

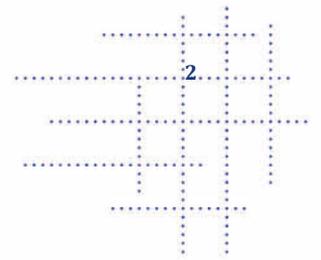
Smart Packaging for Intelligent Logistics



Project plan

Summary (external use)

17 June 2020



A joint initiative of AIPIA and the logistics sector

Smart Packaging for Intelligent Logistics

Summary (external use)

AIPIA
PackZ
DHL
Boston Scientific
Smilde Foods
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Senseanywhere
ItoM
Twinsense
Holst Center
Bright Cape
University of Maastricht/BISCI

IM Efficiency (associate)
SIMSupplychain (associate)
GS1 (associate)
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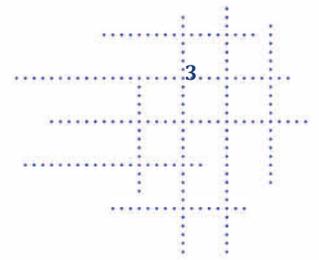


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1. Summary

The Netherlands has a strong international logistics sector. It is facing major challenges and will change dramatically in the coming years due to several ongoing trends. These include increased flows of goods, staffing shortages, and a shift in control to consumers in a world characterised by synchronised transport modes, cross-chain control centres and the desire to reduce the burden of regulation. The shift from containers as a transport unit to monitoring at item level is intensifying. From ship to container, to pallet, to boxes and ultimately to item packaging.



Smart Packaging is becoming the new norm for intelligent monitoring of items and to enable those items to actively communicate the product status during the entire logistics transport trajectory. Smart packaging involves the integration of (invisible) wireless communication and sensors in the packaging. These trends mean that smart packages are penetrating right to the digital heart of the logistics sector. This project is part of the OPZuid programme¹ in the Netherlands because the South Netherlands has the high level of competence required to achieve this.

Smart Packaging stands for intelligent logistics with the following ingredients added: connectivity, integrated sensors, tracking&tracing, invisible watermarks (to support brand protection) and recycling. It helps to extend product shelf life, to improve yields on food and medicines and to reduce fuel and energy consumption. Artificial Intelligence is deployed to meet the huge challenge of translating masses of sensor data into useable information. Blockchain is also an option at product level. These shifts create a digital twin of the supply chain in which customers embrace Augmented Reality (AR) and Virtual Reality (VR) (multimedia) with dynamic pricing as a result.

¹ The Operational Program ERDF 2014-2020 South Netherlands (OPZuid) is a European subsidy program for the Dutch provinces of Zeeland, Limburg and Noord-Brabant. Its main priorities are enhancement of innovation and the transition to a low-carbon economy. The program focuses in particular on innovative SMEs and strengthening cooperation between the business community, knowledge institutions and governments.

The goal of the project is to achieve an integrated solution to Smart Packaging for intelligent logistics. Five specific supply chains (Food, Beverages, Healthcare, High tech and Pharmaceuticals) will be equipped with new Smart Packaging and Smart Supply Chain technology and will be used as demo cases. Brand owners and supply chain partners will test the cases in practice. The project programme will be structured into 6 working groups as shown below.

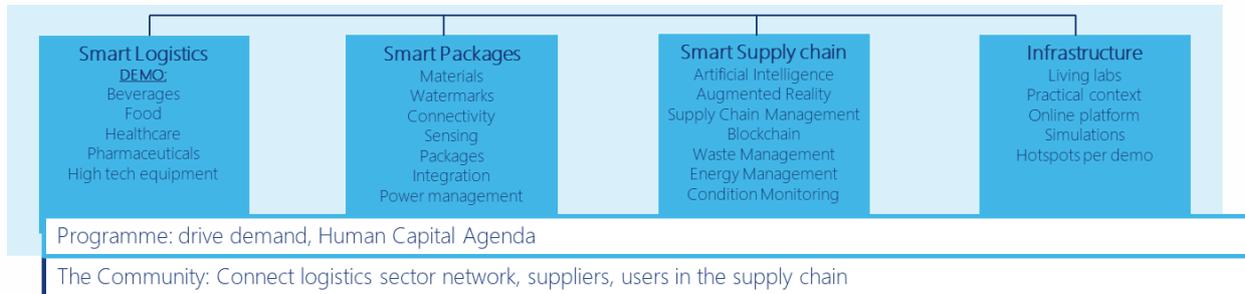


Figure 1: Overview working groups in the innovation programme.

The business case and potential market opportunities are truly remarkable. The combination of the outstanding high tech sector already present in Zuid-Nederland and the excellent international reputation of the Dutch logistics sector as a whole makes this a marvellous cross-over. The calculations made with brand owners show huge revenues. Cautious first estimates already indicate multi-billion turnovers for the sector in Zuid-Nederland. As a global network organisation, AIPIA is the hub for this widely discussed topic which connects chain actors not only in the Netherlands but also in Asia and the US. The result is a strong field of interconnected players from which to generate business.

Smart Packages for Intelligent Logistics is the next step on the path to the future of logistics in which not only physical but also digital supply chains have total connectivity and real-time interactions with users, customers and suppliers.

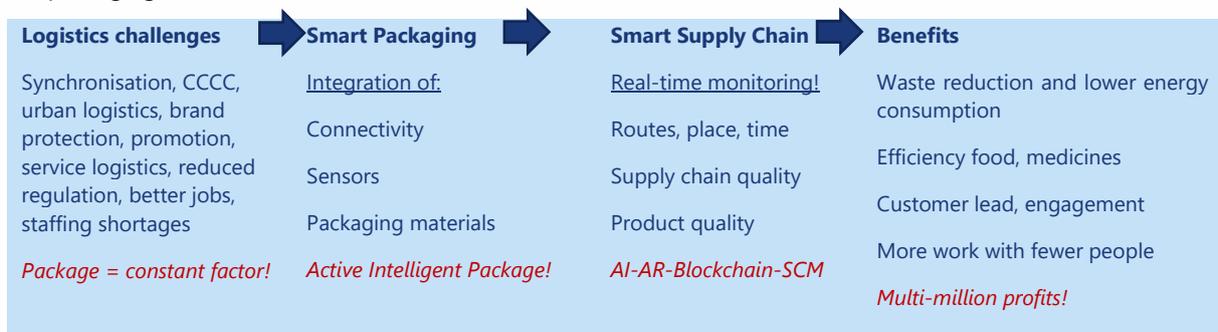
On this journey we will be constantly looking for partners who can contribute to achieving this open system through their technological or other knowledge and skills. This document presents a summary of the Smart Packaging project plan to give insights into the activities. If you are interested in taking part, please contact AIPIA (eef@aipia.info).

2. Project definition

2.1 Background

The logistics sector is facing major challenges and will change dramatically in the coming years due to several ongoing trends. These include increased flows of goods, staffing shortages, and a shift in control to consumers in a world characterised by synchronization, cross-chain control centres and the desire to reduce the burden of regulation.

The shift from containers as a transport unit to monitoring at item-levels intensifying. From ship to container, to pallet, to boxes and ultimately to item packaging, **Smart Packaging** is becoming the new norm for intelligent monitoring of items and to enable those items to actively communicate the product status during the entire logistics transport trajectory. Smart packaging involves the (invisible) integration of wireless communication and sensors in the packaging.

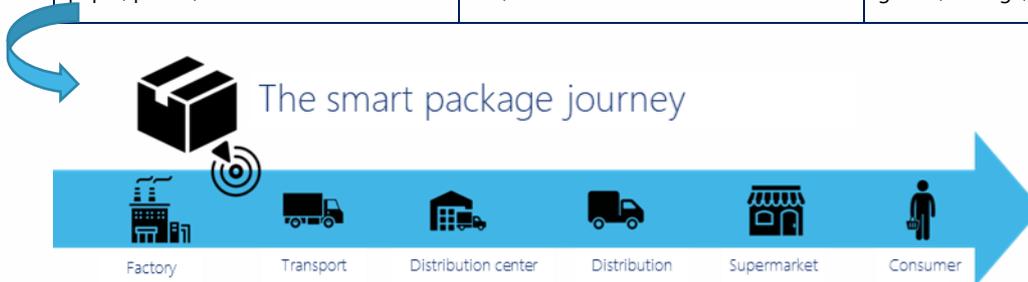


Smart packaging not only monitors product quality but also gives detailed measurements and assessments at every supply chain level. Consumers, transporters and producers alike are increasingly interested in continuously tracking the individual status of items. Smart Packages do this item level through:

- **Continuous connectivity** through wireless internet communication technologies;
- **Real-time track & trace** to check place, route and time information;
- **Real-time condition monitoring** of the product quality and supply chain quality through sensing.

This creates a finely meshed information network for each item: for instance, to monitor the bacterial values and temperature of food products, fermentation of Beverages, shocks to fragile products, or security of seals on pharmaceuticals. Knowledge is power, which in turn can be directed to improve transport and provide security through blockchain technologies. The application of Smart Packaging connects the **physical** product route to the **digital** route!

Packaging material: Glass, cardboard, paper, plastic, wood	Connectivity: NFCs, Wifi, battery, QR+, ICT, ID	Sensing: Temperature, humidity, gasses, leakage, bacteria, shocks
-------------------------------------------------------------------	--------------------------------------------------------	--------------------------------------------------------------------------



Every item has monitoring parameters that are relevant to its condition (shelf life) and quality during and after transport. This project will further develop and standardise these parameters to offer a range of usable monitoring sensors and software applications.



Figure 2: Overview applications, smart package technologies, augmented reality, supply chain links

This brings major benefits. The complete supply chain can be monitored in minute detail using multiple parameters which allow for continuous supply chain improvement (feedback). This level of detail allows for more effective choices on product routing as it provides insight into the most appropriate route for different types of product (e.g. medical products, high tech sensitive equipment or food (feedforward). The availability of massive amounts of monitoring data is the precondition for

- Truly successful **use of Deep Learning** and neural networks
- In turn this allows for application of **Artificial Intelligence** to generate meaningful information on chain categorisation and use
- Security is intensified through connection to sensor data through **Blockchain**
- All of which creates a new generation of prescriptive **Supply Chain Management** as an integrated system
- Connectivity makes the link to **Virtual and Augmented Reality** to achieve customer engagement.

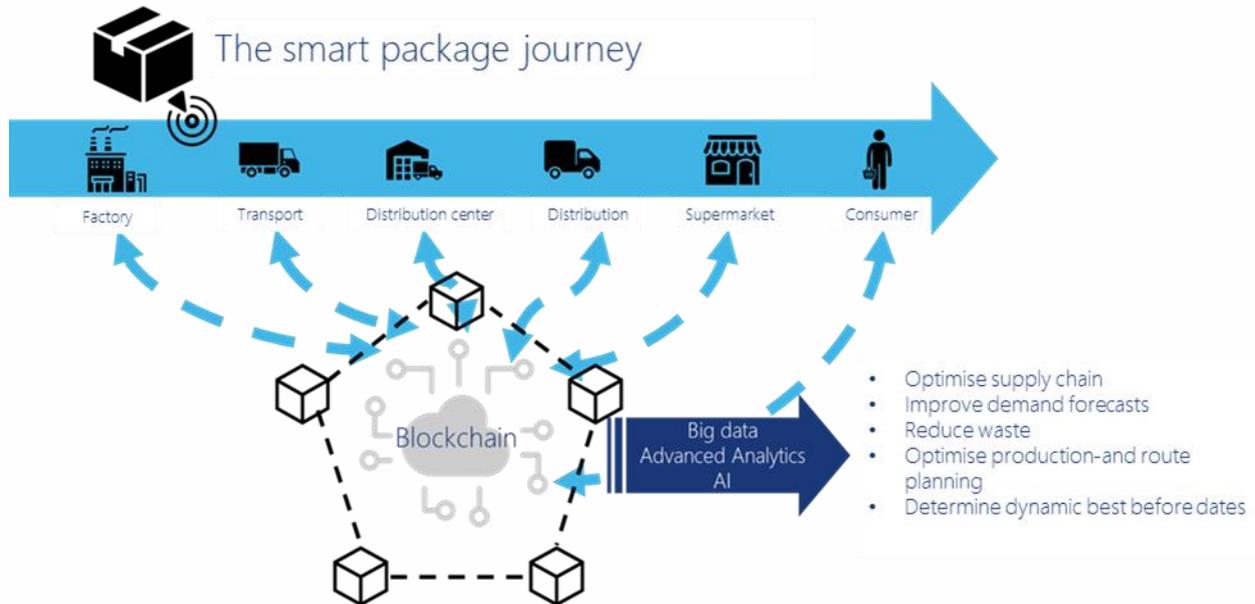


Figure 3: The Smart Package journey through the entire chain with blockchain- and sensing-based benefits

The use of Smart Packaging means that actors makes optimal use of the supply chain (shorter, more appropriate routes) and that product shelf life is extended (monitoring for freshness versus date), products are not damaged in transport (shock monitoring, route selection), medicines are correctly supplied and unused medicines can still be reused at a later date. Smart Packaging is primarily designed to benefit the user and is a way for the logistics sector to achieve cost and time savings and to guarantee and benefit from quality.

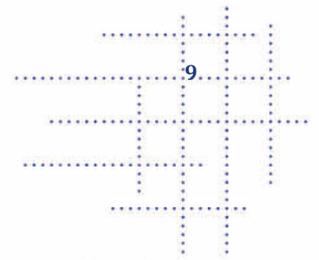
The benefits are huge. To start with, just consider the 190 billion product packages transported around the world each year. Smart Packaging means that large quantities of food can be used instead of tossed, that some medicines can be used after all in the future, and guarantees can truly be applied by using blockchain to make practical connections between monitoring data. The benefits that Smart Packaging creates for the entire chain include:

WASTE REDUCTION	LOWER ENERGY CONSUMPTION	MORE EFFICIENT USE OF FOODS AND MEDICINES
COST REDUCTIONS	SHELF LIFE EXTENSION	MORE WORK WITH FEWER PEOPLE
PREDICTABLE QUALITY OF SUPPLY	REAL PRODUCT QUALITY	BRAND PROTECTION
CONSUMER CONTROL	AUTO ORDERING	CUSTOMER ENGAGMENT

The benefits are huge and have global application. Calculations show how exceptional this is:

Improved use of food: Every western family tosses 24% of the food it buys, which equates to USD 1,600 per family per year. Improved food freshness will certainly improve on this figure by between 25 to 50%. In the Netherlands alone this would save billions of euros. Shelf life extensions would also generate enormous improvements in actually using the food that is produced.

Lower energy consumption: When people reduce waste and recycle more products there is a corresponding reduction in energy consumption which also reduces CO₂ emissions: a 5-10% increase in recycling gives a similar



level of energy saving. In the Netherlands this would again save billions. Of course, it will take time to achieve these savings, but the potential is huge.

More efficient use of medicines: Gradually the instructions on how to use medicines are becoming available in digital form. This saves paper and ensures that the information is always up to date through AR connectivity. The key longer-term gain is re-use of medicines, or rather the option to use medicines that have not yet been opened, for other patients.

Generating less waste Some of the product damage caused in transport can be prevented by adapting the mode of transport (for instance, preventing shocks to sensitive equipment or unnecessary manufacture of products).

Customer engagement, auto ordering, consumer control: If users have a seamless connection to product information through their smart phone, tablet and pc and a corresponding AR/VR experience, a direct relationship springs up between the customer and the user. Research shows that for 64% of respondents experience is more important than price!

Predictable supply chain, real product quality, brand protection: This is what Smart Packaging is all about: monitoring, improving and safeguarding the quality of the product and the supply chain. The customer takes decisions through AR/AR and producers must respond!

2.2 Project goal

The application of Smart Packaging leads to a more efficient supply chain that produces less waste, uses less energy and that costs less. At the same time, it improves the quality of the supply chain, making it more reliable and predictable. Physical products are connected to the digital chain through smart packaging with printed electronics, internet connectivity and smart software based on Artificial Intelligence. This is how the supply chain is optimised and feedback is obtained from the customer base.

Continuous improvement by all stakeholders in the supply chain, in our case implemented in multiple sectors such as Food, Healthcare and High tech equipment. Mobilisation of all the stakeholders in the chain creates an integrated approach to optimise supply chain solutions. Together we make the best choices, bearing in mind individual interests at the same time.

Goal: *To develop an integrated solution with **Smart Packaging** to:*

Deliver products to consumers which are in good condition, secure and subject to control

Monitor individual products through integrated sensors, connectivity and data processing in the supply chain

Use AI and Deep Learning to monitor, categorise and improve the supply chain

Create customer engagement through AR/VR which puts the customer in the lead

We expect that the cost savings in the logistics chain will represent 10-15% of the total costs!

This goal translates to the following technical and organisational goals:

Technical goal

- Develop 5 complete demo routes based on the logistics demand for smart packages
- Develop standard solution for connectivity, sensors, packaging concept
- Develop solution to link smart package with supply chain software, AI, AR, VR and Blockchain

Organisational goal

- The entire chain for Food, Beverages, Healthcare, HTSM equipment and Pharmaceuticals, with examples
- Launch the standardisation process in the entire multidisciplinary community
- Connect the current logistics hotspots in the Netherlands with the leading players
- Connect with related initiatives in logistics and technology programmes
- Connect networks with AIPIA, logistiekNL, Printed Electronics and Smart Systems

The technical and organisational goals will be mutually reinforcing as demo projects are conducted and consortium members start to work together. The ecosystem will also be enhanced as we organise network and matchmaking events, particularly in the logistics hotspots and with related project programmes.

2.3 Results expected from the project

The specific results we expect are related to five chain projects in the chosen sectors. These will specified, developed, built, tested and implemented in a user situation at all stages in the chain We believe that conducting the demo projects in this very practical way will create a forum for sharing and disseminating knowledge through the Zuid-Nederland region and beyond. The table below shows the 5 chain projects and some key players involved in these chains.

PRODUCT PRODUCERS			TRANSPORTCHAIN				DISTRIBUTION TO USER		
SECTORS	SENSING	PACKAGING	REPACKAGING	TRANSPORT	STORAGE: HOTSPOTS	TRANSPORT	DISTRIBUTION	LAST MILE	USER
BEVERAGES	PRODUCER	PACKAGER	SMART PACKAGE	DELIVERY VAN	1. WEST BRABANT	DELIVERY VAN	DC, WINKELS	DELIVERY VAN	USER
FOOD	PRODUCER	PACKAGER	BOX	LORRY	2. TILBURG WAALWIJK	LORRY	DC, WINKELS	DELIVERY VAN	USER
HEALTHCARE	PRODUCER	PACKAGER	PALLET	SHIP	3. VENLO VENRAY	SHIP	DC, WINKELS	DELIVERY VAN	USER
HIGHTECH	PRODUCER	PACKAGER	CONTAINER	TRAIN	4. OSS VEGHEL DEN BOSCH	TRAIN	DC, WINKELS	DELIVERY VAN	USER
PHARMA	PRODUCER	PACKAGER	X CONTAINERS	AIRCRAFT	5. HELMOND EINDHOVEN	AIRCRAFT	DC, WINKELS	DELIVERY VAN	USER
SMART PACKAGE									
SUPPLY CHAIN MANAGEMENT									
HANDLING									

In the entire chain smart packages are produced, collected, transported, redistributed and delivered (and sometimes returned). The three distinctive features are:

1. Smart package: to monitor the product parameters and the connectivity;
2. Supply chain management: to control, improve and make full use of the chain;
3. Handling: to physically handle the diversity of products.

The third feature (Handling) will be the topic of a separate project within OPZuid in collaboration with Holland Robotics. Robotics solutions will be applied to handling throughout the chain and will be linked to the Smart Packaging project at a later date.

The project programme is organised via working groups structured according to the results expected.

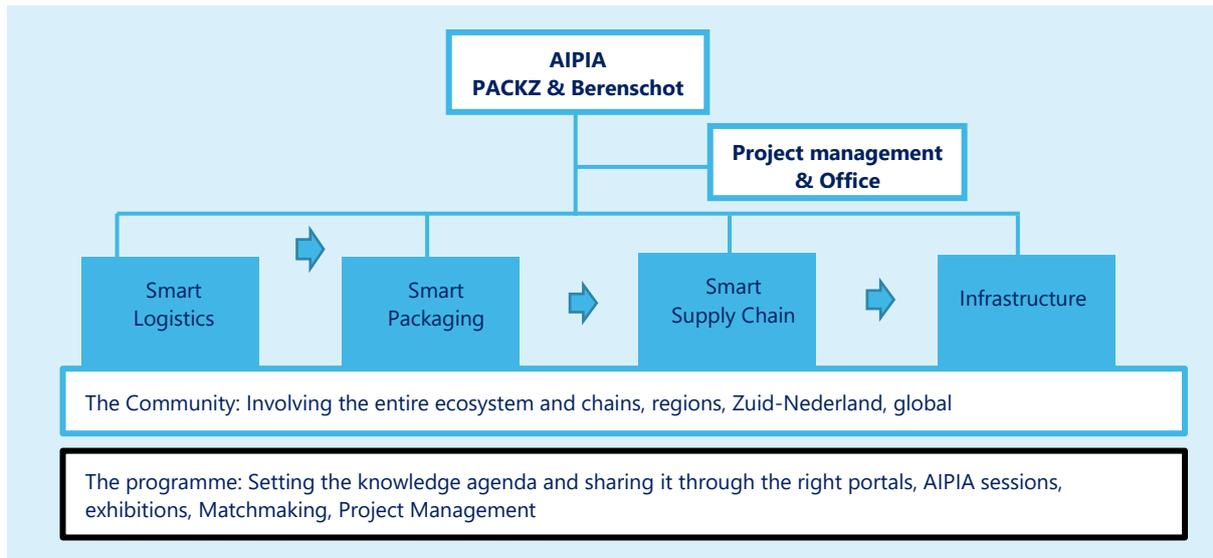


Figure 6. Detailing the working groups and project structure

Smart Logistics: The starting points for the entire ecosystem programme are the new logistics and packaging innovations for the specific product and its related packaging for Food, Beverages, Healthcare, Pharmaceuticals and High tech equipment. Each of the 5 project sectors has its own set of product requirements, such as monitoring of temperature, humidity, leakage, bacteria, gasses and, for instance, shock to detect physical damage. The challenges per project sector are:

DEMO		SMART LOGISTICS				SMART PACKAGES				SMART SUPPLY CHAIN			
Demo name	Sector	Demo case	Full/Filment	Logistics	Test/demo	Materials	Connectivity	Sensing	Package	AR/VR	SCM	Blockchain	AI/ML/DL
Traceability	Beverages	Demo A	Chain impact	Transport processes	Beverages in bottles	Glass	RT, battery, BYOD	Temp, humidity	Single items, bottle	Origin, care	Route and data	Check on values	Statistics, monitoring
Freshness	Food	Demo B	Chain impact	Transport processes	Meat, vegetables or fats	Bioplastic	Sample time, battery,	Temp, leakage, bacteria, gasses	Single items box	Origin, recipes, experience	Route and gegevens	Check on values	From sensor-data to info
Security	Health care	Demo C	Chain impact	Transport processes	Equipment, implants	Foils, cardboard	RT, battery, registration, wifi	Temp, leakage, Shocks, hygiene	Single items box	Instructions for use	Route and data	Check on values	From sensor-data to info
Quality	High tech	Demo D	Chain impact	Transport processes	High Tech equipment	Plastics	RT, battery, registration, wifi	Temp, shocks, ESD, particals	Single items box	Application	Route and data	Check on values	From sensor-data to info
Diversity	Pharmaceutica	Demo E	Chain impact	Transport processes	Transport of medicines	Foils, cardboard	Pallet check to product	Temp, humidity, leakage, gasses	Single items box	Personal instructions, use-trigger	Route and data	Check on values	From sensor-data to info

Smart Packaging: The requirements for the specific products are translated into the packaging materials: cardboard, paper, glass, plastic, wood or organic materials. Smart sensors will be developed which can measure the specified parameters for these packages. Using printed electronics the sensors will be integrated into the package and will mostly be invisible. Using the same techniques, connectivity will be added through NFC chips, bluetooth and wifi, lofar options, energy supply and battery technology too!

Smart Supply Chain: All these sensors will generate large amounts of monitoring data linked to the time, place and route of the specific products. Using Deep Learning (neural networks) AI technology can translate the data into truly useable information about the quality of the product and the supply chain. Block chain can be used to develop proper authorisation relating to the specific product.

Infrastructure: Within the overall project the 5 demo projects will be run in the different chains. For instance, the meta data required in the Food supply chain will be developed, simulated, built and tested through the sensors and connectivity in the smart packaging. The functions will be tested in test centres before the packaging is sent 'out into the world'.

The community: In order to share all the practical and theoretical knowledge gained from the demo projects with the entire logistics community, the meet&match programme will target actors from the logistics hotspots, particularly Zuid-Nederland. In this way we will involve not only logistics partners but also actors in the entire supply chain. A chain approach is vital to make a real impact in the market.

Programme: We are preparing a separate section of the AIPIA website to facilitate programme participation by other parties which will also make a direct connection to the global players. AIPIA organises various global events which attract new audiences every year: in the US (2 locations), Asia (2 locations) and, of course, in our home market in the Netherlands (at the Beurs van Berlage in Amsterdam).

3. Project activities

The six working groups in the project are illustrated below.

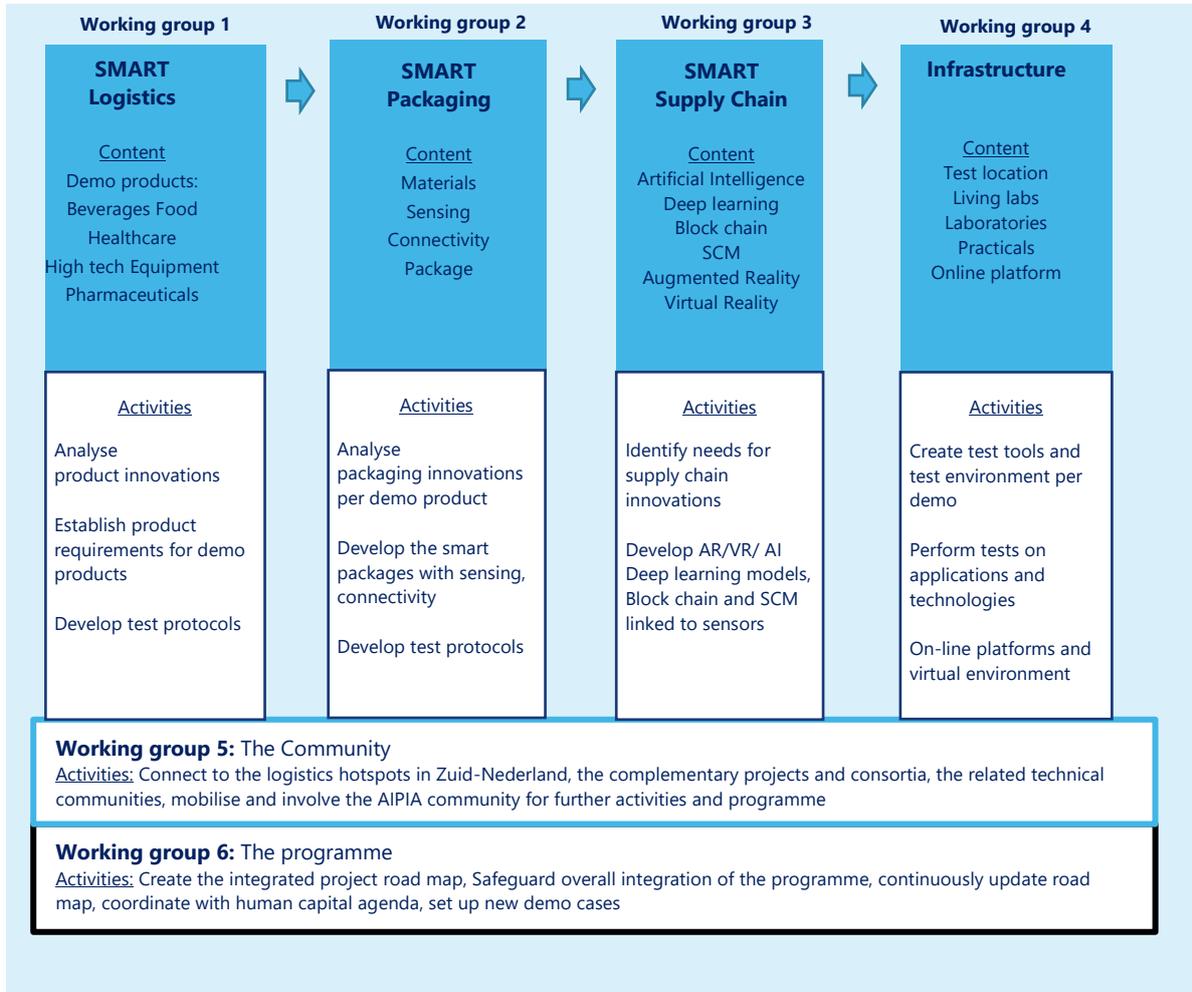


Figure 8. The working groups and their activities within the project

4. Business case

4.1 Arguments to support the Business case

There are three key arguments that support the business case for this project programme:

- The benefits for the logistics sector
- The benefits for the packaging industry
- The benefits for the 5 chosen sectors

Benefits for the logistics sector

The logistics sector in the Netherlands has an annual added value of EUR 53 billion a year and employs 646,000 people. It is therefore a major player in the Dutch economy. It encompasses not only transport and storage companies but also logistics and supply chain functions within forwarding companies. As a key sector in the Dutch economy, logistics supports businesses in other sectors, where logistics accounts for between 8-18% of costs (depending on their size). Their market position depends in part on efficient logistics for timely and reliable deliveries. The improvements that Smart Packaging can bring are therefore vital. The logistics sector needs to increase its production to meet the future needs of the growing world population.

Smart Packaging makes it possible to actually use the foods and medicines produced and reduce waste flows. This will automatically reduce energy consumption, CO₂ emissions and staffing levels. Smart Packaging could bring efficiency gains of between 10-12%, which would equate to at least EUR 10 billion in potential savings.

Smart Packaging makes a game-changing contribution to all three ambitions of the logistics sector in the Netherlands:

1. Handling flows of goods
2. Chain management
3. Attractive innovative country

Benefits for the packaging industry

Packaging industry production in the Netherlands shows an average annual growth of 1.5 to 2 percent. This was equivalent to a EUR 6.5 billion turnover in 2018. The key growth drivers are rising consumer spending, the sharp increase in online retail sales and the persistent growth in exports. In particular, annual volume growth of plastic packaging is 2.5 percent. In 2016 plastic packaging accounted for some 43 percent of turnover (EUR 2.7 billion) but only 18 percent of weight. Reduced packaging weights are an ongoing industry trend because of the benefits relating to costs of materials, and transport and environmental savings. The weight of plastic packaging is now almost 30% lower than ten years ago.

Smart Packaging will create extra added value for the packaging industry. With particular gains in reduced energy consumption (in logistics), in the added value that smart packaging brings and in gains for end users of the products.

Benefits for the 5 chosen sectors

The main benefits of Smart Packaging can be found in particular in the chosen sectors.

Healthcare and Pharmaceuticals	Food and Beverages	High tech equipment
<p>WHO research shows that 50% of all prescribed medicines are not used effectively. People</p> <ul style="list-style-type: none"> • Don't use the medication • Forget the dosage • Don't take it at the right time 	<p>Research by the World Resources Institute shows that:</p> <ul style="list-style-type: none"> • 1.3 billion metric tonnes of food are wasted every year • In 2050 we will need 60% more food to feed a global population of 9 billion people 	<p>Sector research shows:</p> <ul style="list-style-type: none"> • EUR 25 billion annual spend on maintenance. • HTSM market is EUR 120 billion, with EUR 43 billion added value
<p>Multiple studies show the impacts on the sector:</p> <ul style="list-style-type: none"> • USD 100-290 billion in the USA • USD 125 billion in the EU • USD 564 billion global 	<p>Currently we throw away</p> <ul style="list-style-type: none"> • 24% of all food • USD 1,600 per family in the west! • In the USA = USD 24 billion • In the EU = USD 36 billion 	<p>Annual monitoring of the effects of transport on sensitive equipment is increasingly becoming a must.</p> <p>Precise figures will emerge during the project but we expect the impact to be high</p>
<p>At least 10-15% of the benefits worldwide will certainly derive from Smart Packaging</p>	<p>At least 10-15% of the benefits worldwide will certainly derive from Smart Packaging</p>	<p>Gains are expected due to supply chain improvement</p>