition Monitoring (person, food, equipment): Monitoring, diagnostic and assistance devices and materials
Production&Processes	M&A O.02	Opportunity	Product	Automated, precise and personalised treatments: Drug delivery devices products
Production&Processes	M&A O.03	Opportunity	Product	Smart systems enabled energy efficient products
Production&Processes	M&A O.04	Opportunity	Product	The bionic person: Smart active implants or materials
Production&Processes	M&A O.05	Opportunity	Product	Mobile productivity tools and interactive devices: for service support and dynamic interaction with workers
Production&Processes	M&A O.06	Opportunity	Product	Radically-advanced new product concepts and functionalities enabled by smart systems and materials
Production&Processes	M&A O.07	Opportunity	Product	Intelligent products or modules/components
Production&Processes	M&A O.101	Opportunity	Product	Real world connectivity
Transport	TRANSPORT O.01	Opportunity	Product	Safety and security related systems for: Protecting cyclists, detecting explosives, packaging solutions for fresh food
Transport	TRANSPORT O.02	Opportunity	Product	Improved product performance: Energy efficient technologies
Transport	TRANSPORT O.03	Opportunity	Product	Updatable/Adaptable products based on: Interchangeable components and Intelligent control techniques
Transport	TRANSPORT O.04	Opportunity	Product	Sensor technologies that monitor environmental conditions
Transport	TRANSPORT O.05	Opportunity	Product	New control technologies
Transport	TRANSPORT O.06	Opportunity	Product	Improved product performance: Noise attenuation techniques

ETP Cluster	SWOT ID	Type	Class	Description
Energy	ENE O.08	Opportunity	Equipment	Development of control equipment and commissioning tools, ensuring that predicted results are actually obtained by the building system, for RHC
Energy	ENE O.09	Opportunity	Equipment	More sophisticated tools to provide to the operators with more reliable and quick indicationsor measurements of reactor status, to help in the implementation of an appropriate recovery strategy
Energy	ENE O.10	Opportunity	Equipment	Better environmental monitoring systems, models for contamination predictions, health effects of low doses, and effect of contamination on the environment (SNETP)
Energy	ENE O.102	Opportunity	Equipment	Power conditioning equipment for bulk power and grid support
Energy	ENE O.103	Opportunity	Equipment	Electric vehicle charging infrastructure
Energy	ENE O.11	Opportunity	Equipment	Wider and more robust lines of defence with respect to design basis aggressions and beyond design basis events, by defining additional measures to consider in the design and new or improved systems for mitigation of consequences. (SNETP)
ICT	ICT O.07	Opportunity	Equipment	ICT technologies based rail transport system equipment
ICT	ICT O.08	Opportunity	Equipment	Smart equipment for buildings (sensors, actuators, control and communication systems will give new capacities to buildings)
ICT	ICT O.09	Opportunity	Equipment	Electronic imaging equipment
ICT	ICT O.10	Opportunity	Equipment	Robots will autonomously assist with the protection of offices and homes
ICT	ICT O.11	Opportunity	Equipment	Robots will help secure borders or monitor the environment in both routine and emergency operations
ICT	ICT O.12	Opportunity	Equipment	Reduction of ground SatCom equipment and devices costs

ETP Cluster	SWOT ID	Type	Class	Description
Production&Processes	M&A O.08	Opportunity	Equipment	Diagnostic devices and equipment for user friendly, non-invasive and telemedicine applications
Production&Processes	M&A O.09	Opportunity	Equipment	Automation of processes
Production&Processes	M&A O.10	Opportunity	Equipment	Development of new processes enabled by smart systems and related technologies
Production&Processes	M&A O.102	Opportunity	Equipment	Humanoid and animal-like robots
Production&Processes	M&A O.11	Opportunity	Equipment	Intelligent process control and optimisation
Production&Processes	M&A O.12	Opportunity	Equipment	Miniaturised Equipment
Production&Processes	M&A O.13	Opportunity	Equipment	Automated-autonomous, high productive and adaptive equipment
Transport	TRANSPORT O.07	Opportunity	Equipment	Advanced mechatronics and materials enable new equipment with improved performance
Transport	TRANSPORT O.08	Opportunity	Equipment	Enhanced Comfort: reduced noise and vibration, new cooling concepts
Transport	TRANSPORT O.09	Opportunity	Equipment	Reduced emissions: by electric and sustainable bio-fuels based traction, improved diesel and hybrid engines
Transport	TRANSPORT O.10	Opportunity	Equipment	Management and control systems for Safety and security
Transport	TRANSPORT O.11	Opportunity	Equipment	Management and control systems for Equipment health monitoring
Transport	TRANSPORT O.12	Opportunity	Equipment	Management and control systems for Automated or self-assessed operation
Transport	TRANSPORT O.13	Opportunity	Equipment	Management and control systems for Vehicle-infrastructure interaction

ETP Cluster	SWOT ID	Type	Class	Description
Bio-based Economy	BbE O.19	Opportunity	Process	Processing control for nutrient functionality and security
Bio-based Economy	BbE O.20	Opportunity	Process	Control and optimization of processes
Bio-based Economy	BbE O.21	Opportunity	Process	Embedded intelligence and communicating functions on products
Bio-based Economy	BbE O.22	Opportunity	Process	Smart electronic functions on packaging include applications for monitoring and indicating product safety
Energy	ENE O.12	Opportunity	Process	Small-scale power production with small-scale CCS could be a possibility for green power production for all small villages in developing countries that do not have electricity today. Key challenges to be addressed are small-scale transport and storage of CO2. (ZEP)
Energy	ENE O.13	Opportunity	Process	Integration of novel CO2 capture related technologies into power and other industrial processes
ICT	ICT O.13	Opportunity	Process	Ubiquitous Broadband Access using SatCom based processes
ICT	ICT O.14	Opportunity	Process	M2M platforms enabled “intelligence providing” processes
ICT	ICT O.15	Opportunity	Process	Smart Systems as providers of content and making available their knowledge base as content
ICT	ICT O.16	Opportunity	Process	Complex tasks execution enabled by NESSI Framework (“NESSI Core”)
ICT	ICT O.17	Opportunity	Process	Facilitating cost-effective provisioning and seamless composition of services, supporting pervasive and ubiquitous application scenarios
ICT	ICT O.101	Opportunity	Process	Nanophotonic devices allowing the convergence of photonic and electronic technologies and offering reductions in footprint, switching delay and power dissipation
Production&Processes	M&A O.14	Opportunity	Process	New diagnostic tests and processes allowed by smart systems
Production&Processes	M&A O.15	Opportunity	Process	Automation of processes
Production&Processes	M&A O.16	Opportunity	Process	Smart and evolvable equipment: equipment able to offer and add new functionality and intelligence by integrating smart systems as active components
Production&Processes	M&A O.17	Opportunity	Process	Methods and procedures based on smart systems that allow new processes
Transport	TRANSPORT O.14	Opportunity	Process	Performance improvement in Supply chain
Transport	TRANSPORT O.15	Opportunity	Process	Performance improvement in Retrofitting
Transport	TRANSPORT O.16	Opportunity	Process	Performance improvement in Maintenance
Transport	TRANSPORT O.17	Opportunity	Process	Performance improvement in Integrated transport system management
Transport	TRANSPORT O.18	Opportunity	Process	Performance improvement regarding tracking-tracing and navigation
Transport	TRANSPORT O.19	Opportunity	Process	Performance improvement productivity
Transport	TRANSPORT O.20	Opportunity	Process	Performance improvement regarding improved capacity and availability
Transport	TRANSPORT O.21	Opportunity	Process	Performance improvement regarding reduced human errors
Transport	TRANSPORT O.22	Opportunity	Process	Performance improvement regarding passengers comfort
Transport	TRANSPORT O.30	Opportunity	Process	Performance improvement regarding integrated intelligence and automated control

ETP Cluster	SWOT ID	Type	Class	Description
Bio-based Economy	BbE O.13	Opportunity	Services	Intelligent systems to advice consumers based on personal way of life
Bio-based Economy	BbE O.14	Opportunity	Services	Assuring support of claims
Bio-based Economy	BbE O.16	Opportunity	Services	Inventory techniques
Bio-based Economy	BbE O.17	Opportunity	Services	Improve database infrastructure
Cross Initiatives	InS O.07	Opportunity	Services	Intelligent sensors and actuators with improved self diagnosis properties
Cross Initiatives	InS O.08	Opportunity	Services	Software tools for detecting dangerous situations in industrial systems
Energy	ENE O.104	Opportunity	Services	Home Energy Management Systems (HEMS) and Building Energy Management Systems (BEMS) in smart grids
Energy	ENE O.108	Opportunity	Services	Energy-as-a-service is an innovative business model for energy utilities
Energy	ENE O.14	Opportunity	Services	Decentralised load management systems (EU PV TP)
Energy	ENE O.15	Opportunity	Services	Higher controllability of PV systems and loads. (EU PV TP)
Energy	ENE O.16	Opportunity	Services	Functionality to link smart inverters to electricity-consuming devices in homes or commercial premises must be developed. (EU PV TP)
ICT	ICT O.18	Opportunity	Services	Intermodal transportation: convenient and optimised choice of transportation system by integrating data from different traffic information systems and from the ‘smart environment
ICT	ICT O.19	Opportunity	Services	Surveillance and Environmental monitoring and control
ICT	ICT O.20	Opportunity	Services	New services and applications based on hybridization of Earth observation
ICT	ICT O.21	Opportunity	Services	Ubiquitous Messaging Services allowed by satellite M2M networking
ICT	ICT O.22	Opportunity	Services	Smart Systems as providers of content and making available their knowledge base as content
ICT	ICT O.23	Opportunity	Services	Need to care (e.g. including prevention and defence) for increasingly exhaustive private and personal information
ICT	ICT O.24	Opportunity	Services	Smart Systems as enablers of tailored services.
ICT	ICT O.102	Opportunity	Services	E-government
ICT	ICT O.103	Opportunity	Services	Health, inclusion, and assisted living

ETP Cluster	SWOT ID	Type	Class	Description
Production&Processes	M&A O.18	Opportunity	Services	Monitoring services: - Health-person - Buildings - Machinery and Equipment
Production&Processes	M&A O.19	Opportunity	Services	Regenerative medicine
Production&Processes	M&A O.20	Opportunity	Services	Intelligence Services based on: Intelligent Products and Intelligent Buildings
Production&Processes	M&A O.21	Opportunity	Services	Quality assurance services
Transport	TRANSPORT O.101	Opportunity	Services	Existing traffic systems don't provide sufficient information to enable cities to manage traffic flow more effectively
Transport	TRANSPORT O.23	Opportunity	Services	Smart System as components of diverse scenarios: - Equipment health monitoring - Authentication - Ticketing - Traffic management and punctuality
Transport	TRANSPORT O.24	Opportunity	Services	As enablers of new services such as Crisis management
Transport	TRANSPORT O.25	Opportunity	Services	As enabler of new service: Key assets protection
Transport	TRANSPORT O.26	Opportunity	Services	As enabler of new service: Traffic/journey information
Transport	TRANSPORT O.27	Opportunity	Services	As enabler of new service: Intelligent mobility

ETP Cluster	SWOT ID	Type	Class	Description
Energy	ENE O.105	Opportunity	Facilities/Infrastructures	The role that smart grids can play in increasing electricity reliability: adequacy and security
Energy	ENE O.106	Opportunity	Facilities/Infrastructures	Power network infrastructure must be upgraded to enable smart operation
Energy	ENE O.107	Opportunity	Facilities/Infrastructures	During 2015 – 2025 decade the power network needs to become fully automated and interconnected
Energy	ENE O.17	Opportunity	Facilities/Infrastructures	Ageing Monitoring, Prevention and Mitigation, including topics on ageing monitoring of metallic components, R&D topics on concrete material, polymers and electrical equipment, and prevention and mitigation of ageing for metallic components and concrete (SNETP)
Energy	ENE O.18	Opportunity	Facilities/Infrastructures	Modernization of the European meter infrastructure and the introduction of intelligent metering systems will have to happen. Smart meter communication infrastructure and technology. (Smart Grid)
Energy	ENE O.19	Opportunity	Facilities/Infrastructures	Large scale demonstration of smart thermal grids
Energy	ENE O.20	Opportunity	Facilities/Infrastructures	Small-scale transport and storage of CO2
Energy	ENE O.21	Opportunity	Facilities/Infrastructures	Solution need to be found for cost-effectively processing a wide range of sustainable feedstocks
ICT	ICT O.25	Opportunity	Facilities/Infrastructures	Service oriented utility infrastructure for Smart Cities scenario
ICT	ICT O.26	Opportunity	Facilities/Infrastructures	M2M communication enabled platforms
ICT	ICT O.27	Opportunity	Facilities/Infrastructures	Home and building platforms: future homes and offices networked with surrounding smart building facilities up to whole cities and regions
ICT	ICT O.28	Opportunity	Facilities/Infrastructures	Fixed mobile and broadcasting convergence, which aims at integration and creation of a unified communication infrastructure from fixed and wireless mobile networks
Production&Processes	M&A O.103	Opportunity	Facilities/Infrastructures	Asset monitoring and tracking through Internet-of-Things middleware
Production&Processes	M&A O.104	Opportunity	Facilities/Infrastructures	Advanced metering and monitoring of energy consumption in factories
Production&Processes	M&A O.22	Opportunity	Facilities/Infrastructures	Intelligent, safe, energy efficient, healthy, comfortable buildings and underground spaces
Transport	TRANSPORT O.102	Opportunity	Facilities/Infrastructures	Manchester has issued a request for a Dynamic Road Network Efficiency and Travel Information System Solution
Transport	TRANSPORT O.28	Opportunity	Facilities/Infrastructures	High performance rail infrastructures: score in many performance attribute should be improved such as reliability and availability, energy-efficient, safety…
Transport	TRANSPORT O.29	Opportunity	Facilities/Infrastructures	Predictive infrastructure, monitoring capabilities, and intelligence that enable new maintenance services

ETP Cluster	SWOT ID	Type	Class	Description
Bio-based Economy	BbE O.23	Opportunity	General	ETP challenge fits with the technology based challenges of Horizon 2020
Bio-based Economy	BbE O.24	Opportunity	General	Innovative and secure society
Energy	ENE O.22	Opportunity	General	New monitoring and control solutions are needed, to answer several concern society is facing nowadays (drivers) such as: - Increase the reliability and resilience of smartgrid - Reduce uncertainty - Increase concern for the safety of nuclear power plants

12.5.4. Threats

ETP Cluster	SWOT ID	Type	Class	Description
Bio-based Economy	BbE T.01	Threat	Threat	Smart systems are not mentioned in most documents
Bio-based Economy	BbE T.02	Threat	Threat	Interaction of technological knowledge in policy development needs improvement
Energy	ENE T.01	Threat	Threat	Regulatory conditions and financial risk are delaying the deployment of new technologies
Energy	ENE T.101	Threat	Threat	Maintain system security and Cyber security
Energy	ENE T.102	Threat	Threat	Lack of technical standards that will underpin the smart grid system
Energy	ENE T.103	Threat	Threat	Unclear how changes in customer behaviour might emerge
Energy	ENE T.104	Threat	Threat	The convergence of multiple industry members from different backgrounds is required
ICT	ICT T.01	Threat	Threat	Healthcare services requirements
ICT	ICT T.02	Threat	Threat	Customizable user demand focused services will be required
ICT	ICT T.03	Threat	Threat	Actions are required to face Standards, regulation and certification
ICT	ICT T.04	Threat	Threat	Actions are required to face Education and training
ICT	ICT T.05	Threat	Threat	Actions are required to face collaboration
Production&Processes	M&A T.01	Threat	Threat	Smart systems brand (EPoSS) requires to be reinforced. A claim for collaboration among platforms is quite common, but EPoSS isn't mentioned in several documents
Production&Processes	M&A T.02	Threat	Threat	Interoperability standards, protocols, interfaces and adequate software support need to be addressed and developed
Production&Processes	M&A T.101	Threat	Threat	Adopt innovative commercial approaches to large scale delivery through collaborative partnerships
Production&Processes	M&A T.102	Threat	Threat	Technology solutions currently are still fragmented and diverse
Production&Processes	M&A T.103	Threat	Threat	Current robot's difficulties facing tasks involving the manipulation of objects beyond a simple reach-grasp-lift-and-hold task
Production&Processes	M&A T.104	Threat	Threat	Humanoid and mobile robots: actuators and power sources are one of the primary "failure" areas during interactions with people

ETP Cluster	SWOT ID	Type	Class	Description
Transport	TRANSPORT T.01	Threat	Threat	High cost of the required infrastructure
Transport	TRANSPORT T.02	Threat	Threat	Telemetric and telecommunications gaps may also act as barriers to meet future transport objectives
Transport	TRANSPORT T.03	Threat	Threat	There is a need for harmonised standardisation and certification
Transport	TRANSPORT T.04	Threat	Threat	The need to fix the safety problems that automation can potentially cause.
Transport	TRANSPORT T.05	Threat	Threat	Rail industry is facing increasing competitiveness and price pressures which arise structural problems, such as the need to consolidate rail supply industry
Transport	TRANSPORT T.101	Threat	Threat	Fragmented vision on transport infrastructure requirements within some countries
Transport	TRANSPORT T.102	Threat	Threat	Cities are slow to adopt new ITS
Transport	TRANSPORT T.103	Threat	Threat	Fragmented market and value chains
Transport	TRANSPORT T.104	Threat	Threat	The public have a misconception of what ‘Smart Transport’ represents

12.6. References

[1]. Dissel, M. C., Phaal, R., Farrukh, C. J., & Probert, D. R. (2009). Value roadmapping. *Research-Technology Management*, *52*(6), 45-53.