

INFOCOMM
MEDIA

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Creating Connections • Inspiring Innovation

Infocomm Media 2025

Chairman's Message

Dr Yaacob Ibrahim
Minister for Communications and Information

Dear Minister,

At the 2014 National Day Rally, Prime Minister Lee announced Singapore's goal to become the world's first Smart Nation. This lends us the national impetus to leapfrog ahead and build our Smart Nation. We see the role of Infocomm Media 2025 as enabling and complementing the Singapore Smart Nation vision.

The Infocomm Media Masterplan Steering Committee began its work in June 2013, building on the strong foundation put in place over the past 10 years under the direction and plans of the Intelligent Nation 2015 Masterplan and the Singapore Media Fusion Plan. This time, however, our planning approach distinguishes itself from previous plans in three ways.

Firstly, we endeavoured to make this a holistic plan for developing Singapore's infocomm media sector. We involved multiple agencies whose work is essential to support the efforts of this sector. Together, we undertook a systematic and in-depth study of the ways in which the infocomm media sector can harness the potential of upcoming technology and business trends to power innovations and address our national challenges in the next decade.

Secondly, we adopted a private sector-led and consultative approach in formulating our recommendations. Our Steering Committee comprises largely members from various parts of the private sector. We ensured that there was diversity in the composition of the various committees and ensured alignment with other national-level planning efforts. This was to make sure that the process is informed by a broad spectrum of perspectives from both the private and public sectors, locally and from abroad. In refining our preliminary recommendations, we also conducted focus group discussions with the industry, academia and members of the public, and tapped on social media and other platforms to solicit views from the larger community.

Lastly, we developed this report as a "living" reference that sets broad directions to guide the development of strategic areas for infocomm media. We recognise the needs of businesses and Singaporeans will continue to evolve. Over the next 10 years, we also expect disruptive and unpredictable technologies and killer apps to emerge and redefine the contours of the digital landscape. For this reason, we need clearly articulated directions for strategic areas so that Singapore can pursue opportunities and respond to challenges when they arise.

As such, our report does not prescribe the development of specific technologies or solutions, but instead recommends broad directions under three strategic thrusts. The first thrust capitalises on data, advanced communications and computational technologies to bring about a quantum leap in our economic competitiveness. The second thrust nurtures an infocomm media ecosystem that encourages risk taking and continuous experimentation to create Singapore-made content, products and services. The third thrust strives to connect our people through infocomm media to enhance our quality of life and to foster a stronger Singaporean identity.

We believe that our recommendations under these thrusts will further strengthen the infocomm media landscape of Singapore. To realise these recommendations, it is crucial that industry, society and Government participate actively. No one party can realise Infocomm Media 2025. Working together, we can help Singapore achieve sustainable and quality growth, as well as enrich the lives of our people.

We are honoured to have had the opportunity to contribute to the development of the infocomm media sector in Singapore. With the submission of this report, we ask that the Government continue to maintain an ongoing dialogue with industry and the public to ensure that our recommendations keep up with the pace of technological change, and continue to serve the needs of our nation.

Yours sincerely,

A handwritten signature in black ink, appearing to read 'Koh Boon Hwee', written in a cursive style.

MR KOH BOON HWEE
CHAIRMAN, INFOCOMM MEDIA MASTERPLAN STEERING COMMITTEE



**MINISTER FOR COMMUNICATIONS
AND INFORMATION
SINGAPORE**

11 August 2015

Mr Koh Boon Hwee
Chairman, Infocomm Media Masterplan Steering Committee

Dear *Boon Hwee,*

I thank you and the Committee for the time and hard work that have been put into drawing up the recommended directions in this report and its supplementary materials. The Ministry accepts this report and the broad directions set within. These directions will guide the strategic development of infocomm media into 2025.

The bold use of technology, guided by earlier infocomm and media masterplans, has been one of the contributing factors of Singapore's success. As we look to the future, we must continue to tap on technological advancements to create new strengths and overcome the challenges we face.

The transformation and converging of the infocomm media sector will create opportunities for all through new opportunities for business growth and greater convenience and benefits for our people. I am therefore pleased that your committee has looked at the development of infocomm media in a holistic and integrated manner, taking into consideration the views sought from the respective stakeholders in the private, public and people sectors. I also welcome the early trials of some of the recommendations like Heterogeneous Network, Computational Thinking as a National Advantage and Tech Challenges.

I am confident that the recommendations in the report will draw out synergies across the infocomm media sector, and allow us to harness the power of infocomm media to bring about impactful outcomes for Singapore. In this fast changing environment, it is important that the Government remains agile and ready to reshape its strategies and policies in response to challenges and opportunities as and when they arise. We will study the details of the recommendations and work closely with the industry, sector champions and stakeholders to refine and implement them at the appropriate juncture. These broad shifts will position Singapore well as we move towards becoming a Smart Nation.

The Committee has shown that industry partnership bodes well. We look forward to the industry's continued support and active participation.

Yours sincerely,

A handwritten signature in black ink, appearing to read 'Yaacob Ibrahim'.

DR. YAACOB IBRAHIM



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Executive Summary

Purpose of Infocomm Media 2025 and what will Influence its Development

1 In developing this Report, we were mindful that over the next decade, we want to see an infocomm media sector that generates capabilities and innovations that are relevant and contribute towards solving big national challenges. In this way, infocomm media can enrich the lives of everyone in Singapore.

2 We feel the infocomm media sector is poised to play an important role in four national challenges. We believe that infocomm media can be applied to improve productivity growth of businesses through more efficient operations as well as new ways to provide content, products and services to their customers. The infocomm media sector can also create high-skilled jobs for Singaporeans. Infocomm media technologies can support our ageing population through new solutions and services to enable them to keep healthy longer and to lead fulfilling lives. Finally, infocomm media can strengthen our national identity through compelling content, improved understanding, and platforms that support the mobilisation of efforts towards positive social goals.

3 In this Report, we identified the nine underlying technology and business trends that will power many of the innovations over the next decade. How well we understand and harness the potential of these trends will influence the development of infocomm media in the coming years. In particular, technology innovations in Big Data and Analytics, Internet of Things, Cognitive Computing and Advanced Robotics, Future Communication and Collaboration, Cyber Security, and Immersive Media, hold considerable promise in enabling the development of sustainable solutions to our challenges. In terms of business trends, mobility and increased connectivity, as well as media content breaking free from platforms point to boundless opportunities in the mobile and transmedia space. In time, a converged infocomm media sector has the potential to be a stronger enabling force than the individual sectors. Together with the application of good design thinking, the sector can help other sectors lift productivity, and create new content, products and services.

Imagine the Possibilities

4 In 2025, we envision a Singapore transformed for the better by infocomm media. It will be a nation where people live meaningful and fulfilled lives enabled by technology, and where there are exciting opportunities for all. It will be a place where infocomm media enables a better quality of life for our people through world-class connectivity, compelling local content, and technologies to make everyday lives smoother and more convenient. It will be a living lab to entrepreneurs, growth companies and multi-nationals in the infocomm media space where they continually experiment and innovate to contribute to sustainable and quality economic growth.

5 To realise these desired outcomes, the Infocomm Media 2025 sets out to create a globally competitive infocomm media ecosystem that enables and complements Singapore's Smart Nation vision. This ecosystem supports our people and enterprises in tapping on infocomm media to effect economic and social transformation, and to create enriching and compelling content to help bind our communities and foster a common identity.

6 We recognise that we cannot prescribe specific technologies or solutions to develop, because technology will continue to advance at a breakneck pace. On the other hand, leaving it solely to the market may mean that we lose opportunities to integrate and achieve transformational change at the national level. As such, this Report articulates the broad strategic thrusts to address the national challenges we need to solve. Within each thrust, we then propose the capabilities we need to build to effectively harness the power of infocomm media. The strategic thrusts we have identified are:

1st Strategic Thrust: Capitalise On Data, Advanced Communications and Computational Technologies

7 Many of the possibilities for the extraordinary transformation described above will be made possible by data, the "new oil" of the 21st century. Together with better connectivity and more powerful computational technologies, data analytics can be a powerful tool that enables businesses to draw sharper insights into their customers and operations. It can make our businesses smarter, more productive, and more competitive, thereby powering our economic growth.

Better Collection, Transport and Sharing of Data

8 The first part of this strategic thrust is to establish an agile, pervasive and trusted infrastructure required to efficiently collect, transport and share large amounts of data for information and analysis. Our networks need to be agile with the ability to connect intelligently, quickly and seamlessly with one another and with various devices. They have to be pervasive and offer coverage that extends beyond homes and buildings. They also have to be trusted and offer the highest level of resilience, service availability, and security. We can do so by deploying an island-wide Heterogeneous Network to provide seamless connectivity and a consistent quality of experience; establishing a nationwide sensor network with Aggregation Gateway Boxes to efficiently collect a wide range of sensor data, and increased data centre capacity; and boosting our regional connectivity as a Digital Harbour with a digital corridor and establishing a trusted Data Marketplace with complementary data-enablers to securely share private and public data.

Improve our Competitiveness using Data

9 The second part of the strategy is to catalyse a series of transformations across key sectors of the economy, each building on the power of data and data insights, and on computational technologies. For example, media companies can use data insights derived from Total Audience Measurement to have a better sense of the media consumption preferences of their viewers and consumers. In the same vein, insights to consumers' preferences can help companies better target their Digital Advertising effort and personalise the e-Commerce experience they deliver. For Urban Logistics, insights from supply chain data can help companies to optimise processes for faster last mile delivery and more efficient trade fulfilment. In healthcare, insights gained from better understanding of a patient's genome, for instance, can help physicians tailor personalised medicine for targeted and effective treatment of diseases such as cancers and cardiovascular diseases. Finally, with Learning Analytics, educators can personalise their teaching instruction and interventions for individual students according to their learning patterns and capabilities.

10 To succeed in this effort, IDA and MDA will have to do even more than they did in preceding masterplans, to collaborate with stakeholders in these sectors to bring about an infocomm media enabled transformation. This may require the development of new capabilities in these organisations.

2nd Strategic Thrust: Nurture an Infocomm Media Ecosystem that Encourages Risk-Taking and Continuous Experimentation

11 In this strategic thrust, we envisage an infocomm media ecosystem that develops successful Singapore-made content, products, and services. This begins with a future-ready workforce with the right capabilities, and businesses that embrace risk and are prepared to experiment. We think this can be achieved by equal emphasis on measures directed at the workforce and at enterprises.

A Workforce Equipped with New Infocomm Media Knowledge and Skills

12 For the workforce, we advocate direct customised manpower development schemes that are aligned with SkillsFuture Singapore to equip the respective infocomm and media workforce with new knowledge and skills. We believe that Computational Thinking as a National Capability will set us apart as a nation. We can inculcate this foundational skill in young Singaporeans with initiatives like Code@SG in our schools. For those already in the workforce, we can accelerate their professional development through Open and Accelerated Learning. For media professionals, we can create a Story Lab, and develop a filmmaking capability programme and Capability Development Scheme to help them to learn innovative ways of telling stories and create high quality and engaging content from experts. Through such initiatives, we aim to help Singaporeans develop the required skills and a passion for infocomm media as a career.

Build A Sustainable Support Network for Aspiring Start-Ups and Growth Companies

13 For enterprises, we recommend providing infocomm media start-ups with more targeted and tailored assistance, as well as to motivate the sector at large to solve big problems, and to establish physical spaces to explore new technologies and test out proofs of concept. We can start by nurturing a Self-Sustaining Start-up Ecosystem through facilitating crowdfunding as a new major financing model where our start-ups have access to the expertise, international connections, and capital of a wide network of private investors. We can help start-ups crystallise their business propositions

by implementing sector-specific Accelerator and Incubation programmes to complement existing technology-focussed accelerator programmes. In the media space, we can build up the content production capacity and capabilities of our media companies so they become the Partner of Choice of international broadcasters.

Catalyse Innovations and Solutioning through Big Challenges

14 We believe that for the infocomm media sector to be more exciting, innovative, and creative, both the people and the enterprises in the sector must be motivated by the urgency to solve large, meaningful, challenging, and complex problems. We propose working with the National Research Foundation to organise Tech Challenges for the infocomm media sector to take up challenges scoped around enterprise-level problems. Coupled with good design thinking, this could lead to successful products and solutions.

A Living Lab for Infocomm Media

15 We need to continue to promote Singapore as a Living Lab where enterprises can collaborate with public agencies and research institutions to develop, test, and commercialise solutions in a real-life setting. In this Living Lab, we can provide collaboration platforms like IDA Labs and Creators' Space. IDA Labs supports the use of new technologies to create innovative products and services. Creators' Space provides small and medium sized media companies with a production facility to develop engaging digital content.

3rd Strategic Thrust: Connect People through Infocomm Media

16 The infocomm media sector is one of the few that can positively impact the everyday lives of people in a very direct and personal way, making lives richer, easier and more fulfilling. At the same time, infocomm media can help bind us closer as a community and strengthen our national identity.

Better Everyday Lives

17 First, infocomm media can be deployed in a people-centric way, to enable Singaporeans to better manage their health, deepen their learning, enhance their transport experiences, as well as better organise community efforts. We can enable the elderly and patients with chronic diseases to proactively monitor their health in their homes through Smart Health-Assist. Smart Education technologies such as immersive media can improve the experience of pedagogy by making learning more participatory and visceral. This will facilitate learners' mastery of new and practical skills. For our commute, we can use Autonomous Vehicles that communicate with the apparatuses of our transport system to alleviate road congestion. For our community, we can simplify the donating and volunteering process with a Unified Giving Platform that integrates the functions of canvassing for donations and recruitment of volunteers.

Infocomm Media Inclusion

18 Second, we need to ensure that the benefits of infocomm media are enjoyed by our people, including the elderly, low-income families, and persons with disabilities. We need to pay special attention to ensure digital inclusion. All should have access to infocomm media and all should be able to use infocomm media effectively. We can leverage technologies that enable real-time language translation to enhance service delivery and reach out to more Singaporeans. This can bind us closer as a community and strengthen our national identity. With these measures, we put people at the heart of our digital future and, in the process, build a better Singapore for our people.

Making it Possible: Technologies to Power Us Ahead

19 We believe that we need R&D that is closely linked to industry outcomes, and capabilities in strategic technologies to put in place the recommended initiatives in this Report.

20 We think that stronger linkages between research and industry will be needed. It is important to identify challenging problem statements, identify the right companies to partner for value capture through structured programmes (e.g. Accreditation@IDA), provide real-world project opportunities to bridge R&D and industry participants, and connect better local and overseas IPs to industry partners (e.g. Technology Evaluation Programme at IDA). There is a need for the industry development agencies to take a leadership role to ensure that upstream R&D is linked to industry outcomes.

21 There is also a need to invest in strategic infocomm media R&D to help advance Singapore's Smart Nation vision and the initiatives we recommended. The cross-cutting technology capabilities that should be considered for national R&D investment are in these areas:

- (1) Cyber Security and Trust
- (2) Communications
- (3) Cognition
- (4) High Performance Computing
- (5) Analytics
- (6) Interfaces

Conclusion

22 Besides active consultation with stakeholders from academia and the private and people sectors, we crafted this Report in close collaboration with teams that steer related national and sectoral plans. This is to ensure alignment with the directions set out for Smart Nation, the Research, Innovation and Enterprise 2020 national R&D plan, the National Cyber Security Masterplan 2018, and other masterplans like the Sectoral Manpower Plan under SkillsFuture Singapore. We hope that in implementing this Infocomm Media 2025 plan, there will be continued engagement with all the above-mentioned teams and stakeholder groups to understand their needs so that our recommendations and broad directions stay relevant as technology advances.

23 We recognise that some of the possibilities envisaged in this Report cannot happen unless there is a willingness to review existing policies and regulations. This requires willingness across many government ministries to consider how technology can be harnessed to transform the sectors that they oversee. We further suggest that IDA and MDA review and, where necessary, reorganise their work processes and industry development plans, to facilitate the execution of recommendations in this Report.

24 At the same time, our enterprises and people also have an important part to play in the constantly changing environment up ahead. Our enterprises need to continue to look out for new opportunities and actively review their business models. They should also harness infocomm media to innovate and to lift their productivity. Our people of all ages need to proactively level up and expand their infocomm media skills to thrive in the emerging global digital economy. We need to adopt a "maker mindset", a belief that one can learn to do anything and an inclination to experiment with technology, and use it to build solutions to problems. We also believe that Singaporeans of all ages need to build social connections to people outside their immediate circles and to feel a sense of community, so that we are a stronger, more cohesive people.

25 In summary, this Report illustrates the enabling powers of infocomm media. It can drive economic success. It can empower and ease everyday lives. It can connect people. It can make our lives richer, more fulfilling, and easier in every way. It is clear that we cannot afford not to invest in infocomm media if we want to continue to be a successful nation. To realise all that potential, however, the industry and Singaporeans from all walks of life need to work together to harness infocomm media to fundamentally change the way we live, learn, play, work, and connect. Only then can we take advantage of opportunities when they arise and achieve our goals. Only then can we realise sustainable, quality growth, and a better quality of life for our people and, ultimately, make Singapore a better place for ourselves and for generations to come.

The Purpose of Infocomm Media 2025 and What Will Influence Its Development

- 1.1 In developing this Report, we were mindful that over the next decade, we want to see an infocomm media sector that generates capabilities and innovations that are relevant and contribute towards solving big national challenges. In this way, infocomm media can enrich the lives of everyone in Singapore.

Our National Challenges

- 1.2 We identify four national challenges that we feel the infocomm media sector is poised to play an especially important role.

Improving Productivity Growth

- 1.3 The National Productivity Council has set a target of two to three per cent growth in productivity per annum between 2010 and 2020¹. We believe that the infocomm media sector can help businesses achieve this through more efficient operations, as well as new ways to provide content, products and services to their customers.

Creating High-Skilled Jobs

- 1.4 We believe that the infocomm media sector can offer challenging, meaningful and rewarding careers for Singaporeans. By 2030, two-thirds of Singaporeans are expected to hold professional, managerial, executive, and technician jobs, compared to just half today. In other words, there will be 1.25 million² such jobs, compared to 850,000 in 2013. A good number of these jobs will be in the infocomm media sector.

Supporting an Ageing Population

- 1.5 By 2030, 18.7 per cent of our citizens will be aged 65 and older, compared to 12.4 per cent in 2014. We see an opportunity for new markets and services to emerge to serve this significant part of our population. Technology will create new solutions to enable our elderly to lead independent and fulfilling lives, and to keep them healthier for longer.

Fostering a Cohesive Society

- 1.6 We believe that the infocomm media sector will play an important role in helping to deepen national identity and our social cohesion. The growth of high-quality local content will help to define our national identity. Technology that enables our people to self-organise and to mobilise their efforts towards positive social goals will also strengthen social cohesion.

Salient Technology and Business Trends

- 1.7 We identified nine technology and business trends that we believe will power many innovations over the next decade. Their potential has to be understood and harnessed, so that Singapore may reap their benefits in the coming years. These trends are:

Big Data and Analytics

- 1.8.1 Data storage is now so affordable that we are now able to keep immense amounts of data. Any company in nearly every sector of the economy is able to organise its information into large datasets, so as to gain better insights into their customers and to make better business decisions. As a result, the Big Data technology and services market is now one of the fastest growing markets in the ICT industry, with an expected compound annual growth rate of 26.4 per cent until 2018³. This is more than six times the growth rate of the general ICT market. We believe that companies, organisations and governments that ignore the potential of data analytics will operate at an increasing disadvantage.
- 1.8.2 What is particularly exciting for Singapore is the application of data science to enhance the delivery of public services like healthcare and transport. In Chapter 3 of this Report, we illustrate how genetic data of a patient can be tapped on to provide doctors with insights, thereby enabling more targeted and personalised treatment plans for patients. Further, in Chapter 5, we describe how transport data can provide deep insights into commuter travel patterns to guide policy review and formulation and design thinking.

The Internet of Things

- 1.9.1 The Internet of Things refers to a network of devices embedded with electronics, software and sensors and connected by the Internet. Such a network is able to sense, interact, and co-operate by exchanging data with the manufacturer, operator, or other connected devices (often without the need for human intervention). The Internet of Things will expand the volume and range of information that organisations have at their disposal, further amplifying the impact of data analytics.
- 1.9.2 For example, remote health monitoring of patients will produce far more data on the physical condition of a patient than hospitals and clinics have now. The Internet of Things is also an important component technology to support the emergence of autonomous systems.

Cognitive Computing and Advanced Robotics

- 1.10.1 We expect the arrival of more sophisticated and autonomous self-learning machines that can interact with humans to carry out high-level functions. In the future, we expect machines to be able to perform accurate and efficient live multilingual translation from audio-visual sources. This will make possible, for example, real-time translations into various languages and dialects (a boon to a multi-lingual society like Singapore).
- 1.10.2 Robots will also move out of the factory environment, and be increasingly deployed across various service industries and in our midst. One such example is Nao, a 58cm tall humanoid robot developed by Aldebaran Robotics. Nao robots have been used to teach autistic children, to interact with and monitor the elderly⁴ and even to serve customers in banks. The possibilities for applying cognitive computing and advanced robotics in Singapore are endless.

Future Communication and Collaboration Technologies

- 1.11.1 The explosion of new services and connected systems will be supported by new generation communications technologies that will make the best use of the range of licensed and unlicensed spectrum.
- 1.11.2 Singapore has made early investments in new communications infrastructure to the benefit of the economy and society. A good example is the decision to build the next-generation broadband fibre-optic network under the Intelligent Nation 2015 masterplan. We believe that Singapore must continue to remain at the forefront and be ready to be among the early adopters of next-generation communications technology, such as the 5G standard for mobile wireless communications that is expected to be formalised in 2020⁵.

Cyber Security

- 1.12 The media sector, like other sectors in the economy, will be increasingly digitised and reliant on computer networks. Online services and personal data will face increasingly sophisticated cyber-threats. McAfee estimates that the impact of cybercrime on the global economy is currently US\$375 billion to US\$575 billion a year. This amounts to 15 to 20 per cent of the total value created by the Internet⁶. The infocomm sector cannot continue to prioritise convenience ahead of security, and will have to ensure more effective and stronger cyber security. There will also be a need to groom sufficient cyber security experts to support a growing cyber security industry.

Immersive Media

- 1.13.1 Display technologies have improved rapidly. For example, we now have Ultra High Definition and panoramic displays, the increasing use of so-called second screens and pervasive content delivery through social media. The next step is to develop sensory technologies, such as those involving wearables and virtual reality/augmented reality, to create media environments with even deeper contexts and content.
- 1.13.2 Human-computer interfaces have also become more sophisticated and advanced. Armed with technologies ranging from recognition and tracking technologies to natural language learning abilities, computers are now able to improve our daily lives by helping us perform tasks more efficiently, thereby increasing our productivity, and offering us new media experiences.
- 1.13.3 Translation technologies, such as subtitling and language translation, are constantly being improved to increase accuracy and reliability, so as to enhance the media consumption experience. Virtual reality, holographs and augmented reality can also support immersive experiences in areas such as gaming, education and simulation training, as well as biological and experimental visualisation.

Mobility and Increased Connectivity

- 1.14.1 Singapore has the highest penetration rates for mobile devices in the world. Nine out of 10 Singaporeans have a smartphone⁷, and our mobile phone penetration rate is around 150 per cent⁸.
- 1.14.2 Over the next decade, we are likely to see a giant leap in the capability of such devices. They will feature intelligent voice-activated personal assistants, biometric sensors and mobile payments. Businesses across all sectors need to position themselves rapidly to operate across mobile platforms. If they are not 'Mobile-First', they risk becoming irrelevant.

Media Content Breaks Free from Platforms

- 1.15.1 In the past, media content was tied to a few transmission or distribution platforms, such as television and radio. Today, it is increasingly digitised and delivered via the Internet to devices such as smart televisions, smartphones, computers and tablets. Now, media franchises can tell their stories over a wide variety of linear and non-linear platforms, such as television, films and books. The Internet has also enabled content owners to mobilise fans to actively participate in the curation and reproduction of the content. Such fans may attend conventions, co-create fan products and collect different types of merchandise.
- 1.15.2 These developments make possible a transmedia business model, that is to say, a model built on telling stories across multiple media platforms. By cultivating a wide fanbase, they lock-in demand for further iterations of the content. Transmedia creators actively build narrative universes over many different types of media, and use media and consumer analytics to profile their customers and develop customised content, products, and services.
- 1.15.3 A good example of a transmedia franchise is the *Star Wars* brand owned by Disney and managed by its subsidiary Lucasfilm. *Star Wars* began as a series of films but its narrative universe has since expanded to encompass television series, video games, comics and novels. This has the effect of increasing and sustaining fan engagement and loyalty, ensuring the success and longevity of the franchise.

Infocomm Media Convergence

- 1.16.1 We expect to see over the next decade increasing convergence of infocomm media. The process has already begun. This is most evident in the strategy of traditional telecommunications players to enter the content business. This is borne out of the realisation that network access is increasingly commoditised, and that telecoms companies have to avoid the fate of becoming “dumb pipes” that carry other people’s data and other people’s content.
- 1.16.2 Certain capabilities in the media sector, such as visual effects, are already built upon infocomm technology. They have yet to be applied extensively to transform other sectors, such as education (through simulation training), or other services, such as retail. The infocomm sector has had a much longer track record in functioning as an “enabling sector” that helps other sectors to lift productivity, or to create new services. A converged infocomm media sector has the potential to do the same.
- 1.16.3 At the same time, the digital transformation of the media sector is far from complete. Data analytics can transform the way media professionals create media content. Advertising and marketing companies are already increasingly relying on data analytics to perform message testing. It is possible to conceive of more advanced variants of such techniques used as part of script development of long-form content, such as drama series.
- 1.16.4 Netflix is well-known as a successful online video streaming company. What is less remembered is that Netflix started as a brick-and-mortar DVD rental business. The way in which Netflix tapped on infocomm technology to differentiate itself, and to ultimately move up the value chain from content curation and distribution to content creation⁹, and in the process creating award-winning original television series like *House of Cards* and *Orange is the New Black*, illustrates the potential of infocomm media convergence.

Success = The World’s First Smart Nation

A nation where people live meaningful and fulfilled lives, enabled seamlessly by technology, offering exciting opportunities for all. We should see it in our daily living where networks of sensors and smart devices enable us to live sustainably and comfortably. We should see it in our communities where technology will enable more people to connect to one another more easily and intensely. We should see it in our future where we can create possibilities for ourselves beyond what we imagined possible.

Prime Minister Lee Hsien Loong

at the Smart Nation Launch on 24 Nov 2014

- 1.17 What will success look like? Since we embarked on this planning process, the Government has launched an ambitious plan to make Singapore a Smart Nation. In the words of Prime Minister Lee Hsien Loong, a Smart Nation is “a nation where people live meaningful and fulfilled lives, enabled seamlessly by technology, offering exciting opportunities for all.”
- 1.18 This is an exciting and transformational vision. We see our recommendations in this Report as enabling and complementing the Smart Nation vision. It proposes strategies to grow all the key components of this enabling ecosystem: infocomm media infrastructure, agile enterprises, skilled manpower, cutting-edge technology, and world-leading R&D capabilities.
- 1.19 If our infocomm media sector can ride the waves of change and help Singapore to address its national challenges successfully, if as a country we succeed in becoming a Smart Nation, then the reward will be spectacular. Our economy, our society and our way of life will all be transformed for the better.

Imagine the Possibilities

- 2.1 The year is 2025. Life in Singapore has been transformed for the better by infocomm media. The sector is globally competitive; our infrastructure is modern and state-of-the-art; our workforce is recognised for its relevant and marketable skills; and infocomm media companies are supported by world-class research.
- 2.2 Let us look at life in Singapore in 2025 through the experiences of four different individuals from different walks of life.

A Singapore Filled With Opportunities

- 2.3 Singapore in 2025 is a Smart Nation offering many opportunities for businesses and talent. Top-tier multinationals find Singapore an attractive base for their regional and global operations. Home-grown companies thrive in an environment that constantly experiments and innovates.

Case #1: Hassan, 48, a Singaporean working in an infocomm media multinational company that is based in Singapore

Hassan is a human resource director for regional operations at a prominent multinational company. Two years ago, his company decided to house its regional operations in Singapore. It is one of many multinational companies to do so. In the year 2025, Singapore is more than ever a choice destination for businesses targeting the Asia-Pacific region.

Over the course of the last decade, as part of its ambition to position the country as a gateway to the regional market for infocomm media companies, Singapore has robustly upgraded its data-centre infrastructure and cultivated deep and secure infrastructural links with its neighbours. It is this unique connectivity and infrastructure that led Hassan's company to choose the republic as a regional base.

Besides its excellent infrastructure, there are other attributes of Singapore that appeal to Hassan's company. For one, Singapore lives up to its reputation as a Living Lab. Here on the island, companies are able to test out their new technologies and ideas at the many large scale test-beds located in both mature and new regional centres.

Another major draw is Singapore's pro-innovation environment which supports all industries in their use of infocomm media to create new content, products and services, and to improve their operations. Hassan's company, for example, benefits from being able to collaborate with a local research institute on a live subtitling platform that promises to be a world first in being able to cater to the many different languages in the region.

In addition, the Singapore government's emphasis on fostering computational thinking skills among Singaporeans of all ages has produced a workforce equipped with skills needed to power the digital economy. Hassan's company is enrolled in a national training scheme as a training provider for mid-career infocomm media professionals interested in specialisation. Consequently, Hassan finds it easy to recruit capable local talent.

Case #2: Hwee Leng, 32, a Singaporean entrepreneur of an infocomm media business

Four years ago, Hwee Leng came up with a brilliant infocomm media business idea. She promptly quit her job and founded a start-up to take that idea further. Although she did not have prior experience running a business, she was supported by various business incubator programmes available to aspiring infocomm media entrepreneurs. These programmes gave her the industry and research contacts she needed to build her business. In addition, these incubators helped Hwee Leng by providing her with crucial feedback and suggestions on how to refine her ideas to match the needs of the market. With a sharpened business plan in hand, she was able to finance her start-up through a sustained crowdfunding campaign that offered her backers rewards in return for funding her idea.

It is now 2025 and Hwee Leng is running a thriving company and selling her products to customers globally. She manages the delivery of her products to retailers across the globe using real-time tracking and stock replenishment services provided by logistics companies. Through digital advertising, she built a winning global brand for her products.

There is no question that Hwee Leng owes her success to her own hard work and the passion that she pours into her business. Nevertheless, she credits the local start-up ecosystem for providing her with the tools, funding, expertise and support that helped her transform her innovative idea into a sustainable and successful enterprise. Had Hwee Leng founded her company a decade earlier, she would have had to develop her company from scratch, and would have struggled more to cope with the steep learning curve largely on her own.

A Creative Singapore

- 2.4 In 2025, Singapore is a place where content companies and creative talents come together to create compelling local media content that enriches the lives of Singaporeans and keeps communities stronger. By tapping on new technologies, media infrastructure, content sharing platforms and capability building programmes, local content firms are able to capitalise on infocomm media convergence to deliver content that captures the imagination of many demographic groups. This quality content resonates with Singaporeans and brings them closer together, strengthening the Singaporean identity.

Case #3: Anil, 19, Singaporean undergraduate and aspiring screenwriter

Anil aspires to be a screenwriter and hopes to write his own original series in the future. He was inspired by the recent successes of various Singaporean scriptwriters. Writing in Singapore has become a highly-regarded craft. There is now a big market for local stories. Singapore-made dramas and films have improved in quality and appeal and are gaining legions of fans in the region. They are so popular that they now draw tourists to Singapore to visit iconic locations featured in the productions. Many Singaporean screenwriters have also become celebrities in their own right, with devoted fans who follow their work.

Anil conceived the subject matter of his script while combing online reports that analyse the latest audience viewing preferences. While attending a series of story development workshops conducted at the Story Lab over the course of four months, he met a games developer who was keen to develop his storytelling skills, who was also interested in the same subject matter. They shared plot ideas and decided to collaborate on a multiplayer story for a game platform to pitch to a virtual reality platform provider. Through the Story Lab, they were mentored by a group of local and international media practitioners on the latest storytelling techniques for new media platforms.

Over the past week, Anil has been preparing for an upcoming pitch with a major virtual reality platform provider. He has high hopes that the provider will be impressed not only by the team's story outline but also by their ability to convey the story through a multiplayer game on a new virtual platform.

Singaporeans Enjoying A High Quality of Life

2.5 By 2025, both the public and private sectors have successfully deployed infocomm media technologies to transform their services and their interactions with their customers. Singapore is a frontrunner in tapping on innovative infocomm media technologies and solutions to improve the way people live and work. The infocomm media sector is an effective advocate and partner to transform key service sectors including community and social services, e-commerce, digital advertising, education, financial services, health and wellness, logistics, manufacturing and transport. The range of high quality public and private services gives Singaporeans the highest possible quality of life.

Case #4: Grandmother Kim Hui, 68, Singapore pioneer, now retired and living independently in a Smart Home

Hwee Leng decides to visit her mother, Kim Hui. She travels in a taxi that is an intelligent autonomous vehicle. The taxi taps on an island-wide network of sensors that gathers data from road infrastructure, buildings, and other vehicles to analyse current traffic conditions and plots the quickest route to her destination. In the taxi, Hwee Leng watches a live high definition stream of the latest business news, as the taxi drives through underground road tunnels and housing estates. Along the ride, she answers a video call from her overseas client. Her video call is uninterrupted even as she gets out of the taxi and into the lift at her mother's apartment block.

On arrival, Hwee Leng embraces her mother and is pleased to note that her mother is in good spirits. Although Kim Hui is 68 and suffers from diabetes, she is still able to lead an independent life thanks to her Smart Home and personalised Health Concierge.

Kim Hui's Smart Home consists of a network of unobtrusive sensors embedded in the flooring and in the furniture. These sensors include motion sensors that track her movements around the house. There are also sensors in wearables that record her heart rate and other biometric data. The sensors work seamlessly to monitor her movements and medical condition, communicating continuously with each other to ensure that there are no gaps in their coverage. Should Kim Hui suffer a medical emergency while at home or in the neighbourhood, her caregivers and children would be immediately notified by the sensors. In addition, medical assistance would be dispatched without delay, and with the required medication prepared. With the Smart Home, Kim Hui's children are not worried about Kim Hui living alone without a companion, despite her medical condition.

Health Concierge is another enabling technology that Kim Hui and her children welcome. Integrated with smart systems within the Smart Home, the device transmits Kim Hui's health data to the polyclinic in real time, allowing Kim Hui's doctors and other care team members at the polyclinic to monitor her state of health and provide medical instructions remotely. These medical instructions are then relayed to Kim Hui by Health Concierge in Mandarin, her language of choice. All Kim Hui has to do is to follow these instructions and adjust her medicine dosage and exercise regime accordingly.

Besides the Health Concierge, Kim Hui uses other smart devices and apps like the home energy system – which manages her energy usage based on her lifestyle – and media services that are personalised to her viewing patterns and preferences.

These days, life is rich and fulfilling for Kim Hui. She no longer has to travel to the polyclinic weekly for routine check-ups. This means that she has more time and energy to spend on her hobbies and taiji workouts to keep herself hale and hearty. Her social life is active and full, with her days filled with interacting with friends online, meeting friends for tea and taking up new courses. Watching her sprightly mother, Hwee Leng breathes a sigh of relief once again that her mother is well cared for within her home, even when she is not there.

Strategic Thrusts

- 2.6 These scenarios paint the possibilities that can be enabled by infocomm media. Ultimately, the outcome we want is a nation where people live meaningful and fulfilled lives enabled by technology, and where there are exciting opportunities for all. We believe that infocomm media can enable a better quality of life for Singaporeans through world-class connectivity, compelling local content, and technologies to make everyday lives smoother and more convenient. Here, entrepreneurs, growth companies and multinationals in the infocomm media space can experiment in this Living Lab that is Singapore, and contribute to sustainable and quality economic growth.
- 2.7 To realise the desired outcome, Infocomm Media 2025 sets out to create a globally competitive infocomm media ecosystem that will enable and complement Singapore's Smart Nation vision. In this ecosystem, our people and enterprises are able to tap on the potential of infocomm media to achieve economic and social transformation, and tackle our national challenges. At the same time, we will be able to create enriching and compelling local content to help bind our communities and create a shared identity.
- 2.8 We recognise that we cannot prescribe specific technologies or solutions to develop, because technology will continue to advance at a breakneck pace. On the other hand, leaving it solely to the market may mean that we lose an opportunity to integrate and achieve transformational change at the national level. As such, this Report articulates the broad strategic thrusts to address the national challenges we need to solve, and proposes the capabilities we need to build to effectively harness the power of infocomm media. The strategic thrusts we have identified are:

Strategic Thrust 1: Capitalise on data, advanced communications and computational technologies

- 2.9.1 Many of the possibilities for the extraordinary transformation described above will be made possible by data, the "new oil" of the 21st century. Together with better connectivity and more powerful computational technologies, data analytics can be a powerful tool that enables businesses to draw sharper insights into their customers and operations. It can make our businesses smarter, more productive and more competitive, thereby powering our economic growth.
- 2.9.2 The first part of this strategic thrust is to enable better collection, transport and sharing of data. For this to happen, we need to establish an agile, pervasive and trusted infocomm media infrastructure that rides on advanced communications technology. The second part of this strategic thrust is to facilitate the drawing of insights from data and use computational technologies, so as to create new content, products and services. With this, we hope to catalyse transformations in sectors as diverse as international logistics and education.

Strategic Thrust 2: Nurture an infocomm media ecosystem that encourages risk-taking and continuous experimentation

- 2.10.1 In this strategic thrust, we envisage an infocomm media ecosystem that develops successful Singapore-made content, products and services. This begins with a future-ready workforce with the right capabilities, and businesses that embrace risk and are prepared to experiment.
- 2.10.2 To achieve this, we have to equip our students and workforce with the essential knowledge and skills they need to perform in high-value infocomm media jobs. We must make available a sustainable support network for aspiring start-ups and growth companies so that these firms are supported in their creation of products, services and content. We need to mobilise the talent and the enterprises in the infocomm media ecosystem to solve big and challenging problems. Lastly, we should also continue to promote Singapore as a Living Lab to harbour innovation and collaboration for the delivery of cutting-edge infocomm media solutions.

Strategic Thrust 3: Connect people through infocomm media

- 2.11.1 Beyond better jobs, better incomes and better profits, infocomm media will deliver a better quality of life for Singaporeans. This sector is one of the few that can positively impact the everyday lives of people in a very direct and personal way, making lives richer, easier and more fulfilling. At the same time, infocomm media can also help bind us closer as a community and strengthen our national identity.

2.11.2 First, infocomm media can be deployed in a people-centric way, to enable Singaporeans to better manage their health, deepen their learning, enhance their transport experiences, as well as effectively organise the community. Second, to ensure that the benefits of infocomm media can be enjoyed by all Singaporeans, special attention will need to be given to specific groups – the elderly, low-income families and persons with disabilities – to ensure that they have access to infocomm media and are able to use them effectively. By capitalising on technologies that enable real-time transcription and translation, we will be able to enhance service delivery and reach out to more Singaporeans. This can bind us closer as a community and strengthen our national identity. With these measures, we put people at the heart of our digital future and, in the process, build a better Singapore for our people.

WHAT WE WANT

We want a nation where people live meaningful and fulfilled lives, enabled by technology, offering exciting opportunities for all.

Sustainable and Quality Growth

Better Quality of Life

WHAT WE NEED

We need to build our sectors to better tap on the potential of infocomm media to tackle our national challenges, and realise our desired outcomes.

A Globally Competitive Infocomm Media Ecosystem that



Enables and Complements Singapore's Smart Nation Vision



Effects Economic and Social Transformation



Creates Enriching and Compelling Content

HOW WE WILL GO ABOUT DOING IT

We will focus our efforts to reap the full potential of salient technology and business trends through three strategic thrusts.

1



Capitalise on data, advanced communications and computational technologies to bring about a quantum leap in our economic competitiveness

2



Nurture an infocomm media ecosystem that encourages risk-taking and continuous experimentation to create Singapore-made content, products and services

3



Connect people through infocomm media to enhance quality of life in Singapore and to foster a stronger Singaporean identity

2.12 In the subsequent chapters, we will present initiatives to implement these three strategic thrusts. In the spirit of risk-taking and experimentation, we recognise that some of these initiatives may not always work out as we hope they will. Nevertheless, we strongly believe that the strategic thrusts point us in the broad direction we need to head towards in the long run. We are also confident that as the global environment and business conditions evolve, our infocomm media sector will have the wisdom and ingenuity to make necessary tactical adjustments while progressing in this broad direction.

1st Strategic Thrust: Capitalise on Data, Advanced Communications and Computational Technologies

- 3.1 This strategic thrust is informed by the insight that many of the possibilities for the extraordinary transformation of our businesses and our nation are made possible by data, the “new oil” of the 21st century.
- 3.2 Market research firm International Data Corporation has projected that by 2020, the amount of data in the world will grow to 44 trillion gigabytes (a tenfold increase from 2013)¹⁰. It is further estimated that more than 35 per cent of the data can be used for analysis. The Internet of Things, with its plethora of sensors, will further boost the gathering of this data.
- 3.3 Together with better connectivity and more powerful computational technologies, data can be a powerful tool allowing data owners to draw sharper insights into their customers and operations through analysis. Used wisely, data has the power to transform our economy. It can make our businesses smarter, more productive, and more competitive. It can accelerate our economic growth. We believe that the benefits will be even more profound and powerful if we are able to marshal an orchestrated adoption of related component technologies. This will allow us to achieve much more than using the same technologies in isolation.
- 3.4 In this chapter, we introduce our strategy to capitalise on data, advanced communications and computational technologies. The first part of this strategy is to enable better collection, transport and sharing of data. The second is to facilitate the drawing of insights from data so as to create new content, products and services.

Better Collection, Transport And Sharing of Data

We Will Need More Infrastructure

- 3.5.1 To efficiently collect, transport and share massive amounts of data for information and analysis, we need agile, pervasive and trusted networks. Our networks have to be agile with the ability to connect intelligently, quickly and seamlessly with one another and with various devices. They have to be pervasive and offer coverage that extends beyond homes and buildings so that users stay connected at all times. Our networks also have to be trusted and offer the highest level of resilience, service availability and security so that businesses can rely on them.
- 3.5.2 While the Next Generation Nationwide Broadband Network (NGNBN) (implemented under the Intelligent Nation 2015 masterplan) has successfully increased bandwidth capacity in Singapore, it will need further enhancement over the next 10 years. Active equipment must be upgraded and fibre technologies enhanced at the core to handle increasing bandwidth requirements. The NGNBN must also be made more resilient. The Infocomm Development Authority of Singapore (IDA) must ensure that the NGNBN operators have the necessary technical capabilities and have made the necessary investments to keep the network in top-notch condition.
- 3.5.3 We also strongly recommend the implementation of a **Heterogeneous Network (HetNet)** in Singapore, as the next advance for our communications infrastructure. HetNet will allow devices to leapfrog seamlessly to the network that best suits the operating scenario at any one time. It will improve interoperability between networks to provide the best connectivity for Everyone, Everything, Everywhere, All the Time, even when users move between different places (and hence networks). In this way, we will be able to deliver the best experience for users.

ADVANCING OUR COMMUNICATIONS INFRASTRUCTURE

HETEROGENEOUS NETWORK (HETNET)

The HetNet provides the underlying communications backbone to ensure pervasive and robust connectivity. It brings about more efficient utilisation of spectrum and network resources and an improved user experience through seamless switching between networks and the use of small cells to increase network capacity.

CONNECT
EVERYTHING
ALL THE TIME



CONNECT
EVERYONE
ALL THE TIME



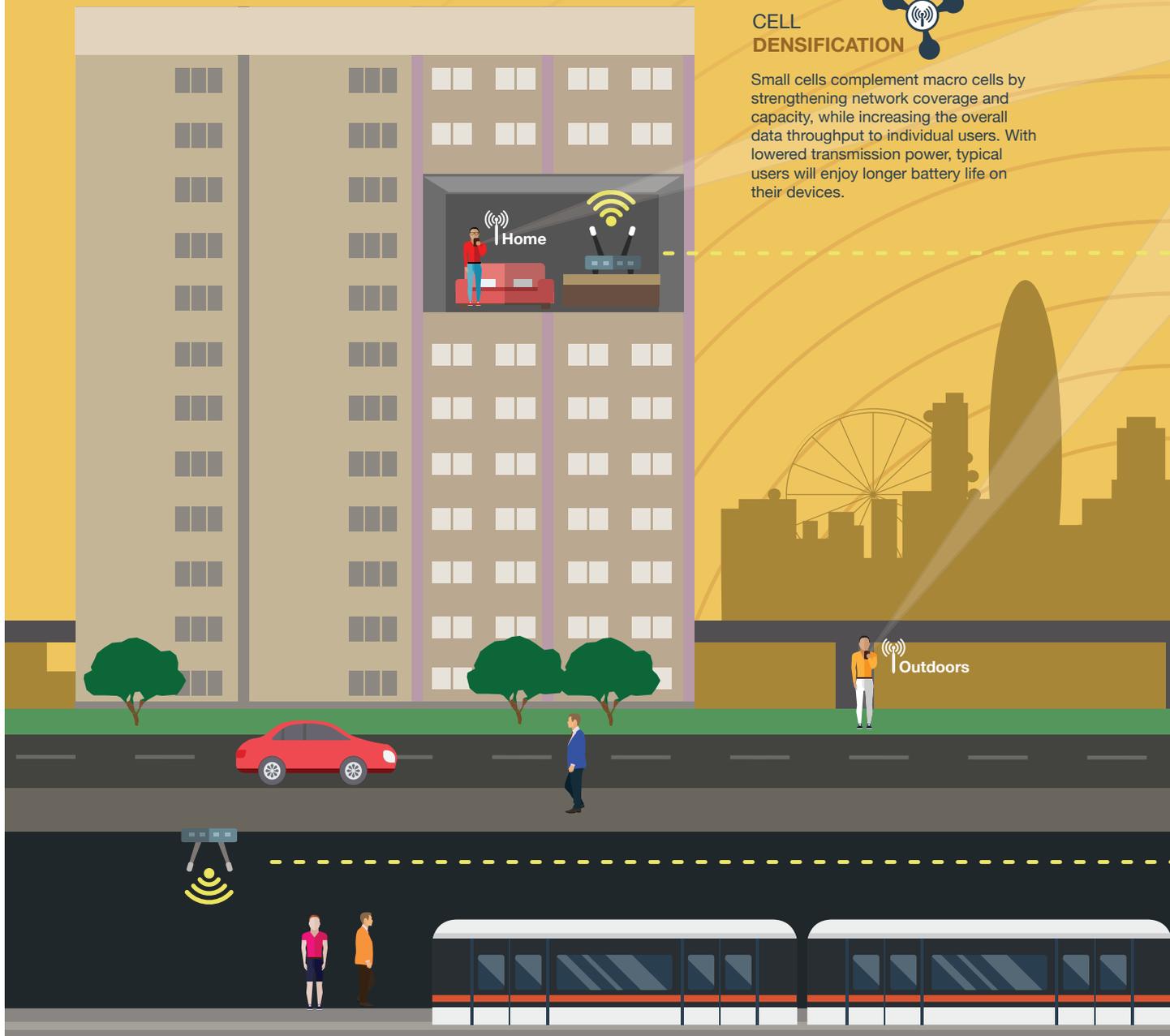
CONNECT
EVERYWHERE
ALL THE TIME



CELL DENSIFICATION



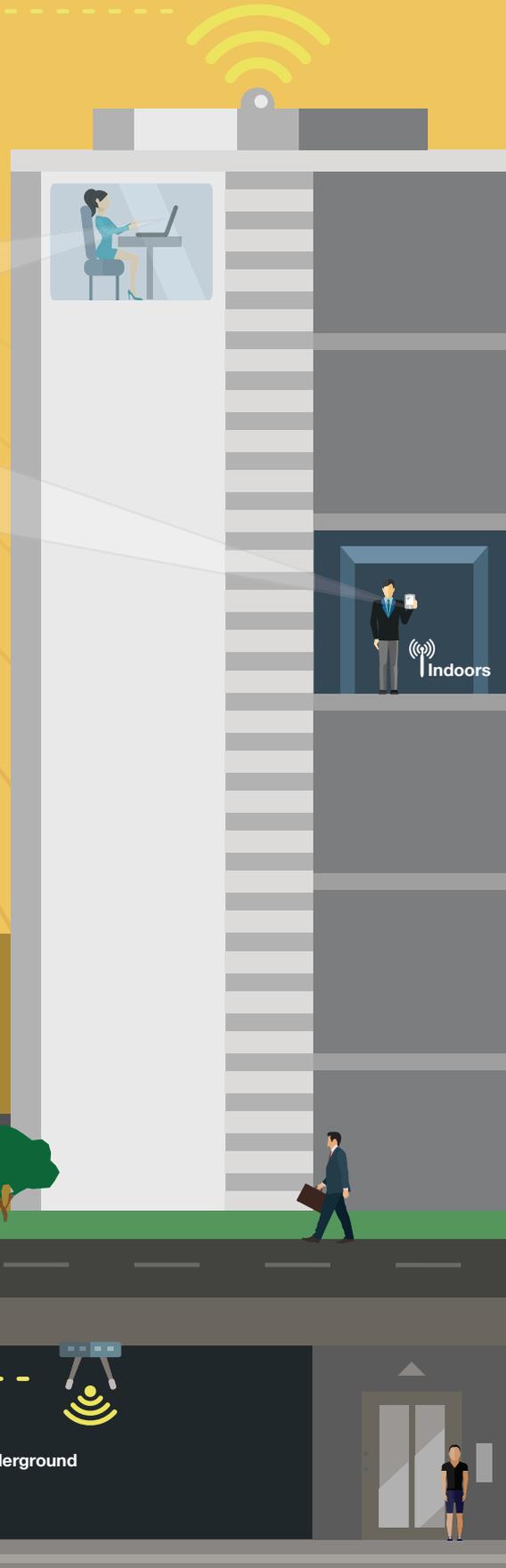
Small cells complement macro cells by strengthening network coverage and capacity, while increasing the overall data throughput to individual users. With lowered transmission power, typical users will enjoy longer battery life on their devices.



SEAMLESS NETWORK SWITCHING



Seamless and intelligent switching between different radio access networks (e.g. between Wi-Fi and 4G) provides better user experience as the devices connect to the best available network based on the users' connectivity needs.

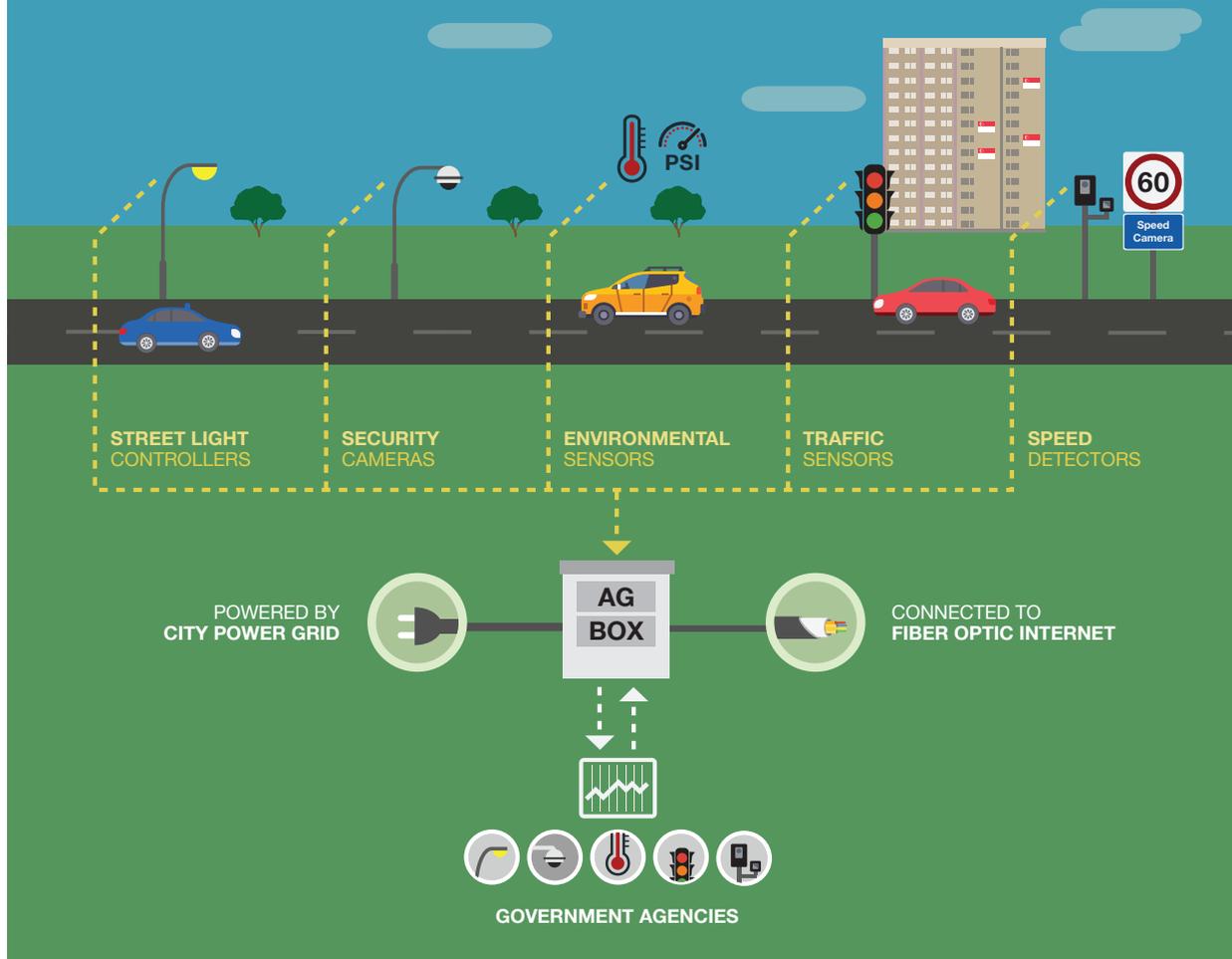


- 3.5.4 HetNet seeks to implement new, innovative technologies, and integrate various radio access technologies such as Wi-Fi and cellular networks. This will optimise the utilisation of scarce wireless spectrum, while maintaining a consistently good quality of service to serve our people's needs. In addition, HetNet will remain both relevant and important even when new network technologies such as 5G are introduced because mobile data volumes will continue to grow. More devices, including sensors (besides smart consumer devices) will rely on wireless networks to deliver information.
- 3.5.5 We must start enhancing our infrastructure now. IDA has taken the first step towards working with industry participants on a series of HetNet trials, including the HetNet Test Circuit¹¹ at the Jurong Lake District. These trials will determine the technical and commercial feasibility of providing uninterrupted high-speed Internet access to a mobile device when users move from their home to an MRT station in the vicinity.
- 3.5.6 For HetNet to become a reality, we will need to overcome a multitude of technological barriers in wireless communications, so that we can accelerate the deployment and acceptance of HetNet. These barriers include seamless LTE/Wi-Fi handovers, IP preservation, premature Wi-Fi selection, and "ping pong" effects¹². These arise from the differences in standards for LTE and Wi-Fi. As a result, moving between LTE networks and Wi-Fi networks leads to disruptions of real-time applications over the networks.
- 3.5.7 We recommend that IDA set up a HetNet Lab to ensure that Singapore is at the forefront of solving problems related to HetNet, and become the lead adopter of HetNet. The HetNet Lab will also enhance Singapore's engineering capabilities in next-generation wireless communications. The HetNet Lab will enable IDA to introduce HetNet technologies into Smart Nation so that citizens and business will benefit from better user experience and wireless data throughput from our communications infrastructure.

We Will Need a Nationwide Sensor Network

- 3.6.1 Various agencies in Singapore already deploy many sensors to improve their ability to better manage public safety, monitor the environment, manage traffic or monitor building systems. Such sensors, however, typically map only to one agency, thus limiting their usefulness to other agencies. The cost of bandwidth supporting these sensors is also significant, discouraging the deployment of high-bandwidth links except to high-priority sensors. This limits the extent to which agencies can benefit from rich, real-time data.
- 3.6.2 We believe that there is considerable scope to deploy sensors in a coordinated manner, so as to enable government agencies to operate holistically and thus manage the city more effectively. Such a nationwide sensor network will also provide residents with more timely information to guide their daily activities.
- 3.6.3 We believe Singapore can achieve this by building an integrated network of sensors across the island to gather vital data. This can be achieved through the deployment of **Aggregation Gateway Boxes (AG Boxes)**. AG Boxes are speedy, secure, cost-effective and scalable sensor and communication suites. When deployed nationwide, they can provide high speed connectivity and serve as key aggregation gateways for a nationwide sensor network. The nationwide deployment of AG Boxes will extend the reach of our fixed network to outdoor locations and can also provide the backhaul for high speed wireless connectivity at these locations.
- 3.6.4 With AG Boxes and HetNet in place, Singapore will be able to collect and transport data between sensors, devices and networks much more efficiently and securely. Both also form important components of our Smart Nation Platform, a key enabler of our Smart Nation vision.

POWERING A NATIONWIDE SENSOR NETWORK AGGREGATION GATEWAY BOXES (AG BOXES)



We Will Need To Be a Harbour For Data

- 3.7.1 A robust communications infrastructure and national sensor network will benefit our people and give our businesses a leg up. It will also attract investors and connect us with the rest of the world. We advocate that Singapore builds on its standing as the world's fastest broadband nation¹³ by building up key complementary infrastructure such as data centres. This will reinforce our position as a regional telecommunications hub, a modern **Digital Harbour**.
- 3.7.2 Being a Digital Harbour will increase Singapore's value to the world. Digital Harbour perform a multitude of business functions and support a plethora of online activities including data storage, computation and processing, media distribution and e-commerce. Our world-class connectivity and Digital Harbour standing will further attract subsea cable investments to Singapore. These will, in turn, create favorable conditions to draw more related investments into Singapore.

- 3.7.3 To realise this, we must set three things in motion. First, we must attract companies with critical data and content to be “Queen Bees” in our ecosystem. The Government should try to get more premium digital content, shared services and value-add services (such as business analytics) companies to anchor their businesses in Singapore. Besides adding to the vibrancy of our ecosystem, these firms will also help us better understand what companies need in terms of data centre space and connectivity, so that we can better design our infrastructure to accommodate their needs.
- 3.7.4 Second, we recommend the Government explore building data centres underground in view of land scarcity. We ask that relevant government agencies work on drawing up a blueprint for underground data centres. This blueprint should synergise with URA’s Central Area Underground Master Plan so as to achieve economies of scale.
- 3.7.5 Thirdly, we are of the opinion that the nation should consider establishing a Data Centre Corridor to further enhance local data centre interconnections. This may involve constructing dedicated fibre rings to interconnect key data centre nodes located in different locations across Singapore, in order to ensure dedicated high speed local connectivity.
- 3.7.6 Finally, the Government should also work with neighbouring countries to promote the laying of more subsea cables in the region. This will improve the latency in our regional networks and bolster Singapore’s regional connectivity.

We Will Need A Data Marketplace

- 3.8.1 A data-driven economy relies on the availability of data for use. While a reliable, pervasive and trusted infrastructure will help collect data, data also needs to be made easily available to businesses and to individuals. This will allow them to make informed decisions that are data-driven.
- 3.8.2 It is currently quite challenging for data users, especially those in the private sector, to discover available datasets. Even when data is available, it takes a lot of time, expertise and resources to mash multiple datasets. Another challenge is that key information about datasets such as data source, quality, version and terms of use is usually not available.
- 3.8.3 We believe the answer lies in the creation of a trusted **Data Marketplace**. Within such a data marketplace, private and public datasets can be made available and discoverable in a systematic fashion. Complementary suites of enablers like metadata registries, data aggregation and data-related tools and resources, privacy enhancing technologies, guidelines on data quality metrics, data versioning, trusted environment and standard for data certification can also be provided to support various aspects of data use. Ultimately, a data marketplace will spur the creation of data-related products and services.
- 3.8.4 We are encouraged by the Government’s efforts to make data more available through its portal, data.gov.sg¹⁴. This data portal makes more than 5,000 publicly available datasets from public agencies accessible to the public. Data users can utilise selected datasets to create applications or to find applications that use government data to deliver services to citizens and businesses.
- 3.8.5 There is currently no private sector equivalent of data.gov.sg. We propose that efforts be made to build a more conducive environment for the exchange of data. IDA has started the ball rolling by launching a Data-as-a-Service pilot that features a Federated Dataset Registry. The registry makes possible the discovery of private sector datasets in a coherent manner and sets guidelines to improve the quality of datasets by encouraging data owners to profile their datasets against a set of recommended data quality metrics. This improves datasets’ discoverability, accessibility and usability. It also helps data users determine which datasets meet their needs, and hence assess datasets more easily.

3.8.6 We also recognise that a constant and sustained demand for datasets will encourage data owners to continue supplying datasets. One way to increase this demand is to interest and educate the public in dataset usage through showcasing how insights can be derived from mashed data for product development, service improvement and increased productivity. We also invite the gaming community to get involved in “gamifying” datasets to generate excitement and promote stronger awareness of the campaign. We further propose that awareness and demand for datasets be raised through technical and business workshops, courses, networking sessions and outreach programmes such as the Data Discovery Challenge¹⁵.

Improve Our Competitiveness Using Data

3.9 With an enhanced network infrastructure, a new nationwide sensor network, a Digital Harbour and a Digital Marketplace in place, we believe the infocomm media sector will be well placed to support the transition of various key sectors in our economy to become more data-driven. In the next section, we share our thoughts on how data insights, used strategically, can improve the competitiveness of sectors such as the media, advertising, retail, logistics, healthcare and education sectors.

Data Insights Will Help Our Media Companies Better Understand Its Target Audience

3.10.1 In Singapore, the viewing preferences and habits of television audiences have always been measured by our national broadcaster, MediaCorp, based on viewership of its free-to-air channels. With the proliferation of platforms beyond scheduled broadcast television, this data is now unrepresentative and inadequate.

3.10.2 To capture more representative data, the MDA is working with the industry to put in place a Singapore Television Audience Measurement system over the next five years. This system will aggregate data from Singapore’s three leading broadcasters: MediaCorp, StarHub TV and Singtel TV. The system will also measure public consumption of audio-visual content across mobile and online to identify trends and shifts over time, such as viewer migration from channel to channel.

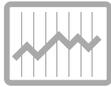
3.10.3 This independent system is intended to be accessed and used by content owners, carriers, producers and advertisers. Data gathered by the system will be made available to the media industry at large, with options for specific platform owners to carry out further customised analysis for deeper business insights. The data will also help the Government fine-tune its policies on industry development and determine how it should allocate its resources. For the public, media data analytics offers the potential of more high-quality content as producers are more in tune with audience tastes and preferences.

3.10.4 Over the longer term, we recommend that the Television Audience Measurement system be expanded beyond audio-visual media to include all forms of media content such as print, cinema, and outdoor/out-of-home platforms. It will be faster and more cost-effective to build a **Total Audience Measurement (TAM+)** system upon the foundation of the Singapore Television Audience Measurement system.

3.10.5 We recommend that MDA move with urgency in promoting the adoption of media analytics, especially among media companies that show potential for further growth (these are also the companies that could qualify for its enterprise development incentives). We also recommend that MDA provide more emphasis on the development of transmedia content in its grant schemes. Transmedia content is particularly amenable to digital engagement strategies that are backed by data analytics. We also counsel patience, as we expect the industry to take time to master new capabilities. At the same time, we urge that companies in the sector learn more rapidly from each other’s successes and failures.

MEASURING MEDIA CONSUMPTION

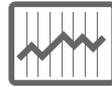
TOTAL AUDIENCE MEASUREMENT



TAM

TV Audience Measurement

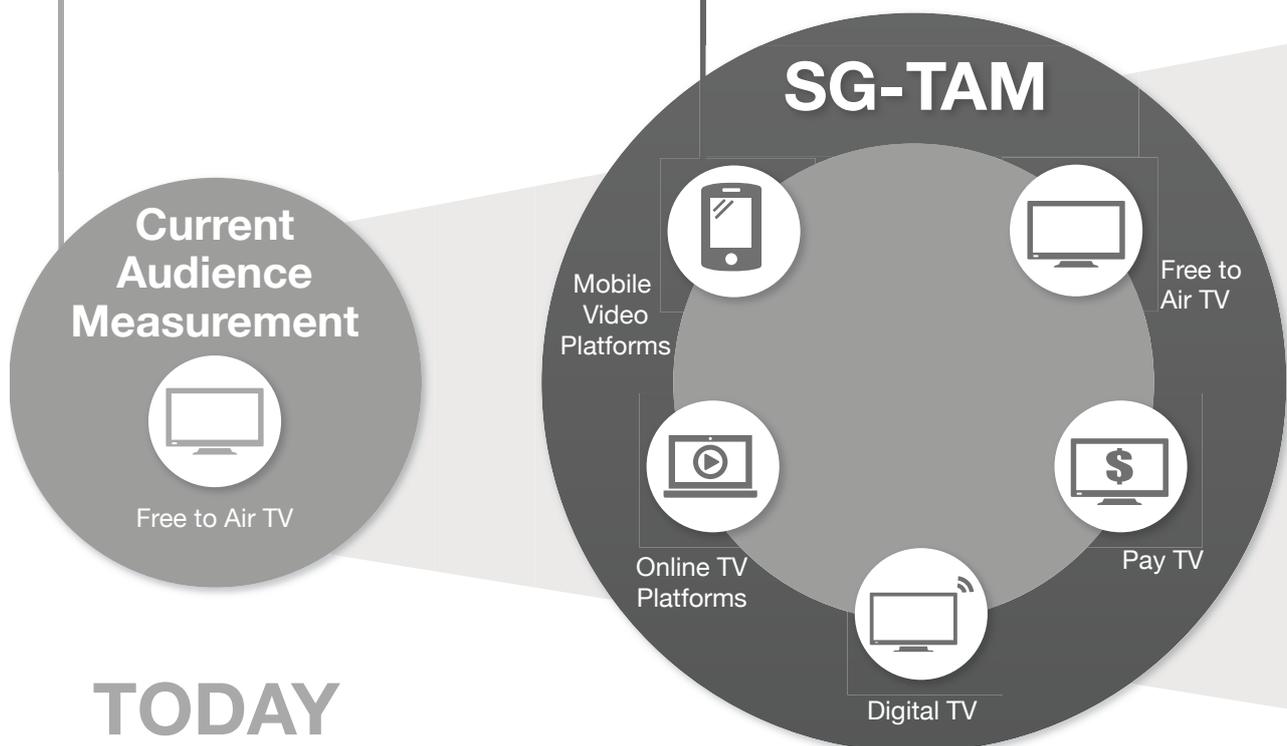
- Only measures Free-to-Air TV viewership
- Audience viewership data not consolidated
- Isolated metrics by channel



SG-TAM

Singapore TV Audience Measurement

- Adapted to measure modern TV formats
- Consolidates viewership data from all TV formats
- Provides unified and reliable viewership metric for all TV formats



TODAY

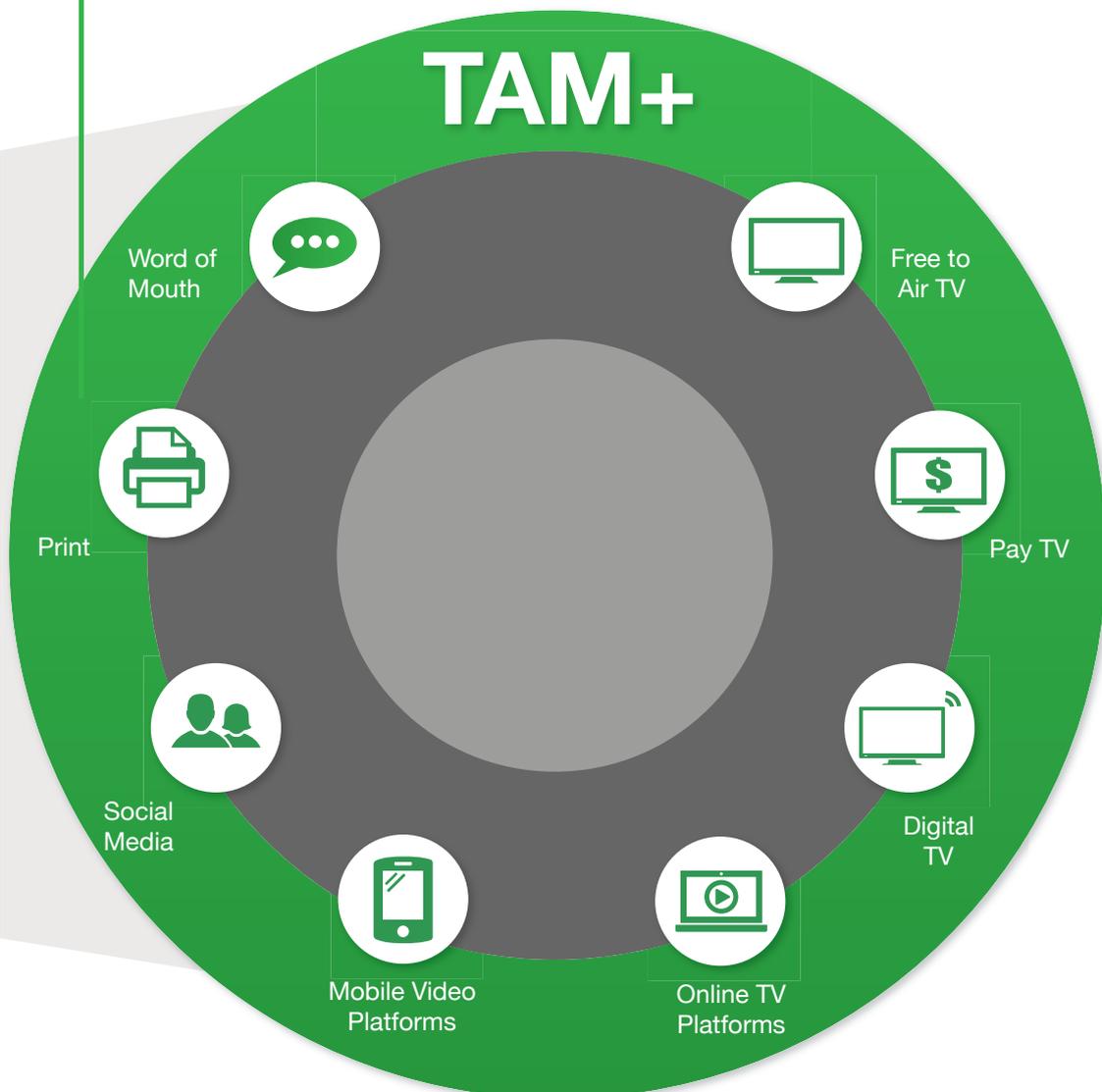
NEXT 5 YEARS



TAM+

Total Audience Measurement

- Extends SG-TAM to measure ad impressions on any device or platform
- Consolidates viewership data from all media platforms
- Provides single metric for total viewership “DNA” of media consumers



THE FUTURE

Data Analytics Will Provide Valuable Consumer Insights for Digital Advertising

- 3.11.1 Besides allowing media companies to gain insights into the preferences and habits of their audiences, TAM+ can also provide rich data to help companies decide how to allocate their advertising dollars. Armed with an in-depth understanding of consumers' shopping and purchasing patterns and behaviour, advertisers can position their products and services more precisely and effectively, down to crafting an advertising message for each individual customer.
- 3.11.2 Data analytics will be an especially powerful tool in digital advertising. Today, digital technology is transforming the face of advertising by creating new marketing channels – such as social media – that are able to strongly influence a consumer's purchasing decisions. Digital advertising provides greater interactivity, targeted engagement, real time optimisation of advertisers' inventories, and more accurate measurements to enable more effective reach per dollar for brand owners.
- 3.11.3 We see synergy between the media sector and the advertising industry in developing solutions that deliver greater value for companies. Both employ the same platforms to reach customers and both need to understand intimately how their customers behave, especially in an increasingly digitised environment. The two sectors have already started to converge, with consumer brands adopting a storytelling approach to branding. Many companies, too, are choosing to market their products through product placement in media productions, by arranging for their products to be inserted into programme storylines and production sets. A strong media sector with a dynamic advertising industry will also provide the sort of business services that are valued by global companies seeking to coordinate their global or regional sales operations in Singapore.
- 3.11.4 For this reason, we advocate that MDA be the lead MCI agency supporting the development of the advertising industry. At the same time, there is much scope for the Government to provide "lead demand" in order to catalyse the development of deeper digital advertising capabilities in Singapore. We are encouraged that government communications already employ digital marketing, with much of its communications conveyed online through websites and apps.

Data Insights and Infocomm Media Will Allow Retailers To Better Engage Customers

- 3.12.1 The retail world has been dramatically reshaped by developments in infocomm media technologies. With consumers' fervent embrace of e-Commerce¹⁶, retailers now have the opportunity to expand their customer base not just domestically but also regionally and globally. However, it also means retailers have to engage customers who come from different backgrounds and cultures. For this reason, the retailers who succeed are those who understand consumer preferences at a deeper and personal level, and who are able to engage prospects and customers through targeted marketing and loyalty programmes.
- 3.12.2 The Government should continue with ongoing efforts to develop the concept of Asia Consumer Insights for consumer behaviour analytics. This will help retailers better understand their consumers in diverse markets, and forge new strategic partnerships to complement and grow their businesses. Singapore is in a strong position to be a hub for brands looking to win Asia consumers, especially now, with global brands looking to Asia for growth.
- 3.12.3 The industry can also work towards bringing in-store innovation technologies to help brick-and-mortar retailers enhance consumer experience. We believe that retailers can gain a competitive edge by offering their customers an omni-channel retail experience that is seamless across all channels – be it mobile, tablet, desktop, brick-and-mortar shops, television, radio, post or catalogue.

Picture this: Julia walks into a boutique where she finds two blouses that she likes. Using an app on her smartphone, she takes pictures of the blouses and searches for information on the two items.

Instantly, a stream of information pops up on her smartphone, including:

- customer reviews of these two blouses;
- the type of customers who have bought the two blouses, and friends on her social media networks who bought similar blouses with links to their reviews of their blouses;
- where the blouses were made;
- the materials used to make them;
- the unique features of each blouse; and
- recommendations on skirts, pants and accessories that would go with the blouses.

After seeing the positive reviews, Julia decides to try the blouses to see how they look on her as well as the recommended accessories. Julia has also enabled the location-based feature of the smartphone mobile app, which senses that Julia is currently in the boutique and sends her a promotion coupon for the blouses and accessories.

After checking herself at the mirror, Julia likes the blouses but finds them a bit pricey. At that instant, she spots the promotion on her mobile phone and instantly takes up the offer. She can choose to pay at the counter and collect her purchases immediately, or pay online and have the items sent to her house. She chooses the latter so she can continue shopping without lugging her purchases around.

Julia benefits from a quicker and more efficient shopping experience. The retailer has cleverly used digital marketing and social media marketing to engage with the customer at every step of the purchase journey. The retailer is able to make offers at the right time to address Julia's concern about the purchase. The retailer is also able to use social media to generate brand awareness, find and engage with prospective customers and grow its customer base.

3.12.4 Technology is also altering the way consumers pay. Contactless payments are now enhancing the retail experience by making payment easy and convenient. For example, consumers can choose to pay through embedded payment credentials in their mobile phone application, or by using a wearable device such as a smart watch or ring. Consumers will be able to analyse and improve their spending behaviour when digital receipts are more widely issued, allowing them to manage their personal finances better. In the short to mid-term, we expect the use of biometrics to become more pervasive as a way to pay more securely. We also expect both merchants and consumers to benefit from enhancements to the real-time domestic payment infrastructure. For example, it will enable instant, low-cost, over-the-air mobile payments to small merchants like hawkers and provision shops. Overall, cash will be used less in all retail realms.

Data Analytics and Infocomm Media Can Make Urban Logistics More Efficient and More Transparent

3.13 Infocomm media can also transform our urban logistics. Logistics firms help fulfil the orders received by retailers, in particular by delivering the ordered goods to customers. To better serve retailers, we believe the logistics sector will need to adopt innovative **urban logistics** solutions, reducing delivery times of goods to retail outlets and for home delivery. Some solutions that can be offered include pre-booking of loading docks, synchronisation of fleet delivery schedules and optimisation of delivery routes. The benefits of smarter logistics can only be realised if logistics companies are prepared to collaborate with each other and share resources optimally. The following example illustrates the benefits for different players in a system that employs urban logistics solutions. This model can also be adapted for home delivery service providers or providers of self-pickup facilities like “parcel lockers”.

AGGREGATED DISTRIBUTION URBAN LOGISTICS



INEFFICIENT DELIVERIES

Delivery vehicles often get dispatched even when they are not fully loaded, which puts more trucks on Singapore's already congested roads.



UNCOORDINATED DELIVERIES

Without coordination, deliveries may all arrive at the same time, which block traffic, upset shoppers and pollute the environment.

This is even worse at horizontal shopping precincts where roads are usually narrow.



PRESENT

FUTURE

AUTONOMOUS DELIVERY VEHICLES

Using autonomous delivery vehicles for smaller packages improves efficiency.

CONSOLIDATION CENTRES

Consolidates goods to fill a single truck, to reduce the number of trucks on our roads.

DEDICATED DELIVERY CORRIDOR

Built above- or under-ground, these let autonomous vehicles make direct, safe and efficient deliveries.

ROBOTICS

Robotics speed up goods consolidation, sorting and handling, enabling smooth and automated deliveries in the same day.

IN-MALL LOGISTICS OPERATIONS

Dedicated logistics team within malls coordinates deliveries and schedules. Deliveries are consolidated before making the last mile delivery to retailers inside.

CLOUD-BASED SCHEDULING SYSTEM

Sends traffic updates to suppliers, helping them plan routes and arrivals to avoid congestion or delays.



INSIDE MALL DISTRIBUTION MODEL

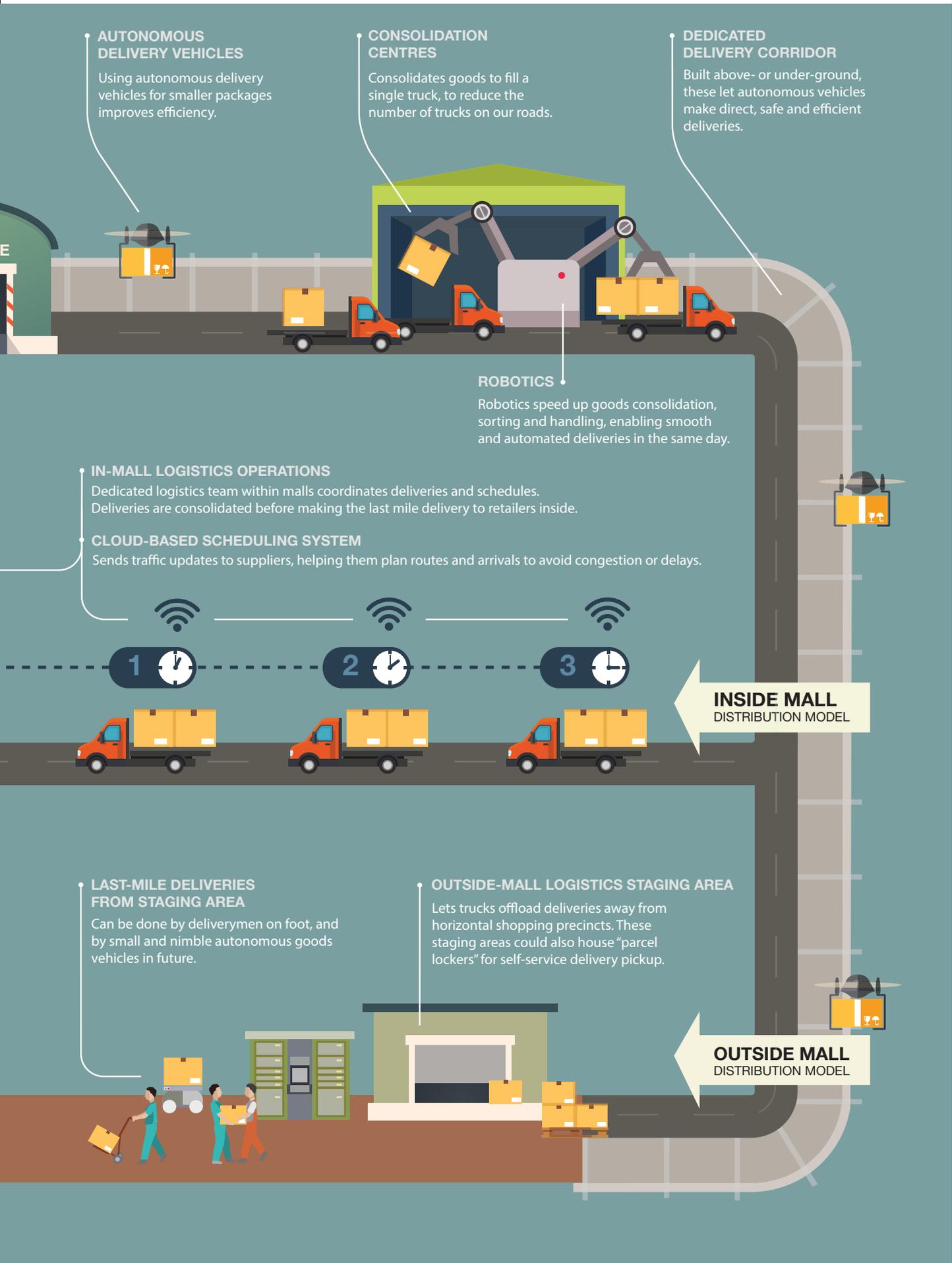
LAST-MILE DELIVERIES FROM STAGING AREA

Can be done by deliverymen on foot, and by small and nimble autonomous goods vehicles in future.

OUTSIDE-MALL LOGISTICS STAGING AREA

Lets trucks offload deliveries away from horizontal shopping precincts. These staging areas could also house "parcel lockers" for self-service delivery pickup.

OUTSIDE MALL DISTRIBUTION MODEL



Before: Inefficient Urban Logistics

Express Delivery Pte Ltd is an SME business started by Teck Eng 30 years ago with one truck. The fleet has since expanded to 15 trucks that serve the local retail industry. In recent years, the company has stopped growing because of the high cost of the vehicles, high labour costs and the difficulty of hiring drivers. However, Teck Eng did not think technological investment would benefit his company. In fact, his employees, especially the drivers, find infocomm technology daunting. The company continued to use outdated technology such as walkie-talkies for communication and spreadsheets to record data.

The company's old world ways led to the problems that they faced. Without suitable technology and applications, the company had difficulty tracking the whereabouts of its drivers and fleet. The company could not take in more delivery contracts as a lot of time was taken up to queue for and use the shopping mall's unloading bays. Resources were used inefficiently and productivity was low. Coupled with increasing operating costs, profits fell.

Fashion Unlimited Pte Ltd, a retailer with outlets in many malls, employs Express Delivery to replenish its stock. But when its rents rose, its in-store inventory areas were downsized to yield more selling space. With a smaller inventory space, Fashion Unlimited was able to keep only a very small amount of stock at its outlets. As a result, Fashion Unlimited arranged for Express Delivery to make multiple deliveries each day, and for their shop assistants to take in delivery of new arriving stock each time, sometimes during peak shopping hours. This adversely affected Fashion Unlimited's operating costs, customer service and revenue.

Further, the traffic situation at RIM, a shopping mall in a busy precinct that housed a Fashion Unlimited outlet was affected. The road that led to the mall's unloading bay and carpark always had a buildup of delivery trucks and passenger cars. RIM has received many complaints from shoppers about delivery trucks and trolleys getting in their way, as well as deliverymen hogging passenger lifts.

After: Improved Logistics Landscape

After years of falling profits, Teck Eng finally invested in a suite of IT solutions that enables logistics companies to pre-book loading docks deployed by the malls, synchronise delivery schedules of fleets and optimise delivery routes. The difference is dramatic.

These days, Express Delivery can drop off goods at the loading dock much quicker by pre-booking a time slot through a Dock Scheduling System. Furthermore, by handing over the goods to the In-Mall logistics operators to do the last mile delivery to the retailers within the mall, its trucks can turn around much faster. This enables the company to take on more delivery runs than before, hence increasing the company's profits. The company's productivity has also improved tremendously after it started using an affordable pay-as-you-use cloud-based Fleet Management System. This system arms drivers with easy-to-use devices that synchronise their delivery schedules with the rest of the fleet. The system also optimises the route that each driver needs to take to get to his delivery destination, and allows clients to electronically sign off on delivery notes.

Fashion Unlimited also benefits from this smart urban logistics capability. It can now outsource daily stock storage to an In-Mall operator at RIM for Just-In-Time replenishment at its outlet. This means that Express Delivery needs to make only one delivery run to the outlet each day to replenish stock. Fashion Unlimited's shop assistants have more time to serve customers, because the delivery schedule is predictable and coordinated by the In-Mall operator. Lastly, with the value-add home delivery service provided by the In-Mall operators, the outlets can now offer free home delivery to their customers. With lower inventory and higher sales, Fashion Unlimited's turnover has increased by 15 per cent.

RIM has also benefitted from the Dock Scheduling System and In-Mall operator services. Now, traffic goes smoothly in and out of the mall. Shoppers are happy and the image of the mall has improved. Furthermore, for a small fee, the In-Mall operator also helped RIM to manage the unloading bay facility and provide concierge services to the shoppers including bag deposit and cold storage for perishables. This leaves RIM more time and resources to manage other mall operations.

Data Insights Can Facilitate International Trade and Logistics

- 3.14.1 One common obstacle retailers face in selling online – especially for SMEs – is the complexity in launching e-Commerce operations. They find it difficult to embark on it as it involves multiple service partner agreements and integrating processes to manage new products, inventory, orders and returns.
- 3.14.2 We believe that one possible solution is to develop a one-stop-shop Fulfilment Service platform, which will manage product placements and orders management across different marketplaces and web stores on a single integration platform. The Fulfilment Service platform will also be able to manage the outsourcing of inventory management, goods distribution, and logistics service support for retailers. In addition, it can serve as a cost-efficient regional network to help connect retailers to overseas consumers. A Fulfilment Service platform will reduce the complexity of e-Commerce operations and allow retailers with limited ICT capabilities to hop on the e-Commerce bandwagon.
- 3.14.3 In the longer term, there is potential to scale up the Fulfilment Service platform into a Fulfilment Exchange Hub. A Fulfilment Exchange Hub will offer e-Commerce fulfilment capabilities, common business services and resources for retailers and online marketplaces in the Southeast Asia region. These retailers and marketplaces can use the Exchange Hub to source for optimised fulfilment solutions for both local and regional operations. They can also engage logistics service providers that offer their services on the platform.
- 3.14.4 Like the media and advertising sectors, the logistics sector can benefit from technology adoption. We recommend that the logistics sector considers the use of infocomm media to facilitate real-time information sharing amongst supply chain partners. A secured cloud-based Logistics Platform that supports multi-party, multi-echelon collaboration will enable supply chain partners to better coordinate and execute their supply chain planning. The platform can be operationally neutral and opened to all logistics companies. The logistics sector can also tap on Internet of Things technologies to acquire and transmit data, such as location of goods in real time, throughout the supply chain on this platform. This will facilitate real-time supply chain sensing and allow all parties to respond in a timely manner.
- 3.14.5 The information gathered from the Logistics Platform and Exchange Hub can be used to develop a Collaborative Commerce Network. The intelligence from the Collaborative Commerce Network can be applied to areas such as predictive demand forecasting, supply chain optimisation, new product design, business development and digital marketing. Through such a network, Singapore can develop the ability to recognise commonalities across markets, scale online expansion strategies for local players, and deepen the knowledge of Asian Digital Consumers.
- 3.14.6 Finally, data can help plug some of the information gaps that exist today within the global trade and trade finance ecosystem. A national commercial and trade credit bureau can be established to provide credit rating reports on trading companies. These reports will help financial institutions improve lending decisions and processes. The bureau can also help trade companies assess the creditworthiness of importers and the performance history of exporters. They can then better decide whether to enter into a trading agreement with these parties. In the longer term, the bureau can evolve to accredit regional or even global companies for trade.

Data Insights Will Further Our Study of Genomics for Personalised Medicine

- 3.15.1 We believe that over the next decade, the advancement of technology in the healthcare field will expand beyond measurements of a patient's physiological functions. We think the next frontier is the analysis of a patient's genome for a personalised treatment.
- 3.15.2 Insights gained from better understanding of a patient's genome¹⁷, for instance, can help physicians plan a more targeted and effective treatment for cancers and cardiovascular diseases. The efficacy of certain drugs may also be dependent on the patient's genome. Certain gene markers may be a predictor of the likelihood of developing certain diseases, and preventive steps could be undertaken before symptoms develop. Much work remains to be done before genomics-driven, personalised medicine can be proven to be a cost-effective treatment. It is necessary that such treatments be validated through evidence-based approaches.

- 3.15.3 The question for Singapore is whether we should begin to prepare for such possibilities in the medical field. We believe Singapore can, if it chooses to, establish itself as a centre with complete profile of Asian genomes. We have a modern and well-organised healthcare sector, which has already made significant investments in healthcare infocomm technology. At the same time, we see the price of sequencing genomes falling rapidly. This presents an opportunity to bring genomics from the research labs into clinical practice, underpinned by an enabling regulatory framework.
- 3.15.4 We recognise that the Government will have to weigh other considerations, including the timing of the introduction of such treatments in Singapore. In particular, if left to the market, we may see the emergence of pseudo-treatments that serve only to increase the cost of healthcare with no appreciable health benefit to society. Nonetheless, we believe the potential benefits to be too important to ignore. We thus recommend that the Government look into how to proactively prepare for and support genomics-driven and evidence-based approaches to personalised medicine.

Data Insights Will Dramatically Change Education And Training

- 3.16.1 Data analytics has already begun to revolutionise education. Technology is one of the greatest enablers of learning. Data insights are helping to accelerate learning and are enhancing the quality of the learning experience. Over the next decade, the education and training sector will have the capability to apply data science so as to personalise learning. The use of **learning analytics** can provide crucial insights into students' learning strengths and difficulties. Through data analytics, teachers can obtain insights into their students' learning patterns. These insights can then be used to personalise teaching instructions and interventions for individual students.
- 3.16.2 Data analytics can also help to pinpoint weaknesses in a cohort of students. For example, it may help a school recognise a correlation between its students experiencing difficulty in one part of the curriculum (e.g., acceleration in Physics), with another part of the curriculum (e.g., graph reading in Mathematics). Instead of more drills and practices on speed and acceleration, the teacher is now able to give more targeted remedial instruction on graph reading for this group of students, focusing on linear and exponential gradients. The possibility of such precise intervention deepens learning for students and enhances the productivity of teachers.
- 3.16.3 Used wisely, data insights can help the nation meet urgent training needs in Continuing Education & Training (CET). Already the Singapore Workforce Development Agency (WDA) is working towards this, as described in its Continuing Education & Training Masterplan (2015-20).
- 3.16.4 We are very excited about the possibilities that data insights can bring to education. What we advocate is more imaginative use of this capability. In particular, we urge CET practitioners to explore the delivery of learning material on-demand to enable working adults to learn at their convenience. For example, this may mean offline bite-sized learning packages delivered to mobile devices so that adult learners can learn when commuting or during their work breaks. We also advocate that continuing and training practitioners explore the possibility of enabling assessment on-demand so that working adults can take their tests when they are ready. The result is a more learner-centred approach and a more vibrant education and training ecosystem.

Data Insights Will Enable Us To Build Robots To Augment Our Capabilities

- 3.17.1 Data analytics will also be one of the supporting capabilities that enable the development of cognitive software systems, which in turn will provide the intelligence for autonomous systems, or robots. Autonomous systems are trained using artificial intelligence and machine learning algorithms, so that they build knowledge as they interact with humans. Over time, autonomous systems can complement, augment and enhance our cognition and capabilities in knowledge work, physical activities, navigation and human-agent interactions.
- 3.17.2 More broadly, data analytics, along with various innovations in machine learning, enables the rapidly developing field of cognitive computing. This is being applied to many other knowledge-based sectors besides the ones outlined above. Such capabilities in cognitive computing will power not only what some have coined the automation of knowledge work, but also the automation of menial work, through advances in robotics and other autonomous systems.

- 3.17.3 We believe that over the next decade, robots will be deployed extensively outside of factories and in a wide variety of service sectors. We believe that this trend will be accelerated as a result of our economy adapting to a smaller labour force. There already exists robots suitable to work alongside human workers in a production line, at prices starting from US\$23,000¹⁸.
- 3.17.4 Over the years, the Government has introduced many initiatives to encourage local enterprises to adopt new technologies to overcome manpower and resource constraints. An example is the enhanced iSPRINT programme, which offers companies subsidies of up to 70 per cent of the costs to deploy proven ICT-based productivity solutions and up to 80 per cent to pilot emerging technology solutions such as robotics.
- 3.17.5 We ask the Government to continue to engage stakeholders in the economy to explore the adoption of autonomous systems to improve productivity and augment industry capabilities. We feel that there is potential especially in the logistics sector for greater use of advanced automation and robotics to facilitate the movement of goods. For example, autonomous systems such as haptic sensor robotics can sort and pack goods faster and more accurately than humans. This will reduce the turnaround time for logistics companies when preparing shipments for imports and exports as well as for local deliveries.

Summary

The 1st Strategic Thrust of Infocomm Media 2025 is to capitalise on Data, Advanced Communications and Computational Technologies. There are two parts to this strategy:

- (1) Establish an agile, pervasive and trusted infocomm media infrastructure that rides on advanced communications technology. We can do this through initiatives like:
 - Heterogenous Network (HetNet)
 - Aggregation Gateway Boxes (AG Boxes)
 - Digital Harbour
 - Data Marketplace
- (2) Catalyse a series of transformations across a whole range of sectors of the economy, each building on the power of data and data insights, and on computational technologies. To succeed in this effort, IDA and MDA will have to:
 - Do even more than they did in preceding masterplans to collaborate with stakeholders in these sectors, to bring about an infocomm media enabled transformation.
 - Consider the need to develop new capabilities in their organisations.

2nd Strategic Thrust: Nurture an Infocomm Media Ecosystem that Encourages Risk- Taking and Continuous Experimentation

- 4.1 To realise our Smart Nation vision, we will need an infocomm media ecosystem that does not shy away from appropriate risk-taking, and that embraces innovation through continuous experimentation. The infocomm media sector should be capable of creating more successful Singapore-made content, products and services.
- 4.2 A strong infocomm media ecosystem must begin with the workforce and with the enterprises. We have to equip our students and workforce with the essential knowledge and skills they need to perform in high-value infocomm media jobs. We must make available a sustainable support network for aspiring start-ups and growth companies so that these firms are supported in their creation of products, services and content. We need to mobilise the talent and the enterprises in the infocomm media ecosystem to solve big and challenging problems. Lastly, we should also continue to promote Singapore as a Living Lab to harbour innovation and collaboration for the delivery of cutting-edge infocomm media solutions.

A Workforce Equipped with New Infocomm Media Knowledge and Skills

- 4.3 Today, the infocomm media industry is well supported by an effective pre-employment training (PET) system, comprising the Institute of Technical Education (ITE), the polytechnics and the universities. Students generally have good employment outcomes and are well trained. There are areas where we can do better (e.g., in helping students to be more industry ready, as well as improving the retention of students from these programmes in the industry).
- 4.4 The CET systems have also matured over the past 10 years. The infocomm sector has developed the National Infocomm Competency Framework¹⁹ (NICF) to guide individuals to grow their skills, to provide individuals and businesses with a reference for career progression pathways, and for businesses to develop their training programmes.

Workforce Training System Improvements

- 4.5.1 We believe that our workforce training system should build upon these strengths and do more in the following areas:
- (1) Ensure that it is aligned with and fulfils the objectives of the national direction of SkillsFuture²⁰ Singapore.
 - (2) Go beyond the equipping of functional skills, to cultivate in workers the willingness to take risk and innovate.
 - (3) Recognise that the sector will compete with other sectors for talent and allow, as far as possible, for talent without formal infocomm media qualifications to enter the sector.
 - (4) Support all segments of the workforce, from new entrants to experts to (especially) freelancers.
 - (5) Recognise that a passion for a career in infocomm media should be developed earlier, and not when students are in the institutes of higher learning.

4.5.2 We also recognise that in the area of manpower development, the issues facing the infocomm sector and the media sector are quite distinct and that it is necessary for manpower development schemes to be customised for these respective sectors.

Infocomm Manpower Development

4.6.1 We believe that over the next decade, our manpower strategies for the infocomm sector must address the following:

- (1) Our workforce must develop proficiency in many different programming languages²¹. We will need workers trained in data analytics, cyber security, software and platform development, infrastructure deployment and network communications. They must also be familiar with adjacent disciplines such as business domain knowledge and data visualisation. We also need researchers with knowledge of embedded systems, distributed and high performance computing and machine learning.
- (2) There will be fewer new entrants to the labour market. More than ever, we will need workers already in the industry to acquire new skills in line with new technological developments.
- (3) To attract and retain the next generation of workers, we need infocomm careers to have a compelling and meaningful purpose. Fortunately, we are well positioned to offer that as technology is a powerful enabler to create new solutions and to solve big and challenging problems. We also need to meet the needs of the next generation workforce in terms of their desire for autonomy, flexibility and work-life harmony. More than ever, we need more robust talent management practices in the industry.

4.6.2 All these trends and challenges call for different manpower development strategies, which include:

- (1) Developing coding and computational thinking as a national capability to develop a technologically-literate and future ready workforce, boosting interest among students in infocomm and reinforcing the perception of infocomm as a rewarding career.
- (2) Developing talents to be industry-ready at tertiary level to prepare our graduates for the workforce and reduce “leakage” of infocomm technology graduates to other fields.
- (3) Accelerating professional development to grow local infocomm professionals to address the shortage of local skilled professionals.
- (4) Improving talent hiring and management frameworks to better attract and retain talents within the infocomm sector.

We Will Need To Start Grooming Our Talents From Young

4.6.3.1 We believe that developing a technologically-literate society is essential if Singapore is to reap the benefits of a Smart Nation. We should inculcate in our children an early interest in infocomm media and innovation. Skills like coding (the language of computational thinking) and computational thinking (which draws on the power of computing to solve problems build systems and understand human behaviour) are important in our increasingly digitised environment. Our young should be empowered with the confidence that they have the means and the imagination to take on big and complex problems, and to solve them.

4.6.3.2 As part of our early exploration of **Computational Thinking as a National Capability**, IDA launched a collective set of initiatives under the Code@SG movement in 2014 that focused on teaching coding and computational thinking skills to pre-tertiary students. Code@SG is intended to engage students in infocomm and spark their interest in and passion for technology. It allows young students to experiment, solve problems, and develop innovative solutions through the use of technology. Besides increasing the foundational infocomm knowledge of our future workforce, this will also provide opportunities for students to hone their creativity and innovativeness. As part of Code@SG, IDA launched Code for Charity, an event where students executed simple coding challenges

to unlock funds for needy students in the polytechnic and university. IDA also worked with the Ministry of Education to successfully pilot the Code for Fun²² enrichment programme for upper primary and lower secondary school students.

- 4.6.3.3 We are encouraged by the positive reception of these early pilots and recommend that the Government continues to work towards scaling up this programme to reach all schools.
- 4.6.3.4 We also recommend that the school infocomm clubs be supported by IDA to cultivate in the members a passion for infocomm. We support the shift from equipping them with knowledge on how to use computer software, to equipping them with skills to create software and robotics solutions. We can build on the ICT Learning Roadmap²³ and the National Infocomm Competition²⁴ to create more platforms where members of infocomm clubs can showcase their achievements, interact and learn from the wider online ICT community.
- 4.6.3.5 We recommend that efforts be made to explore how to expose younger children (such as pre-schoolers) to technology. The Maker Movement²⁵ has spurred educators to reinvent education through maker-centred learning taught through play on the pre-school front. This fresh approach emphasises creation and creativity, and promotes experimentation, expression, iteration and collaboration with the goal of developing a can-do spirit and building the resilience and nimbleness to fail fast and learn quickly. Technology toys like littleBits²⁶ and KIBO²⁷ are useful for supporting maker-centred pedagogies that promote learning through play and learning across a wide variety of disciplines in place of rote learning and the simple consumption of ready content.
- 4.6.3.6 There is an emerging trend towards the “Internet of Toys” where technology toys like DynePod allow children above five years of age to programme a wearable device that is able to detect when a friend’s toy is in range to set off an alert. These toys are connected to cloud services, allowing children to programme alerts for household items around their house. This new wave of technology toys is empowering the next generation of innovators from a very young age.
- 4.6.3.7 Primary and secondary schools also provide a great opportunity for students to learn how to deploy simple sensors and to collect and analyse real-time environmental data gathered, as part of scientific investigations. This will encourage scientific investigation and inquiry-based learning for students, enabling real-world problem solving of events in their schools monitored through the Internet of Things. These skills will help to develop our students into a new generation of digital citizens who are ready and comfortable living in a smart environment where they supply as well as consume data as a way of life.
- 4.6.3.8 We also urge IDA to do more to promote infocomm as an exciting and fulfilling career. We are convinced that the sector has much to offer young people and that it is not often appreciated how talents in the infocomm sector have the opportunity to improve the world through infocomm technology.

We Need to Develop Talents to be Industry Ready at Tertiary Level

- 4.6.4.1 Our tertiary education in computing and related disciplines has resulted in good employment outcomes thus far. Nonetheless, we believe that with some refinement, it can provide even more industry-ready graduates. We recognise that this cannot be the responsibility of the institutes alone. In line with the direction of SkillsFuture, we believe that the industry has to play a strong role in partnering with the institutes of higher learning.
 - (1) We recommend making work-study integrated degree programmes available to polytechnic graduates who have been working at least a year. This will allow polytechnic graduates working in SMEs and start-ups to gain relevant industry experience and exposure while studying to obtain a degree. This recommendation will complement the SkillsFuture Earn and Learn Programme that helps fresh polytechnic graduates (in their first year after graduation) to obtain specialist and advanced diploma qualifications while working. Besides helping polytechnic graduates advance their career quicker, this programme can also help SMEs and start-ups put in place talent management practices to develop and retain promising talent. The relevant institutes of higher learning could do their part by offering part-time infocomm degree programmes and considering the exemption of specific modules for polytechnic graduates.
 - (2) We also hope institutes of higher learning can lend their support by promoting computer science as an elective or minor subject for other degree programmes at tertiary level to serve the anticipated need for “technology hybrid professionals”.

We Will Need to Accelerate Professional Development to Grow Local Infocomm Professionals

- 4.6.5.1 Besides preparing our young and students for an infocomm career, we also need to ensure our current workforce remains relevant. The traditional method of upskilling infocomm professionals through conventional classroom-based training, while still relevant, is inadequate to meet the industry's constant need for proficiency in new technology areas.
- 4.6.5.2 We recommend **open and accelerated learning** programmes for our infocomm professionals to meet immediate and emerging demand for new skills such as big data analytics. IDA can consider adopting the following approaches for these programmes:
- (1) Work with the industry to identify relevant and credible massive open online courses. Online learning offers flexibility to infocomm professionals who may find it difficult to take time off to attend classes and training. With massive open online courses, infocomm professionals have a wider range of courses to choose from, including niche courses that may not be available locally (due to our smaller market size).
 - (2) Work with the industry to enhance company-based training programmes to cater to different levels of infocomm professionals. For fresh entrants, make available structured apprentice training programmes at companies to fast-track them into tech specialist jobs. For mid-career professionals, offer work attachments coupled with structured and on-job-training workshops on emerging technology areas at multinational corporations, large infocomm local enterprises, training institutions or overseas organisations. These entities can set up attachment programmes to offer resources and expertise to mentor and train professionals including theoretical studies and real data and problem statements to let the professionals gain hands-on experience.
- 4.6.5.3 We see that infocomm and the science, technology, engineering and mathematics (STEM) disciplines share a common base set of skills that facilitates the conversion of STEM professionals to infocomm professionals. IDA should work with the industry to put in place a tech conversion and emplacement programme for STEM professionals who wish to switch to a career in infocomm.

We Will Need to Improve The Way We Hire And Manage Our Infocomm Professionals

- 4.6.6 While it is important to groom and attract talent to the infocomm sector, it is equally important to retain our infocomm talent. We urge infocomm companies to build on the existing National Infocomm Competency Framework to enhance their talent development and management practices including career progression, training and development, compensation, and benefits. We also urge the Government and the industry to recognise excellence and advancement in infocomm talent management practices through the presentation of recognition awards. We are encouraged that the Singapore Computer Society (SCS) launched the Best Tech Company To Work For Award last year to honour tech organisations in Singapore that possess robust talent development framework, enviable corporate culture and innovation excellence.

Media Manpower Development

- 4.7.1 For the media sector, we are of the view that despite rapid transformation of the media industry due to media convergence, it remains critical to enhance the ability of the workforce to have strong story-telling and intellectual property creation skills. Unlike proficiency in computer programming languages, the theory of story-telling is not sufficient. Much of the expertise remains innate and can only be honed through sufficient opportunities to practise the craft in collaboration with others.
- 4.7.2 To develop local capability to generate compelling stories for multimedia platforms, we recommend that the Government establish a Story Lab in Singapore for media professionals to incubate original story ideas and explore innovative ways of storytelling. Local and international renowned media practitioners can be invited to mentor **Story Lab** participants in the development of stories and scripts. The Story Lab can also develop and implement programmes for students to cultivate storytelling know-how from young. In addition, the Story Lab can promote collaborative, team-based methods of story development, especially for extremely long running series.

- 4.7.3 Besides Story Lab, we also propose helping Singapore media companies learn how to create high-quality, engaging content by giving them the opportunity to learn from experts through a **capability development scheme**. Through masterclasses, workshops, seminars, and on-the-job training conducted under the mentorship of renowned media practitioners, local media talents can absorb knowledge and deepen their craftsmanship in aspects such as achieving strong audience engagement, developing innovative formats and writing compelling scripts. We also recommend that such schemes be designed such that they are accessible to freelancers as well, as they constitute an important part of the media sector.
- 4.7.4 We further recommend that the Singapore Film Commission establishes a **filmmaking capability programme** for Singaporean filmmakers. MDA can identify partners to run the programme, offering filmmakers a series of masterclasses and one-on-one mentoring by expert practitioners and veterans in critical skillsets like scriptwriting, character development, directing, scheduling and budget planning. Through the programme, our talent will also develop professional relationships with the expert practitioners that will be helpful to their filmmaking careers.
- 4.7.5 For the workforce in the media sector, we recommend that innovative CET approaches be adopted. In particular, we feel that more can be done to provide media professionals access to credible massive open online courses relevant to the media field.
- 4.7.6 We also note that the games sub-sector is the fastest growing media subsector in terms of employment size. In view of this, we are encouraged that the Government has launched an Earn-and-Learn programme for the games sub-sector in March 2015 and will commence in October 2015 for the first intake, under the framework of SkillsFuture. Through such a programme, fresh graduates from the Institute of Technical Education and polytechnics can have the opportunity to build on skills and knowledge acquired in school to better transit into the workforce. We recommend for such a programme to subsequently be extended to other media subsectors such as broadcast, film and video.

Build a Sustainable Support Network for Aspiring Start-ups and Growth Companies

Funding and Mentorship Support For Our Infocomm Media Start-ups and Growth Companies

- 4.8.1 We are encouraged by the rapid development of the infocomm media start-up scene. They are the more visible achievements of current plans, including the Interactive Digital Media Programme Office (IDMPO) funded by the National Research Foundation (NRF). Today, Block 71 is recognised globally as an icon of Singapore's vibrant start-up ecosystem.
- 4.8.2 We believe that Singapore should consolidate these gains, and there is a **self-sustaining start-up ecosystem**. Private sector leadership is important not only as a source of funding, but also for their smart market connections and the mentorship of angel investors.
- 4.8.3 We recommend that the Government do more to facilitate crowdfunding as a major new financing model. This could take the form of equity- or rewards-based crowdfunding.
- 4.8.4 In equity-crowdfunding, securities in the start-up or SME are offered in exchange for funding. While this concept is relatively new in Asia, equity crowdfunding has produced exciting results in the UK, US, and Europe²⁸. If properly complemented by a clear regulatory posture that ensures robust governance and investor protection, equity crowdfunding can be a positive force in helping start-ups gain funding that they might otherwise not have been able to obtain. Equity crowdfunding platforms can also provide an early signal of market interest and feasibility. In order for equity crowdfunding to take off and benefit our local infocomm media start-ups, we feel it is imperative that the Government continue to facilitate discussions between start-ups, crowdfunding operators, and the relevant agencies to shape the policies and environment that will allow equity crowdfunding to flourish. The Monetary Authority of Singapore (MAS) is currently exploring equity crowdfunding as a viable source of start-up funding²⁹. We hope that quick progress can be made on this front.

4.8.5 Rewards-based crowdfunding is the practice of raising project funds from a large number of people in return for non-equity incentives. For media projects, rewards-based crowdfunding, in the form of tickets to a media project's film premiere or limited-edition merchandise, may be more suitable. It may also be suitable for financing limited product-runs. The attraction of rewards-based crowdfunding goes beyond funding – it is a way to engage potential customers and to obtain early market validation of the potential of the product, as well as to cultivate a customer or fan base early.

4.8.6 However, to launch a successful crowdfunding campaign requires careful and deliberate planning and execution. We urge MDA to equip our local media enterprises with the necessary skills to tap on this platform successfully. Such skills include marketing of the project, engaging potential investors or donors, gauging market reaction to new product ideas, securing market validation for refinement of prototypes, and converting investors or donors to fans. To do so, MDA of Singapore will have to identify relevant partners to coach and work alongside with our local media enterprises to launch successful crowdfunding campaigns.

Business Accelerators

4.9.1 Today, there is a healthy range of incubator and accelerator programmes to help start-ups in their early development. We believe that as the start-up ecosystem grows in maturity, the value of **sector-specific incubators and accelerators** will increase. These can provide more targeted and tailored assistance for our start-ups, thereby increasing their chances of succeeding. We support the current strategy of IDA's investment subsidiary partnering overseas professional accelerators to establish in Singapore. Such accelerators bring with them experience and high quality mentorship networks.

4.9.2 We also recommend that as the games industry shares many common characteristics with the infocomm sector, it will benefit from having an accelerator and incubation programme focusing on the game industry. We think that such a programme can be rapidly scaled up, modelled after the programmes developed by IDA.

Partner of Choice for Global Media Companies

4.10.1 The constraint to growth for media production houses is not equity investment, since the nature of the media industry is such that financing is assembled on a project-by-project basis. What media production houses lack is an assured and sufficiently large volume of projects that will enable them to reap economies of scale.

4.10.2 Currently, we have many media companies operating at around S\$1 million in annual revenue³⁰. We believe that a deliberate strategy should be pursued, to help a handful of these companies to vault into the S\$3 million annual revenue bracket. To achieve this, the media companies cannot just rely on commissions from the local market. We therefore support MDA's strategy to make these companies the **partner of choice** for international broadcasters looking to launch new products and service offerings for the region and beyond.

4.10.3 Such associations will raise the capability of our media companies to consistently deliver performance standards that satisfies the highest quality demanded by the international broadcasters and open up access to new markets for their services.

Accreditation

4.11.1 We endorse the strategy of accreditation of infocomm start-ups and SMEs, and recommend that Accreditation@IDA be scaled up rapidly. The programme has been successful in helping companies build track record and credibility, and create more opportunities for their products and solutions to be showcased and exported overseas³¹. It also recognises the important role of Government as a lead-buyer for sophisticated infocomm solutions, and how this can create growth opportunities for companies.

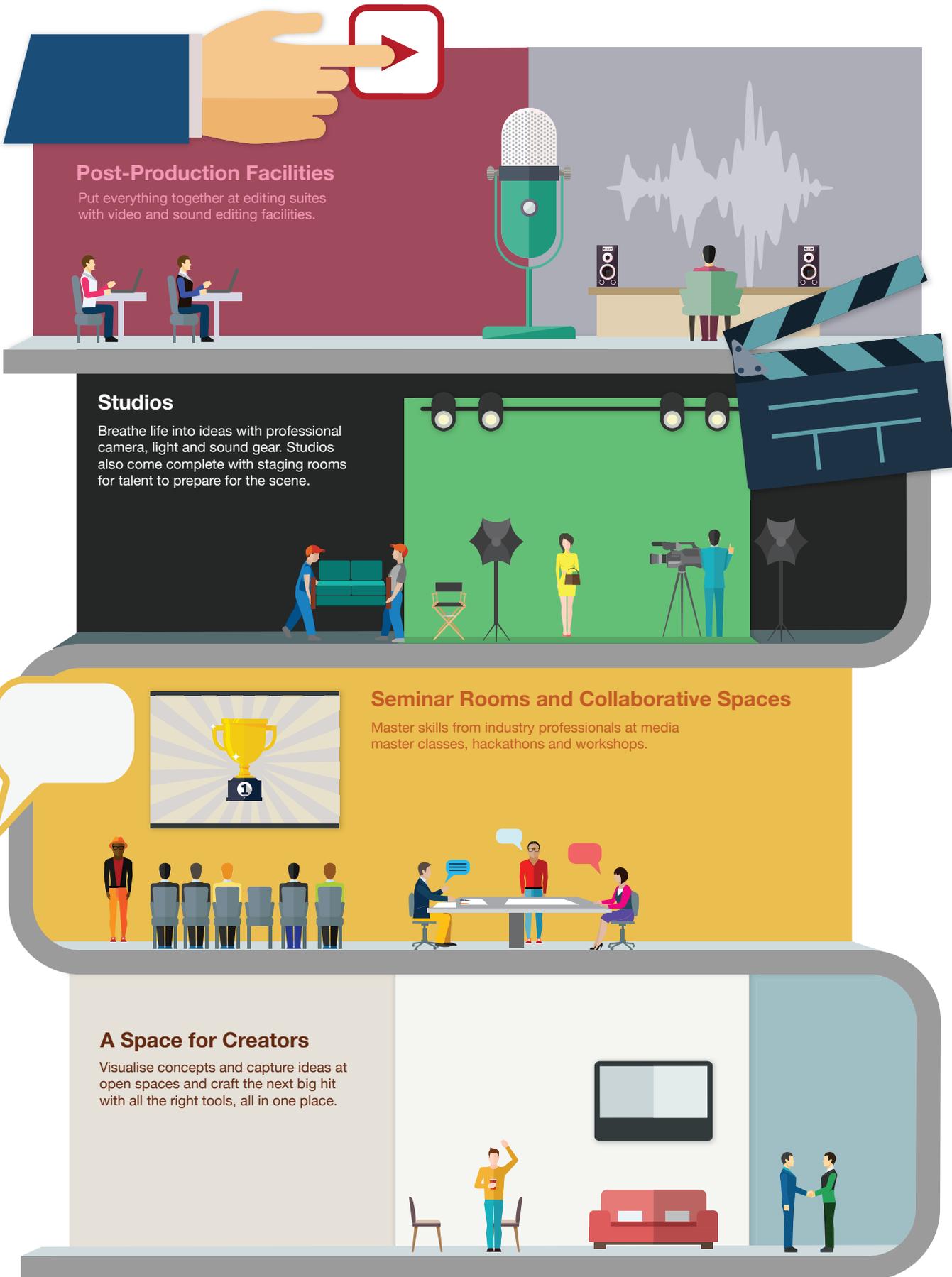
Catalyse Innovations and Solutioning through Big Challenges

- 4.12 We believe that for the infocomm media sector to be exciting, innovative, and creative, both the people and the enterprises in the sector must be motivated by the urgency to solve large, meaningful, challenging and complex problems. The Prime Minister Lee, in outlining the aim of the Smart Nation, has already identified three areas where “moonshot” goals can be found: ageing, healthcare, and urban density. We need to mobilise the entire sector – including research institutes, institutes of higher learning, technology companies, inventors, engineers, technicians, entrepreneurs – to work towards innovating solutions that will make a difference in these three areas.
- 4.13 Currently, the NRF sponsors the National Innovation Challenges to harness multidisciplinary research capabilities towards addressing large, complex problems facing Singapore. To date, R&D funding has been granted for Energy, and Land & Liveability³².
- 4.14 We propose working with the NRF to launch **tech challenges** for the infocomm media sector. These can be modelled after DARPA’s Grand Challenge³³. The Grand Challenge focuses on problem statements that have high pay-off in terms of user needs that push technology frontiers that require multidisciplinary capabilities, engage and excite innovation stakeholders such as research institutes, institutes of higher learning and industry. In line with the Smart Nation areas outlined by Prime Minister Lee, our infocomm media tech challenges can be in developing assistive technologies to help older workers remain in an inclusive workforce, home care solutions for patients with chronic diseases, and real-time multi-language speech translation for effective service delivery.
- 4.15 We also recommend that more be done by the infocomm media sector to draw in the design disciplines, as good design underpins many of today’s successful digital products and services. IDA has established a Centre of Excellence (COE) in Software Design and Development. The Centre promotes the adoption of agile computing and user experience practices and methodologies in the development of government digital services. A new Interactive Digital User Experience Lab will be introduced to enhance in-house capabilities for government digital services. The same capabilities must also be successfully adopted across the infocomm media sector.
- 4.16 Apart from challenges scoped around national-level problems, we also recommend efforts to have public sector agencies and private companies define enterprise-level challenges. Some public agencies have already embraced this model of crowdsourced innovation³⁴. A good example of private sector tech challenge is Unilever’s Overall Opinion Score Prediction Challenge³⁵. The challenge, which ran over two months from December 2014, attracted 621 submissions from 133 participants.
- 4.17 We expect that as software is embedded into more products, the separation between software development and manufacturing (not always a hard distinction to begin with) will become even more porous. The implication is that innovation by infocomm media companies will not stop at just software development. It will increasingly extend into the manufacturing of physical products. Singapore should continue to offer innovators the ability to pursue the innovation-to-production process in Singapore. This will leverage on Singapore’s strong IP protection regime. Singapore’s competitive advantage may not be in mass production, but we believe there is a case to be made for the manufacturing of prototypes or copies of early production runs.
- 4.18 The innovation to production process can be facilitated by a product innovation platform³⁶ where different actors in the product creation and manufacturing processes are brought together. The platform can also help to match the product design with production processes and methods, as well as match prototyping and precision engineering companies with product designers.

A Living Lab for Infocomm Media

- 4.19 The Singapore Economic Development Board (EDB) has been promoting Singapore as a Living Lab, where companies can collaborate with public agencies and research institutions to develop, test, and commercialise innovative urban solutions in a real-life setting.
- 4.20 We are encouraged that the EDB intends to extend the Living Lab framework overseas on a highly selective basis through a pilot programme in the next two years. Announced in March 2015, the creation of “Overseas Living Labs” will help companies bring technologies developed in Singapore to growing cities worldwide, particularly where there is a need to test bed technologies in a different climatic condition or in user environments not available in Singapore. The initiative will enable our local firms to gain new technology know-how as well as to have a live environment to trial their innovations.
- 4.21 We need to build on these efforts to develop Singapore as a Living Lab by creating a space to spur innovation with infocomm media. We recommend that resources be allocated to set up physical labs to enable individuals, companies, and government agencies (potential lead users) in the infocomm media sector to come together to explore new technologies and test out proofs of concept. It can also be a place where:
- (1) Certain shared facilities are offered, so as to provide infocomm media companies with access to up-to-date systems.
 - (2) Technical mentorships and workshops can take place, which can be helpful for start-ups that are building their prototypes.
- 4.22 IDA has already pioneered such a concept through its two IDA Labs. For media companies, we recommend the creation of a **Creators’ Space**, a physical environment to help media SMEs keep pace with technological advancement in digital and online video productions. The facility will provide online content creators with access to production studios and equipment so as to support the next generation content creators who are producing content for non-linear platforms, to prototype new ideas and collaborate with one another. Creators who are part of this community will have access to workshops and masterclasses on production, audience engagement and data analytics, opportunities to learn from mentors, as well as community networking opportunities.
- 4.23 We also recommend initiatives to make it more affordable and convenient for production companies to use Singapore landmarks or locations as backdrops in their productions. Currently, local production companies either have to film these landmarks on location or create 3D models of these landmarks. Both these options are costly, especially for smaller production companies.
- 4.24 To reduce duplicative cost and operational strain, we suggest that the Government and media industry work together to set up a **repository of Singapore Models and Footages**. The content can include a collection of 3D models of iconic buildings, landmarks and monuments, and digital footages of events of national significance. Content production companies will have the opportunity to use the digitised content in this repository to quickly create realistic and relatable settings for use in their films, programmes, games and visual effects. Content in the repository needs to be continually refreshed in subject matter and in production techniques. Not only will the depository have to capture the changing face of Singapore over the years, it also needs to be updated with the latest digital imaging technologies, techniques and standards.

FOSTERING IMAGINATION CREATORS' SPACE



Post-Production Facilities

Put everything together at editing suites with video and sound editing facilities.

Studios

Breathe life into ideas with professional camera, light and sound gear. Studios also come complete with staging rooms for talent to prepare for the scene.

Seminar Rooms and Collaborative Spaces

Master skills from industry professionals at media master classes, hackathons and workshops.

A Space for Creators

Visualise concepts and capture ideas at open spaces and craft the next big hit with all the right tools, all in one place.

Summary

The 2nd Strategic Thrust of Infocomm Media 2025 is to nurture an infocomm media ecosystem that encourages risk-taking and continuous experimentation. This can be achieved by putting equal emphasis on measures directed at the workforce and the enterprises:

- (1) For the workforce, the strategy is to direct customised manpower development schemes that are aligned with SkillsFuture Singapore to equip the respective infocomm and media workforce with new knowledge and skills, develop a passion for infocomm media as a career from young and instil the willingness to take risk and innovate. This can be done through initiatives like:
 - Computational Thinking as a National Capability
 - Open and Accelerated Learning
 - Story Lab
 - Capability Development Scheme

- (2) For the enterprises, the strategy is to provide infocomm media start-ups with more targeted and tailored assistance, to motivate the sector at large to solve big problems and find “moonshot” goals, and to establish physical spaces to explore new technologies and test out proofs of concept. This can be done through initiatives like:
 - Self-Sustaining Start-up Ecosystem
 - Sector-Specific Incubators and Accelerators
 - Partner of Choice
 - Tech Challenge
 - Living Lab for infocomm media that includes Creators’ Space

3rd Strategic Thrust: Connect People Through Infocomm Media

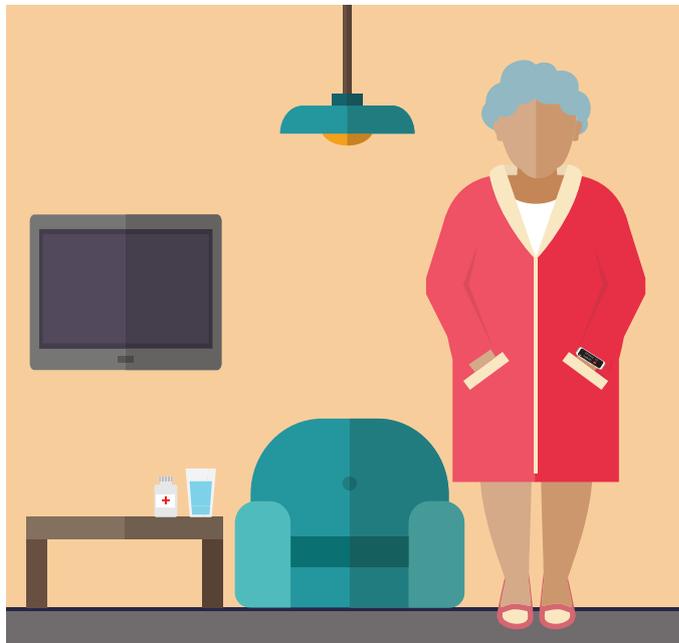
- 5.1 Infocomm media will deliver a better quality of life for our people. This will be felt in more than just better jobs, better incomes, and better profits. The infocomm media sector is also one of the few that has the opportunity to positively impact the lives of people in a very direct and personal way. Our 3rd strategic thrust seeks to answer the question of the layman: “How will all of this be of benefit to me?”
- 5.2 We believe that as Singapore exploits the possibilities of advances in data, advanced communications, and computational technologies (1st Strategic Thrust), it will also become possible for infocomm media to powerfully improve the everyday lives of Singaporeans. It will be felt in greater convenience. It will also be felt in the wider and stronger sense of inclusion – powered by technology. However, such benefits will not be felt as powerfully unless there is a clear national intent to ensure that the technologies are deployed in a way that is people-centric. We explore some of the more exciting possibilities.

Better Everyday Lives

Infocomm Media in Health and Wellness

- 5.3.1 We see great opportunities for treatments, therapies, or consultations to take place in the home, rather than at health institutions. This will provide many benefits such as reduced cost to healthcare institutions, and greater convenience for patients. The basic communications infrastructure in a home (i.e., a home capable of being fitted with necessary sensors and with seamless communications links to a healthcare professional) will open up many opportunities and applications.
- 5.3.2 There is a growing range of consumer healthcare solutions such as wearables or home sensors for a variety of health-related applications. Some may not meet the more stringent requirements of accuracy and reliability in order to be deployed in a therapeutic setting. However, we believe that it is a matter of time before clinical-grade or comparable sensors are developed.
- 5.3.3 **Smart Health-Assist** is one of the possible applications that we put up for consultation in the planning process. The response was very positive. Over the last year, IDA has worked with the Ministry of Health (MOH), healthcare and wellness stakeholders and the public to refine the concept. We note that IDA plans to pilot the idea in one of the HDB precincts in the Jurong Lake District in the second half of 2015.
- 5.3.4 We see the developments in this space moving quite quickly in the next few years to support more healthcare use cases. Hence, we recommend that a fairly aggressive and bold approach be taken to trial new Smart Health-Assist solutions rapidly and for the Government to make timely decisions to scale up. This will ensure that the benefits are reaped by Singaporeans as early as possible. Over the next decade, we expect technology to evolve rapidly, and thus agility and responsiveness to new advances in technology is called for.
- 5.3.5 We also think that developments in robotics suitable for deployment in service settings should be actively monitored, as these are likely to have bearing on whether they are ready for deployment in various healthcare settings. This will further support the notion of ageing-in-place, especially for the elderly who stay alone at home most of the time.

DELIVERING SENSOR-ENABLED HEALTHCARE SMART HEALTH-ASSIST



WEARABLE SENSORS

Wearable devices with sensors monitor important vitals such as:

- Heart rate
- Blood pressure
- Body mass content
- Blood-oxygen level
- Glucose level



INTELLIGENT MEDICATION

Nano-sized sensors in pills can remind patients to take their medication, or keep their caregivers up-to-date on their patient's treatment progress.



HOME-INTEGRATED SENSORS

Wirelessly connected sensors built into rugs or the floor can measure weight and gait of the patient as she moves around the house.



REMOTE MEDICAL CARE

With cognitive computing, healthcare providers can easily analyse anonymised data from sensors nomatter where their patients are. This lets them find best treatment options, and even accelerate clinical research.

Doctors can collaborate with their patients, healthcare providers or care givers remotely.

Doctors can change dosages or prescribe new treatments remotely, and update their patients via wearable sensors or mobile devices.



CONNECTED HEALTHCARE

Sensors can send collected vitals to the patient and her caregivers over secured connections.

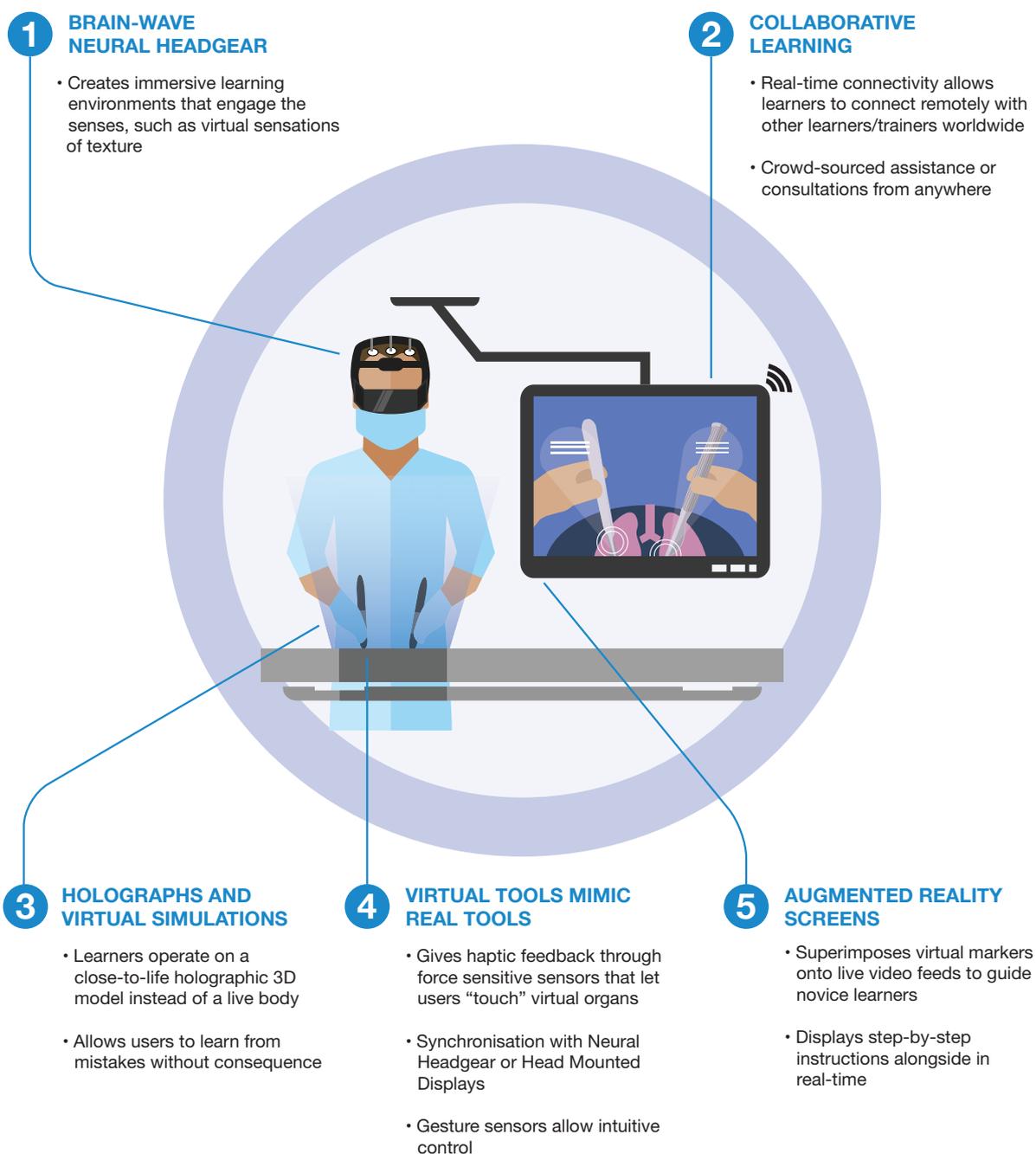
Caregivers can get real-time access to the patient's vitals and they can monitor the well-being of the patient remotely. Family members too can receive healthcare updates on their loved ones remotely.

More emergencies can be averted because sensors can instantly alert caregivers and even emergency services, if anomalous data is detected.

Smart Education

5.4.1 In Chapter 3 (para 3.16.2), we illustrated how data analytics can provide more targeted remedial assistance in the school environment, thus increasing teacher productivity and also increasing the productivity of the time spent by the student in remedial classes. We think there is considerable untapped potential in the use of infocomm media technology in transforming the provision of education services. In particular, we think that the only way to scale up the SkillsFuture programme significantly, is to deploy infocomm media technologies extensively. For example, certain procedures or routines (e.g., disassembly of a jet engine by a technician or administering an injection by a nurse) may be costly or impractical to replicate. Technology like augmented and virtual reality headsets, haptic feedback gloves, and other devices that provide immersive virtual reality can provide a better way to provide realistic training.

SMART, IMMERSIVE LEARNING WITH VIRTUAL REALITY SIMULATIONS



Medical student, Xavier has excellent diagnostic skills and good clinical acumen. However, he lacks confidence when it comes to performing surgical procedures. His mentor suggests that he practises surgery using the university's laparoscopic training system.

The next day, an excited Xavier shows up at the laboratory for his first training session. He is ushered to a cubicle. Here, his senses tell him that he is in a virtual operating theatre with a virtual body awaiting his surgery. In the middle is a table with probes and forceps that are connected to a force feedback device embedded in the table. As he uses the probes and forceps, he can feel the multiple layers of tissues, as well as the different textures and grains of the organs and blood vessels. He is elated when he manages to make the precise incisions required and remove the damaged tissue.

At the end of the training session, the training system congratulates him on a great first attempt and gives him pointers on various aspects that he can improve on to minimise damage to the surrounding tissues. Xavier is very encouraged and looks forward to the next few sessions, which will bring him, closer to mastering surgery.

Intelligent Transportation

- 5.5.1 We note that the Land Transport Authority (LTA) has developed a comprehensive masterplan for intelligent transport systems. We expect that some projects identified in this Report, such as the AG Boxes, HetNet, and Digital Marketplace can help to realise many of the benefits envisaged.
- 5.5.2 For example, higher quality open source datasets released by transport authorities and public transport operators will encourage the development of a wide array of context-aware transport apps that can meet various needs to an even greater degree than today's existing transport apps.
- 5.5.3 Another example is that the next generation of transport applications are built upon data collected from integrated sensor networks, or through crowdsourced inputs. Greater customisation, such as on-demand buses, customised bus routes and pre-booked seats, may all become possible. Commuters will benefit from a new class of "taxi-like" services at cheaper rates and yet experience reduced travel times.
- 5.5.4 The elderly or disabled can also benefit from using mobile applications to help them to plan routes that are disabled-friendly or to maximise the proportion of their walking route that is sheltered. Public buses can broadcast their location and estimated arrival time, and also their available passenger capacity. Higher quality information can be provided to vehicles, enabling real-time routing to less congested routes.
- 5.5.5 We also recommend that Singapore adopt a forward-leaning strategy on the deployment of autonomous vehicles. We believe Singapore should have a coordinated strategy, connecting technical feasibility to a clear and supportive policy and regulatory framework to guide their deployment. Singapore can and should be among the pioneering cities in the world for the deployment of autonomous vehicles.

Siew Ling, a retired teacher, has just moved into a new housing estate that has walkways that connect to nearby amenities and bus stops. Today, she has a medical appointment with a specialist at Urban Hospital for an examination of her swollen knees. Mobility is a big issue for Siew Ling. She depends on public transport to get to the hospital. A tech-savvy and resourceful senior citizen, Siew Ling uses an interactive application installed on her smart device to search for the most convenient way to get to the hospital.

Looking at the information, Siew Ling is relieved to discover that there is a barrier-free walkway from her block to the bus stop. While waiting for the bus at the bus stop, Siew Ling receives the latest transport information on how crowded the oncoming buses are. Real-time information on bus arrival times is also displayed prominently at the bus stop so commuters know which buses are arriving soon. Siew Ling makes the decision to wait for the elderly- and disabled-friendly bus as she is too weak to stand throughout her journey and requires some form of assistance. When the bus finally arrives, she boards the bus and pays the bus fare using her smart device.

Throughout the trip, Siew Ling continues to access a wide variety of personalised interactive travel information on the move, including weather forecasts and commuting patterns. After alighting at her bus stop, Siew Ling takes an autonomous vehicle that serves as a shuttle bus bringing visitors to designated drop-off zones within the hospital compound.

Smart Community Services

- 5.6.1 Central to the social transformation of Singapore is getting more Singaporeans to contribute through donations or volunteering to good causes. By engaging in such activities, Singaporeans will be exposed to ways of life different from their own. This will strengthen their sense of community solidarity and national identity. Infocomm media technologies can facilitate this process by providing opportunities for more Singaporeans to play a part in contributing to the community.
- 5.6.2 Due to limited resources, the rate of technology adoption in the community and social sector is low when compared against other sectors. This hinders information sharing among social service providers and creates information siloes, resulting in disjointed social service delivery to beneficiaries. We are encouraged that the Government recognises this and is developing a national case management system that enables service providers to better coordinate the delivery of social assistance and social services to individuals and families in need³⁷. Nonetheless, more can be done to mobilise our community to contribute to charitable and social causes.
- 5.6.3 Over the medium term, we propose improving community service by creating a unified giving platform for donors and volunteers to offer their time, money and/or expertise in a convenient, one-stop fashion. While there exist organisations that consolidate donations or manage volunteers, they typically focus on particular target segments or particular aspects of giving. For example, the Community Chest and SG Gives focus on the consolidation of donations for the poor, and SG Cares focuses on the recruitment of volunteers. A unified platform that integrates the canvassing for donations and the recruiting of volunteers will simplify the process and encourage more Singaporeans to come forward to serve their preferred cause be it for the poor and the needy, or other social causes such as the environment and animal welfare.
- 5.6.4 In addition, such a platform can offer data analytic tools to enable charities to better match the demand for and supply of volunteers, and to better understand charitable giving trends as well as donor and volunteer behaviour. This will improve the effectiveness of their operations and campaigns, and their communications to their stakeholders. In the longer term, the platform can be adapted to include entirely new models of philanthropy and community engagement. For example, the platform can enable people to trade services using their time as a medium of exchange.

Infocomm Media Inclusion

- 5.7 We are mindful that special attention should be given to specific community groups – the elderly, low-income families, and persons with disabilities – to ensure that the benefits of infocomm media are available to them.
- 5.8 We note that both IDA and MDA have developed programmes to address the needs of these groups. IDA created the **Digital Inclusion Fund** to:
- (1) Increase computer ownership and Internet penetration in low-income households;
 - (2) Increase the numbers of silver netizens;
 - (3) Increase the adoption of infocomm media and assistive technology among the disabled; and
 - (4) Uncover new areas and new target audiences that may require attention.
- 5.9 MDA launched the Digital TV assistance scheme, to help low-income households successfully migrate to digital television. It has also directed broadcasters to expand the range of subtitled programmes and increased the number of subtitled languages, to facilitate access by those hard of hearing.

- 5.10 We recommend that IDA and MDA ensure that such schemes are funded in a sustainable manner, and that they are regularly reviewed in order to ensure that the products and services that are funded keep up with market developments. This will ensure that no Singaporean will be left behind from the benefits brought about by infocomm media and the Smart Nation programme.
- 5.11 We also recommend that both IDA and MDA encourage greater innovation in the various inclusion initiatives so that they continue to be relevant and impactful. For example:
- (1) For low-income families, we can conduct surveys to better understand their needs for infocomm technology. This will help to better formulate financial assistance schemes, as well as support the infocomm media related learning needs of low-income students in partnership with the Ministry of Education (MOE), Institute of Technical Education (ITE) and polytechnics.
 - (2) For the seniors, we can identify the specific needs of different categories of seniors. It will ensure that seniors are well prepared for various digital migrations (such as the cessation of 2G mobile services). It will also ensure that seniors are confident to perform online transactions including e-government services on their own, and also encourage them to participate in various online initiatives, such as the crowdsourced Citizen Archivists Project³⁸ led by the National Archives of Singapore.
 - (3) For the disabled community, we can conduct more detailed studies into various disabilities, in order to develop a menu of potential assistive technology solutions for each disability type. With these solutions, people with disabilities can enhance their interactions with others and participate in online activities. For instance, a software that translates photos into voice descriptions helps persons with visual impairment access their friends' photos on social networking platforms. Another example is for people with autism to use Alternative and Augmentative Communication tools to express their feelings or make their requests known to others.
- 5.12 Another important enabler for community inclusion is the deployment of **language translation** technologies. We believe it to be especially relevant for Singapore as we have a multiracial population that speaks four national languages and many dialects. Translation technologies will enable Singaporeans to consume content produced in the languages of different ethnic and cultural groups. These can help us develop a deeper understanding of each other's culture and bring our communities closer.
- 5.13 We would also like to see the application of near real-time and real-time text-to-speech natural language translation technologies in service delivery. Such technologies do not merely benefit the disabled. Language translation can be applied in the service sector including the public sector to increase service productivity (a bilingual employee can potentially serve customers in more than the two languages he is conversant in). It can remove any remaining structural impediments to more wide-scale adoption of e-government services. For example, citizens who are not conversant in English may find it easier to access e-government services delivered in their preferred language.
- 5.14 We would also like to see local broadcasters explore the use of automatic speech recognition technologies. Over time, when these technologies become more precise, our broadcasters can tap on them to provide near real-time and real-time live multilingual subtitling for live programmes, as well as for video on demand content on their interactive television platforms.
- 5.15 Machine-learning technologies in this area are rapidly maturing. To ensure that Singapore can benefit fully from these technologies, it is necessary for a national effort to populate the lexicon with local variations of meaning as well as pronunciation. This will increase the level of accuracy for language translation. On the R&D front, Singapore should continue to build capabilities in ASEAN language translation through the Universal Speech Translation Advanced Research project and Baidu-I2R Research Centre programmes³⁹.

Summary

The 3rd Strategic Thrust of Infocomm Media 2025 is to connect people through infocomm media to enhance the quality of life in Singapore and foster a stronger Singaporean identity. There are two parts to this strategy:

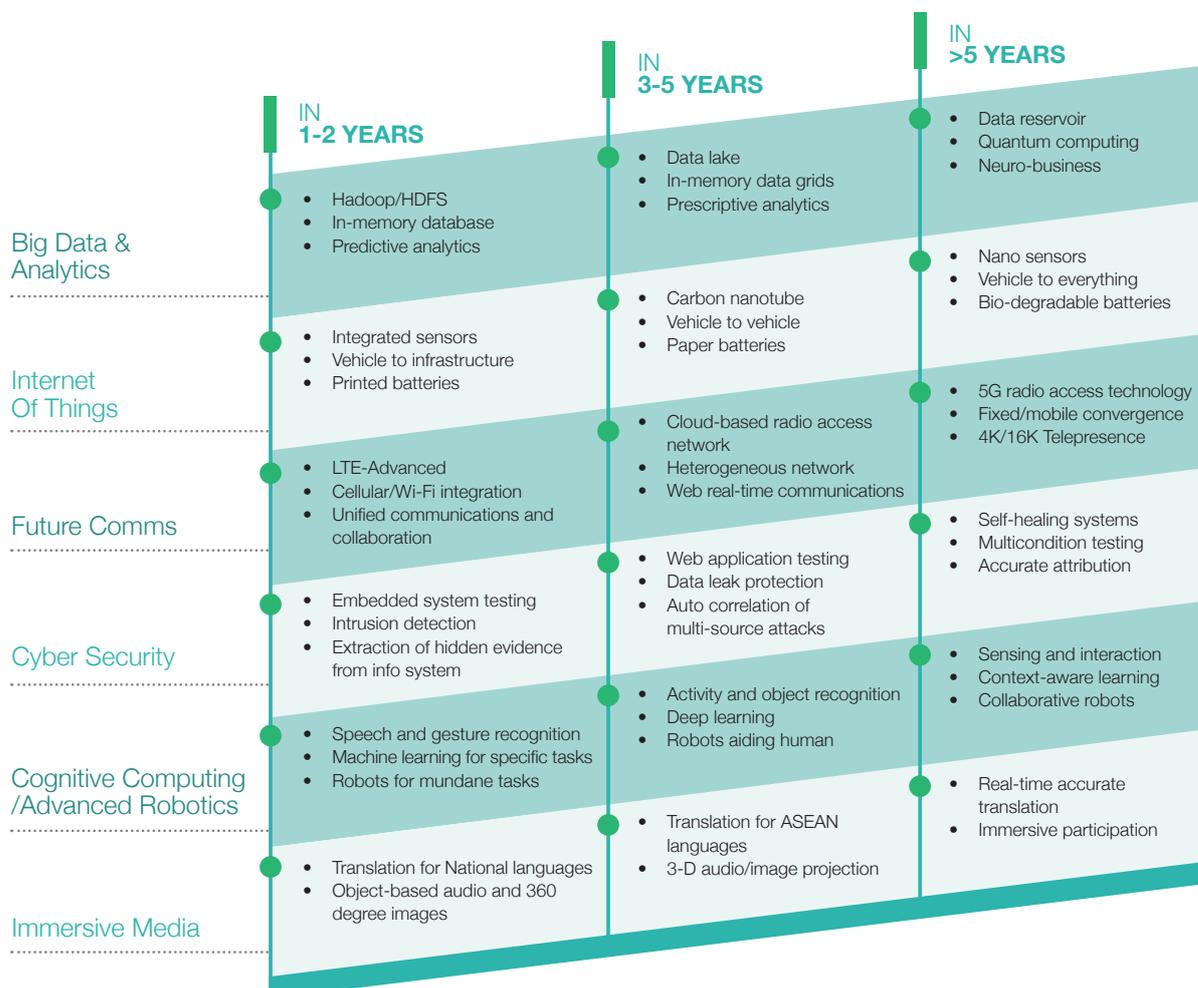
- (1) Deploy infocomm media technologies in a people-centric manner to improve various aspects of everyday life. This can be done through initiatives in these areas:
 - Smart Health-Assist
 - Smart Education
 - Intelligent Transportation
 - Smart Community Services

- (2) Ensure that the benefits of infocomm media can be enjoyed by all Singaporeans and Singaporeans are brought closer as a community with a common identity. This can be done through initiatives like:
 - Digital Inclusion Fund
 - Language Translation

CHAPTER 6

Making It Possible: Technologies To Power Us Ahead

- 6.1 Not all the ideas in this Report are immediately implementable. The state of technology is a key constraint. In some cases, the technology is not yet sufficiently mature in order to be cost-effective. In others, several of the component technologies are already available, but until the last component is ready, the solution cannot be implemented.
- 6.2 In the next decade, we believe that new technological discoveries will provide fresh insight to existing problems. New research directions may also open up surprising new pathways to solve our national challenges.
- 6.3 We cannot predict in advance the exact sequence in which various research directions will bear fruit. Navigating the next decade will thus require an agile infocomm media sector – one that is poised to take advantage of new breakthroughs as they are uncovered.
- 6.4 We believe that advances in six technology areas will play a significant role in facilitating the emergence of many of the solutions we envisage in this Report. These six areas constitute our infocomm media technology roadmap. The roadmap is delineated into three timeframes, namely, short- (one to two years), mid- (three to five) and long-term (greater than five). We have a fairly good idea of what may emerge in the next one to two years. Beyond this time horizon, we are less certain about the time frame in which they become possible.

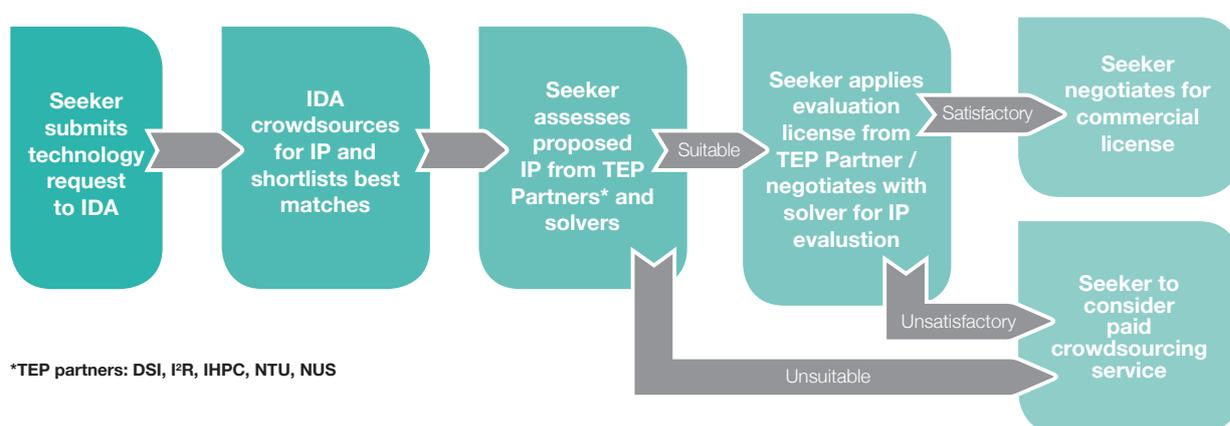


- 6.5 For each of these six technology areas, we have developed sub-roadmaps that reflect the industry's view of the likely trajectory in terms of the evolution and mainstream adoption prospects of component technologies.
- 6.6 The confluence of one or more of these six technology areas will also open up many opportunities for innovation. Cognitive Computing and Cyber Security are enablers across many sectors. Cognitive Computing enhances the intelligence of systems to learn and improve their capabilities over time, while Cyber Security technologies enhance the trustworthiness of systems and protect us against evolving cyber threats. The different technologies can also work together to help us transform our sectors. For example, Future Communications, the Internet of Things, and Big Data & Analytics can help us improve healthcare by enabling the development of Tele-health, Personalised Healthcare, and Optimised Healthcare Delivery. These same technologies also make possible the Last Mile Delivery in Urban Logistics, International Trade and Logistics, and E-Commerce.

Improving the Link between Research and Industry

- 6.7 The technology roadmap outlines what is possible based on technology breakthroughs in Singapore and the world. However, the technology intellectual property (IP) that emerges from research institutes and universities still have to be translated into commercial products and services. We think that this is an area where Singapore can do better.
- 6.8 There is currently considerable information asymmetry between companies seeking technologies solutions, and the institutions owning the IP. Initiatives like the Tech Challenge described in Chapter 4 (para 4.14) can help to draw more technologies out of universities and research institutes. By providing a focus on big challenges, we can build new capabilities that we desire and solve interesting and significant real world problems in radical and beneficial ways. This can enable greater public and private collaboration, and encourage the development of more innovative technology products.
- 6.9 Having a focus on big challenges is insufficient to engender quality research outcomes, we must also identify the right companies and start-ups with the ambition to scale, grow quickly and ultimately build a strong presence on the world stage. A process that helps to identify industry partners that give better value-capture outcomes from research is needed to refine current processes of IP translator platforms and research assistance schemes. For example, IDA has set up Accreditation@IDA, a programme that evaluates and accredits tech companies in their technical products, commercial viability (e.g. cost of offering versus other competitors), legal and financial suitability, etc.
- 6.10 We propose that IDA continue to work closely with tech companies and user organisations to develop innovative tech solutions leveraging on IPs available locally and overseas through its Technology Evaluation Programme. The programme simplifies the process of sourcing for IP, mitigates the risks in IP adoption, and complements existing in-house R&D efforts.
- 6.11 To achieve these objectives, IDA has partnered with and made available IPs by the Data Storage Institute (DSI), the Institute for High Performance Computing (IHPC), the Institute for Infocomm Research (I2R), Nanyang Technological University (NTU), and the National University of Singapore (NUS). Technology crowdsourcing is also conducted to source for IPs from other local and overseas technology owners ("solvers").

- 6.12 Under this programme, tech companies and user organisations (“seekers”) source for matching IPs by submitting their technology requests to IDA. This is one more type of quality assistance that IDA provides to accredited companies that can also serve to connect promising growth companies to efforts within the research community domestically and abroad. When a suitable IP is found, they may apply for a short term no-fee evaluation licence from Technology Evaluation Programme partners, or negotiate with other local and overseas solvers to evaluate the IP. Upon satisfactory evaluation, they may seek a commercial licence of the IP with its owner.
- 6.13 If no suitable IP is found, or the outcome of IP evaluation is unsatisfactory, IDA will help refer the seekers to appropriate intermediaries who are able to help source for suitable IPs globally.



- 6.14 We also strongly recommend that industry development agencies continue to exercise strong leadership linking upstream R&D efforts to industry outcomes. These agencies are best placed to do so as they are close to the market and the industry. This will catalyse the creation of economic or social value for companies that take on technology commercialisation roles. Relevant industry development agencies need to also consider allocating sufficient resources to promote Singapore’s research capabilities and the productisation of our R&D discoveries.

On Our Wish List: Technology Capabilities That Singapore Will Want to Build

- 6.15 We believe that innovations in the infocomm media sector should be powered by technological IP developed both locally and abroad. This is the only way for companies to maintain their distinctive competitive edge.
- 6.16 We strongly support the development of a strategic research programme to build research and engineering capabilities in areas that can help advance Singapore’s Smart Nation and Infocomm Media objectives. The Strategic Research Programme in Interactive Digital Media⁴⁰ is an encouraging example. Since its launch in 2006, the programme has built good research capabilities in areas such as social media analytics, and modelling and simulation.
- 6.17 There is potential to further align upstream R&D efforts with the industry and sector development directions identified in this Report. Recommended initiatives in this Report can lead demand, and identify the cross-cutting capabilities (capabilities that will benefit more than one area or sector) needed for infocomm media infrastructure development and sectoral transformation.

6.18 We recommend developing these capabilities ourselves in cases where R&D strengths exist locally⁴¹. Critically, these are the capabilities, when built, are likely to significantly spur the innovation and invention of technologies that will differentiate Singapore's industries from others. Building such capabilities will also help us address some of our national challenges. The following diagram shows the cross-cutting technology capabilities recommended for national R&D investment.

Cross-Cutting Technology Capabilities Recommended For National R&D Investment



6.19 The finalised list of targeted capabilities, associated R&D roadmap for each capability, and recommended approach for capability development will be submitted to Singapore's Research, Innovation and Enterprise Council (RIEC) later this year. These recommendations will then be considered for inclusion under the Research, Innovation and Enterprise (RIE) 2020, which is Singapore's R&D plan for the next five years, covering infocomm and media as well as other scientific domains.

Summary

The technology roadmap outlines six technology areas that will be vital for many of the ideas in the Infocomm Media 2025 plan to become possible in the future.

- (1) There is a need for stronger linkages between research and industry:
 - The industry development agencies should take the leadership role to ensure that upstream R&D is linked to industry outcomes.
 - It is important to identify challenging problem statements, identify the right companies to partner for value capture through structured programmes (e.g. through Accreditation@IDA), provide real world project opportunities to bridge R&D and industry, and connect better local and overseas IPs to industry partners (e.g. through IDA's Technology Evaluation Programme).

- (2) There is a need for a Strategic Research Programme to help advance Singapore's Smart Nation and Infocomm Media objectives. The cross-cutting technology capabilities recommended for national R&D investment are in:
 - Cyber Security and Trust
 - Communications
 - Cognition
 - High Performance Computing
 - Analytics
 - Interfaces

Conclusion

1 This Report proposes three strategic thrusts to guide the infocomm media sector: to capitalise on data, advanced communications and computational technologies; to nurture an infocomm media ecosystem that encourages risk-taking and continuous experimentation; and to use infocomm media to connect our people. Each thrust focuses on a different area but they share one unifying goal – to foster a globally competitive infocomm media ecosystem that enables and complements our Smart Nation vision, that brings about economic and social transformation and that creates enriching and compelling content.

2 For each thrust, we outlined strategies along with recommendations on how Singapore can capitalise on salient technology and business trends that will take centre stage in the near future. For example, we proposed the roll out of HetNet, AG Box and Digital Harbour to help the nation meet the anticipated increase in demand on its infrastructure arising from the growing need for seamless connectivity, increased use of data analytics as well as changing consumer habits. Likewise, we believe accelerator and incubation programmes and tech challenges will spur innovation and the development of new products and services by local companies. The fostering of computational thinking and storytelling capabilities in our people will help keep them relevant in the digital economy. We also proposed broad directions on the use of infocomm media to benefit key sectors that we foresee will face growing resource constraints and rising demands for resources. Our priority recommendations can be found in the summaries of Chapters 3, 4 and 5.

3 To support the three thrusts, we proposed a set of cross-cutting capabilities to be considered for national R&D investment. These recommendations are intended to synergise with the priorities of Singapore's Research, Innovation and Enterprise Council, and are designed to direct the nation's research capabilities towards supporting economic growth and meeting national needs.

4 We are very aware that our recommendations cannot work in a vacuum. For this reason, we crafted this Report in close collaboration with teams that steer various other national and sectoral plans. We also actively consulted with stakeholders from the academia and the private and people sectors. Specifically, we shaped our recommendations to align with the directions set out in related national initiatives like Smart Nation, Research, Innovation and Enterprise 2020, the National Cyber Security Masterplan 2018 as well as other masterplans like the Sectoral Manpower Plan under SkillsFuture Singapore.

5 We hope that in implementing Infocomm Media 2025, the Ministry and its agencies continue to engage with all the above-mentioned teams and stakeholder groups to understand their plans and needs so that our recommendations and broad directions stay relevant as technology advances.

6 We recognise that some of the possibilities envisaged in this Report cannot happen unless there is a willingness to review existing policies and regulations. This requires willingness across many government ministries to consider how technology can be harnessed to transform the sectors that they oversee. We further suggest that IDA and MDA review and, where necessary, reorganise their work processes and industry development plans to facilitate the execution of recommendations in this Report.

7 All the same, our enterprises and people still have an important part to play in the constantly changing environment up ahead. Our enterprises need to continue to look out for new opportunities and actively review their business models. They should also harness infocomm media to innovate and to lift their productivity. Our people of all ages need to proactively level up and expand their infocomm media skills to thrive in the emerging global digital economy. We need to adopt a "maker mindset", a belief that one can learn to do anything and an inclination to experiment with technology and use it to build solutions to problems. Also we believe that Singaporeans of all ages need to build social connections with people outside their immediate circles and to feel a sense of community, so that we are a stronger, more cohesive people.

8 In summary, this report illustrated the enabling powers of infocomm media. It can drive economic success. It can empower and ease everyday lives. It can connect people. It can make our life richer, more fulfilling and easier in every way. It is clear that we cannot afford not to invest in infocomm media if we want to continue to be a successful nation. To realise all that potential, however, the industry and Singaporeans from all walks of life need to work together to harness infocomm media to fundamentally change the way we live, learn, play, work and connect. Only then can we take advantage of opportunities when they arise and achieve our goals. Only then can we realise sustainable and quality growth and a better quality of life for our people and, ultimately, make Singapore a better place for ourselves and for generations to come.

Notes and References

- ¹ Economic Survey of Singapore 2014 (February 2015) - Source: Ministry of Trade and Industry
- ² Population White Paper (January 2013) – Source: Ministry of Trade and Industry
- ³ IDC Worldwide Big Data Technology and Services Forecast. Source: <http://www.idc.com/getdoc.jsp?containerId=prUS25132014>
- ⁴ Source: <http://www.aldebaran-robotics.com/en/Solutions/For-Research/human-robot-interaction.html>
- ⁵ Source: ITU towards “IMT for 2020 and beyond”, International Telecommunications Union
- ⁶ Source: McAfee, June 2014. Net Losses: Estimating the Global Cost of Cybercrime. The Economic Impact of Cybercrime. Commissioned by the Centre for Strategic and International Studies.
- ⁷ Deloitte Global Mobile Consumer Survey 2014.
- ⁸ Singapore’s mobile penetration rate in 2014 was 148 per cent.
- ⁹ How Netflix Reinvented Itself (23 April 2013) – Source: Forbes, Inc <http://www.forbes.com/sites/petercohan/2013/04/23/how-netflix-reinvented-itself/>
- ¹⁰ EMC Digital Universe with Research & Analysis by IDC (2014), <http://www.emc.com/leadership/digital-universe/2014iview/executive-summary.htm>
- ¹¹ A showcase of the HetNet trials at Jurong Lake District is expected to be ready towards the end of 2015.
- ¹² The “ping-pong effect” refers to the excessive handover effects of frequent movement of mobile units between the cells in a mobile cellular network. The “ping-pong” effect adds on to the load of wireless networks, hence, it is necessary for network operators to reduce this undesirable effect.
- ¹³ Singapore is the world’s fastest broadband nation, according to Ookla’s Net Index, a US-based global speed index. Internet users in Singapore have been enjoying the world’s fastest broadband link of around 104 Mbps since Dec 2014. Hong Kong with its download speed of around 95 Mbps is in second position, followed by South Korea (80 Mbps) and Japan (67 Mbps). – “Singapore tops global speed index for broadband links”, Straits Times, 9 February 2015
- ¹⁴ Officially launched in June 2011, data.gov.sg is the first stop for the search and discovery of all publicly available government data.
- ¹⁵ Organised by the Infocomm Development Authority of Singapore, the Data Discovery Challenge is a competition launched to encourage the use of both private and public datasets to develop new ideas to improve the way we live, work, learn and interact in Singapore.
- ¹⁶ The latest prediction from market research company eMarketer is that global e-Commerce sales will hit US\$1.471 trillion in 2014. This is close to a 20 per cent increase from 2013.
- ¹⁷ The genome is the genetic material of living things that is contained in its Deoxyribonucleic Acid. Genomics is a molecular biology discipline that studies genomes.
- ¹⁸ New Robots Designed to Be More Agile and Work Next to Humans - 13 Apr 2015 (Source: The Wall Street Journal) <http://www.wsj.com/articles/new-robots-designed-to-be-more-agile-and-work-next-to-humans-1428945644>.
- ¹⁹ More information can be found at www.nicf.sg.
- ²⁰ More information on SkillsFuture Singapore can be found at www.skillsfuture.sg.
- ²¹ In 2015, Wikipedia lists 600 programming languages (excluding programming language variants) and 12,000 public application programme interfaces. Of these, 20 are commonly used for data analytics.
- ²² Code for Fun was pilot tested in 22 schools from April 2014 to November 2014. Two thousand and five hundred students from Primary 4 and 5 and Secondary 1 and 2 participated in the pilot.
- ²³ The ICT Learning Roadmap serves as a guide in structuring progressive infocomm technology training in various infocomm technology domains. It is helpful for teachers running infocomm clubs and for students with aspirations in an infocomm career. More information on the Roadmap can be found at http://www.infocommtalent.sg/ICT_Learning_Roadmap.aspx.
- ²⁴ The National Infocomm Competition is the largest network of infocomm technology competitions in Singapore. Its objective is to recognise top talents in Singapore in various infocomm technology domains. More information on this initiative can be found at <http://www.infocommtalent.sg/nic.aspx>.
- ²⁵ The Maker Movement is a trend in which individuals and groups of individuals employ do-it-yourself or do-it-with-others techniques and processes to create unique products, mostly involving the use of technologies like 3D printers, electronics and robotics which has become more affordable and accessible.
- ²⁶ littleBits are do-it-yourself electronics for prototyping and learning. It allows you to make your own electronic creations with no soldering, wiring or programming required (<http://littlebits.cc/intro>).
- ²⁷ KIBO is a robot kit designed for young children aged four to seven. It lets them programme their own robot using wooden blocks to create a sequence of instructions (<http://kinderlabrobotics.com/kibo/>).
- ²⁸ London Is Now the World’s Crowdfunding Capital – August 2014 (Source: Forbes) <http://www.forbes.com/sites/jasonhesse/2014/08/15/forget-nyc-or-san-francisco-london-is-the-worlds-crowdfunding-capital/>
- ²⁹ MAS Sets Out Proposals for Securities-based Crowdfunding – 16 February 2015 (Source: Monetary Authority of Singapore) <http://www.mas.gov.sg/news-and-publications/media-releases/2015/mas-sets-out-proposals-for-securities-based-crowdfunding.aspx>
The Infocomm Development Authority of Singapore / the Media Development Authority of Singapore, together with SPRING, has been providing the Monetary Authority of Singapore with industry inputs on proposed regulations for securities-based crowdfunding in Singapore.
- ³⁰ Source: Department of Statistics (2013).

- ³¹ "Amazing" results seen for IDA accredited tech companies – June 2015 (Source: The Business Times) <http://www.businesstimes.com.sg/government-economy/amazing-results-seen-for-ida-accredited-tech-companies-amended>
- ³² From 2011 to 2015, S\$300 million in grant was dispensed for the Energy theme. Another S\$135 million was allocated to support R&D for projects under the Land and Liveability theme from 2013 to 2018.
- ³³ The Defense Advanced Research Projects Agency is an agency of the U.S. Department of Defense responsible for the development of emerging technologies for use by the military.
- ³⁴ DataMall@MyTransport.SG by the Land Transport Authority is a data sharing initiative that taps on open innovation. Other public agencies like the Health Promotion Board and National Environment Agency have also made available their datasets for the Data Innovation Challenge that was launched in June 2013.
- ³⁵ Unilever's challenge was for participants to develop a robust model that could predict consumer preferences based on its extensive and detailed customer survey datasets. The objective was to reduce the number of questions asked, and reduce the number of times the product has to undergo testing.
- ³⁶ Source: Gartner's Hype Cycle for Discrete Manufacturing and PLM, 2014.
- ³⁷ "Government Awards Tender to Develop Common IT System to Coordinate Social Service"
- May 2014 (Source: MCCY) <http://app.msf.gov.sg/Press-Room/Government-Awards-Tender-to-Develop-Common-IT>
- ³⁸ <http://www.nas.gov.sg/citizenarchivist/>
- ³⁹ R&D programmes at Baidu-IR Research Centre led to the creation of many successful apps including VoiceTra4U, a mobile app that translates 30 languages including 27 dialects used in ASEAN, and some language processing modules deployed in Baidu's online translation service.
- ⁴⁰ The Interactive Digital Media Strategic Research Programme builds on Singapore's unique multicultural, multilingual identity and our strong information and communication infrastructure to create new innovative niches in the vast and rapidly changing interactive and digital media sector. The programme supports research in areas such as animation, education and edutainment, games and effects, "on-the-move" media services and media intermediary services.
- ⁴¹ To assess R&D capabilities, we consulted local research institutes and institutes of higher learning on their research strengths for the capabilities identified.

Acknowledgement

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