

# Effect of Intelligent Technology Infrastructure on Hospital Operating Costs and Patient Care

by Graeme Robertson

## Executive summary

Healthcare lags behind other industries when it comes to the implementation of information technology. The World Health Organisation estimates that 20-40% of resources spent on healthcare are wasted. However, new advances in technology make it possible to integrate previously separate facility systems to form an “intelligent” hospital infrastructure. As a result, significant improvements in patient care and reductions in operational costs are possible. This paper reviews approaches for justifying infrastructure investments.

## Introduction

One of the main challenges facing healthcare organisations around the world today is that of an ageing population. The United Nations (UN) predicts that by the year 2100, the number of persons aged 60 or over is expected to more than triple, increasing from 841 million in 2013 to 2 billion in 2050 and close to 3 billion in 2100. The UN goes on to state that “66% of the world’s older persons live in the less developed regions and by 2050, 79% will do so. By 2100, this figure will reach 85%.”<sup>1</sup> In addition, population ageing will bring on a dramatic increase in illnesses which have age as a dominant risk factor, such as cardiovascular disease, cancer, diabetes and chronic respiratory disease. Healthcare costs will continue to rise as treatment and care costs are high for these diseases.

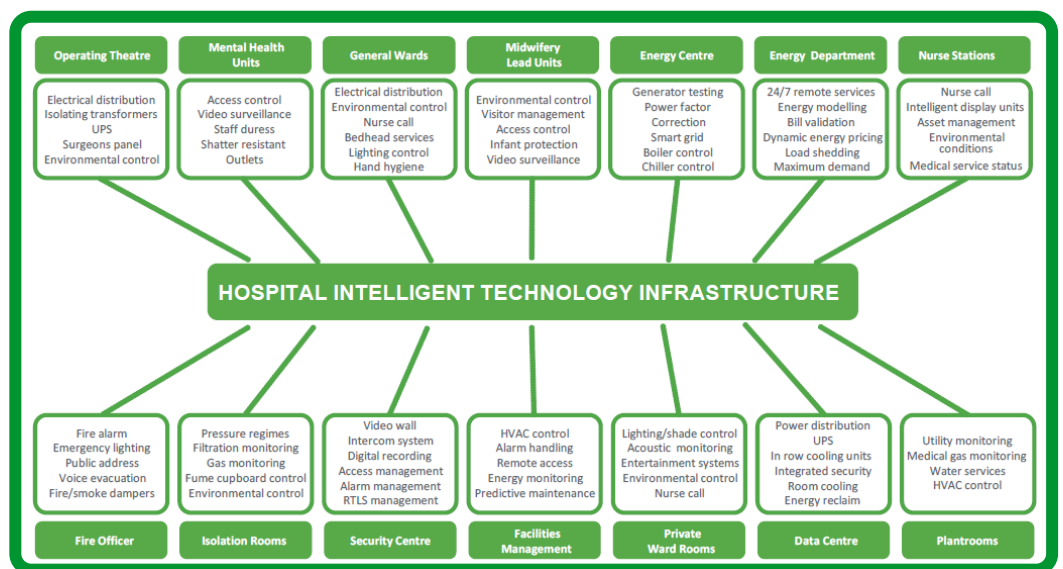
According to the World Health Organisation (WHO), the promotion of efficiency and the elimination of waste are major initiatives that should be launched in order for healthcare providers to address this challenge. WHO is recommending a focus on the following areas:<sup>2</sup>

- Performance of healthcare workers
- Improvements in hospital efficiency and quality of care
- Reduction of medical errors and redundant processes
- Analysis of population health needs and identification of appropriate services

WHO estimates that 20–40% of resources spent on healthcare are wasted. At the core of this efficiency problem are antiquated and siloed processes and systems for servicing patients. Fortunately, new advances in technology now make it possible to integrate previously separate facility systems together to form an “intelligent” hospital infrastructure. As a result, significant improvements in patient care and reductions in operational costs are possible.

## Defining an intelligent infrastructure

Healthcare providers will require tools to help them cope with these new challenges. An intelligent technology infrastructure (ITI) is one such tool (see **Figure 1**) that stems from the progressive development of Information Communication Technology (ICT) and other emerging wireless and mobile communications protocols. Acting as a central nervous system for the hospital, an intelligent technology infrastructure integrates traditionally disparate



**Figure 1**  
An intelligent infrastructure connects many departments to allow for a patient-focused approach to operations

<sup>1</sup> United Nations. "World Population Prospects, Key Findings and Advance Tables", *The 2012 Revision*. New York 2013.

<sup>2</sup> WHO, "World Health Report 2010: Health Systems Financing: The Path to Universal Coverage."

systems, such as power, building management, security, and IT to enable communication across systems, as well as real-time monitoring, optimisation, and automation. When a hospital's systems can "talk" with each other, the infrastructure as a whole is strengthened and builds intelligence, leading to more effective use of all resources.

With an intelligent technology infrastructure, hospitals can:

- Improve patient and staff wellbeing with staff safety and patient clinical monitoring systems.
- Enhance the patient's experience with nurse call services, and control of their own lighting, temperature, window blinds, and more.
- Promote energy efficiency with the control and monitoring of energy sources.

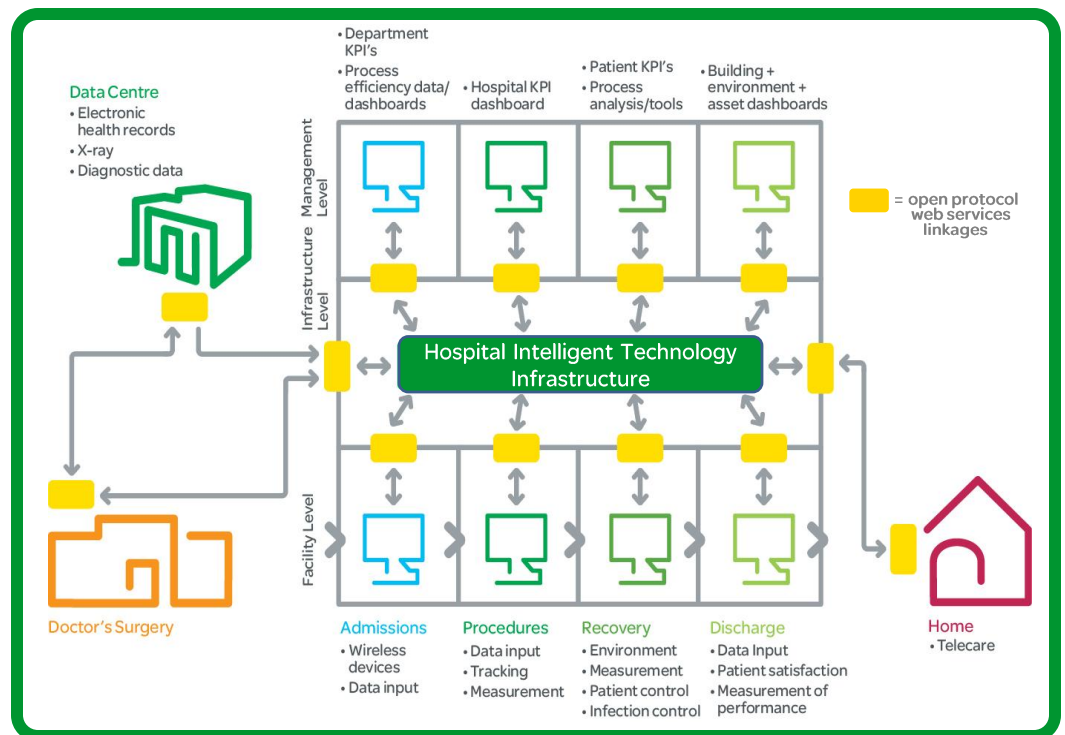
## Intelligent infrastructure benefits

An intelligent technology infrastructure improves each patient's journey through the healthcare process. In many areas of the world, patients now have more choices for where they receive their healthcare, placing additional pressure on hospitals to stay competitive. Good or bad, the experience a patient has while in a hospital will likely impact their decision to return when they next need care.

The journey a patient experiences will be affected by a variety of factors including clinicians, catering, cleaning, and the healthcare facility itself. By connecting medical and facility hardware and software and enabling wireless communication, medical staff can access the information they need, anytime, anywhere in order to keep patients safe and satisfied with their overall experience (see **Figure 2**).

Mobile solutions allow practitioners to stay in continuous contact, whether at the patient's bedside, in examination rooms, or in emergency treatment centers, to effectively develop and deliver patient assessments, and make more informed care decisions based on collaborative treatment plans.

**Figure 2**  
This graphic illustrates the range of possible technology pathways in relation to the overall patient journey.



An intelligent hospital infrastructure also provides maximum “uptime” of systems through a resilient design that incorporates sophisticated power management techniques. This results in higher availability of systems and services than was previously possible through conventional, separate discrete systems. The architecture allows all the systems to interoperate and for users within different departments to access the information they need to better service their patients. A hospital that is always “on”, from the power in the operating room to availability of electronic records, will provide the safest possible environment for patients, staff, and visitors.

The design of the infrastructure facilitates a distributed intelligence. This implies that systems interoperate in different ways across multiple departments of the facility. The architecture will allow for operational gains such as reductions in energy consumption through active monitoring of energy resources, improvement of patient and staff safety through intelligent access control systems, and improved environmental control (lighting, temperature, humidity) in patient rooms. The infrastructure is designed to allow interoperability of all services across the healthcare facility.

The infrastructure is also built to easily adapt to expansion and change. Using open protocol technologies, the infrastructure integrates new technologies or a new wing to the facility in a rapid and cost effective manner. WHO estimates that in the United States alone, \$335 billion a year is wasted in healthcare due to the lack of interoperability of information systems.<sup>3</sup> The efficiencies gained from an intelligent hospital infrastructure helps to reduce that waste.

*“It is estimated that in the United States alone \$335 billion a year is wasted in healthcare due to the lack of interoperability of information systems.”*

*- WHO, 2010*

## CapEx benefits

By integrating the various facility systems into a single network, healthcare organisations can realise the following capital expense (CapEx) benefits:

- Reduction of wiring and associated installation costs that would be traditionally dedicated to individual subsystems. Both the number of cables and the average length of cables are reduced.
- Less time spent on commissioning the systems, which leads to cost reductions in construction labour.
- Reduction in the number of active network devices required to run the ICT network.

The principle of intelligent infrastructure and distribution of that infrastructure can be applied to many hospital environments and situations. Consider the example of ventilation and power systems in new hospital construction. Delays in new construction can potentially affect the project’s gross margin. Typically, the preceding contractor needs to complete their own work before installation and commissioning for the HVAC system can be started. If the preceding contractor fails to complete their work in accordance with the construction program, inevitably the time allowed for commissioning and installation is reduced, and can result in increased project risks, such as inefficient work, safety hazards, delays, and added cost.

An intelligent technology infrastructure solution provider delivers an air-handling unit (AHU) to the construction site with the majority of the Building Management Systems (BMS) already installed and pre-commissioned, or pre-fabricated. By carrying out the majority of the installation and pre-commissioning work remotely, project efficiency is improved and potential risks are reduced, ultimately saving the healthcare organisation time and money on their new construction project.

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<sup>3</sup> WHO, “World Health Report 2010: Health Systems Financing: The Path to Universal Coverage.”

## OpEx benefits

Network availability can be bolstered when an intelligent infrastructure is enabled. This results in operating expense (OpEx) benefits that save the hospital time and money in the following ways:

- Resiliency and high availability can be better managed in a single network than in many separate networks.
- Network management and diagnostics can be integrated into the systems to indicate whether the point of failure is in the network or in the equipment, which leads to better failure detection and shorter reaction time.
- Openness and flexibility allows future technological developments to be easily adapted to standard Ethernet/IP communications.
- Power over Ethernet (PoE) techniques reduce maintenance and reconfiguration costs.
- A collective integrated dashboard offers views specific to the job role of the individual staff member.

## Staff productivity

- Intelligent staff information systems allow staff to react to events more quickly. For example, procedures on how to respond to security and life threatening events can be delivered via intelligent touch screens at nurses' stations in case of an emergency.
- Improved information transfer reduces time that the medical staff needs to spend on requesting facilities intervention.

## Patient satisfaction and safety

- Communication and response time with the staff is improved. Patients can use information displays to communicate different needs directly with nurses instead of just calling a nurse via a nurse call button.
- Access to the Internet allows patients to communicate with friends and family via web, email, or other social services.
- Information can be delivered to a patient interface in case of a fire or other threats. For example, exit routes can be shown in three dimensional patient displays and information screens along the way.

## Improving the patient journey

The range of possible technology pathways which can be deployed to improve patient journeys is broad. Both existing and emerging technologies should be leveraged, where opportunities to integrate both technology types should be pursued so that an efficient, low cost platform can be developed.

Emerging technologies, such as micro total analysis systems and nanotechnology must undergo a lengthy process in order to gain regulatory compliance and prove financially viable in the world's major healthcare markets.

Database integration using the HL7 standard can facilitate much faster retrieval of medical information to aid diagnosis and treatment, and in some cases speed the documentation of medical procedures.

Telehealth, the use of electronic information and telecommunications technologies to support long-distance clinical health care, patient and professional health-related education, public health and health administration, has already been deployed in several countries. **Table 1**

illustrates the delivered benefits, such as a 38-45% reduction in care costs and 50% average reduction in length of stay in care homes. The results of one such study of 131 telehealth users from North Yorkshire, UK by the department of health are detailed in **Table 1**.<sup>4</sup>

**Table 1**

*Study of 131 telehealth users in North Yorkshire, UK*

Service type	Number of users	Traditional package		Telehealth services package			
		Annual cost £	Traditional avg cost £	Annual cost £	Telehealth package avg cost £	Variance £	Cost reduction %
<b>Residential care</b>	60	784,775	13,079	417,511	6,958	367,264	47%
<b>Community support</b>	71	480,024	6,760	356,336	5,018	123,688	26%
<b>All packages</b>	131	1,264,799	9,654	773,847	5,907	490,952	39%

As emerging technologies become more widely used in telehealth, providing more sophisticated intelligent sensors and analytics, the range of health services will expand. This will enable a greater scope for the use of preventative care and its resultant cost savings.

A range of opportunities exists to intelligently combine technology pathways both with each other and with healthcare facilities and processes to improve patient journeys. To provide an example of the scope for improvements in this area, an analysis of an endoscopy department showed that at its least efficient, only 4% of the patient journey (13 of 345 minutes) is spent on activities that contribute directly to the patient outcome<sup>5</sup>. In order to combat inefficiencies and improve patient journeys, many healthcare organisations are employing a concept known as lean thinking to processes. Developed by Toyota, “lean” is basically about getting the right things to the right place, at the right time, in the right quantities, while minimising waste and being flexible and open to change.

Wireless mobility enables healthcare providers to access and communicate real-time patient data anywhere on the facility premises. On demand information is available at the patient bedside, in examination rooms, or in emergency treatment centres. Mobile solutions allow practitioners to stay in continuous contact, developing and delivering patient assessments, and making more informed care decisions based on collaborative treatment plans.

When designing new healthcare facilities, the lean approach can be used in conjunction with building information modeling (BIM). This approach is highly suitable for hospitals, for example an office building may have four moving parts, whereas a hospital will have 50 or 100 moving parts. By modeling healthcare projects, the early adopters of BIM are seeing reduced project costs, shortened schedules, and increased project quality. The biggest gains are the result of improved coordination of complex building systems and the ability for real-

<sup>4</sup> Department of Health and Choose Independence. “A review of the evidence base for Telecare”. 2007.

<sup>5</sup> OECD Health Data. “Health expenditure as a share of GDP OECD Countries,” 2009

time visualisation of hospital processes once the facility is operational. **Table 2** outlines the possible combinations of technology pathways and healthcare processes that can deliver value during the patient’s stay.

**Table 2**

*Intelligent technology pathway combinations*

Technology	Application	Benefits
<ul style="list-style-type: none"> <li>• WI-FI</li> <li>• VOIP</li> <li>• Voice recognition</li> <li>• RTLS</li> </ul>	Centralised nurse call system with staff using mobile voice recognition pendants and patients able to communicate with a central operator	<ul style="list-style-type: none"> <li>• As the call for assistance is directed to the appropriate member of staff, the response time to critical calls reduces, freeing 22% of the time registered nurses spend responding to calls where an aide could have responded.</li> </ul> <p>* based on study at St Francis Medical Centre, Illinois U.S.</p>
<ul style="list-style-type: none"> <li>• RTLS</li> <li>• WI-FI</li> <li>• Intelligent integration</li> </ul>	Real time tracking and management of healthcare processes	<ul style="list-style-type: none"> <li>• Reduced average length of patient stay (ALOS) by 10-30%</li> <li>• Optimal bed occupancy rate achieved for maximum efficiency</li> <li>• Improved infection control (4% reduction in MRSA infection)</li> </ul> <p>* based on studies at San Antonio Community Hospital, Upland U.S &amp; Mills Peninsula Health Services, Burlingame, U.S.</p>
<ul style="list-style-type: none"> <li>• RTLS</li> <li>• Digital signage</li> <li>• Intelligent integration</li> </ul>	Automatic monitoring system for hand hygiene compliance – a simple contact is monitored in each soap dispenser and linked to the staff RTLS to ensure appropriate hygiene compliance before entering patient room (uses Hawthorne effect).	<ul style="list-style-type: none"> <li>• Improved infection control</li> <li>• Reduced average length of patient stay</li> <li>• Increased patient safety</li> <li>• Increased patient satisfaction</li> <li>• Improved financial performance</li> </ul>
<ul style="list-style-type: none"> <li>• Patient environmental control systems</li> <li>• Patient communications and entertainment systems</li> <li>• Automation of manual processes</li> <li>• Intelligent integration</li> </ul>	Fully integrated patient control system managed via a multipurpose touch screen enables control of the complete room environment in terms of temperature, humidity, light level with acoustics, air-quality and liquid contamination monitoring.	<ul style="list-style-type: none"> <li>• Improved infection control</li> <li>• Improved recovery rates</li> <li>• Reduced average length of patient’s stay</li> <li>• Increased patient satisfaction</li> <li>• Improved financial health (also in terms of energy saving)</li> <li>• Improved staff efficiency (staff functions such as window blinds automated)</li> </ul>

## Investment strategies

The range of investment possibilities in technology pathways to improve the patient journey can be split into the following broad categories in terms of the main beneficiaries:

- Clinical / organisational – covering productivity, direct costs, infrastructure and a range of organisational targets and KPI’s.
- Patient / standard of care – optimising the patient journey.

Most investment possibilities will result in some degree of overlap between clinical / organisational and patient / standard of care benefits and returns. The range of possibilities in terms of main categories is outlined in **Table 3**.

**Table 3**

Range of investment possibilities

Investment	Category	Benefits and Returns
<b>Medical grade ICT infrastructure upgrades and replacements</b>	Clinical / organisational – using converged voice communications technology, electronic transmission, and viewing of x-ray images and electronic stock ordering	<ul style="list-style-type: none"> <li>• Emergency department: adult patient journey time reduced by 23% and investment payback time of 14 months achieved.</li> <li>* based on European Commission study at Nottingham University Hospital ED UK.</li> </ul>
<b>Data centre physical infrastructure upgrades, replacements, and outsourcing</b>	Clinical/organisational – using resilient critical power, advanced energy efficient in row cooling and integrated physical and data security	<ul style="list-style-type: none"> <li>• An essential investment as dependency on ICT increases so does the need to protect and support the storage and processing of the data.</li> <li>• Returns need to be assessed mainly in terms of the risk of not investing although aspects such as running costs and scalability can be assessed using direct financial models.</li> </ul>
<b>Integrated environmental controls for patient rooms</b>	Patient/standard of care using temperature and solar blind control to increase amount of natural light patients receive and simultaneously provide patient control and improve comfort conditions	<ul style="list-style-type: none"> <li>• Reduced ALOS</li> <li>• 20% reduction in pain medication due to reduced perceived stress in more comfortable conditions</li> <li>• Further benefits to improve infection control, as blinds are located within window panes, which facilitate more effective cleaning.</li> <li>* based on study at Gateway Medical Center, Clarksville TN U.S.</li> </ul>
<b>RTLS for medical equipment</b>	Clinical / organisational –using a wireless network of equipment tags, bridges and server to allow staff to locate medical equipment	<ul style="list-style-type: none"> <li>• Time spent searching for missing equipment reduced from 20-30 minutes to 5 minutes</li> <li>• Ordering of new replacement equipment (for equipment presumed lost) postponed</li> <li>• Reduction in rented equipment costs</li> <li>• Returns measured in terms of time saved by staff and reduced equipment expenditures due to equipment being presumed to be lost</li> <li>• A highly scalable investment, which can be performed on a small scale and expanded once benefits and returns are established</li> <li>* based on study at Texoma Medical Center Denison TX, U.S.</li> </ul>

A number of barriers face any healthcare organisation wishing to procure an intelligent technology infrastructure.

**Barrier: Lack of funding or difficulties raising capital** – As many private hospitals are unprofitable and many public hospitals suffer from underfunding, the issue of raising capital can be very difficult. The issue of who should pay for these types of improvements is another key question that fuels many debates.

**Recommendation:** Rental purchase agreements have proven to work in some cases. For smaller scale investments, the CFO and/ or CEO can be approached if investments in technology pathways show clear financial and organisational benefits. Many hospital CEOs believe funding should come from outside the hospital. Options include funding from the healthcare industry and insurers (in the case of private healthcare) or from government investment (in the case of publicly funded healthcare).

**Barrier: Lack of knowledge or expertise within the healthcare organisation** – Oftentimes, in-house expertise is limited to older technology in an existing network.

**Recommendation:** In cases where new technology needs to be integrated, outside experts can be brought in to help in experience building, knowledge sharing and piloting of new applications. The abilities of outside experts to build a holistic business case, which accounts



for all necessary measures, including staff training and contains an ongoing assessment of implementation effectiveness, should be closely examined.

Procurement strategies should be based on a qualitative assessment of technical solutions and delivery and support capabilities. A scoring matrix can help to rank ability to deliver, support and develop the pathway project throughout its lifecycle. Existing procurement models mainly used for transactional business should be avoided when possible, as the relationship between client, designers, and outside experts, and vendors is geared toward a working partnership.

Effective staff training prior to and after project implementation is crucial to success and to avoid any errors due to lack of familiarity with equipment or processes. In some cases, a backup process using the previous system can run in parallel, depending on the assessed risk of start-up or “teething” problems.

Self-sufficiency to manage the new technology infrastructure should be a key aim for the healthcare organisation, as over dependence on external suppliers may not be in the best interests of patients and staff.

In some cases, a technology infrastructure can lead to a re-organisation of staffing within a particular department, for example, in an emergency department, a different number and mix of emergency department assistants and registered nurses may be required following a converged mobile communications pathway application. Work shift patterns may also change following the implementation of a pathway that dynamically tracks patient demand.

## Conclusion

A new approach is required when planning future investments in healthcare to achieve the stated aim of “getting the most out of technologies and health services” and deliver better value to both the healthcare organisation and the patient. Recommendations to further the development and adoption of an intelligent infrastructure and the associated benefits include:

- Greater focus on an intelligent infrastructure and technology pathways from central governance bodies, such as the UK’s National Health Service (NHS), Joint Commission International (JCI), and the WHO, through the top-down approach to inform and encourage greater uptake of new technologies.
- Development of new international standards for healthcare ICT infrastructures, including all sub-categories for better management of patient flows and outcomes.
- More attention and value placed on technology infrastructure and pathways by national or regional healthcare organisations to stimulate further development and innovation from the private sector.
- Broader recognition for the role of engineers and ICT professionals in the future of efficient healthcare delivery.



### About the author

**Graeme Robertson** is Global Business Development Director at Schneider Electric and has worked in the field of Intelligent Systems design for hospitals for over 20 years. He holds a bachelors degree in Energy Engineering from Napier University in Edinburgh and is a member of the Institute of Energy. Graeme has worked on several award-winning hospital projects recognised by the International Academy for Design & Health and has published numerous papers in global journals and for industry conferences.