# STRATEGIC REVIEW OF NON CLINICAL IoT

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# TESTED Project

**The TESTED project focuses on the innovation opportunities offered to healthcare providers and other public bodies through the provision and implementation of an Internet of Things (IoT) in non-clinical applications.**

These applications may include, for example, water management, health and safety, energy use, waste management, estate management, medical equipment asset and inventory and many other such areas.

While the IoT can clearly support clinical and patient focussed aspects including diagnostics, treatment, management and aftercare, the 'hidden' aspects of healthcare provision are often less considered. In non-clinical applications, for example, water management, health and safety, energy use, waste management, estate management, medical equipment asset and inventory and many other such areas, there are substantial opportunities for businesses, government agencies, academics and the healthcare providers themselves to develop efficient and effective IoT solutions. The TESTED project uses this non-clinical focus to test the potential for IoT applications comparing three regions in the NPA area. It includes the mapping of current IoT infrastructure and use within each region to establish a comparative baseline; a review of stakeholder opinions of those engaged within the infrastructure as suppliers, stakeholders or end-users; identification of best practice; and, the development of a common but regionally flexible IoT strategy that will enable each region to support IoT Testbeds, and a process whereby such testbed projects (pilots) can be evaluated.

The results from TESTED will be an easily replicable methodology for use in any other region and with any other public body.

NHS Highland    Ulster University    region västerbotten

# Executive Summary

The growth of technologies related to the Internet of Things (IoT) has been rapid, complex, and comprehensive. Originally developed within the context of manufacturing, the health and care sector has seen, from a clinical perspective, a rapid increase in the design, development, and deployment of IoT technologies. These include medical diagnostics, monitoring devices for a wide range of conditions, and even remote treatment approaches. In non-clinical settings, the deployment of IoT devices and systems has been somewhat less rapid, but is perhaps, equally, or even more important. This is because the systems that support clinical care are generally widespread, applicable to the whole system of the health and care providers and use significant amounts of resources and staff.

Some of the greatest costs of healthcare systems are staffing, energy, equipment, and the running of the 'estate' i.e. hospitals and other buildings. Where it is possible to implement and invest in non-clinical IoT, clear benefits can be seen, with increased efficiency, reduced costs, remote monitoring and management and recued travel, better data analytics and other positive outcomes. At the same time, there is a range of challenges or barriers to the implementation of non-clinical IoT in healthcare systems. These include issues with security and data confidentiality, legacy problems in large, old healthcare providers, bandwidth and latency issues and a range of other technical challenges.

Despite these challenges, IoT in healthcare continues to proliferate especially in the clinical setting, and the non-clinical aspects of healthcare need to be supported to develop wide ranging scalable approaches that can lead to an interconnected clinical-nonclinical system. The existing complexities in healthcare systems are more than suitable for the implementation of IoT, and the brief overview of policies, use cases and processes illustrating progress in four Northern European regions reveals some of the key pointers and steps to ensure further progress takes place.

# Contents

# 1.0 Introduction

## 1.1 IoT in Healthcare

The Internet of Things (IoT) has begun to dominate societies across the World. Indeed, the spread of IoT is by default making the World more connected. It is estimated that by 2025, there will be 100 billion connected IoT devices and a global economic impact of more than $11 trillion (1). There is no real single definition of IoT, but essentially it relates to the "*network connectivity and computing capability extends to objects, sensors and everyday items not normally considered computers, allowing these devices to generate, exchange and consume data with minimal human intervention*" (2). In healthcare, the definition of IoT usually focuses on the mobile and medical devices that obtain data and transfer it to other health or eHealth systems. By the end of 2019 there were 620 publicly known IoT platforms worldwide (in 2015 there was less than half this number) (3).

## 1.2 IoT Healthcare Market

Opportunities clearly exist in healthcare for companies operating in the IoT sector. While many companies have focussed on the opportunities in clinical IoT, others have begun to exploit the non-clinical healthcare IoT market. There is a rapid global growth in the IoT market generally, with the Global IoT market size being at $330.6 billion in 2020 and expected to reach $ 875.0 billion by 2025 (4) are experiencing a rapid growth in IoT innovations, and although some non-clinical operations are recognised, this is an underdeveloped market, but one that is full of disruptive opportunities using IoT technologies.

The Deloitte 2020 Global Healthcare Outlook report specified some important movements for the future of healthcare in relation to digital transformation and interoperability, stating that cloud computing solutions, 5G technology, AI, Natural Language Processing (NPL), big data analytics, Data As A Platform (DAAP), Robotics, sensors, enterprise applications, blockchain systems, and learning platforms, alongside Internet of Medical Things (IoMT) were all components of the shift towards a more connected automated world (5). While they discussed these in relation to clinical care, it is not difficult to transfer all or most of these innovations to the non-clinical setting, and to see how their deployment can be supported through system wide IoT infrastructures and technologies.

## 1.3 Motivators of IoT in Healthcare

The motivations for this rapid development within the healthcare sector are the rapid development of healthcare technological advances in general, an aging population which requires more effective monitoring, the rise in chronic diseases, and an increasing demand for low-cost and low-energy solutions to healthcare management especially in response to the need for carbon reduction in relation to the management of climate change (6). The mark of a buoyant market for IoT in healthcare is evidenced by some of the key players in that market segment, namely, AdhereTech, Inc., Cerner Corporation, Cisco Systems, Inc., General Electric Company, Google, International Business Machines (IBM) Corporation, Koninklijke Philips N.V., Medtronic, Microsoft, and Proteus Digital Health (7).

## 1.4 Barriers and Challenges for IoT in Healthcare

At the same time, it is important to recognise that the development and deployment of such technologies and a non-clinical IoT infrastructure across large scale healthcare systems such as the NHS, faces a range of challenges and potential barriers. Antiquated legacy systems, some of which will be tightly coupled with other similarly antiquated legacy systems such as working practices, building facilities and others, can mean that the introduction of new systems, especially those that appear to be radically innovative, faces a range of barriers including cost issues, resistance from staff and departments, physically and software change difficulties, demands on connectivity that cannot be met and a host of other problems.

In older healthcare systems, such as the NHS, where the estate owned by the organisation may be anything between 5 to 150 years old, the staff may be unskilled in any IT processes, the resources and funding may be limited. Seeking to deploy widescale IoT infrastructure and technologies in non-clinical settings such as building management, water and energy management, transport and fleet management, waste, ventilation, and a host of other non-clinical areas may seem an insurmountable challenge. In addition, constantly evolving business needs can result in error prone, costly, and difficult manual work arounds and interventions and data inaccuracies (8). For large risk-averse healthcare providers, the perception of such likelihoods can reduce enthusiasm and commitment for innovation and IoT development from the very start. The cyber security requirements of large healthcare systems can also require a unified security approach across the whole organisation, and the introduction of separate technologies / innovations without IoT infrastructure development, can lead to an increase in security risks, that again reduces enthusiasm for change at all levels of management within an organisation.

## 1.5 Regional Progress in Healthcare IoT

Despite these barriers and concerns, the reality is that IoT, in both the clinical and non-clinical setting, will develop regardless of individual organisations, departments or individuals. The Alliance for Internet of Things Innovation (AIOTI), for example, is contributing to Europe wide collaborations such as the Smart Networks and Services Partnership (5G IA), a combined EU and industry partnership seeking to support the development, deployment and use of 5G in Europe and globally (9). AIOTI is also considering the development of new interest groups seeking to obtain funding and to support developments including Logistics, Supply Chain, Resilience and Test Beds, all of which would have an IoT foundation in development and implementation (10).

One of the barriers to the more rapid spread of the IoT market in healthcare is the capacity and connectivity of communication systems. Healthcare providers are often large, very complex, relatively old organisations, with limited resources to spend on what are sometimes perceived as less important activities such as eHealth, when clinical demands are high. In some regions of the world, general connectivity and accessibility to online / Web sources is relatively low, and without such accessibility the opportunities presented by IoT in the healthcare sector can be reduced.

The EU has recognised this issue and has developed a number of policies and strategies aimed at increasing access. These include a commitment to a 'broadband Europe’ and a target of reaching a European Gigabit Society by 2025 (11). At the national and regional level, governments are seeking to move towards a similar target. Scotland is soon to receive a roll-out of IoT capability (12), Northern Ireland policy makers have committed to transform regional connectivity with an ultrafast digital infrastructure (13), and in Sweden the Government has committed to achieving a 'Completely Connected Sweden' by 2025 (14). These developments mean that the potential for healthcare IoT is becoming an increasing opportunity for business and for the healthcare providers alike.

While this is an exciting change and is being viewed by many tech companies and the healthcare sector with some interest, the potential for non-clinical applications is yet to be fully developed in any region, and there is substantial opportunity to effect rapid change in a wide range of non-clinical IoT applications. This is important for the healthcare sector as non-clinical IoT may revolutionise what is often the 'hidden' iceberg on which the visible smaller part of the iceberg i.e. clinical and health and care services, is based. This non-clinical aspect clearly also offers exciting and potentially large-scale impact opportunities, transferring existing and new technologies that will fit with the work of the non-clinical departments from an efficiency and business management perspective.

## 1.6 Report Focus

This report summarises some important information on IoT and its implementation to assist in the development of a common, but regionally flexible, non-clinical IoT strategy. This strategy document (that is a planned output of the TESTED IoT project) will enable European Regions to support non-clinical IoT Testbeds, and offer a process to evaluate, validate, and transfer into implementable services, if usable and cost efficient.

Summary information has been pulled from a number of key global, European, and other relevant publications and reports, including the 2016 TechTarget IoT Agenda (15) and the CENSIS IoT guidance reports (produced in partnership with the Scottish Futures Trust (16), and the Scottish Government and Digital Scotland (17)). This non-clinical IoT summary report will introduce the concept and context of IoT and non-clinical IoT, assess the market sector size and growth, collate the principal benefits and risks of non-clinical IoT, examine the technical and non-technical needs and barriers to deployment, and highlight already existing non-clinical utilisations of IoT in health care systems including the NHS. .

## 2.0 Defining Non-Clinical IoT

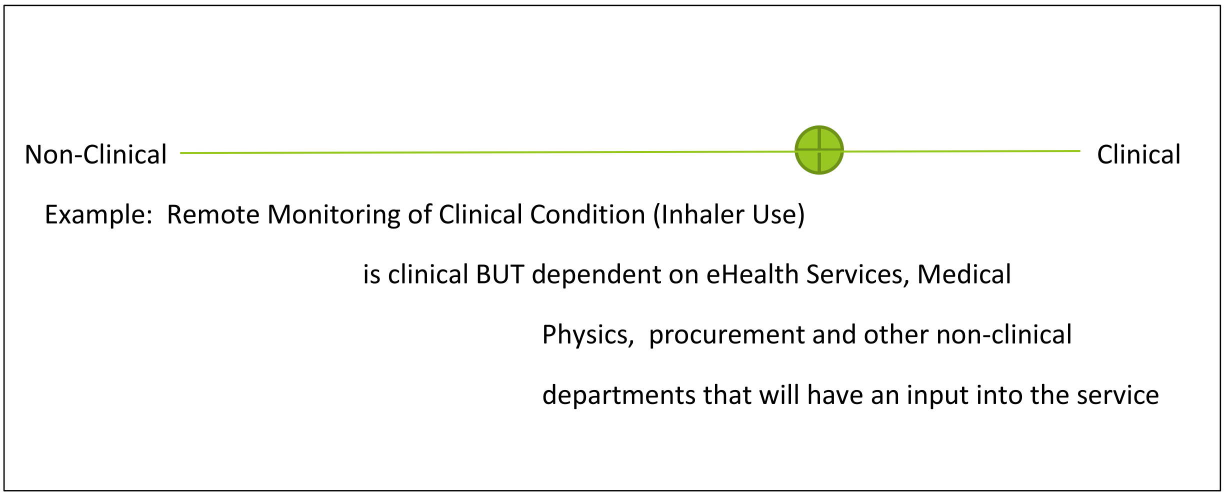
A definition of IoT has been discussed previously in this report, but for reinforcement of the concept, TechTarget (18) describes IoT as a network of physical objects that have unique identifiers capable of producing and transmitting data across the web automatically. CENSIS describes how IoT is concerned with connecting the devices to the internet and each other, and also (19) describes IoT as a system of things using the internet or a private network to connect and communicate with each other.

While there is an acknowledged IoMT i.e. Internet of Medical Things, there is no specific definition of non-clinical IoT that applies to healthcare systems. Instead, in general, non-clinical IoT is seen as parallel to IoT that exists in non-healthcare settings, i.e. in other public bodies, in commercial businesses and in manufacturing. However, it can be argued that taking this viewpoint does not show a full understanding of how healthcare systems work, and how the non-clinical and clinical systems exist in complex interdependences. Such relationships need to be understood if the challenges and impacts of introducing IoT in clinical or non-clinical settings are to be properly and effectively managed.

In healthcare services the non-clinical functions supporting end-user (patient/carer/healthcare professional) facing actions are key to sustainable service delivery. If they fail, substantial high-risk effects on the end user can occur. Technologies that increase the efficiency of such functions (for example, water management, fleet transport, medical equipment maintenance and monitoring and many other facility and related functions), are seen as increasingly important. This is because such technologies can reduce cost, improve health and safety, reduce the need for inefficient staffing, reduce travel, reduce carbon emissions, and provide overall improvement of functions.

Taking this approach, it is clear that when IoT is planned for implementation into a healthcare system, its non-clinical and clinical potential impacts must be considered. One way to do this is to estimate the degree to which the IoT system, programme or process is clinical or non-clinical. For example, the following continuum reveals that a process or project may be placed at a given point showing that the 'other' impacts need to be considered 'more or less'.

Figure 1: Non-clinical and clinical



For any IoT project or service change, using a simple model such as this to determine the ‘whole’ of the impact, not just clinical impacts, is important if a whole system approach to the use of IoT is to be developed effectively.

# 3.0 The Benefits of Non-clinical IoT

Through an ability to transfer data over a network without requiring human-to-human or human-to-computer interaction, IoT offers a range of benefits. As well as supporting clinical and patient focussed healthcare including diagnostics, treatment, management, and aftercare, IoT can also support the 'hidden' aspects of healthcare provision (20). In non-clinical applications, for example, water management, health and safety, energy use, waste management, estate management, medical equipment asset and inventory and many other such areas, there are substantial opportunities for businesses, government agencies, academics, and the healthcare providers themselves to develop efficient and effective IoT solutions. The TechTarget IoT Agenda lists nine ways that IoT can be utilised to produce a range of benefits to operational efficiency and effectiveness:

1. Decision making - allowing gathering of date to make better decisions to benefit the organisation
2. Innovation - new products and service opportunities or new markets
3. Compliance - new and more effective ways to monitor and report compliance requirements
4. Profitability - cost savings and increased productivity leads to increased profit
5. Environment - pollution levels, air quality and flooding alerts
6. Society- monitoring health and social care
7. Safety - people exposed to less hazardous environments
8. Efficiency - better use of time speeds up processes
9. Productivity - identifying and reducing process errors

A summary of clinical and non-clinical IoT opportunities and benefits was developed in a 2017 report by Aruba Networks. Their research showed that while patient monitoring and the uses of connected patient diagnostic and treatment IoT was a substantial usage of the technology, energy saving and remote monitoring and maintenance of assets was equally, if not more important.

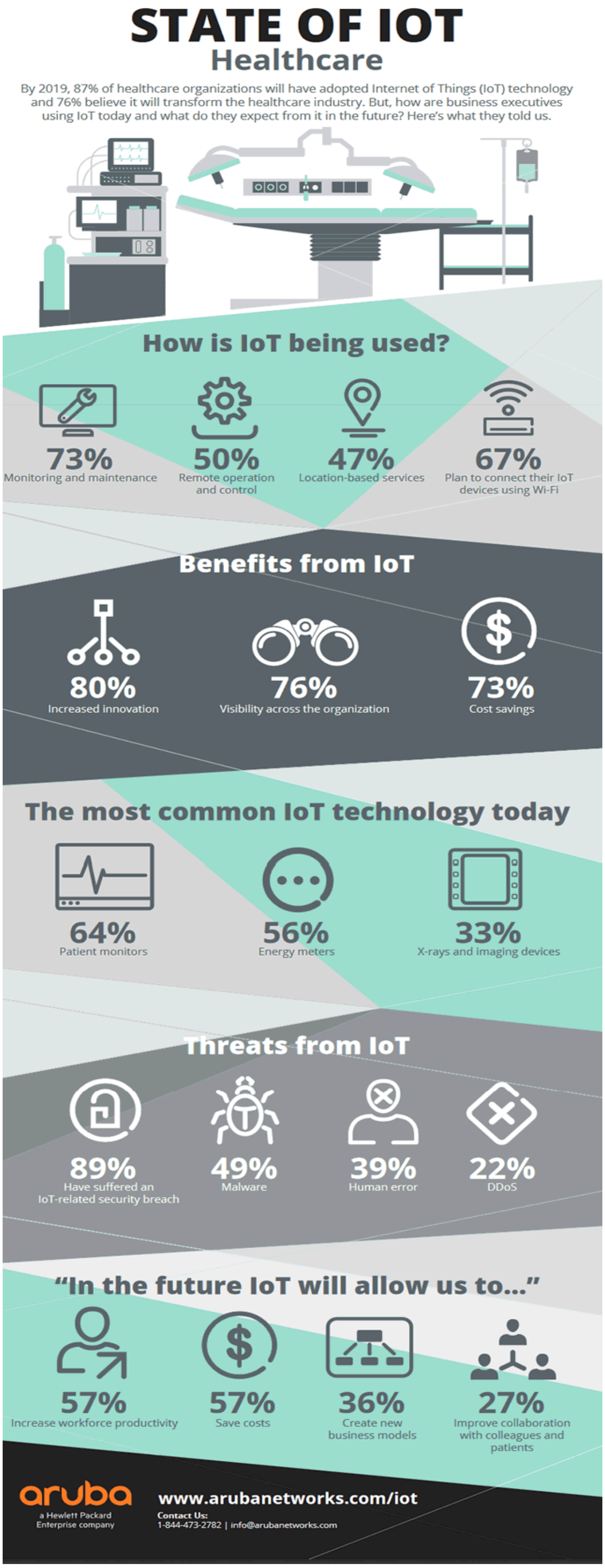



Figure 2: State of IoT Healthcare (Aruba Networks (21))

There is increasing interest in the concept of the connected smart hospital (22), where at the basic and core level, the focus on non-clinical IoT is around the use of Radio Frequency Identification (RFID), IoT enabled devices and IoT enabled 'assets' alongside a more traditional IoT inclusion of a range of devices and monitors. This focus can be said to be 'cross-industry' and is also inclusive of 'predictive' maintenance (23) and the introduction of specific assets such as SMART beds. Over time, as new hospitals and other healthcare facilities are planned, designed, and built, such approaches will become standard. Currently, one of the main challenges facing large scale healthcare systems is that the age of the estate and the assets held by those systems, is difficult to address due to a wide range of complex issues.

An overall strategy should be developed to exploit these potential benefits while recognizing and strategizing action to reduce the associated operational risks. The next section will consider risks and appropriate possible actions for these risks.

# 4.0 Key Risks and Actions for Non-Clinical IoT

It is important to recognise the risks central to IoT implementation and include steps to reduce risk in any strategy. IoT phenomena significantly increases the security risks faced by the organisation and users. One of the main issues surrounding healthcare (and any IoT) is that of uncertainty. With any new technological advance, the very 'newness' of the technology means it has inbuilt risks with devices connected to the internet with an operating system being at risk of being compromised and being utilised as a backdoor for attackers into the organisation's network.

Tissaoui and Saidi (24) point out that healthcare IoT (including non-clinical) places "*complex demands in terms of heterogeneity of devices, scalability, wide scale use of wireless data transfer technology, optimum energy use, data management, privacy protection bandwidth, data rate and latency*" as some of the main problems or challenges for healthcare providers aiming to install IoT.

The industry online magazine Security affirms these points and provides some more "*unpartitioned networks, insufficient access controls and the reliance on legacy systems, has exposed a vulnerable attack surface*" (25) , and while this does focus on patient data primarily, the integration in clinical and non-clinical systems means that this threat is across the healthcare provider. In addition, the TechTarget IoT Agenda (26) lists 7 key risks and actionable strategic responses; disruption and denial or services, understanding the complexities of vulnerability, vulnerability management, identifying and implementing security controls, the need for capability for security analytics, modular hardware, and software components and a rapid and increasing demand for bandwidth requirements.

This section outlines specific challenges or problems that exist in current systems and suggests actions that may need to be taken to make progress in non-clinical IoT.

## 4.1 Uncertainty in IoT in Healthcare Systems

**Problem:** Tissaoui and Saldi (27) identify uncertainty in healthcare systems as providing a number of barriers to the take up of IoT (including non-clinical). These include structural uncertainty, methodological uncertainty, uncertainty regarding parameters, and uncertainty in decision making. Uncertainty in their view includes deviations from expected states (28) and changes which are difficult to estimate because there is not enough available information (29). Specifically they identify some of the causes of uncertainty in healthcare IoT as inconsistent data (i.e. using different DFID readers at the same time), incomplete data (where items that have been tagged might be stolen for example), ambiguous data (where interference from radio frequencies might cause inaccuracies through deflection) and redundant data (extra data that is captured that is superfluous).

**Actions:**

- Prioritise the data management for IoT systems
- Invest in data management and resource
- Carry out risk assessments and gather as much existing information and data as possible to reduce uncertainty and to support IoT implementation decision-making

## 4.2 Legacy Issues in Healthcare Systems

**Problem:** Some healthcare organisations are thought to be overconfident in their security in relation to IoT because they don't have full visibility over their connected device network. This is especially true where software and devices often, once purchased, stay working within the healthcare organisation for ten years or longer. It is not just devices that can be put at risk from a legacy perspective, but also processes – healthcare systems still often rely on physical audits of equipment checking for maintenance and repair scheduling (30).

**Actions:**

- Reduce reliance on physical audits by installing automated remote monitoring and repair of devices
- Automate processes wherever possible

## 4.3 Heterogeneity of Devices

**Problem:** In large scale organisations like healthcare systems, the very size and number of devices that may be used can cause an issue of heterogeneity for IoT systems. In other words, with so many different devices there can be problems with different data formats on an IoT platform – which works most efficiently when the devices and data are heterogeneous (31).

**Actions:**

- Over time or when purchasing devices seek to obtain heterogeneity with existing devices
- Seek to find ways to obtain heterogeneity of data formats for the IoT platform

## 4.4 Scalability

**Problem:** Scalability in IoT healthcare systems is both horizontal and vertical. Horizontal scalability is expanding the network so that the number of hardware devices and software programmes can be hosted, whilst vertical scalability is about improving the efficiency of existing hardware and software by adding more resources (32). The problem is that the healthcare system requires flexibility, adaptability, capacity, and energy resources – some of which are not necessarily characteristics that are found in old, large scale healthcare organisations.

**Actions:**

- CEOs and senior managers in healthcare systems have to be made to understand that investment into these scalability requirements is vital – a difficult issue when publicly funded healthcare systems work on an annual funding basis
- Procurement of devices has to be systematic and the healthcare provider's procurement department has a key function to ensure that this takes place

## 4.5 Disruption and Denial of Services

**Problem:** Ensuring the continuous availability of IoT-based devices to avoid potential operational failures and interruptions to services.

**Actions:**

- A system for dealing with compromised IoT devices
- A system for remotely wiping and/or disabling the connectivity of lost or stolen devices.
- Other policies to manage 'Bring your own device' (BYOD) and protect the privacy of organisational data

## 4.6 Understanding the Complexity of Vulnerabilities

**Problem:** IoT devices may introduce new and unfamiliar hardware, platforms, and software unknown to organisational IoT networks and produce vulnerabilities. Accurately identifying the complexity and severity of these vulnerabilities can be difficult.

**Actions:**

- Correctly gauging the risks associated with IoT devices.
- Incorporating security controls into projects involving IoT devices

## 4.7 Vulnerability Management

**Problem:** Devices that provide built-in web servers to enable admins to operate remotely makes IoT devices highly vulnerable to hackers. This will require ways to quickly patch IoT device vulnerabilities; prioritize vulnerability patching; upgrading custom firmware and deal with the default credentials provided when IoT devices are first used.

**Actions:**

- Compliance team to certify that the device is ready for production,
- Test the security control on a periodic basis
- Make sure that any changes to the device are closely monitored and controlled
- Any operational vulnerabilities found are addressed promptly.

## 4.8 Identifying and Implementing Security Controls

**Problem:** Identifying where security controls are needed for this emerging breed of Internet-connected devices, and then implementing effective control.

**Actions:**

- Conduct customized risk assessments, often relying on third-party expertise, to identify what the risks are and how best to contain them.
- Organizations which embrace IoT must define their own information security controls to ensure the acceptable and adequate protection of the IoT evolution.
- Privacy protection must be in line with national, regional, and local policies and guidelines

## 4.9 Fulfilling the Need for Security Analytics Capabilities

**Problem:** Identifying legitimate and malicious traffic patterns on IoT devices.

**Actions:**

- Put in place actionable threat intelligence measures to identify the threat.
- Use the best analytical tools and algorithms to detect malicious activity, improve user support efforts and the services being offered to the users.
- Build the right set of tools and processes required to provide adequate security analytics capabilities.

## 4.10 Data Management

**Problem**: Even in developed countries the legacy problems that exist can cause substantial challenges to the implementation of IoT (both non-clinical and clinical). Paper driven systems remain common, and poor estate management through individual buildings leads to a lack of coherence in approach.

**Actions:**

- Automated centralised databases
- Use of block chain and smart contracts
- Connected Building Management Systems
- Tracking of items or staff using DFID / Smart Phone
- Remote equipment management and monitoring

## 4.11 Modular Hardware and Software Components

**Problem:** Attackers will seek to compromise the supply chain of IoT devices, by implanting malicious code and other vulnerabilities. This will exploit only after the devices have been implemented in an enterprise environment.

**Actions:**

- Security should be considered and implemented in every aspect of IoT to better control the parts and modules of Internet-connected devices.
- Enterprises should proactively set the stage by isolating these devices to their own network segment or vLAN.
- Technologies such as microkernels or hypervisors can be used with embedded systems to isolate the systems in the event of a security breach.
- It may prove necessary to adopt a security paradigm like the Forrester Zero Trust model for IoT devices.

## 4.12 Rapid Demand in Bandwidth Requirement

**Problem:** Network traffic jumping will increase when more devices connect. Increased demand for Internet will potentially proliferate organisation continuity risks. Critical applications need to receive their required bandwidth, to avoid poor experiences by customers, negative impact on employee productivity and profitability

**Actions:** To ensure high availability of their services, enterprises must consider:

- adding bandwidth and boosting traffic management
- Monitoring capacity planning
- Watch the growth rate of the network so that the increased demand for the required bandwidth can be met.

## 4.13 Energy Use

**Problem:** While IoT in healthcare often uses a large number and multiplicity of devices that in themselves use relatively little energy, and in fact often have energy saving cut-outs when not in continuous use, the actual scale of use can mean that there is an energy demand equal to or greater than more traditional approaches to the management of a specific issue.

**Actions:**

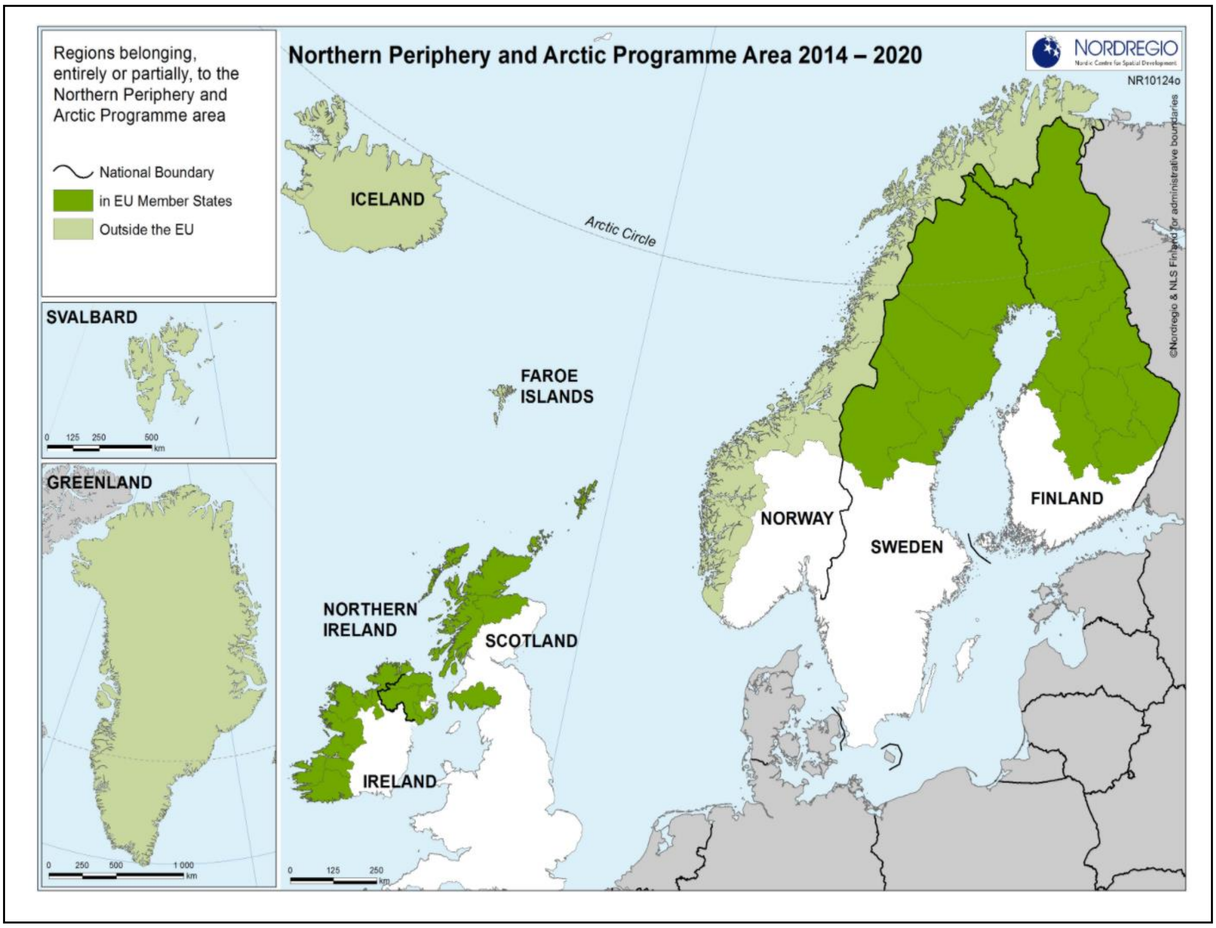
- An evaluation of the required energy demand should be a key action in the development of non-clinical IoT
- A Risk Assessment of reduction or failure in energy supply must be complete
- Back up systems for energy supply should be put into place and many systems, non-clinical included, in healthcare systems are vital for patient and staff safety
- New sources of energy should be investigated to make sure these are as low cost and sustainable as possible

This section has considered the risks, issues central to IoT implementation; it also considers actions and steps that could be taken to reduce risk. The next section will look at case studies in four specific regions of the NPA area.

# 5.0 Northern Territory National IoT Profiles

To illustrate some of these benefits, risks, and responses, and to provide a basis for a strategy for other regions going forward, four European Regions have been included to briefly show how non-clinical IoT has been developed in each region at different levels, what policies exist for non-clinical IoT at Government and health service levels, and an example or two of non-clinical IoT in action.

The four selected NPA regions have been included not only because they are partners of the TESTED project, but also show a range of approaches to non-clinical IoT. They are all partners in the Interreg Northern Periphery and Arctic Programme Area and are funded by the Programme for the IoT project.




(Programme_area_map_final.jpg (3506×2481) (interreg-npa.eu)

They are also largely rural regions within the partner countries, and the remote and rural nature of some of these regions means that interest in providing comprehensive, efficient, and integrated systems for the delivery of non-clinical IoT is high.

## 5.1 Scotland

### 5.1.1 Government Policy on IoT

In partnership with private sectors allies, including Scottish Enterprise and Highlands and Islands Enterprise, the Scottish Government in 2018 launched a 3-year project worth £6million to develop an Internet of Things network (33). Supporting the nation's public and private services to utilise IoT technology and services, the network named IoT Scotland, became the most long reaching wide area wireless sensor network in the UK (34).

Following the creation of the IoT network, the Scottish Government acted to strengthen the digital future of the public sector by creating the IoT Dynamic Purchasing System (DPS). The system created a more direct channel for IoT technology and services to be accessed by the public sector and third sector bodies (35). System suppliers hold places on the framework offering hardware, software, services for device and data management, analytics, and security. The Scottish Government created user friendly documents to accompany the DPS including a suppliers list, a supplier's guide and a buyer's guide (36).

The Scottish Government is forecasting growth in the public sector's engagement with IoT technology and services over the next few years.

### 5.1.2 IoT Expert Perspective

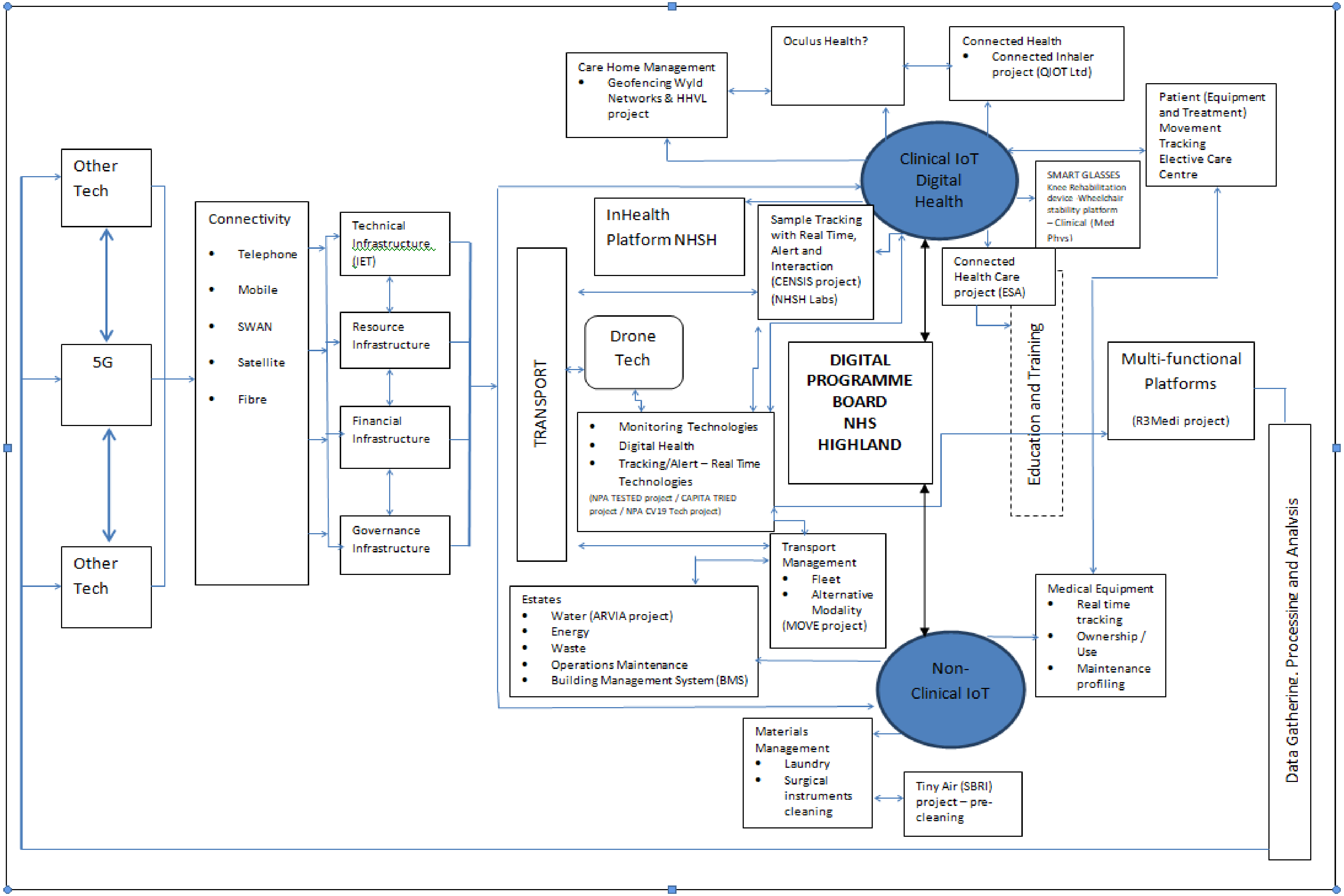
A lead IoT technical expert with 30 years experience offered a personal perspective on the current Scottish IoT milieu, incorporating views on the value and growth of IOT within Scotland and challenges faced within the industry. Emphasis was placed on the potential for non-clinical IoT solutions to improve the digital economy for Scotland positioning Scotland as a world player for non-clinical outcomes. Tensions between commercial operators, mobile networks operators and different target sectors were recognised, but the growth of Digital SMEs was thought to provide exciting fertile ground for IOT innovations. Value was placed on the importance of being able to digitalise unprocessed data especially when combined with other data sets, to inform decision making. Further weight was placed was on the role of Artificial Intelligence and Machine Learning to progress the capability for predictive information to enhance operational decisions helping transform the efficiency of everyday organisational tasks. The need for a robust assessment of security requirements was viewed as essential, requiring the application of best practice principles from the outset for all IoT developments. However, a major concern was the current digital skills gap within Scotland.

The development of Censis was referenced as fundamental to advancing IOT in Scotland. This is Scotland's innovation Centre for sensing, imaging, and Internet of Things (IoT) technologies working with private and public organisations to help overcome technology barriers to achieve business transformation. The Scottish Government is now supporting digital IoT businesses through funding and start-ups plans and has developed a recent IoT strategy including dynamic purchasing systems.

### 5.1.3 Healthcare IoT Innovations

Using NHS Highland as one example of the development of healthcare IoT systems , the Health Board has focussed on both aspects of IoT, clinical and non-clinical and has developed an integrated approach in line with the development of a non-clinical IoT strategic plan and an overarching digital health strategic programme. The diagram below illustrates how such an approach might be developed and encompasses a wide range of potential areas for IoT implementation.

As just one example of a potential non-clinical IoT innovation in NHS Highland, in 2018, the Scottish Innovation Centre for Sensor and Imaging Systems and Beringar launched an IoT trial at Caithness General Hospital to improve asset tracking and maintenance. The Hospital used IoT to monitor and track the whereabouts of hospital beds using Bluetooth tags. The tags transferred real-time data on the bed's location and maintenance to a dashboard monitored by NHS personnel. See IoTtrial for more details (NHS Highland IoT testbeds - CENSIS)Trials have since taken place at hospital facilities in Manchester using LED smart sensors. The sensors build an 'IoT sensory system' to monitor a range of activities in the hospital including motion, occupancy, temperature, ambient light, energy consumption and the movement of assets. Cloud-based software then translates the data into insight to build smart, safe, and more efficient operations for patients and staff. Assets like hospital beds and ventilators can be located in real time, ensuring more time is spent with patients rather than searching for equipment. The project's estimated cost savings are £38,000 annually with a four-year return on investment. See IoTtrack for more info.



Care Home Management
• Geofencing Wyld Networks & HHVL project
Oculus Health?
Connected Health
• Connected Inhaler project (QIOT Ltd)
Patient (Equipment and Treatment) Movement Tracking Elective Care Centre
Other Tech
5G
Other Tech
Connectivity
• Telephone
• Mobile
• SWAN
• Satellite
• Fibre
Technical Infrastructure (IET)
Resource Infrastructure
Financial Infrastructure
Governance Infrastructure
TRANSPORT
InHealth Platform NHSH
Sample Tracking with Real Time, Alert and Interaction (CENSIS project) (NHSH Labs)
Clinical IoT Digital Health
SMART GLASSES Knee Rehabilitation device Wheelchair stability platform – Clinical (Med Phys)
Connected Health Care project (ESA)
Drone Tech
DIGITAL PROGRAMME BOARD NHS HIGHLAND
Education and Training
Multi-functional Platforms
(R3Medi project)
• Monitoring Technologies
• Digital Health
• Tracking/Alert – Real Time Technologies
(NPA TESTED project / CAPITA TRIED project / NPA CV19 Tech project)
Transport Management
• Fleet
• Alternative Modality
(MOVE project)
Estates
• Water (ARVIA project)
• Energy
• Waste
• Operations Maintenance
• Building Management System (BMS)
Non-Clinical IoT
Medical Equipment
• Real time tracking
• Ownership / Use
• Maintenance profiling
Materials Management
• Laundry
• Surgical instruments cleaning
Tiny Air (SBRI) project – pre-cleaning
Data Gathering, Processing and Analysis

## 5.2 Faroe Islands

### 5.2.1 Government Policy on IoT

The Government and commercial service provider investment into the country means that very close to 100% of the Islands has access to the highest internet speeds in the world with 5G across the whole country expected to be completed largely in 2020 (37) Investment at this level means that the national infrastructure is extremely supportive of IoT in non-clinical usage.

There are three hospitals in the Faroe Islands, and with a population of only 50000, there is limited resource available for investment into new technologies and the IoT in general terms. Any IoT is more likely to be clinical in nature, especially where clinical support is required due to any reduction in clinical specialisms (38). The National Hospital allows all visitors access to the Wi-Fi with their own devices, which is a positive move towards accessibility, but which may hold risks for security (39).

### 5.2.2 Use Cases of Non-Clinical IoT in Healthcare

Globe tracker, an IoT company based in the Faroe Islands, offers an excellent example of a non-clinical IoT technology solution utilised to assist asset geo-tracking. The company is an industry-leading solution designed to remotely monitor and manage supply chain assets in global transit. The globe tracker sensory devices store and transmit live data through cellular connectivity to offer real-time insight and actionable intelligence on cargo care and shipping/reefer operations. Robust security is built into the Globe tracker strategy as the system is dependent on a powerful monitoring system. More information is available from the Globe Tracker website: https://www.globetracker.com/gt-sense-reefer/

## 5.3 Northern Ireland

### 5.3.1 Government IoT Policy

Northern Ireland policy makers have committed to transform regional connectivity with an ultrafast digital infrastructure (13). These developments mean that the potential for healthcare IoT is becoming an increasing opportunity for business and for the healthcare providers alike.

### 5.3.2 Use Cases of Non-Clinical IoT in Healthcare

The ability to understand the location of every medical bed and their associated mattresses is becoming a necessity, and the raft of legal, regulatory and policy forces driving the adoption of effective bed tracking has never been greater. In Northern Ireland HealthCare Analytics as a case study are using IoT to meet this tracking need. All too often, clinical, and medical engineering teams face a daily battle to locate beds and mattresses; they are frequently being under utilised and poorly maintained, creating a significant yet avoidable cost and risk burden. Inevitably, compromises in relation to time and cost efficiency, safety, patient care and risk management are common.

The Northern Ireland Health Service has worked with Healthcare Analytics (40) and Multitone Electronics to design and build an efficient IoT solution that enables non-clinical key assets such as beds and mattresses to be tracked - managed effectively, providing real time asset location, with a built-in task management application for monitoring the availability, cleaning, and maintenance of these assets. This enables the recycling of assets more effectively and is linked to other hospital systems to deliver real time information to other critical systems improving the patient pathway. The system uses multiple technologies, including passive RFID tags, barcode scanners and approved smart applications to deliver a simple, yet comprehensive management system. This works with staff, reducing rental costs and the administrative burden, crucially allowing more time to be spent with patients.

With current bed occupancy rates in most NHS hospitals now at 95% and above, the locating and efficient management of beds and other assets is paramount:

- Locating/managing assets in a large NHS Trust is a huge almost impossible and very time-consuming task. There is no audit/traceability of the maintenance, service, or cleaning history of a bed.

- 9% of patients will suffer a Healthcare Acquired Infection (HCAI), with 30% being avoidable and every Healthcare Professional understands the significant negative impact this can have on both the patient and length of stay. Currently it is impossible to trace the source of infections; therefore eradication of an infection outbreak can take days/weeks.

- Nursing Staff spend (on average) 21 minutes on every shift looking for equipment; it is important that the right bed is tracked for the right patient e.g. bariatric to reduce bed sores.

- Northern Ireland Trusts currently purchase 25% more than need to improve the availability of medical equipment. Improved device management, availability/utilisation reduces the need to invest in new beds and mattresses and additional inventory.

- Improved device management, availability/utilisation reduces need to loan beds/mattresses to accommodate short-term demand. The process of bed/mattress rentals can be automated through this asset tracking and management; significant rental charges can be avoided by ensuring clinical staff only use specialist beds/mattresses when necessary.

Further the NI IoT company Kinsetsu founded in 2016 provides a suite of intelligent asset management software to optimise IoT sensors. They provide real-time tractability of critical assets; assets can be tangible such as people, devices, vehicles, or intangible such as space and location. Kinsetsu customers include healthcare trusts, education ministry of defence and field engineers. Early on in product development Kinsetsu made a strategic decision to create a platform that could be deployed multiple times for different applications/clients. Their suit of products includes:

- **digital mapping (Track)** where assets van be seen in real-time, and map offers quickest route to retrieve them
- **Ktrach** which tracks assets moving from building to building
- **Kstop** which monitors and manages individual transport journeys e.g. adult social care (or children – bus service) can track entry and exit points, delays, seat space, fuel consumption, routes
- **Kcare**- response to covid- offering digital contact tracing. E.g. staff delivering healthcare equipment to people's homes- track and trace of covid alert
- **Kscan**- enables any asset to be added in the field on android phone
- **Homebug**- in development to support independent living

## 5.4 Sweden

### 5.4.1 Government IoT Policy

In Sweden, the Government has committed to achieving a 'Completely Connected Sweden' by 2025 (14). Sweden is among the leading countries in the diffusion and use of digital technologies. Internet use by individuals and businesses is widespread and the digital divides along lines of age, education, income, and firm size are narrower than in most OECD countries, at the same time broadband availability, quality and affordability are reasonable in comparison with many other countries.

Sweden's capability to embrace the digital transformation has been a main driver of its strong economic performance in recent years. The economy has high share of value added produced by the information and communication technologies (ICTs) and is among the top ten exporters of ICT services worldwide.

Through digitalization, Swedish firms have moved up along global value chains in manufacturing, focusing their activities on high value-added services. As the digital economy evolves at a rapid pace, Sweden faces new opportunities and new challenges:

- increasing tradability of digital services is opening up new markets at the time when international competition in manufacturing is getting stronger
- "big data" and artificial intelligence are enabling new business models and new services, but require that digital risks and privacy to be effectively managed
- open public sector information and open government data to citizens, an area where Sweden seems to be lagging.

- scale up programmes for digital innovation in order to exploit economies of scaling research and testing
- policy coherence has become essential to seize the benefits of the digital

An IOT-initiative by Umeå University has gathered regional, academic, municipal, and corporate actors in an initiative called Digital Impact North. The actors joined forces and will contribute to regional development and the smart sustainable society based on a powerful collaboration between a growing and increasingly competitive IT sector, an IT research that is a leader in more and more areas of knowledge, an IT education that can deliver the required skills , and a growing number of organizations that are considered pioneers in their respective sectors. The initiative will succeed in that most of the puzzle pieces are already in place and a long-term plan for how the process will be driven forward.

The approach to establish Region Västerbotten as a European leader in strategic digitalization and smart sustainable society is based on a number of sub-strategies. Among other things that:

- Accelerate the region's pace of innovation and renewal through joint innovation and project strategies.
- Raise the region's levels of knowledge and competence in IT and artificial intelligence through broad investments in research, education, analysis of the surrounding world, foresight processes, dissemination of knowledge, etc.
- Strengthen the region's attractiveness and renewal through joint communication and networking strategies.
- Develop and add innovation-driving resources such as project offices, business development units, lab and experimental environments, test beds, seminar structures, etc., thereby contributing to the region's innovation pace and project intensity across the area's knowledge and sector boundaries.

### 5.4.2 Use Cases of Non-Clinical IoT in Healthcare

*Project 1 Smart real estate services*

The IoT hub in Umeå will focus primarily on three areas in property management, water, and sewage systems, efficient maintenance, and optimized use of premises. By using the public actors' premises to test different implementations of IoT, the project can contribute to more cost-effective property management.

Various examples of how this should be tested include: Installation of sensors at the University Library's study workplaces so that students can directly see where there are vacancies, to avoid walking around and looking. Installation of sensors in various classrooms, conference rooms and meeting rooms will measure attendance to provide a better basis for follow-up and planning. Sensor data must also be used to plan maintenance in new ways, for example, only premises that have been in use need to be cleaned, instead of doing so according to a predetermined schedule. Sensors will also be installed in public places to show citizens where activities are taking place and attract visitors.

Vakin is also participating in the project, where tests will be carried out to measure levels in sewage wells. To spread general knowledge about IoT, the project will create an IoT environment at Umevatoriet where the public can experiment and learn more about the possibilities and limitations of technology.

*Project2: Increased security with flexible home care*

The composition of the population in Sweden is changing to consist of a larger proportion of children and the elderly, with an ever-smaller proportion of working age who will take care of the other groups. Sweden is also a country with very sparsely populated areas and long distances, which contributes to more challenges regarding care and care for the elderly. In order for us to be able to maintain the same quality and security for the elderly, new innovations and solutions are required in the home care service.

In this project, new solutions are created by using IoT devices in the homes of the elderly. The devices are used to detect events that may require supervision. When such an event is detected, for example, a message can be sent, to a relative or staff in the care. This has several positive effects, as the efforts can be made when needed, and not just scheduled. It saves travel time and resources when everything is in order and gives people the opportunity to stay at home longer.

By setting up IoT devices in homes and connecting them to an open technology platform, the project will find new services and opportunities in how IoT can be used to simplify everyday life and create greater security. The IoT's sensors send data to the technology platform, which processes data from several different IoT devices into activity information. In the event of a deviation from its usual pattern, relatives and / or municipal care and nursing are notified, with the aim of creating safer housing.

Through case studies, the project will see how different subsystems can be connected and together create a portfolio of services that can be offered to the residents, all depending on their individual needs. There are currently pilot apartments in Skellefteå and during the project, implementation will also take place in Uppsala municipality and Kiruna municipality. The municipalities have different conditions, which provide an opportunity to see how the solution works in different contexts. The ambition is for the whole thing to become part of the obvious range of eHealth support for healthcare providers.

## 6.0 What do These Regional Examples Show? Some Thoughts for Future Progress

Clearly, the regional examples are brief and will not include all of the non-clinical activities that are currently active, and indeed, the rapid change within the IoT world, means that at best such summaries are a snapshot of what has happened at a regional level.

What it does reveal is that IoT in general has seen a rapid increase especially in relation to patient monitoring, diagnosis and to some extent, treatment. From the non-clinical IoT perspective, there are commonalities across the regions which are useful to identify, as it is these commonalities that can help to build a firm basis on which to build effective, agile, and responsive strategies. These commonalities include the management of the 'estate' in healthcare systems; the monitoring, management and tracking of specific equipment; the use of IoT in non-clinical maintenance and prevention work; and the management of assets in the supply chain. Each of these approaches is large scale and likely to apply to healthcare non-clinical systems in any locality.

Any strategy or way forward that is developed needs to be sufficiently flexible to reflect local issues and contexts, as one of the problems that has faced the scaling up of technologies in healthcare systems in the past has been the inflexibility of public bodies rooted as they often are in historical legacies that pose challenges to achieving change. To that end, the following recommendations are suggested as possibilities for strategic change in non-clinical IoT, and these are further developed in the TESTED Strategy.

**Recommendations:**

- **Explore opportunities for non-clinical IOT using Cost Benefit Analysis and Strategic Risk Assessment**
- **Develop and scale up non-clinical IOT**
- **Develop an inclusive communication IOT literacy strategy for health workforce**
- **Explore opportunities for staff participation and grassroots IOT developments and integrate with strategies developed at national, regional and local levels (use of match mapping)**
- **Investigate how best to respond to the technical challenges that act as barrier to IOT roll-out**
- **Develop security systems that reflect national regulations and information governance requirements to maintain data confidentiality and to manage security concerns through IOT scale up**

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