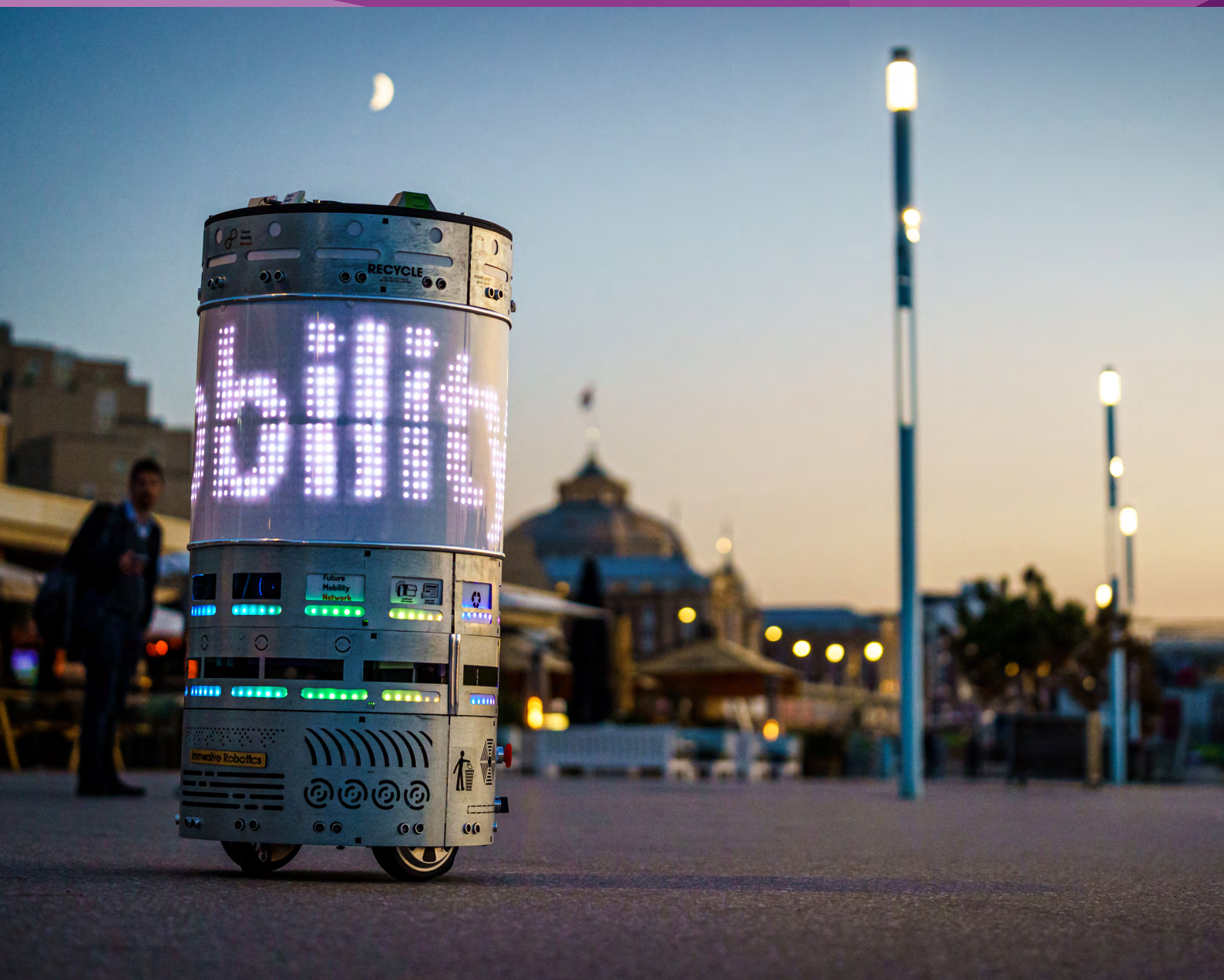# Smart technology in public spaces

Lessons and successes from 5 years of Living Lab Scheveningen

Den Haag

Living Lab Scheveningen (LLS) is perhaps the most unique living lab in the Netherlands. Since 2020, the Municipality of The Hague has been testing a smart city infrastructure there to assess whether and how it can contribute to the social issues of mobility, safety & security and energy transition. It is precisely by experimenting in public spaces that the municipality learns about the opportunities and challenges of new technology in the city. In this publication, the LLS team shares experiences with building the infrastructure and its use for the safety and liveability of the seaside resort, among others.

## Smart city

In November 2021, the Municipality of The Hague received the World Smart City Award in the Energy & Environment category: a prestigious recognition for the Living Lab's journey up to that point. That journey began in 2014 with the introduction of the 'Smart City The Hague Roadmap' and has since resulted in the construction of a digital infrastructure in Scheveningen and the development and implementation of several smart applications.

## Smart infrastructure

On the boulevard in Scheveningen, the municipality has installed a fiber optic network, running from the Zwarte Pad in the north to the Noordelijk Havenhoofd in the south. Underground, that network connects street furniture such as lampposts, kiosks, charging poles and bus shelters. Above ground, those objects can be equipped with cameras, sensors, antennas and network equipment. In that way, they can support a range of new digital applications. All together, this forms the digital infrastructure, also known as Smart City Infrastructure (SCI).

That infrastructure enables technological solutions to societal challenges, for example crowd measurement and port registration for safety and liveability in the area. But also local storage and distribution of sustainably generated electricity, helping to prevent grid congestion.

## Unique for several reasons

LLS is a testing ground in public space. It is a vast area in which people live, work and play. Unlike most living labs, it is not a demarcated area or regulation-free zone, so all laws and regulations relating to public space must be complied with. This makes it not only a testing ground for the technology itself, but also a collision test with laws and regulations. In addition, it is important to think about how the technology will fit into its surroundings, so that the outdoor space does not become cluttered.

Its seaside location adds further dimensions: shipping and activity in the port, plus a lively beach and surf culture in the seaside resort. On sunny days and during events, it can get extremely crowded. There are also two Natura 2000 sites on the north and south sides, adding further complexity. In short, with Scheveningen, the municipality has (deliberately) chosen an interesting but complex test environment.

## Area, use and technology

In Scheveningen, The Hague is applying an integrated approach in which area development directly considers the use and construction of technology – the LLS team's vision is 'area, use, technology'. The development of smart applications and digital infrastructure goes hand in hand with area development and matches the specific issues of the location in question. For new applications, it assesses what type of camera or sensor is needed and where best to place it. The existing infrastructure enables new equipment to be connected easily and without digging.

## In-house

After exploring the options with market players, the municipality decided to build both the underground and overhead digital infrastructure in-house – rather than purchasing them as services. This enables the municipality to gain its own experience with all facets of infrastructure development and applications, and define its own role in this process. By owning the network, the municipality maintains control over the architecture and data sources. Moreover, it is not dependent on external parties for the costs and conditions of using the infrastructure.

'We knew that technology would become increasingly important to keep public spaces liveable. As a municipality, however, we had yet to learn how to deal with this. By joining the restructuring of Scheveningen's boulevard, we have saved a great deal on costs and created an environment in which we can learn and innovate together with residents and entrepreneurs.'

Marijn Fraanje, former CIO, currently Director of Spatial Planning and Economy.

'As a municipality, you want to make sure that residents' data is handled carefully. That's why we chose to do it in-house at the time.'

Dirk van Brederode, former Project Leader of Smart City at the Municipality of The Hague, currently Manager Digital Society, Association of Netherlands Municipalities [*Vereniging van Nederlandse Gemeenten*, VNG]

## Socially relevant innovation

This is important, because new technology brings new dilemmas. These can include data collection and privacy. The Municipality of The Hague has become increasingly critical of data collection in public spaces and wants to retain control over it. By, indeed, testing in public spaces, the municipality gains a better understanding of the ethical, legal and social implications of using new technology.

## Included in area development

In 2017, there were plans to revamp the boulevard under the *De Kust Gezond* ['A Healthy Coast'] programme. This was a good opportunity to think about building a digital infrastructure. The restructuring of the boulevard enabled a great deal of work to be carried out simultaneously. Since the ground would be opened anyway, the first section of the fiber network could also be laid immediately. As a result, the cost of construction was only a fraction of the investment that would have been required had it been realised separately.

In 2019, the Hague City Council adopted a proposal to fund the digital infrastructure. For the period from 2019 to 2024, the municipality has made €535,000 available annually for this, with contributions from the province of South Holland and the Rotterdam The Hague Metropolitan Region [*Metropoolregio Rotterdam Den Haag, MRDH*].

'Due to the '*De Kust Gezond*' programme, groundwork has already started on the boulevard. We took advantage of this work to immediately lay the digital infrastructure simultaneously. This enabled us to link these later – at no extra cost or inconvenience to residents – with above-ground facilities such as lampposts and kiosks.'

Ruben Strauss, Project Manager Engineering Office [*Ingenieursbureau*].



**Legend**
- Cable conduits at strategic locations
- Basic infrastructure without branches
- Basic infrastructure with branches to hubs

The Pier

Westbroekpark

Harbour

Tramline

4
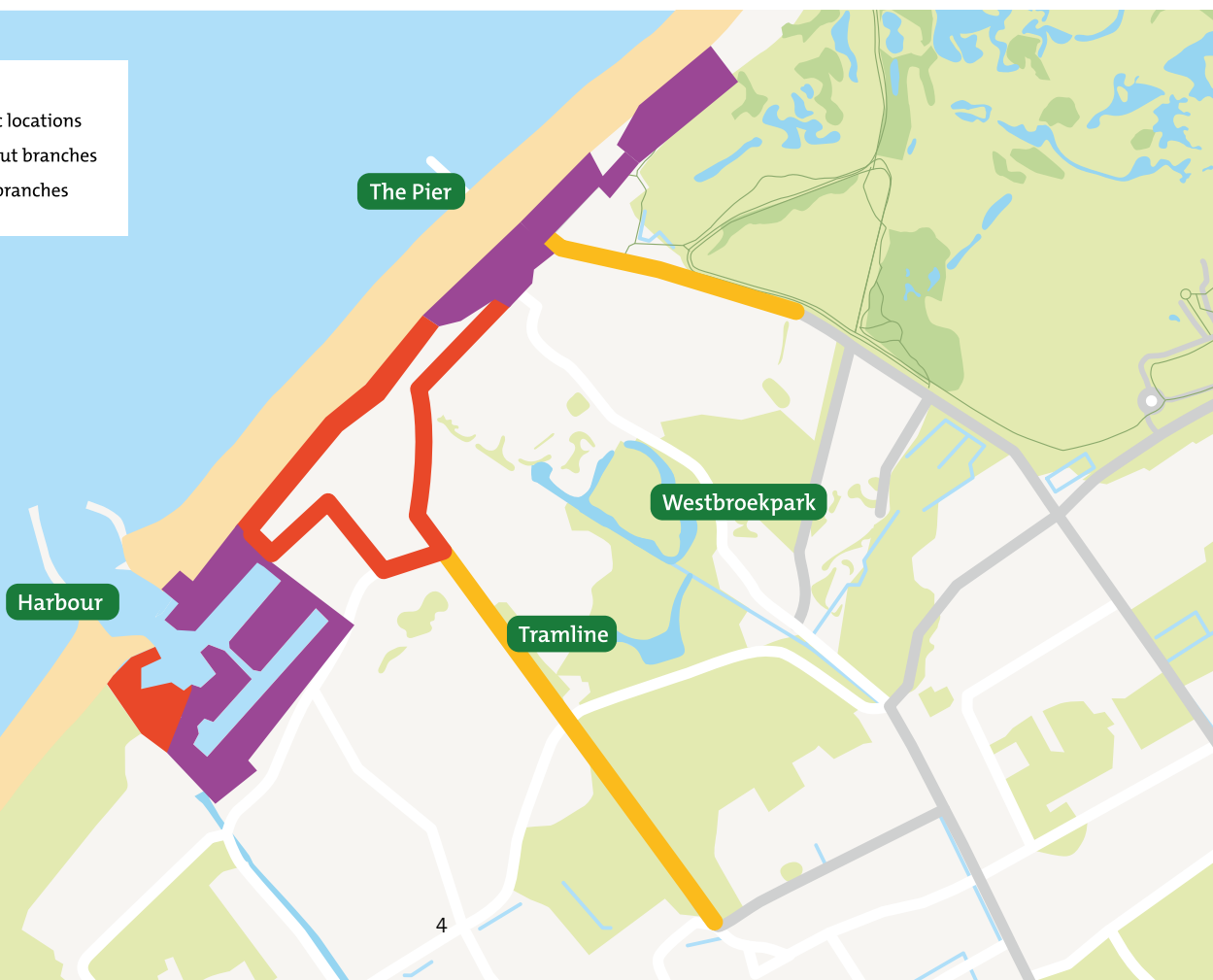
## Initial applications

The LLS team was already able to start developing the initial applications in 2020. This began with a pilot project using noise sensors, which were able to distinguish various types of noise, giving better insight into the causes of noise pollution experienced by residents. Other applications from that time were intended to make visitors aware of the possibilities of technology in public spaces. Examples include a robot that cleans up cigarette butts after a busy beach day, a self-driving rubbish bin that cleans up litter on the promenade, and children's bracelets with a QR code to reduce the likelihood of going missing.

## Innovations successful *and* discontinued

In selecting possible applications, the LLS team was able to draw on an extensive list of 150 ideas. These had already been drafted with residents, business owners and municipal departments in 2017. Some of these ideas have evolved into successful, scalable innovations that are now actually in use. These include the Crowd Safety Manager (an advanced 3D map that displays crowds in an area in real time), the Scheveningen Harbour Registration System and the Smart Beach Grid (an energy grid for local distribution of sustainably generated energy).

Other projects have been halted for various reasons. In some cases, the solution was too expensive, implementation proved unfeasible in practice or the technology did not work well (enough) – as was the case in a pilot for identifying riots. In one case, although the technology worked well, there was no longer a social need for its application. This was the case with the smart camera that could detect the use of nitrous oxide using artificial intelligence. The problem with nitrous oxide had now subsided on the boulevard, so the use of technology to combat it was no longer considered proportionate.

## Municipal client

The LLS team initially made its own choice of innovations but gradually shifted its focus to solving specific problems for local municipal clients, such as the Port Authority, the Mobility Department, the Energy Transition team, the Public Order and Safety Directorate, the police and Scheveningen district council.

That collaboration with municipal clients is crucial. This assesses an initiative not only for technological feasibility, but also for its applicability within the municipality's existing processes and procedures. Asking the client to co-pay for the solution reinforces commitment. This increases the chances of the solution actually being adopted by the internal organisation. Increasingly, external parties are also contributing financially because they have an interest in using the digital infrastructure, such as the police and event organisations.

## Innovation difficulties

Innovation is often accompanied by challenges and unexpected developments, requiring flexibility and adaptability. A good example is the State Council's nitrogen ruling, which had major consequences. The decision halted the construction of a new boulevard in front of the Kurhaus hotel. This subsequently delayed the development of part of the digital infrastructure.

In addition, the rollout of 5G is slower than expected in 2019. This reduced the need to install small 5G antennas (small cells) on street furniture (hubs). On the other hand, some applications have actually become possible thanks to the rapid development of certain technologies, especially the emergence of artificial intelligence (AI).

## Daily practice

In addition to external hurdles, Living Lab Scheveningen also has to deal with day-to-day practice, which is often the biggest challenge for innovations. For example, some existing lampposts cannot be connected to fiber optics because the municipality has agreed with residents that there will be no digging in that area in the coming decades. In addition, the 14 new smart lampposts, which actually do have fiber optic connections and are equipped with connection points for power, sensors and cameras, create new maintenance challenges for the Public Lighting and Charging Infrastructure [*Openbare Verlichting en Laadinfra,* OVL] department.

LLS may be a testing ground, but it is fully embedded in everyday life and work. Every trial, every application and every decision must take into account both the new and the current situation, on all fronts: from design to maintenance and from working methods to legislation.

'By having a visible presence on the boulevard, the lab increases awareness and support among residents, business owners and other stakeholders. Here, we can quickly test solutions to local issues and jointly shape the use of technology in our district.'

Mendy van Veen, City District Director Scheveningen

'For the Public Lighting and Charging Infrastructure Department, the Living Lab is an excellent opportunity for management to discover how new technologies work. We included our experiences with the smart lampposts in the tender for making 28,000 light fittings in the city smart.'

René Oomkes, Manager of Public Lighting and Charging Infrastructure (OVL).

# Embedding in existing organisation

Along with the construction of the infrastructure comes the question of how to manage it. Because the digital infrastructure is completely new to the municipality, there are no existing processes, protocols and manuals for management, maintenance and expansion yet. For example, who will clean the cameras, which quickly become soiled by sand and salt? And what about billing and VAT if the municipality will supply power to beach pavilions through the Smart Beach Grid? One LLS team member even completed a brief training course to become an installation manager, because this knowledge was legally required but difficult to take on within the existing organisation.

In addition to various practical, organisational and legal issues, the position of the LLS team within the civil service structure of the municipality is also a challenge. Where does administrative responsibility for the living lab lie? And what place in the organisation is best suited for a small team with a unique mission and a different way of working from the usual civil service organisation?

## Search for the optimal embedding

The Smart City team, originally set up within the Urban Development Department [*Dienst Stedelijke Ontwikkeling, DSO*] Economics, together with the Energy Transition and Resilience teams, was transferred to the Department of Municipal Administration [*Bestuursdienst, BSD*], led by a quartermaster. The Smart City team then moved to the CIO office of the Department of Municipal Administration. Here, the Living Lab Scheveningen was set up, led by an executive-level management group with representatives from BSD, DSO and the Department of City Management [*Dienst Stadsbeheer,* DSB]. This brought together expertise in the fields of area development, urban management and digitalisation – an essential combination of area, use and technology.

The team consisted of internal and external staff, who were fully available to set up the living lab.  They worked alongside DSO and DSB staff, who divided their time between their regular duties and LLS. Later, the CIO office was transferred from the Department of Municipal Administration to the Directorate of Information & Automation (I&A), and the LLS programme moved with it. This made collaboration with departments responsible for technology easier. But the distance to area (DSO) and use (DSB) increased. As of two years ago, the LLS programme has been merged with other Smart City projects in I&A's Digital Innovation and Smart City Expertise Centre.

# Transparent – including about privacy and ethics

To build support outside the municipality, it is important to make projects concrete, tangible and visible. Living Lab Scheveningen is tackling this in several ways. One of the initiatives is Smart@Sea, an annual participation festival on the boulevard. This festival is organised mainly to engage school-children, students and young professionals in the possibilities and limits of smart city applications.

Local residents play an active role in shaping the 'Innovation Table in Scheveningen' – themed sessions in which they are directly involved in the Living Lab. There is also the Scheveningen Info Point [*Infopunt Scheveningen*], located next to the Pier. Here, visitors can get information and participate in tours of the Living Lab throughout the year. Since 2020, 2,000 people have participated in these activities, including residents, administrators, council-lors and boulevard visitors from the Netherlands and abroad.

The various forms of participation also address issues such as privacy and ethics. For LLS, it is crucial to discuss these issues, as the pursuit of socially responsible innovation is central. For that reason, tools such as IAMA, DPIA and Ethics Tables are used in innovation (see box). These tools help determine the impact of data processing or algorithms in advance. This approach is in line with the Principles of the Digital Society (Association of Netherlands Municipalities [*Vereniging van Nederlandse Gemeenten*, VNG]) and the Hague Data Strategy, which emphasise ethical data use, protection of personal data and social utility.

The Municipality of the Hague is transparent regarding the pilots being carried out and how it collects and uses data. Among other things, the municipality provides various registers, which can be accessed on the website.

## Tools for assessing and safeguarding privacy & ethics

- Human Rights and Algorithms Impact Assessment [*Impact Assessment Mensenrechten en Algoritme*s, IAMA]: helps assess the potential human rights impacts of algorithms.
- Data Protection Impact Assessment (DPIA): identifies in advance the privacy risks of a data processing operation and helps in taking measures to mitigate these risks.
- Guiding ethics [*Begeleidingsethiek*]: ethics tables, workshops with stakeholders on the connection between ethics and technology
- Moral deliberation [*Moreel Beraad*]: offers participants the opportunity to collectively discuss ethical issues from their work.
- The Ethical Data Assistant [*De Ethische Data Assistent*, DEDA]: supports data analysts, project managers and policymakers in recognising ethical issues in data projects, data management and data policy.
- Digital Mirror City ethical framework [*Ethisch kader Digitale Spiegelstad*]: developed by the Municipality of The Hague based on national guidelines. Will be used to develop a digital mirror city (a 3D city model that visualises all of the data).

'The ELSA Lab AI MAPS is a research programme focusing on the ethical, legal and societal aspects of AI applications for public safety. The Living Lab Scheveningen offers us as academics the opportunity not only to discuss these values theoretically, but also to test concretely, together with the municipality, how to preserve these values when using technology.'

Gabriele Jacobs, Professor of Organisational Behaviour and Culture, Erasmus University Rotterdam

# Applications

This is a selection of the applications being developed at the Living Lab Scheveningen. More information on other applications can be found on the website.

## Crowd Safety Manager (CSM)

- **Social relevance:** Safety and liveability.
- **Innovation:** An advanced 3D map that visualises congestion in an area in real time based on data from various data sources, including traffic counts, car park occupancy, public transport, anonymous visitor location data and the weather. The map can only be accessed by authorised employees of the municipality and police.
- **Goal:** The 3D map enables police and the municipality to manage crowds preventively, for example by deploying traffic controllers, enforcement officials and police officers.
- **Together with:** Police, municipality and market players for technology.
- **Status:** The CSM was successfully tested in 2022 in Scheveningen. Since then, the tool has been deployed during the beach season and at several major events around the country. A few examples are the Invictus Games and the Vuelta in 2022, King's Day in Rotterdam in 2023 and King's Day in Emmen in 2024. In addition, the tool was used at The Life I Live festival in The Hague in both 2023 and 2024.

## Crowd measurement

- **Social relevance:** Safety and liveability.
- **Innovation:** Cameras with smart software that can calculate from images the number of people present at a given location. Privacy is ensured because images are translated directly at the source into numbers of people and then immediately deleted.
- **Goal:** Display up-to-date information on crowds on the boulevard in the Crowd Safety Manager. This helps to take the appropriate measures during busy summer days in Scheveningen.
- **Together with:** An Italian technology company and a European camera supplier for the technology and with the police to install the cameras. In addition, crowd density data is shared with the police via the Crowd Safety Manager.
- **Status:** Crowd density data from the smart cameras on the boulevard will be displayed in the Crowd Safety Manager starting from summer 2024 during the beach season.

## Port registration system

- **Social relevance:** Safety and liveability.
- **Innovation:** A privacy-friendly video registration system that automatically detects boat traffic entering and leaving the port using artificial intelligence. The date, time, type and cruising speed of the vessel are recorded for each sailing movement, with no crew members in view.
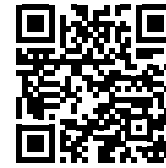
'Together with the municipality, we set up SHIELD, an innovation hub where we experiment and learn about digital innovations that promote safety in the city. In the Living Lab at Scheveningen, we can investigate which of these innovations have potential to be applied on a large scale. For example, the Crowd Safety Manager. That was started in Scheveningen and then also deployed for King's Day.'

Johan van Rijn, Manager Innovation Team, Police Unit The Hague.
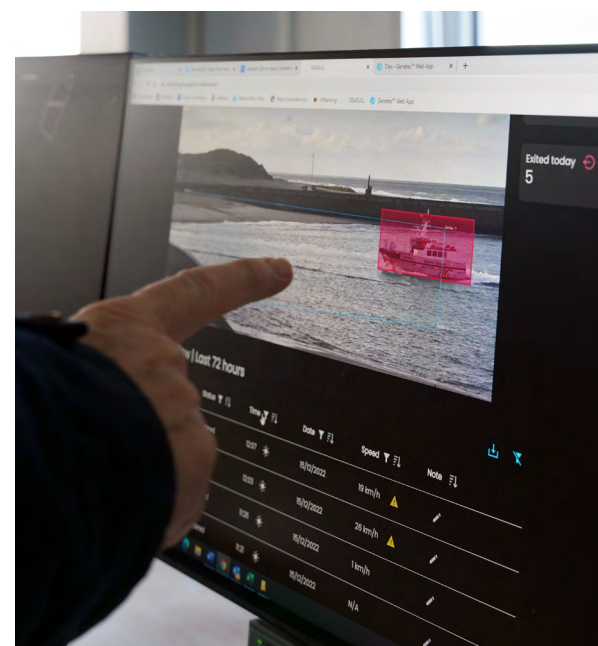
- **Goal:** The information offers the Port Authority greater visibility – literally and figuratively – of inbound and outbound maritime traffic in the port. This is needed to strengthen port management.
- **Together with:** The Port Authority and market players for technology.
- **Status:** The system was put into operation in late 2022. In cooperation with the police, a study is being carried out of how the data from this system can contribute to tackling undermining.

## Sound sensors
- **Social relevance:** Sound and sound perception.
- **Innovation:** Nine noise sensors have been installed on the boulevard to record noise nuisance. An algorithm converts the sounds into a spectrogram, which distinguishes between types of sound. The recordings are removed immediately afterwards and privacy is not compromised.
- **Goal:** The boulevard generates a great deal of noise in summer, from beach tents, parties, recreational users and traffic. This can create a nuisance for nearby residents. The municipality wanted to use the (objective) data to talk to local residents about the (subjective) experience of noise pollution. What noise is perceived as a nuisance, and when? The innovation also enabled a 'sound prediction' to be made and accessed through a web page.
- **Together with:** A startup from The Hague that provided the technology and some residents of the flats on the boulevard (for sensors on their balconies).
- **Status:** The trial ended after two years and the sensors were removed. Sound recognition did not work well, and the data could not be properly utilised within the municipal organisation.

## De 'Wave'
- **Social relevance:** Health, safety.
- **Innovation:** A sports beach is located on the boulevard. To encourage people to exercise more at night as well, lighting was needed. For that reason, in 2021, the Wave was installed: a smart light column made of 3D-printed beach sand with sensors, which responds to athletes' movements using hundreds of lights.
- **Goal:** Increase the sense of safety and challenge people to exercise more by means of a single solution using lighting.
- **Together with:** A Rotterdam-based technology startup. This company was selected from the Startup in Residence Intergov programme: an innovation programme in which startups collaborate with governments on innovative solutions to societal challenges.
- **Status:** The project has ended. After being placed on the sports beach, the object was damaged by vandalism. It was then moved to the Northern Boulevard for better visibility and a larger user group. However, it was eventually removed completely. The technology did not function properly because the hardware was severely affected by the sand and salty sea air.

## Nitrous oxide detection
- **Social relevance:** Nuisance.
- **Innovation:** A smart camera that uses artificial intelligence to detect whether nitrous oxide use may be present. The algorithm was trained to distinguish nitrous oxide balloons from other balloons by recognising a
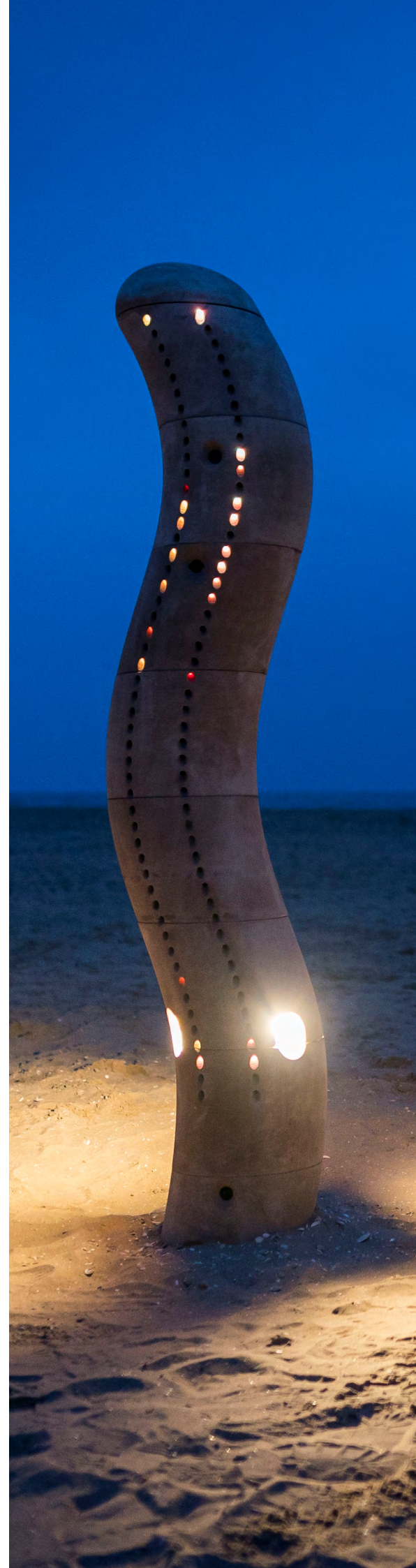
balloon being held at mouth height. If nitrous oxide use is identified, the camera can send an anonymous signal to enforcement, which assesses the situation on the spot. The camera does not take or share recordings – the images are deleted directly after processing.

- **Goal:** Since July 2023, the nitrous oxide ban has been enforced. With the trial, the municipality and the police investigated whether smart cameras could help enforcement agencies in this regard.
- **Together with:** The Hague Enforcement Agency [*Haagse Handhavingsorganisatie*], the Public Order and Safety Directorate [*Directie Veiligheid*], the police and technology startups from the Startup in Residence Intergov programme.
- **Status:** In 2023, the trial was evaluated and the camera was removed. The application worked accurately, but by now the nitrous oxide nuisance on the boulevard had diminished. This removed the need to introduce the system in Scheveningen.

## The Smart Energy Grid

- **Social relevance:** Energy transition.
- **Innovation:** A smart and autonomous low-voltage grid, to which solar panels and heat pumps are connected, as well as charging stations, beach pavilions, a beach volleyball stadium and a power supply for events. Using a smart battery, users have greater control over their energy usage. The battery recharges when the solar panels are generating a great deal of energy and provides energy at peak times – such as when a beach pavilion has the BBQ, oven and induction plates on at the same time.
- **Goal:** Monitoring, forecasting and controlling the use of locally generated energy – thus contributing to solving grid congestion.
- **Together with:** Stedin and market players for technology. Funding from Opportunities for West [*Kansen voor West*], a European economic stimulus programme to promote competitiveness in the West Netherlands.
- **Status:** The power grid now has so many applications of its own that it can be seen as a test environment in its own right. To enable power sharing with private parties, the municipality plans to set up an energy cooperative. Starting in 2024, Stedin will apply the best practices of this smart grid to other low-voltage grids.

'Together with the Municipality of The Hague and local entrepreneurs, we are exploring the development of an autonomous grid. This open-source system, which uses forecasting and control models, will be able to independently prioritise based on renewable energy availability. In this way, we can not only make the grid more sustainable, but also connect more customers.'

Angela Hulst, Manager Innovation, Stedin

# Digital infrastructure

The basis of the digital infrastructure is an extensive fiber-optic network totalling 11.5 kilometres in length. Underground, that fiber network connects street furniture, such as lampposts and kiosks, to other objects in the outdoor space. Above ground, the fiber network consists of sensors, cameras, energy meters and gateways for wireless connectivity, such as LoRaWAN and 5G.

## Dutch Government Reference Architecture [*Nederlandse Overheid Referentie Architectuur*, NORA]

When designing the digital infrastructure, the Municipality of The Hague took inspiration from the Dutch Government Reference Architecture (NORA). It is divided into five layers (see figure). The layers represent the relationship between the hardware, software, applications and other components of the infrastructure, as well as the information, organisation and foundations.

> ### Tip:
> scan the QR code for a detailed description of the digital infrastructure.

## Two parts, five layers

The architecture consists of two parts. The first is the enterprise architecture, which includes the principles and structure of the information, or metadata. This enterprise architecture consists of three layers: (1) the foundations layer, (2) the organisation layer and (3) the information layer. The second part describes the system architecture, consisting of the (4) applications and (5) the network

The hardware comes together in the network layer, which is divided into the following components:
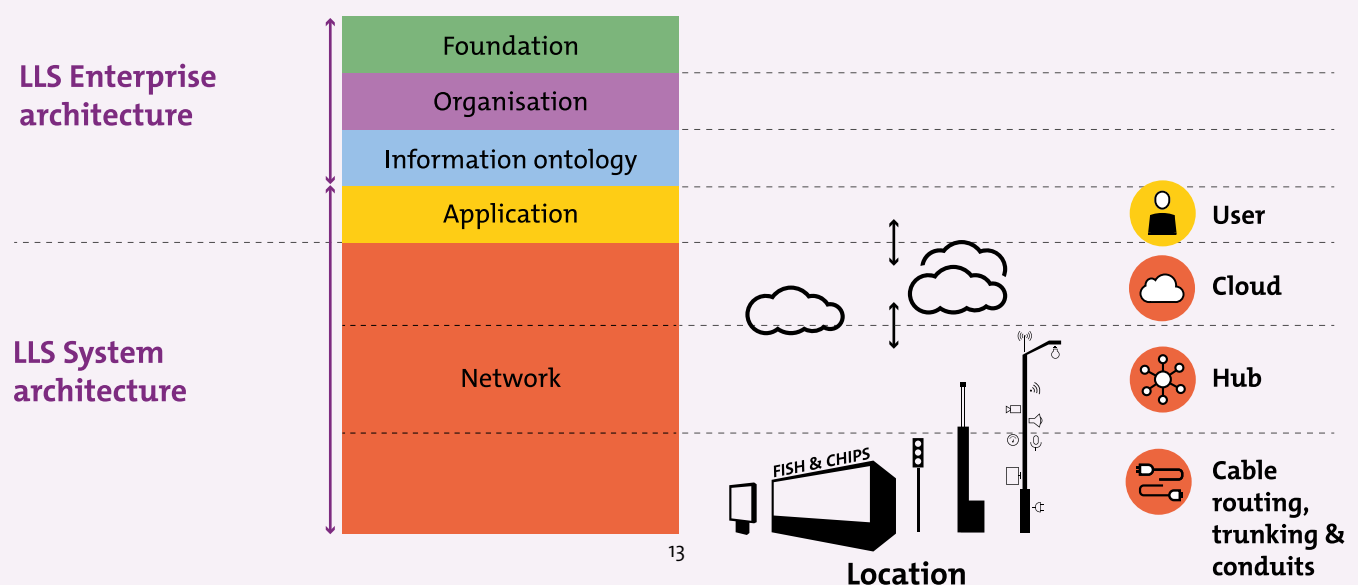
- The physical infrastructure: fiber optic cables and power supply
- Hubs: such as lampposts, kiosks and scanning cars
- Sensors and actuators: including the light sources and cameras in the hubs. These are the smart devices that record or display information, such as parking volumes or numbers of passers-by.
- The cloud: the set of servers where data lands and on which applications run, and the equipment that connects all of the network components and facilitates data transfer.

The five layers are designed as separate units but work closely together based on open standards. This ensures a scalable digital infrastructure and prevents 'vendor lock-in', so the municipality does not become dependent on a single external party.

> The digital infrastructure is defined, built and tested based on the layered architecture, properties, design rules and concept selections.



**LLS Enterprise architecture**
- Foundation
- Organisation
- Information ontology

**LLS System architecture**
- Application
- Network

- User
- Cloud
- Hub
- Cable routing, trunking & conduits

FISH & CHIPS

Location

13

## Properties

The necessary properties have been identified for each layer. Not only functional requirements, but also so-called aspect requirements. This includes privacy, cybersecurity, sustainability, availability, reliability, physical safety and maintainability. Moreover, the architecture still takes into account external factors, such as the particular weather conditions of a coastal area. On top of all the other requirements, equipment in the vicinity of beach and sea must be resistant to sand and salty air.

## Design rules

To provide guidance, the LLS team has drawn up design rules. These serve as ground rules for designing systems, data, procedures and applications. One of these rules is nationwide scalability, meaning that the infrastructure should be modular and applicable anywhere in the country.

Another basic principle is that new systems must work together with the existing infrastructure. The privacy and cybersecurity of each layer individually is also a design rule, ensuring that each component of the infrastructure is secure by design and contributes to General Data Protection Regulation (GDPR) compliance.

'We were asked at an early stage to help think about this challenging project. What makes the LLS special is that it is not just about building a fiber network. The LLS was created from an integral vision of digital connectivity, which is required for future applications, even for those solutions that are currently unknown.'

Reindert Hommes, Tallgrass

## Concept selections

In addition to design principles, concept selections have also been laid down. These do not serve as strict rules or advice for a set course of action. Above all, they offer a clear explanation of the considerations, choices, options, scenarios and analyses made by the Municipality of The Hague during the design process. Based on these concept selections and customer requirements, system requirements were derived and documented in a System Requirements Specification. This document is used during tenders and for assessing suppliers' solutions.

# Smart lampposts



When experimenting with smart applications in outdoor space, the LLS team encounters several challenges. The team should be open to both practical and forward-thinking approaches. Just as for coordination with many different — and varying by application — parties, whether multiple sensors or a single one. A practical example is the purchase and installation of smart lampposts.

## 1. Making decisions based on limited information and choices

When selecting the smart lampposts, the LLS team encountered the problem that few variants were available and extensive testing in public spaces had not yet taken place.  Moreover, it was still unclear during selection which sensors would be needed. This forced the team to make decisions based on limited information, aiming to be as future-proof and flexible as possible.

They selected lampposts based on functionality, future adaptability and aesthetics — to avoid a cluttered appea-rance of the outdoor space. Sensors were integrated into the lampposts and space was reserved for future sensors. In addition, the lampposts were given a special coating to counteract flyposting.

## 2. Behind every decision is a new issue

From the perspective of social innovation, privacy and ethics, it is important to keep residents and visitors well informed. This is all the more important in LLS, because the sensors are subtly concealed in the lampposts.

Initially, prominent signs were temporarily placed next to the lampposts to alert people to the technology present. As a result, a proportionately large amount of attention was given to sensors — even though there was little impact on privacy, since the applications were designed on a privacy by design basis.

The information boards also created clutter in the outdoor space. And another, new issue presented itself: how do you explain on a sign that the cameras conduct crowd density measurements where faces are blurred and images are not kept longer than three seconds? This required a new form of communication (see box).

Determining the height and location of those signs also requires something just a little different from placing, say, road signs. On the one hand, solid and strategic — against vandalism. But not to the smart lamppost itself; they are too expensive for that. And not at every lamppost, because that looks messy. Stickers were already not an option because of the masts' coating.

Each individual application requires consultation with different parties — in this example, in addition to the Public Lighting & Charging Infrastructure Department [*Afdeling Openbare Verlichting & Laadinfra,* OVL], also the Hague Street Organisation [*Haagse Straatorganisatie*] and the Public Space Advisory Committee [*Adviescommissie Openbare Ruimte*].

## 3. Performing your own maintenance

A traditional lamppost only needs power at night, but smart lampposts also need power during the day, for sensors. The lighting aspect and power supply is the responsibility of the OVL department, but the connectivity and sensors — the innovative part of the lampposts — are managed by the LLS team itself. This is partly because it is not profitable to enter into separate maintenance contracts due to the limited scale, but also because this is the best way for the team to learn from what can go wrong. For example, if a sensor in a smart lamp post begins to flicker, it is the LLS system architect who goes up the ladder to fix the problem.

## Visual language

The Municipalities of The Hague, Amsterdam, Rotterdam and Utrecht, together with the VNG and a design agency, have developed the 'National communication guideline for government sensors in public spaces' – a visual language about sensors that is easy for everyone to recognise. The guideline and visual language are being tested extensively, both with resident groups and with experiments in the four cities.

# Experiences and recommendations

## 1.  Pioneering and co-creation

LLS is a unique journey with no pre-existing examples to learn from – it was truly pioneering. That was the intention: to learn through experience and discover the challenges in deploying new technology for social issues in the city. Initially, the municipality approached this as a project with a clear beginning and end, including schedules and flowcharts. It soon became clear that it is a complex, multi-layered and dynamic process, involving many different parties and having diverse interests. Rather than a straight, mapped-out path, co-creation in public space turned out to be more like a dance, with accelerations and delays. This requires flexibility and the ability to move with changing circumstances.

## 2.  Learning objective determines location

Do you choose a controlled, constrained environment (field lab) or an open lab in public space (living lab)? It is important to choose a venue that is not only technically suitable and available, but which also matches your learning objectives. Indeed, location influences what and how you can test and determines the nature and extent of the challenges you face.

The choice of a 'living lab' brought The Hague unique insights but also made the initiative complex. Innovation in public spaces means many people are watching and taking part in decisions, whether it is about opening up streets, privacy or local ordinances. This can hamper progress but also ensures that policy and legal issues are quickly uncovered. Especially compared to experimenting in a field lab: a delineated environment with limited regulation.

## 3.  Socially responsible innovation

A recurring question is: do we start with the technological capabilities and find a problem owner with that, or do we start with an existing societal problem and a corresponding owner? Developing from technology does not automatically lead to a warm reception by the intended users. Moreover, the pace of technological developments is difficult to predict, as is which applications will be successful. The LLS team has learned to find a balance between these approaches. They do this by thinking about their challenges and how technology can support them from the start, together with the responsible departments.

'In urban development, we need to think ahead and take into account major transitions that The Hague is facing. For example, what will it take to make self-driving cars possible on a large scale? A vision of a digital infrastructure that supports new, often unknown applications is essential for designing the city of the future. We are working on this in the Environment Vision 2050 [Omgevingsvisie 2050].'

Marijn Fraanje, former CIO, currently Director of Spatial Planning and Economy.

## 4. Privacy and ethics central

Socially responsible innovation also means: paying attention to the ethical issues that arise when applying technology in the city. This goes beyond mere compliance with rules. Similarly, ethics is about what a municipality wants to allow or avoid and how it wants to shape digitalisation in the city within its boundaries. Several tools are available to examine the ethical side of innovations in advance (see page 9). It is important to determine for each innovation which instrument is the best fit.

## 5. Engagement of clients

The commitment – both time and financial – and active involvement of decision-makers and employees from the organisation is crucial. The client must also be willing to experiment and learn, without expecting a ready-made solution right away.

It is mainly the clients who bear the development costs for the applications. This increases awareness of the need and value of the innovation, ensures that resources are allocated where they are needed most, promotes end-user involvement in the development process and increases the likelihood of the innovation being adopted by the organisation after the testing phase.

## 6. Integrated approach: area, use and technology

The Municipality of The Hague takes the view that 'area, use and technology' must be addressed integrally. Combining area development, user applications and associated technology is practical, future-proof and financially advantageous. In fact, it should be standard practice to include provision for digital infrastructure in the development, design and management of public spaces, just as is done with water and electricity. Ideally, a municipality-wide vision would be developed for this, which would then be laid down in the Public Space Manual [*Handboek Openbare Ruimte, HOR*].
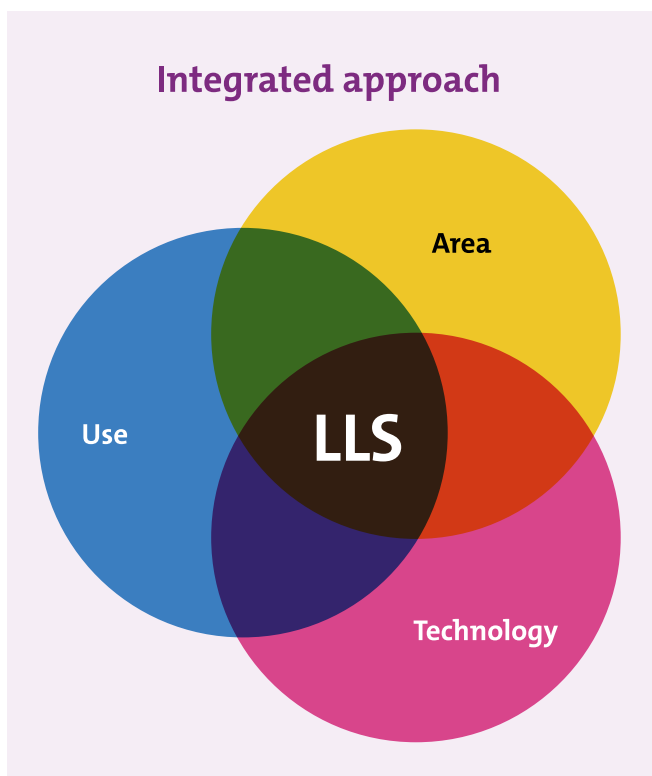
## 7. Standardised innovation process

OBased on design thinking principles and experiences from the living lab, the LLS team developed an innovation process – an iterative method in which an idea is developed step by step into an experiment. The process consists of several phases, such as ideation, prototyping and validation. In some cases, in the ideation phase, a challenge is issued to the Startup In Residence Intergov programme.

The involvement of a municipal client is required at all stages, as well as intensive coordination with other centres of expertise within the municipality. Tasks and roles are clearly defined, so everyone knows exactly what is expected of them. In addition, specific decision moments are built in to determine for each phase whether an experiment continues or stops. In this way, the LLS team can effectively support the municipal organisation in innovation and experimentation.

## 8. Connection

To properly use, manage and maintain the digital infrastructure in the future, it is essential to firmly embed work and responsibilities in the municipal organisation. Since the launch of the living lab, a search has been carried out to find the best embedding, governance and composition of the innovation team. After five years of pioneering, the LLS team concludes that the best approach is a multidisciplinary team led by a multidisciplinary steering committee.

The composition of both the board and the team should vary over time to suit the various stages of development of the lab. By having employees from various departments be part of the innovation team for a longer period of time, valuable knowledge is brought in from within the organisation. When these employees return to their regular positions after their contribution, they take the knowledge and experience gained with them, spreading innovation knowledge throughout the organisation. This approach creates a strong connection between the innovation team and the rest of the organisation – one of the key success factors.

## 9. Ambassadors and visibility

With initiatives such as Smart@Sea, the Innovation Table in Scheveningen and tours of the Living Lab, the Municipality of The Hague is committed to active participation by local residents, entrepreneurs and visitors. The alderman – with Smart City in their portfolio – also plays an important role as an ambassador for the LLS by highlighting its importance in the Municipal Executive and in national administrative consultations.



### Integrated approach

Area

Use

LLS

Technology

To engage the internal organisation more actively, LLS is building a network of ambassadors: colleagues who support and help spread the vision. A physical innovation lab or space in City Hall is also being considered, where colleagues can discover (the opportunities and challenges of) new technologies. In addition, experiments can be carried out at City Hall itself. For example, the LLS team will count visitors at an exhibition on Smart@Sea in the Atrium of City Hall.

## 10. Innovation is a political consideration

The coalitions in the Municipality of The Hague have identified smart city developments as a strategic theme for the city, making the use of smart technology in the city not only a technical issue but also primarily a political choice. This means the Municipal Council must actively participate and make decisions. The councillors toured the Living Lab and visited Smart@

Sea. Moreover, the Municipal Council receives an annual update, which is placed on the agenda for debate.

In recent years, the Municipal Council has paid increasing attention to LLS. The Council discusses current applications, desirable and undesirable aspects, future possibilities and topics such as transparency, privacy and ethics. This is important because it enables the Council to effectively exercise its monitoring and policy-setting role.

'As a municipality, we are constantly working on the future of the city. Preparing for the emergence of new technologies plays an important role in this. It is a huge challenge that it is not always certain in advance how technological developments will unfold. That is why we set up the Living Lab Scheveningen: to experiment with new technology. The LLS itself was also an experiment in itself. How do you set up a lab such as this? What is the right governance structure?

The fact that we already won the Smart City Award with the LLS in 2021 felt like a reward for the municipality daring to stick its neck out. The Living Lab has since been the incubator for countless innovative applications. I think it is important to highlight these innovations and discuss them with residents and entrepreneurs. It is important to know how they view all this new technology in the outdoor space.

I think we are still at the beginning of what is possible. The LLS is much more than just infrastructure. It is a platform in which we can experiment permanently, and in consultation with all stakeholders.'

Saskia Bruines, Deputy Mayor of the Municipality of The Hague.

# Want to read more?

**Smart technology for safe cities:** a publication of Impact Coalition Safety & Security, on technological innovations in urban safety.

**National communication guideline for government sensors in public spaces:** a guideline to inform citizens about data collection with sensors in outdoor spaces.

**Judicial Explorations:** a journal of the Scientific Research and Documentation Centre [*Wetenschappelijk Onderzoek- en Documentatiecentrum, WODC*]. This theme issue looks at the role of artificial intelligence in Living Lab Scheveningen and the ethical, legal and societal challenges involved.

**Living Lab Scheveningen (LLS) System Specification:** A publication of the Municipality of The Hague on digital infrastructure architecture.