Digital Government, Smart Nation: Pursuing Singapore's Tech Imperative

Ng Chee Khern

HOW TO BUILD GOOD SOFTWARE
Li Hongyi

ATTRACTING TECH TALENT: START WITH CULTURE REDESIGN
Karen Tay

BRINGING DATA INTO THE HEART OF DIGITAL GOVERNMENT
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ETHOS

ETHOS is a publication of the Civil Service College, Singapore. It aims to provide thought leadership, insight and context on a wide range of public policy issues of interest to Singapore.

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Editorial

by **Vernie Oliveiro & Aaron Maniam**
Guest Editors

Singapore's ambition to be a Smart Nation, driven by and harnessing technology, is at heart about making this city-state the best home possible for its citizens. But what does it really mean to be "smart" these days?

F. Scott Fitzgerald offers a clue in one of his short stories: "The test of a first-rate intelligence is the ability to hold two opposed ideas in the mind at the same time, and still retain the ability to function". True smarts, he suggests, come not from the glibness of the smart-aleck, but from something much deeper.

This issue explores some of the opposed ideas—the apparent tensions and trade-offs—that both underpin and animate Singapore's Smart Nation efforts.

Most critically, this hugely complex ambition requires a whole-of-nation effort, not just deliberate government action. The lead article by Ng Chee Khern, Permanent Secretary for Smart Nation and Digital Government, lays out some of the key multi-sectoral transformations that Singapore is making (*p. 4*). Beyond simply adopting technology, the government is building on existing strengths as it undergoes profound shifts in policies, strategies, processes, organisational structures, projects, systems, and people. These intertwined, mutually reinforcing

> **Governments will need to acquire different habits of mind and ways of working, which must coexist with more orthodox mindsets.**

transformations enable it to serve citizens in ever better ways in this digital age. Jane Lim (*p. 20*) and Rachel Chen (*p. 30*) discuss transformational changes in the economy and society respectively; these must be adopted by organisations and individuals if they are to not only understand but also seize opportunities and participate meaningfully in the digital age.

Digital Government requires governments to think of data as a strategic asset, rather than conceptualise resources in the traditional terms of finances and people. Daniel Lim discusses the key changes the Singapore Government is undergoing to become more data-driven, including reorganising its data architecture, enhancing data literacy among public officers, and creating and identifying use cases that can facilitate and deepen digital transformation. If, as he says, data is "the raw fuel that powers and sustains digital transformation", then the governments should be thinking about the political-economy that manages the generation and use of data (*p. 42*). Accountability, privacy, security, efficiency and convenience will need to be balanced in order to nurture the social license for data-driven government.

Governments will also need to acquire different habits of mind and ways of working, which must coexist with more orthodox mindsets. A key principle of digital government is that many of the techniques used in software engineering are also applicable to public policy and management. At the same time, since more policies, operations, and services will come with a layer of technology, it is truer today than ever before that all public servants need to understand best practices in developing good technological products. For both these purposes, Li Hongyi's insights on how to make good software may be especially useful to prompt reflection on the habits, practices and competencies of a government that is truly "digital to the core" (*p. 54*). Karen Tay draws on experiences from Silicon Valley to observe how organisational cultures as a whole might need to change in order to attract and retain engineering talent (*p. 64*). Abhilash Anselm and Tiana Desker describe what the Agile work approach looks like in their teams, and how it differs from traditional bureaucratic practices (*p. 74*). All three contributions show that the creation of digital organisations concerns everyone in an organisation, not just engineers.

Serving in the digital age will demand that governments both seize opportunities and manage risks. Rahul Daswani and Jevon Tan discuss how digital technologies can both augment security operational capabilities and introduce new threats such as cyberattacks and deep fakes (*p. 92*). A multi-agency approach is needed to manage risks and progressively apply technology to defend against threats and enhance security. Governments will also have to partner industry to both nurture innovation while working for the public good. David Hardoon and Shameek Kundu reflect on the balance between these imperatives for the financial industry (*p. 102*). In the complex, rapidly-changing environment fostered by digital technology, the public and private sectors will need to know each other well in order to harness synergies and manage differences.

Leonard Loo's piece on how his team took just one year to develop FormSG, from an idea to a product used by thousands, illustrates what digital transformation in government looks like in practice at an individual level (*p. 86*). The story of his team's relentless focus on problem-solving and producing good work contains useful advice on public entrepreneurship, and

provides inspiration for any officer with a good idea. The challenge for public managers is how to encourage and enable others to identify opportunities to solve problems and create value for everyone, while managing the equally important priority of probity in the use of public funds.

Amidst the push for digital transformation, there might be a temptation to measure digitalisation simply by the presence—and survival—of digital projects. Aaron Maniam suggests how governments must balance this instinct with more meaningful measures and evaluations of digital success. His piece will be particularly useful to public managers who must not only deliver useful products that solve citizens' problems, but also steward IT systems, platforms, resources such as finance and time, and data security (*p. 110*).

In many ways, all public policy is about the delicate reconciliation of opposed ideas: current technology trends simply make the contradictions more acute. We hope that these articles highlight both the challenges and opportunities in the Smart Nation effort, and point a way towards insight and wisdom. ■

Serving in the digital age will demand that governments both seize opportunities and manage risks.

Digital Government, Smart Nation:
PURSUING SINGAPORE'S TECH IMPERATIVE

by **Ng Chee Khern**

Singapore's ambitious
Smart Nation initiative
is about harnessing
technology to stay ahead as
a global city and to improve
lives and livelihoods for all.

Ng Chee Khern is Permanent Secretary
for Smart Nation and Digital Government
in the Prime Minister's Office. He leads
the Government's efforts in driving the
development of digital enablers for citizens
and businesses, and applying digital and smart
solutions to improve the lives of citizens in
a Smart Nation.

What Is Smart Nation?

Through the Smart Nation initiative, we aim to make Singapore "an outstanding city in the world…for people to live, work and play in, where the human spirit flourishes."[1] To achieve this, we have to apply technology systematically and extensively, rather than in a piecemeal manner, to improve the lives of our people.

But first, why does Singapore need to be a Smart Nation? Growth in two main factors of production drove Singapore's growth in the first 50 years: our labour force, and capital investment. As our population ages and the inflow of immigrants slows (given our finite physical space), labour as a factor of production will grow more slowly. Consumption as a percentage of GDP will also likely rise relative to investment as Singapore's population ages. The main contribution to growth and prosperity will have to be total factor productivity, which could be achieved through a mix of technology and better business processes.

Besides continuing to build prosperous and flourishing lives for Singaporeans, Smart Nation can be a reason why home-grown talent would want to continue living here, and why foreign talent would want to relocate here. This is the magnetic pull exuded by the world's leading cities, such as New York, London, San Francisco, Shanghai and Tokyo.

Smart Nation is also necessary to accelerate the process of integrating technology into our collective efforts to improve lives, lest Singapore fall behind relative to other global cities. Modern-day classrooms, hospitals and workplaces; the very concepts of retirement and a pension; the city in its horizontal spread (trains and cars) and vertical reach (elevators)—these improvements to human wellbeing were enabled by the first and second Industrial Revolutions. The nature of all these will shift again as the technologies of the fourth Industrial Revolution change our lives. The first two Industrial Revolutions allowed us to automate menial, physical chores. The third and fourth Industrial Revolutions are allowing us to automate even more of such tasks, and to devote a greater proportion of our lives to meaningful, enriching activities. To give a personal example: it used to be that vacations could be a stressful experience, because of the unfamiliarity with a new environment. These days, with Google Maps and review sites, travelling has become much less anxious and a lot more enjoyable.

Smart Nation: What It Takes

Building a Smart Nation is a whole-of-nation effort which can be thought of in terms of three pillars: Digital Government, Digital Economy, and Digital Society. The first pillar, led by the Smart Nation and Digital Government Group (SNDGG), involves agencies across the Public Service. The Ministry of Communications and Information (MCI) leads work for the other two pillars. Other articles in this issue discuss Digital Economy (p.20) and Digital Society (p.30), so this article will focus on Digital Government.

SMART NATION FRAMEWORK

SMART NATION TRANSFORMING SINGAPORE THROUGH TECHNOLOGY

supported by
STRATEGIES

Digital Readiness Blueprint

Digital Economy Framework for Action

Digital Government Blueprint

and
ENABLERS

CYBERSECURITY

DATA

TALENT AND MANPOWER
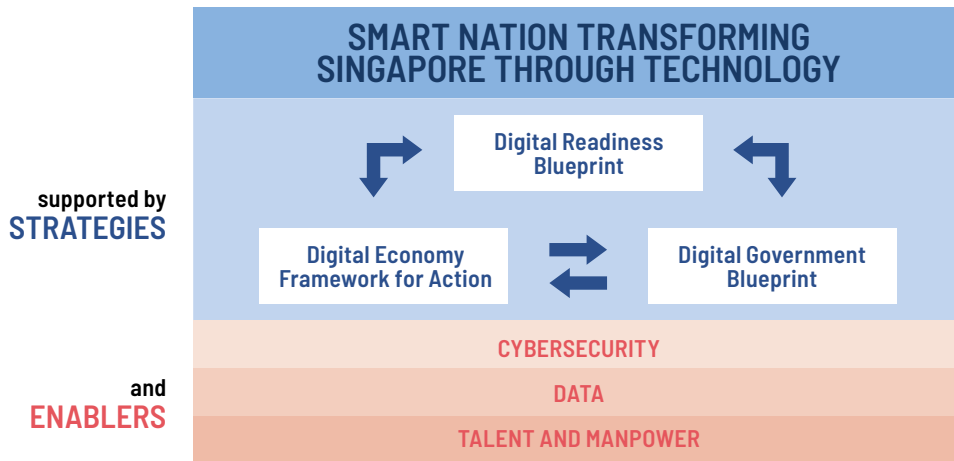
Unlike in many other countries where innovation and the application of technology are driven by the private sector, in Singapore, the Government has traditionally set the pace. We expect digitalising the Government will set in motion deep changes that will spread to the private and people sectors.

Digital Government: Where Are We Today?

When it comes to Digital Government, Singapore is fortunate to be building on strong previous efforts. Our digitalisation journey started about three decades back, with the National Computerisation Programme in the 1980s. Led by the National Computer Board (now the Government Technology Agency or GovTech), the Programme focused on automating data, processes and systems. By the 2000s, we had shifted to providing government services online,

first as websites and then as phone applications when mobile phones exploded in popularity. Since the 2010s, we have been focusing on making our services more integrated, and experimenting with different approaches to being citizen-centric.

Heading into the future, we are off to a good start. Most transactions between citizens and the Government today can be done online, and integrated apps that reduce the time taken to fulfil inter-agency requests have been growing in number. But such efforts have been sporadic or agency-led. A central, coordinating entity can accelerate the process, which was why SNDGG was formed in May 2017. Soon after our formation, we launched five Strategic National Projects: National Digital Identity, E-payments, Moments of Life, Smart Nation Sensor Platform and Smart Urban Mobility. Most of these are digital platforms, upon which more use cases can be explored over time.

In the course of the next two years, we have gone further than just having more

projects and systems. We have also put in place policies and strategies, processes and organisational structures; we have also recruited and groomed talent to systematically exploit digital technologies and to sustain the momentum in the longer term. Collectively, these efforts will drive the Government to become digital to the core.

POLICIES AND STRATEGIES: NEW WAY OF WORKING AND THINKING

In the past, other than in agencies that have a heavy engineering component, technology did not feature often as an agenda item in policy forums and senior management meetings in the Government. This is shifting. Policymakers are increasingly taking responsibility for technology. For instance, all public agencies now have a role to play in achieving targets set out in the Digital Government Blueprint (DGB). Two such targets aim to achieve 75% to 80% citizen and business satisfaction levels with government digital services. We have made some progress in achieving these goals. Between 2017 and 2018, the score for citizen satisfaction rose from 73% to 78%, while the score for business satisfaction rose from 64% to 69%.

The DGB targets are ambitious but not unrealistic. For this reason, the DGB is a living document, so targets may be revised as we plan further digitalisation initiatives. For example, we will be updating the DGB when the National AI Strategy is ready later this year.

SNDGG has also been working with all Ministries to develop comprehensive plans

DIGITAL GOVERNMENT BLUEPRINT

2 PRINCIPLES
3 STAKEHOLDERS
6 OUTCOMES
6 STRATEGIES
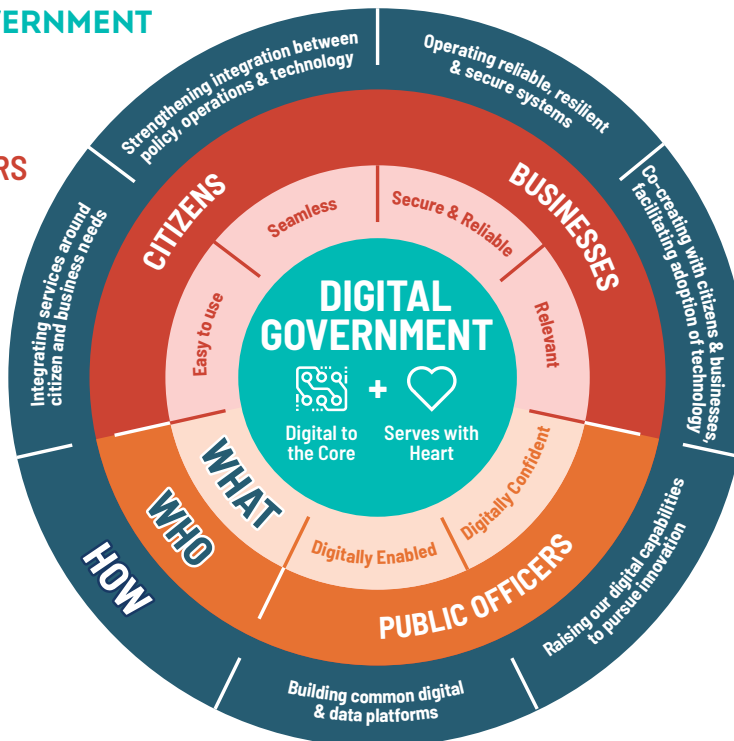
DIGITAL GOVERNMENT BLUEPRINT KPIS

STAKEHOLDER SATISFACTION		Citizen Satisfaction with Digital Services (via survey)	*75-80%* to rate very satisfied
		Business Satisfaction with Digital Services (via survey)	*75-80%* to rate very satisfied
END-TO-END DIGITAL OPTIONS		Services that offer e-payment options (inbound and outbound)	*100%*
		Services that are prefilled with Government-verified data	*100%*
		Services that offer digital options for wet ink signatures	*100%**
END-TO-END DIGITAL TRANSACTIONS		Percentage of transactions completed digitally from end-to-end	*90-95%**
		Percentage of payments (inbound and outbound) completed via e-payments	*100%**
DIGITAL CAPABILITIES		Number of public officers trained in data analytics and data science	*20,000*
		Number of public officers with basic digital literacy	*All* Public Officers
TRANSFORMATIVE DIGITAL PROJECTS		Number of transformative digital projects	*30-50* over a period of 5 years
AI, DATA AND DATA ANALYTICS		Percentage of Ministry families that use AI for service delivery or policy making	*All* Ministry families to have at least one AI project
		Number of high-impact data analytics projects	*10 cross-agency projects* per year, and *2 projects* per Ministry family per year
		Core data fields in machine readable format, and transmittable by APIs	*90-100%*
		Time required to fuse data for cross-agency projects	*Less than 10 days* to share data for cross-agency projects

* Excludes services or individuals where the KPI cannot be met for valid reasons. These reasons can include legislative reasons, or that certain segments of our population (e.g. the elderly or persons with disabilities) are unable to have access to or use digital tools.

for digitalisation. The first round of plans, completed in June 2018, was useful in quickly identifying "no-regrets" digital initiatives that Ministries felt would be high in impact. Some of the initiatives, such as the Ministry of Home Affairs' digitisation of death registration and the Ministry of the Environment and Water Resources' automated meter reading infrastructure that enables near real-time information on water consumption patterns, will significantly improve service delivery and how agencies operate.

However, the first round of plans was ultimately a list of projects. From 2020, Ministries will include digitalisation planning in their strategic planning cycle, so the plans are linked to and support the Ministries' missions. Integrating with the strategic planning cycle also means resourcing, data requirements and capability development will be simultaneously considered.

In addition, Ministries will be encouraged to explore digital technologies beyond application development, such as artificial intelligence (which allows more personalised and anticipatory services), data analytics (which allows more evidence-based and data-driven policy making), and Internet of Things (IoT) or smart systems (which will go much further in creating a good living environment in Singapore). An agency

KEY MILESTONES FOR STRATEGIC NATIONAL PROJECTS

Smart Nation
SINGAPORE

	2018	2019	2020 and Beyond
National Digital Identity (NDI)	NDI Developer & Partner Portal; SingPass Mobile (SPM); More features for SPM	MyInfo for 145 Govt and 155 private sector services; SingPass login for private sector services; Launch of MyInfo Business	Digital signatures for paperless trials (2020); Widespread adoption of NDI (2022)
E-Payments	Govt agencies start using PayNow; SGQR Payment Standard; PayNow Corporate; Unified e-payments system at hawker centres, coffee shops, industrial canteens	Use of bank cards for public transport; Rollout of 50,000 Unified Point-of-Sales terminals; Payment Services Bill	Non-bank FAST access
Smart Nation Sensor Platform (SNSP)	Personal Alert Button Trials; Lamppost-as-a-Platform Tender; Drowning Detection Trial	Lamppost-as-a-Platform Trial	City-level sensor data available for industry and public (2022)
Smart Urban Mobility		Trial of on-demand autonomous shuttles; Trial of on-demand public bus services; Trial of hands-free ticketing technology; Trials of autonomous buses	Potential pilot deployment of AVs for public transport (Early 2020s)
Moments of Life (MOL)	Pilot MOL app for families with young children	On-boarding of private hospitals for electronic birth registration; Launch of Parents Gateway; More services for active ageing and end-of-life matters; Expanded suite of services for families with young children	
Core Operations, Development Environment, and eXchange (CODEX)	Automated testing of Govt apps; Standards to improve Govt digital services	Begin migrating Govt systems to cloud; More developer-friendly tools and APIs; Central repositories to facilitate inter-agency data sharing in improving services	Majority of Govt systems on commercial cloud (2023)

Infographic courtesy of the Smart Nation & Digital Government Group

that has made good progress on this front is the Ministry of Manpower, which has deployed cameras and sensors to improve the monitoring and enforcement of workplace safety at construction sites.

PROCESSES AND ORGANISATIONAL STRUCTURES: STARTING FROM THE TOP

Policies and strategies, however well laid, can only have a chance of success if processes and structures are designed to facilitate the harnessing of technology.

For example, we are witnessing a paradigm shift where agencies are beginning to see technology not just as an expense, but also as an investment in new strategic capability: that it is about how technology can help agencies reach topline growth (faster time-to-market for services, improved service delivery) in achieving mission objectives. This is not to say that we are not striving to be cost-efficient in using technology, but that cost-efficiency should not be the only consideration.

But even if agencies are to treat technology as a strategic capability, conventional approaches to resourcing do not allow projects to be started quickly. The traditional funding cycle takes place only once a year, and if the project proposal is supported, there is still the calling for and then evaluation and awarding of tenders. For in-sourced projects, time is needed to hire developers. To put this in perspective: it can often take longer to obtain the resources for a project than to build a prototype. In addition, the project team has to work out pricing and commit to recovering system costs, before they have even had the chance to work out requirements with users.

Over the course of 2018, SNDGG worked with the Ministry of Finance (MOF) to revise this resourcing approach, to facilitate the Government's exploitation of technology. MOF has now implemented a new resourcing framework to enable more agile digitalisation, allowing for nimble initiation of pilots and proof-of-concepts, to test hypotheses or assumptions before scaling. To date, about 40 projects have received funding through this framework. Some interesting ideas include a computer vision-powered drowning detection system, and speech-to-text software.

> We are witnessing a paradigm shift where agencies are starting to see technology as a strategic capability or profit centre.

If we are to digitalise effectively, the process of integrating policy/ops with technology must also be improved. Good policy/ops-tech integration happens when the policy/ops communities and technologists know how technology can best be applied to achieve agencies' missions, and work together to achieve them. The lack of policy/ops-tech integration today is reflected in anecdotes of designers and engineers complaining about "announcement-driven development", which happens when they are committed to project deliverables—without prior consultation—by their policy counterparts. Business owners often decide on the solution before the technical team of designers and engineers has done its user research.

To improve ops-tech integration at the highest level, we have revised organisational structures. We have appointed a Chief Digital Strategy Officer (CDSO) at the Deputy Secretary level in every Ministry, to oversee delivery on their Ministry's DGB targets and digitalisation plans. The CDSO is supported by the Ministry's CIO, to encourage management-level conversations on how technology can support business needs. The CDSO also coordinates and has clear lines of authority over the ICT and Digitalisation Steering Committees within their Ministry, which also involve agencies' CIOs, Chief Data Officers and Chief Information Security Officers (CISOs).

Beyond structures, policy/ops-tech integration can be achieved if policy makers lay down clearly the outcomes they want to achieve or the problems they want to solve, and then give engineers sufficient autonomy to research and come up with technical solutions. We must develop solutions that are evidence-based and driven by user research.
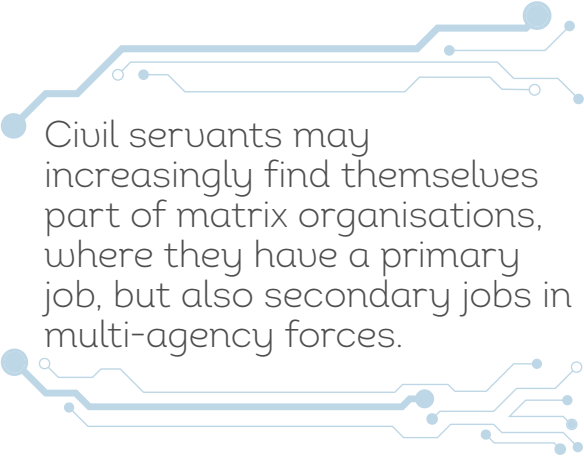
One of the best ways to achieve policy/ops-tech integration is through agile software development, where policy or ops officers work closely with the technical team—and in some cases, are even co-located with them—and constantly iterate their solution through testing with users. This approach to software development is gaining recognition in the public service, and together with the growing awareness that digitalisation is a priority, we are witnessing an unprecedented opportunity to build an engineering culture in the public service.

A third example of a process we need more of is giving space to tech-push and whitespace projects. Tech-push goes

REVISED GOVERNANCE STRUCTURE FOR POLICY/OPS-TECH INTEGRATION
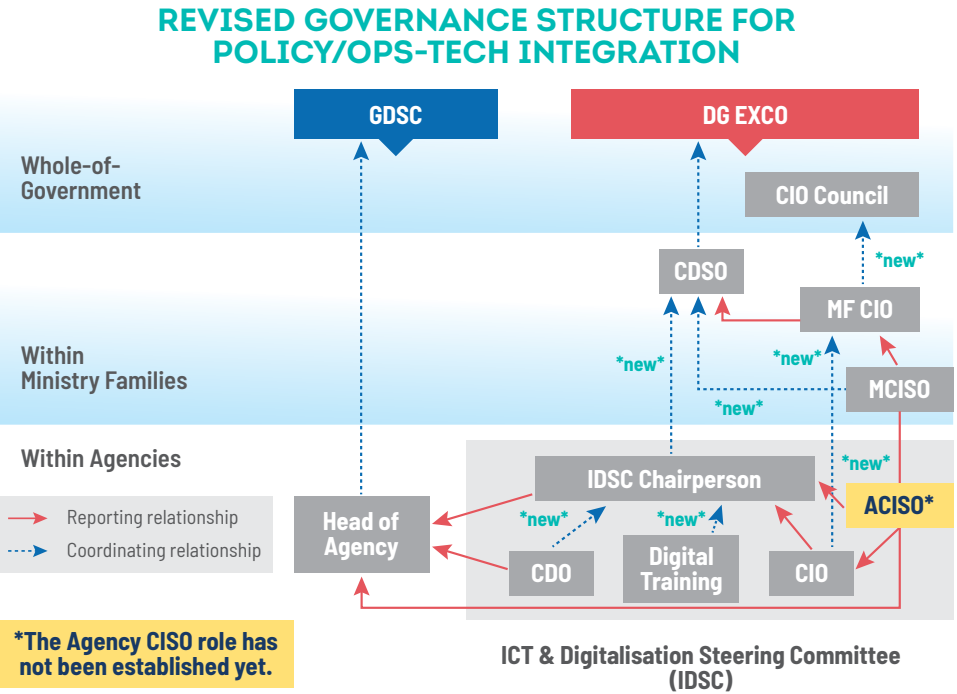
beyond ops-tech integration and gives engineers freer rein in how to innovate. We have seen the value of tech-push: in fact, many of GovTech's products and platforms were developed this way, without any business owner. Today, these products and platforms, such as *Beeline* and *Moments of Life* are well accepted and considered mainstream.

> Civil servants may increasingly find themselves part of matrix organisations, where they have a primary job, but also secondary jobs in multi-agency forces.

To structurally enable tech-push and white space innovation, SNDGG is starting a new digital experimentation and implementation unit. The unit will operate in a sandbox environment, where officers not only get to develop new products, but also test future directions for ICT policies, and try out new organisational approaches to building and running tech organisations—including in traditionally non-ICT areas such as HR and procurement. We expect this unit to model itself on how a modern tech organisation should look like, and to have its practices adopted by the rest of government where relevant.

A fourth set of process and structural changes that has been forged is having multi-functional, multi-agency teams to provide integrated services to citizens. The Government had previously experimented with this through the establishment of the Municipal Services Office and its *OneService* app, and more recently, the *Moments of Life* project. Unlike most task forces, which disband once they deliver a product, we need such teams to remain: because in the digital age products have to be constantly updated and upgraded beyond their "delivery" date. As a result, civil servants may increasingly find themselves part of matrix organisations, where they have a primary job, but also secondary jobs in such multi-agency task forces.

The last example of change in SNDGG's organisational construct is the designation of a functional leader or professional head of the Information and Communications Technology and Smart Systems (ICT&SS) community in the Government. This functional leader is the Government Chief Digital Technology Officer (GCDTO). The GCDTO will increase the coherence and lift the standards of the ICT&SS community through the creation of common concepts of operations, common platforms and technical standards, common competency frameworks and training, as well as a common HR scheme.

PROJECTS AND SYSTEMS: SHOWING EARLY SUCCESS

For greater coherence across the Government, SNDGG prioritises and brings together engineering resources across Government to work on large, complex but high-impact digital technology projects. These would include the aforementioned Strategic National Projects, though agencies retain the autonomy to commission other high impact projects that are largely within their domains and do not need whole-of-government coordination. SNDGG, working with MOF, evaluates the funding proposals for agencies' projects to avoid

SMART NATION PROJECTS

Beeline
www.beeline.sg

An open, cloud-based smart mobility platform offering data-driven shuttle bus services for commuters. With Beeline, commuters can activate (or "crowd-start") direct, private express bus routes catering to their personal travel needs, especially during peak periods. Commuters book seats on the bus routes in advance, via a mobile app.

Beeline bus routes are adaptive: new routes are activated based on commuters' demand and existing routes may evolve over time. There are currently 13 private bus operators on Beeline, more than 200 drivers and 300 Beeline routes running.

Parking.sg
www.parking.sg

A mobile application that lets users pay for short-term parking charges through their mobile devices at all existing coupon-based public car parks. The app serves as an alternative mode of payment instead of paper parking coupons.

Useful app features include an advance alert 10 minutes before a parking session expires, and the ability to extend the parking duration remotely.

Moments of Life
(Families)
www.tech.gov.sg/media/technews/
the-tech-behind-the-moments-of-life

A Smart Nation initiative that supports families with children aged six and below, this service bundles useful services and information on a single, one-stop digital platform. Users can register a child's birth, apply for the Baby Bonus, find preschool facilities using geolocation technology, access a child's upcoming medical appointments, and more.

The Moments of Life app also provides parents-to-be and caregivers with up-to-date information on applicable government schemes and benefits, parenting tips and event listings based on their specified interests.

The app was developed based on insights gathered through citizen engagement sessions to identify and better understand parents' challenges and needs.

Whole-of-Government Application Analytics (WOGAA)
www.tech.gov.sg/media/technews/
your-sentiments-matter-in-the-
design-of-government-digital-
services

Jointly developed by GovTech and SNDGO this platform provides a set of common metrics and measurements that enables public agencies to monitor the performance of their websites and digital services in real-time, conveniently and cost effectively. A central dashboard shows the overall health status of government websites and digital services. An analytics tool can also be embedded within agencies' websites and digital services for performance tracking.

WOGAA monitors the performances of Government websites, but will not track personal data. Instead, the insights derived help agencies improve public service delivery, set their web strategies and provide information for policy making.

myResponder
www.tech.gov.sg/media/technews/
meet-the-man-using-myresponder-
to-save-lives

Developed by the Singapore Civil Defence Force (SCDF) in collaboration with GovTech, myResponder is a means to crowdsource for lifesavers.

Whenever the SCDF is notified of a medical emergency and assess it to be a case of cardiac arrest, it sends out a message to community first responders (CFRs) registered on the app who are within 400 metres of the patient. Currently there are more than 41,000 registered CFRs on the app.

The app also provides alerts on minor fires, namely rubbish chute fires that account for approximately 50% of fires in residential estates. CFRs that are in the area can help to put out these small fires and take geo-tagged photos of the extent of the damage.

duplication and to provide guidance on how to build the projects that do get approved.

For example, we have developed a Singapore Government Technology Stack, and want agencies to use components in the Tech Stack when developing their systems. The Tech Stack comprises various layers of component: the bottom layers are fundamental components such as data and infrastructure, and the upper layers comprise micro-services and applications. Agencies are encouraged to use what is centrally available and customise only at the upper layers.

The Tech Stack signals a departure from the way the Government has traditionally done software development. We are moving from monolithic to modular system architecture, and this saves time and effort in developing and maintaining digital services. It also greatly reduces the time-to-market for digital services since agencies don't have to reinvent the wheel. Examples of projects built using components of the Tech Stack include the *Business Grants Portal, MyCareersFuture* and *Moments of Life.*

The Singapore Government officially adopted a commercial cloud-first policy in June 2018. We intend to migrate the majority of Government ICT systems to the commercial cloud over the next five years, as the cloud brings benefits such as access to best-in-class services for our engineers, lower hosting costs, and reduced system downtime.

Collectively, these efforts will achieve greater interoperability between and coherence across Government ICT systems. Standards of use, including cybersecurity, will be uplifted. At the

same time, this strikes a balance between commonality of platforms and standards at the infrastructure layer and innovation at the application layer.

PEOPLE: BUILDING UP OUR COMMUNITY

To build a Digital Government in support of a Smart Nation, we need a sizeable bench strength of skilled engineers. In particular, we want to hire specialists or peak technical talent, and engineers with experience managing big technology projects. We need to partner the private sector better, and reach out to citizens to make sure the design of our digital products and services are informed by actual experiences and user research. Smart Nation is ultimately a whole-of-nation effort, and we need the private and people sectors to play their part also.

We are moving from monolithic to modular system architecture.
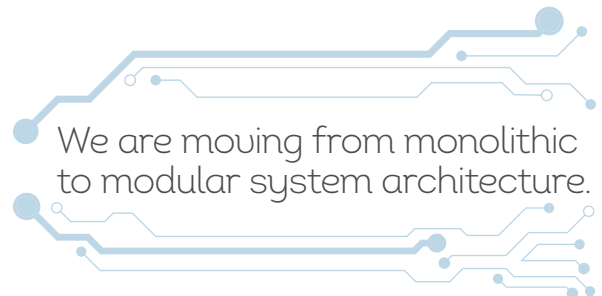
To attract tech talent, GovTech's HR scheme has been revised to match the attractive salaries tech talent would otherwise command in the private sector. We are also stepping up recruitment of overseas Singaporeans who have worked in technology companies, having organised Singapore Tech Forums in the Bay Area for the past two years. Through the Forum, we share how Singapore's dynamic tech ecosystem can support their ambition, and that there are abundant opportunities whether they join the public or private sector here. We have

SINGAPORE GOVERNMENT TECH STACK (SGTS)

A better, smarter and faster platform for building digital applications

BETTER EXPERIENCE

Develop a more seamless, consistent and connected experience across government digital services.

SMARTER PROCESS

Enable easier exchange of data across the government for richer insights that will help with policy and solution development as well as monitoring of operations.

FASTER ROLLOUT

Faster deployment of solutions without the need to develop infrastructure from scratch

DIGITAL SERVICES

Easy-to-use, accessible and secure digital government services that improve lives of citizens and business.

MICROSERVICES

Reusable common services that agencies utilise to build applications such as the National Digital Identity for authentication.

MIDDLEWARE

Software services such as APEX (API Gateway) and WOGAA (analytics) that allow for rapid development, deployment, testing and monitoring.

HOSTING PLATFORMS

Scalable hosting containers with secure connectivity.

Infographic courtesy of
the Government Technology Agency

a Smart Nation Fellowship programme that allows overseas Singaporeans who are working in the private sector to take a three- to six-month stint with us, to collaborate on digital or engineering solutions that will have an impact on people's lives.

At the same time, we have to improve the management of tech talent within the Public Service. To this end, we have developed a common HR scheme for digital technologists, so that they can take on ICT&SS roles across different agencies to enhance their exposure and contribution. The scheme allows them to pursue leadership opportunities, either becoming a specialist or assuming a leadership role in an ICT&SS agency. A Talent Leadership Committee has been established in tandem, to more systematically groom and plan for succession for our talents and key ICT&SS positions. The Administrative Service has also established an engineering track that allows Administrative Officers to spend more time in engineering jobs to deepen their expertise. This is modelled after the Singapore Armed Forces Overseas Scholarship Scheme that allows officers more sustained stints on the ground to build deep expertise.

Our tech talent can join many agencies. SNDGG has established a Centre of Excellence for ICT&SS, comprising the C3 Capability Centre in the Defence Science and Technology Agency, the Geospatial Capability Centre in the Singapore Land Authority, and GovTech's Capability Centres in five areas: Application Design, Development & Deployment, Data Science & Artificial Intelligence, Sensors & IoT, Government Cybersecurity, and Government Infrastructure. These Capability Centres and the talent within

them have been crucial in rebuilding engineering capabilities within the government, and have been both the cause and result of the Government being able to in-source ambitious and socially meaningful digital projects.

> We need to partner the private sector better, and reach out to citizens to make sure the design of our digital products and services are informed by actual experiences and user research.

However, given the finite size of the Government's ICT&SS workforce, we must go beyond the public sector to raise the capabilities of our partners in the private sector. We have been increasingly open to co-sourcing and sharing our approach to software engineering with the private sector, as well as encouraging them to build applications using components of the Singapore Government Technology Stack. In October 2018, we hosted our inaugural STACK Developer Conference, which saw 1,200 attendees—more than half of whom were from the industry. The feedback for STACK was positive, with attendees appreciating the Government sharing its technology roadmaps. We are targeting an even bigger Developer Conference in 2020.

This sharing is not one-way. Leading cloud service providers like Amazon, Google and Microsoft are not just

supporting the migration of Government systems, but sharing best practices with our IT teams and helping to train and certify them. GovTech has also come up with a Digital Technology Attachment Programme, to let our engineers gain industry exposure through a short stint with partnering companies, and a Technical Mentorship Programme which matches our project teams with local or overseas technical mentors. I am glad to report that all mentorship opportunities with Silicon Valley-based mentors have been taken up.

Finally, becoming an effective digital government demands that we reach out to our citizens. MCI has programmes to raise the digital readiness of the public, and SNDGG co-creates with the public by involving them in user research for digital products, as well as getting them to test beta applications. Through a new programme, Smart Nation Co-Creating with People Everywhere (SCOPE), we partner agencies such as the People's Association and the National Trade Union Congress, leveraging their outreach events to garner public feedback on products under development. We believe that this increases the ownership citizens feel towards these products, and makes them more inclined to use the products once they launch.

Conclusion

We are still in the early days of a long journey towards becoming a Digital Government and a Smart Nation. Most of the cutting edge innovations for digital technologies come from technology companies in the private sector. We have to make sure that the Government as a whole, and in particular GovTech, has top talent and is able to

exploit technology on the same level as these top tech companies. There is strong political support for our work, and digitalisation is a key component of Singapore's overall Public Sector Transformation. We also have a strong core of strongly committed officers in both SNDGG and across the ICT&SS community in the Government, who are passionate about this mission to make Singapore an outstanding city with the aid of technology.
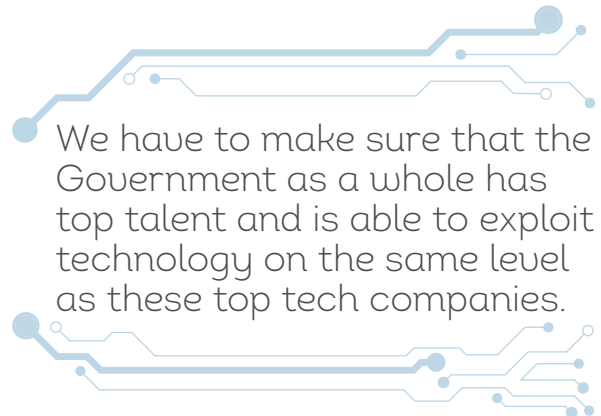
> We have to make sure that the Government as a whole has top talent and is able to exploit technology on the same level as these top tech companies.

But there is a lot more work to be done and challenges to be overcome. Although I am optimistic, a lot of hard work and commitment is still needed. On the surface, the public sector is a monopoly. There is no "Netflix" to disrupt us if we continue to operate like "Blockbusters". But Singapore has no monopoly on the world stage—as a country we can be disrupted and left behind in geo-political and socio-economic terms. So we have to put pressure on ourselves, not by looking at other governments and how digital they are, but by looking at whether Singapore as a whole is economically and technologically competitive relative to other countries.

If we are serious about Digital Government setting the pace for Smart Nation,

our agencies and the whole-of-Government must continually look for ways to raise our game, innovate, and use digital technology as a multiplier for our effectiveness. We have collectively created some momentum, delivered some good digital products, and less visibly, gone "under the hood" to change policies, raise capabilities, and modernise infrastructure. Let us build on what has been done, and accelerate the work. ■

Note

1. Smart Nation Singapore, "Transcript of Speech by Prime Minister Lee Hsien Loong at Smart Nation Launch, 24 November 2014", accessed April 23, 2019, https://www.smartnation.sg/whats-new/speeches/smart-nation-launch.

SERVICES

Services 4.0:

A New Wave of Innovation and Partnerships

by **Jane Lim**

Emerging technologies promise new service possibilities—but organisations need to understand how best to embrace, apply and develop them to advance their goals.

Jane Lim is the Assistant Chief Executive of the Sectoral Transformation Group in IMDA, which partners the public and private sectors to accelerate the growth of Singapore's digital economy and spearhead digital transformation for industry sectors. She has also worked on social sector financing, energy utilities, manpower planning and policy, and intellectual property policy.

What is Services 4.0?

Over the past few decades, we have seen the services economy evolve from the era of manual services (1.0) to efficient Internet-enabled services (2.0) to self-services enabled by mobile, wireless and cloud technologies (3.0). In phase 4.0, we envision **seamless** services that are **end-to-end**, **frictionless**, **empathic** and which **anticipate** customer needs using emerging technologies. This is the vision for Singapore's digital economy articulated in the Services and Digital Economy (SDE) Technology Roadmap, launched in late 2018.

Depending on the type of services offered and customers' preferences, some organisations may choose to keep part of their products or processes at various levels, or provide Services 4.0 selectively. What is important is to figure out where this makes sense and decide deliberately, based on the potential and relevance of new technologies.

What is important is to decide **deliberately**, based on the potential and relevance of new technologies.

SERVICES 4.0 | AN EVOLUTIONARY JOURNEY

SERVICES 1.0 MANUAL
Enabled by TOOLS

In this early stage, tools are used to help with services performed manually. For example, a customer writes a letter to a bank requesting a credit limit increase, which may take days to process.

SERVICES 2.0 EFFICIENT
Enabled by the INTERNET

With the advent of the Internet, Web-based innovations like portals and online databases have made services more efficient. The bank customer uses the bank's web portal to ask for a credit limit increase.

SERVICES 3.0 SELF-SERVICE ON-THE-GO
Enabled by MOBILE technologies

In the age of mobile devices, enhanced connectivity, through wireless technology and cloud computing, enables convenient customer self-service anytime anywhere, further reducing effort. The bank customer can now use his mobile app to increase his credit limit wherever he is.

End-to-End I Frictionless I Anticipatory I Empathic

SERVICES 4.0 SEAMLESS
Enabled by EMERGING TECH

Companies harness the power of data and analytics to anticipate customer needs and provide choices. For example, the bank is able to predict that a major increase in expenditure is coming up and proactively offer the customer a choice of increasing his spending limit temporarily. This ensures that customer experience is pleasant and frictionless.

Source: IMDA

WHAT TECHNOLOGY TRENDS ARE ENABLING THIS?

The SDE Technology Roadmap identifies nine key technology trends that will drive the transition to Services 4.0. I highlight three of these trends that have broad-ranging potential to change the way we experience services, how fast they can be delivered, and the kinds of jobs and skills we will see in the future.

4 More Natural Technological Interfaces

3 Greater Human-Machine Collaborations

5 Greater Use of Codeless Development Tools

2 More Empathic, Cognitive and Affective AI

6 More Seamless Services enabled by Everything-as-a-Service (XaaS)

1 Pervasive Adoption of AI

7 Cloud Deployment Matures with Hybrid and Multi-Cloud

8 Blockchain Decentralises Trust

9 API Economy Takes Off

Source: IMDA

Pervasive Adoption of Artificial Intelligence (AI)

In the next three to five years, globally, there is an expected exponential increase in commercial AI-based applications in three major categories:

- *Product applications* that embed AI in products and services to provide end-customer benefits (e.g., Google Maps or Apple's Siri)
- *Process applications* that incorporate AI into an organisation's workflow to automate processes or augment worker effectiveness (e.g., Robotic Process Automation), or
- *Insight applications* that harness advanced capabilities to inform operational and strategic decisions across an organisation (e.g., machine learning).

Retail, finance and logistics are three industries that already heavily utilise AI. In retail, AI is used to personalise recommendations, perform store and crowd analytics, and manage pricing. In logistics, AI is used to manage inventory, and optimise distribution routes, task allocation, scheduling and shipping. In finance, AI is applied in areas like identity authentication and verification, banking transactions and payments.

How might AI unlock new value? An economist might think of AI as a tool that *lowers the cost of prediction*. It used to be prohibitively expensive to make personalised recommendations at scale, but AI has made this accessible for many

companies. Current AI tools are both specific and powerful, offering us ways of applying prediction that can facilitate better decisions under uncertainty.

Developments in machine intelligence will mean **more empathic**, **cognitive and affective AI**. AI assistants are being trained to better detect and understand emotions, analyse moods and sentiments to better connect with customers, and be more responsive in customer service.

Humans and AI algorithms working together have been shown to perform better than either humans or AI acting alone.

Human-Machine Collaborations

At the heart of Services 4.0 is an ecosystem allowing machines to augment workers' performance by automating repetitive tasks. This lets workers focus on more "human" tasks such as creativity, critical and analytical thinking, emotional intelligence, innovation and judgment. For instance, a private banker can spend more time with his clients and less time on administrative on-boarding paperwork if the back-end processes can tap on information databases and provide relevant alerts.

In what has come to be known as "collaborative intelligence", humans and AI algorithms working together have been shown to perform better than either humans or AI acting alone. For example, in healthcare, doctors working in tandem with AI achieve higher rates of diagnostic accuracy than either AI or doctors working by themselves. In freestyle chess, a "centaur" team of

Services 4.0 in IRAS

With its service mantra of "No Need for Service is the Best Service", IRAS aspires to go beyond merely converting manual processes to digital services: it wants to reduce processes that require input from taxpayers.

In 2016, IRAS set out to anticipate and then integrate customer needs into taxpayer-centric processes focused on life cycles or business operations. IRAS developed partnerships with the private sector to advance digital tax solutions. Through its API marketplace, it introduced various APIs that let accounting software developers seamlessly integrate tax issues into accounting systems that businesses are already using. This has enabled new services such as letting employers submit salary details to IRAS with just a single click.

IRAS has also invested in future-proofing its workforce by driving adoption of Robot Process Automation (RPA) at the enterprise level and equipping officers to serve the public using digital channels. About 50 of IRAS's non-IT officers have been certified as RPA developers.

humans and machines does better than either human-only or machine-only competitors.

Everything-as-a-Service (XaaS)

Everything-as-a-Service (XaaS) is an approach in which capabilities, products and processes are treated not in individual silos but as a horizontal palette of services available across organisational boundaries. With XaaS, organisations may even extend their internal services to become digital edge businesses serving external customers and partners.

Such developments are made possible by a technology ecosystem built on **Cloud Native architecture**. This features multi-cloud, component services that can be reused in a variety of applications, as well as Application Programming Interfaces (API) that make available component services from best-in-class providers or which offer new services to external parties. What this all means is that organisations can be more agile and flexible, gain access to a wider ecosystem of resources and deliver new products and services more quickly.

How Can the Public Sector Harness Services 4.0?

As the Public Service as a whole transforms to better serve users, Services 4.0 can help public sector agencies think through the next step in how services are provided to citizens, businesses and internal customers. There are three key aspects to consider: **Anticipating Needs, Augmenting Workers** and **Partnerships**.

Anticipating Needs

Beyond merely meeting needs, the challenge is to think about whether we can anticipate specific needs, and organise ourselves to deliver just-in-time services in response or stop problems before they occur. We already have a range of tools such as design thinking to support service journeys and business process re-engineering. These can be further coupled with the power of larger or more combined datasets and AI applications, to solve real world problems or contribute to fundamental improvements in customers' lived experiences.

For policymakers, questions to reflect on might include how we might advance social services to better identify those vulnerable or at risk. We should think about how data and interventions can be brought together across a range of domains, such as social needs, healthcare or employment, to deliver individualised assistance for specific situations.

On the business front, we might be able to customise economic support or assistance for companies at different stages of growth, or based on particular transactions they conduct.

We should also think about how we can **build citizen and customer confidence in AI**. There is growing potential for AI to be deployed in our organisations in future. Internationally, there is increasing discussion about how organisations can be responsible AI users and mitigate different risks in AI deployment. Companies are starting to consider how they can minimise or mitigate inherent bias in their algorithms, or how to enhance the *explainability* of AI (i.e., explaining how deployed AI models' algorithms function or how the decision making process incorporates model predictions). In January 2019, IMDA released a **proposed model AI governance framework** which provides a set of principles and practical guidance for organisations looking to embrace greater use of AI.[1]

The challenge is to think about whether we can anticipate specific needs, and organise ourselves to deliver just-in-time services in response or stop problems before they occur.

Augmenting Workers

Services 4.0 is about creating the workplace of the future, where humans and machines collaborate closely for higher productivity and to create greater value. Technology has the potential to boost the productivity of many jobs. Many organisations are deploying RPA to free up time typically spent on manual, time-consuming tasks such as form filling, checking figures or combining multi-source input. This enables workers to spend more time on more higher-level tasks such as analysis or customer engagement. Furthermore, while AI can provide predictive power far beyond what a single human can do, it does not substitute for human judgment. AI therefore improves rather than replaces human decision-making.

AI improves rather than replaces human decision-making.

What this means is that Singapore needs to invest massively in equipping our workforce with digital skills. All public officers, regardless of their roles, need to be comfortable with using technology. They will increasingly need digital skills, such as using RPA and data analytics. At the same time, relational skills such as creativity, judgement, empathy, negotiation and collaboration will be even more highly valued by organisations.

Robo-colleagues in Singtel

Singtel has introduced RPA assistants that augment business units' capabilities and increase efficiencies. Non-technical staff have been equipped with the skills to develop their own bots, which can help with digital sales, resolve technical issues in the field, and automate claims processing. Singtel's chatbot, Shirley, can support call centre agents by suggesting appropriate responses to customers. In the future, we will see more organisations like Singtel, where human colleagues are able to take on more value-added work by tapping on the service of robo-colleagues who help them with certain tasks or processes.

Partnerships

For both the public and private sectors, partnerships are key enablers for realising Services 4.0. For citizen journeys to be more integrated, we have to connect multiple processes across agencies, or work with platforms that are already being used by customers.

Public sector organisations looking for good technology partners can tap on **IMDA's Accreditation@SG Programme**, which accredits promising and innovative Singapore-based infocomm and media companies, based on technical assessments of their products, financial assessment, people and processes. The programme collaborates with government agencies to come up with potential solutions and match accredited companies to address problem statements.

Good practices to enable smooth and successful collaborations with private sector partners include:

- Staying up to date with changes in the technology landscape as well as use cases in enterprises and other government agencies.
- Sharing problem statements and domain knowledge openly, to enable collaboration and co-development of more transformative and innovative solutions.
- Management giving working teams leeway to try fast, fail fast and learn fast, to continuously iterate and keep innovating.

Conclusion

To realise the ambition of Services 4.0, Singaporeans and the enterprises they work for will have to take on digital skills and embrace digital tools and solutions. Without this, key advances in technology

AI Collaboration with Accreditation@SG Company

For a joint ideation workshop, Ministry of Culture & Youth, Ministry of Communication and Information, Infocomm Media Development Authority, and National Library Board collaborated with Taiger, an AI and business process automation company. The agencies provided domain knowledge and problem statements in procurement, while Taiger provided tech knowledge to propose new ways of addressing the challenges. Taiger then produced a quick prototype concept to solidify the ideas. The partners are now working on a multi-agency procurement virtual assistant pilot to handle a majority of procurement enquiries consistently with the agencies.

such as AI will remain in the preserve of a small number of companies and their workforce, exacerbating wage disparities.

Whether in small or large companies, leadership is key to setting the right mindset for embracing new technology. Every technology strategy needs a people strategy. Leaders need to be clear that digital transformation is part of every business line's responsibility, and is not just for the IT department or an innovation lab to take up. Leaders also need to help middle management understand technology so that they can change how products and services are designed and delivered. The organisation must also give workers the necessary support to pick up new skills and encourage them to invest in the digitalisation journey.

Services 4.0 is about reimagining the future and having the courage to disrupt ourselves before we get disrupted. As a nation, Singapore must reimagine our value proposition to the region and the world in a digital age, even as we strengthen the position we have already built up through physical connectivity. Our enterprises and public agencies must figure out what new value they can bring to their customers, what their competitive strengths are, and where they should bring in partners. As individuals, each of us can keep abreast of technology trends, and help each other do the same. Together, we can leverage technology to create better solutions and enable more meaningful and enriching lives. ■

Services 4.0 is about reimagining the future and having the courage to disrupt ourselves before we get disrupted.

READYING SINGAPORE

to be a Digital Society

by **Rachel Chen**

The Digital Readiness Programme Office is pursuing comprehensive, relevant and inclusive measures to help Singaporeans make the most of a brighter digital future.

Rachel Chen is Director for Digital Readiness & Learning in Singapore's Ministry of Communications and Information.

How Do We Gird Ourselves To Live In The Future; To Embrace Its Promise While Avoiding Its Pitfalls?

IN a terrifyingly prescient 2016 episode of the TV series *Black Mirror*, Lacie, a young woman obsessed with status, navigates a world in which social ratings determine access to services, rewards and opportunity. Every interaction she has—with the cashier at the supermarket checkout, a stranger in the lift, her best friend—is assessed by a rating: anything below a 4.5 out of 5 is unthinkable. In the episode, Lacie spirals into obscurity in a vicious cycle of successively lower ratings, until she eventually ends up where all 0.0 raters in her world end up: a prison cell.

Lacie's story is presented as a cautionary tale: despite her best efforts, she gradually loses control over her identity, life and destiny. Her world is uncomfortably close to our world. China, for example, has laid the groundwork for a social credit rating system on an unprecedented scale. One cannot help but wonder about the implications for some 1.4 billion Chinese.

The sophistication of technology today is cause for both celebration and concern. Each new technological disruption has the potential to reshape how humans think, act, interact and live, even as it addresses profound human problems. At the same time, new challenges and unintended consequences arise, such as those captured so powerfully in *Black Mirror*. How do we gird ourselves to live in such a future; to embrace its promise while avoiding its pitfalls?

WHAT IS A DIGITAL SOCIETY?

There are many ways to describe this future: it is full of potential and possibility, but also unknowns and wicked problems. It is also fundamentally and inexorably digital. Digitalisation has brought us to a tipping point: where once we marvelled at how we could store information on magnetic tape or transmit it around the world, we are now witnessing how entire worlds can exist in the virtual realm, built on logic and value systems that have surpassed their roots in the physical world. There are no maps or guidebooks to this vast new territory: only possibilities surmised by the visionaries among us, and unfamiliar dangers lurking around each bend.

Some nations have already ventured into these uncharted lands. Estonia offers what is known as e-Residency—where people around the world who have never stepped into the country can be acknowledged as Estonian residents, Singaporeans included. Private enterprise in China, hungry for progress, has succeeded in building an economy where the smallest hole-in-the-wall stall takes for granted that you will not pay in hard cash. On a recent trip to China, I was offered only two options for my bill everywhere—AliPay, and WeChat Pay—and given incredulous looks when I asked to use the humbler cash alternative. On a different end of the spectrum, India has for the last decade been building up Aadhaar, a pervasive digital identity system serving 1.3 billion residents via mobile biometric means. This might very soon usher in not only a mobile-first or mobile-only but a post-mobile era for online payment services.

Singapore too is making inroads. We have continually built infrastructure for connectivity, from 3G to 4G and now 5G. We are piloting and testing frontier technologies, including autonomous vehicles. We set up a council looking specifically into the ethics of AI use. Most recently, we introduced legislation to be used against the most egregious of online falsehoods that are propagated with malicious intent. We have even set up an institute in Nanyang Technological University dedicated to studying the impact of technology on society in a multi-disciplinary, multi-stakeholder manner.

A wide range of steps have been taken, yet there is still more to be done in understanding digital society. What will it mean for every last Singaporean to be part of this new world? How can we ensure that the necessary skills and mind sets required become an ingrained part of who we are?

WHY DO WE NEED TO BE PREPARED FOR A DIGITAL SOCIETY?

Singapore's Smart Nation drive is not just inspirational and aspirational—it is existential. When Prime Minister Lee Hsien Loong announced in 2014 his vision for Singapore to be a "nation where people live meaningful and fulfilled

> Singapore's Smart Nation drive is not just inspirational and aspirational—it is existential.

lives, enabled seamlessly by technology, offering exciting opportunities for all", he also spoke about needing the right organisations, the right skills, and most of all, the right mindsets for this.[1]

Today, Singapore is implementing this vision by transforming our economy to create jobs and opportunities in this new digital paradigm, and by building digital government infrastructure and capabilities that fundamentally transform the public sector. In parallel, the government is also raising the digital readiness quotient of Singaporeans, so that all can participate in and transact within this digital society without coming to harm. Singapore must do all three things—digital government, economy and society—if we are to deem ourselves to have succeeded.

The values that have guided us in the building of our nation will not change: hard work and resilience, meritocracy, good governance, multiculturalism. The values that have guided the work of the public service likewise will and must not change: integrity, service, excellence. This is because people fundamentally have not changed. We have the same needs, wants, desires, dreams—we are simply living them out in a new digital era.

Digital technology has always only ever been a tool for human hands and minds, because we are *Homo sapiens* with ethical values whose decision-making processes cannot readily be replicated.

Many stories have been told of how computers have failed once and again, sometimes spectacularly, without the intervention of a human being: YouTube bots mistakenly conflated the burning of Notre Dame with 9/11; Target's algorithms identified a teenager as being pregnant, after analysing her shopping patterns, and sent mailers to her house; Google's image recognition tagged pictures of African-Americans as gorillas. As we grapple with visions of Ultron or Skynet rising up against humanity, we would do well to remember that in a digital society, we are still the only ones in charge of making sure that we use technology for good, and that people are not reduced to mere ratings and patterns.

DIGITAL READINESS FOR A DIGITAL SOCIETY

It is, of course, one thing to understand and welcome digital society, and quite another to be digitally prepared to make the most of it. How do we ready ourselves to live and thrive in a digital age?

At Singapore's Ministry of Communications and Information (MCI), we see Digital Readiness as having access to digital technology, having the literacy and know-how to use this technology, and being able to participate in and create with technology. At the basic level, digital readiness involves **providing access to digital connectivity and devices** in a widespread, affordable manner. Hand-in-hand with basic access

We are still the only ones in charge of making sure that we use technology for good, and that people are not reduced to mere ratings and patterns.
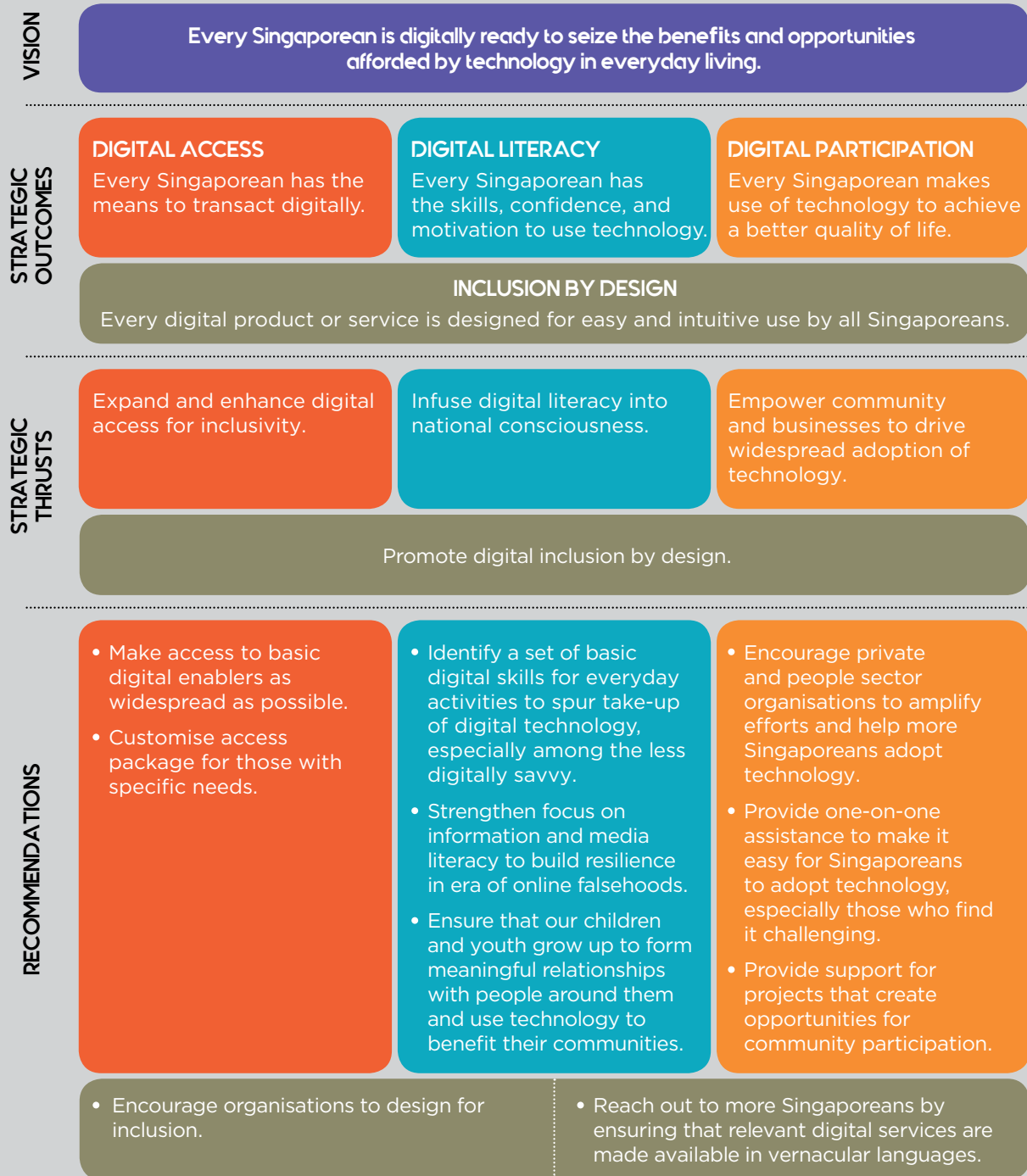
DIGITAL READINESS BLUEPRINT

VISION

Every Singaporean is digitally ready to seize the benefits and opportunities afforded by technology in everyday living.

STRATEGIC OUTCOMES

DIGITAL ACCESS
Every Singaporean has the means to transact digitally.

DIGITAL LITERACY
Every Singaporean has the skills, confidence, and motivation to use technology.

DIGITAL PARTICIPATION
Every Singaporean makes use of technology to achieve a better quality of life.

INCLUSION BY DESIGN
Every digital product or service is designed for easy and intuitive use by all Singaporeans.

STRATEGIC THRUSTS

Expand and enhance digital access for inclusivity.

Infuse digital literacy into national consciousness.

Empower community and businesses to drive widespread adoption of technology.

Promote digital inclusion by design.

RECOMMENDATIONS

- Make access to basic digital enablers as widespread as possible.
- Customise access package for those with specific needs.

- Identify a set of basic digital skills for everyday activities to spur take-up of digital technology, especially among the less digitally savvy.
- Strengthen focus on information and media literacy to build resilience in era of online falsehoods.
- Ensure that our children and youth grow up to form meaningful relationships with people around them and use technology to benefit their communities.

- Encourage private and people sector organisations to amplify efforts and help more Singaporeans adopt technology.
- Provide one-on-one assistance to make it easy for Singaporeans to adopt technology, especially those who find it challenging.
- Provide support for projects that create opportunities for community participation.

- Encourage organisations to design for inclusion.

- Reach out to more Singaporeans by ensuring that relevant digital services are made available in vernacular languages.

Source: Ministry of Communications and Information

is basic literacy—having the skills and understanding to use digital technology safely and confidently—whether in tasks like operating a mobile device, or having good cyber hygiene habits.

To be digitally ready includes being able to guard against online ills. A stark difference between yesterday and today is the complexity and speed of information use. We need to be self-aware and discerning about what we do online. The 3 Rs of literacy in the analogue world (reading, writing and arithmetic) have been joined by three more: **Information, Media, and Cyber Literacy**. Much has been said about fake news having been around since the Garden of Eden; in a digital society, being aware of the trade-offs between convenience and privacy, experience and security will help us avoid the temptation of the online serpents of misinformation and hackers. We need to engage with technology safely, smartly, and kindly, as the Media Literacy Council's Better Internet Campaign exhorts us to, rejecting toxic behaviours like cyber bullying, online vigilantism and doxxing.

Closely linked is the idea of **Digital Participation**. In a digital society, we need to not just be good consumers and receivers, but also good creators, producers, communicators, translators. All individuals and organisations must participate in this. We should strive to enable others to engage with technology, especially the most digitally vulnerable.

We need to not just be good consumers and receivers, but also good creators, producers, communicators, translators.

Everyone needs to be ready to use these tools, so that they have a chance to claim a share of these new digital opportunities for themselves.

WHO AND HOW TO BUILD DIGITAL READINESS

How do we do this? We know that building digital readiness does not happen exclusively in the digital domain—in fact, it happens in the physical one, and we will succeed only if we bridge the physical and the digital.

This begins by being inclusive. Digital readiness requires the involvement of everyone, not just the ones who "do tech". MCI began by setting up the **Digital Readiness Programme Office** in 2017, an experimental start-up with four people. Charged with strengthening the digital readiness of all Singaporeans, we started out by bringing together many disparate parties. We generated momentum, raised awareness, and convinced people that this was an important endeavour.

As a result, the **Digital Readiness Blueprint** was produced, with recommendations advocating last-mile digital inclusion, while still caring for public needs. Last year, the 3P Digital Readiness Council was set up to provide strategic direction and to build networks for the next phase of Digital Readiness. One of its first initiatives was the **Digital Participation Pledge**, launched this year to encourage organisations to pledge commitment and support. All government ministries have since taken the pledge. We have also set up the **Our Singapore Fund for Digital Readiness**, which supports ground-up efforts from community and student groups, developed a **National Framework for Digital Media and Information Literacy** to guide

programme owners in their delivery of digital literacy programmes and courses, and rolled out a **Tech Connect** service to be progressively made available at all community centres across the island, where Singaporeans can get one-on-one 'concierge' assistance with their digital needs. All this was made possible only through collaboration with other agencies like the People's Association, the Ministry of Culture, Community & Youth and the Ministry of Education, and we hope that through such initiatives we can sustain efforts to help all Singaporeans live and thrive in a digital society.

In the course of thinking about the work of digital readiness, MCI has been guided by four main principles:

Different strokes, different folks

Everyone approaches digital readiness from a different starting point. We are therefore focused on levelling up people to a better understanding of what tech is and can do, from whatever current plane they are on, to whatever is a reasonable improvement for each individual.

Know the baseline, know what success looks like

We have to know where we are today, and where we are headed. Earlier this year, we completed a baseline survey for Digital Readiness, the first of its kind in Singapore. Engaging with 3,000 respondents representing Singaporean society today, we set out to understand Singaporeans' levels of access to technology, digital literacy and digital skills, and their attitudes towards technology.

Find the hook

The UK's Behavioural Insights team has suggested that if we want to encourage a behaviour, we have to make it Easy, Attractive, Social and Timely (EAST). This is where the digital readiness conversation turns to *hooks* and *killer apps*. We need to know the compelling reasons that make people want to transact digitally, so there is an incentive to learn the skills needed. For example, Netscape redefined surfing in the early days of the internet; iTunes in 2001 made it difficult for consumers to say no to Apple; Facebook has revolutionised how people network, interact and even live their lives today. What is the equivalent in health and wellness, communications and perhaps wayfinding applications that could encourage even the fearful to try their hand at technology? The Smart Nation Digital Government Group has, for example, developed the *Moments of Life* app, designed to be helpful in ways that people may not even think about, at specific moments of their lives—when getting married, when becoming a parent for the first time, when reaching a senior age. This is a start, but there remain many more possibilities for us to think about.

Empathy, empathy, empathy

It all starts with knowing who we are trying to help, which means spending

There are very different needs and different levels of preparedness that we need to address.

The Digital Readiness framework of **Access, Literacy and Participation** builds on the idea of inclusion and focuses strongly on the individual. The 10 recommendations are categorised into four **STRATEGIC THRUSTS**.

1 Expand and enhance digital access for inclusivity

The first step to being digitally ready is having access to the digital world. Today, this is no longer only about having the right devices and internet connectivity: to transact digitally today, a number of other digital elements, or enablers are also needed.

These recommendations focus making sure all segments of Singaporeans have access to basic digital enablers. They also strengthen support for those with particular needs, such as seniors and low-income households.

2 Infuse digital literacy into national consciousness
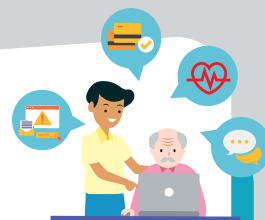
In a digital society, citizens not only have access to technology, but embrace it, and use it confidently and effectively to connect with the world around them. Digital literacy means appreciating digital technology's possibilities, but also thinking critically about any information received.

These recommendations highlight the basic skills and values needed to participate meaningfully in a digital society. They spell out basic digital skills for day-to-day activities, and emphasise information and media literacy. They focus on helping young people form meaningful social relationships, so that they grow up using technology to benefit their communities.

RECOMMENDATION	SEGMENTS REACHED
Make access to **basic digital enablers** as widespread as possible	• Low-income households • Seniors
Customise access package for those with specific needs	• Seniors • People with disabilities • Low-income households / students

RECOMMENDATION	SEGMENTS REACHED
Identify a set of **Basic Digital Skills** for everyday activities	• Seniors • General population
Strengthen focus on **info and media literacy** to build resilience to deliberate online falsehoods	• All population segments
Ensure our youth have the essential **values to thrive in the digital age**	• Students • Youths • Parents

All organisations can help Singaporeans acquire skills and adopt digital technology. This is why we established a **Digital Participation Pledge** for organisations to voluntarily commit to supporting digital participation and digital inclusion in Singapore by doing the following:

A **Ensuring that employees have an opportunity to adapt to technological changes by equipping employees with foundational digital literacy skills for work** (e.g., nominating workers to the SkillsFuture for Digital Workplace programme)
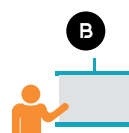
B **Educating customers on digital services** (e.g., setting up experiential learning journeys for less digital-savvy customers)

3 Empower community and businesses to drive widespread adoption of technology

To thrive in a technology-rich society, we must not only consume technology but also be prepared to use it to create products, content and services, and connect with communities.

These recommendations focus on fostering opportunities for community participation. They outline how businesses can ensure digital inclusion. They also offer one-on-one support for the digitally vulnerable or challenged.

4 Promote digital inclusion by design

When it comes to digital initiatives—be it an app, a website or communications—appropriate design, content, language and relevance can go a long way in getting everyone involved in digital society.

These recommendations help individuals and organisations design and develop digital initiatives with users in mind, so that overall user experiences will be positive and useful. This will in turn promote the adoption of technology.

RECOMMENDATION	SEGMENTS REACHED
Encourage private and people sectors to help more Singaporeans adopt technology	• Businesses • VWOs • Government agencies • Individuals
Support projects that create opportunities for digital community participation	• Individuals • Community Groups • VWOs
Provide one-on-one **services** to answer digital queries	• Seniors • General population

RECOMMENDATION	SEGMENTS REACHED
Encourage and educate organisations with **guidelines to design for digital inclusion**	• Seniors • Businesses • Designers • General population
Provide more services in **vernacular languages** to reach out to more Singaporeans	• Seniors • General population, especially non-English speakers

C **Designing digital services and products in a way that is simple and intuitive for users** (e.g., setting up regular feedback channels and identifying areas of improvement on user design and experience)

D **Giving support for Digital Readiness activities and initiatives** (e.g., participating in a nationwide project on digital literacy for seniors)

Organisations who pledge their commitment will be part of a Digital Participation network, and those who are already quite digitally ready can collaborate with and help their less-digitally ready peers. **There will be benefits, incentives, and public recognition for organisations who pledge their commitment.**

We cannot know how each new disruptive idea will change the playing field, and at what speed.

real time on the ground, talking to the community, to Social Service Agencies, to industry, understanding pain points, aspirations and ideas. In the process of ensuring that all groups are able to thrive in a digital society, we then learn a lot about the characteristics of these groups, including their needs and hopes for the future.

WHAT ARE THE CHALLENGES?

This is not easy. Like every journey of discovery, the road to being a Smart Nation and digital society is paved with good intentions and replete with exciting innovations, but there are very different needs and different levels of preparedness that we need to address.

There are many **unknowns** that emerge as we push forward with digital society. In the present, we are focused on implementation, grounded in current paradigms. But we cannot know how each new disruptive idea will change the playing field, and at what speed. We need to be prepared to constantly learn and unlearn, plan and adapt, celebrate and regroup.

As we advance, we also find that the **scope** of digital readiness expands. Basic access, skills and knowledge for the digitally vulnerable precede the advent of deep fakes, fake news and anti-social and anti-civil behaviour in the online space. All of these behaviours are bound up with what it means to be

a good citizen—and that's why there is never a dull moment in this job.

The multi-stakeholder, multifaceted nature of digital readiness requires shifts in organisational **mindsets**. As digital society throws up new problems to solve, we in the public sector must find new ways of doing things, and perhaps even let go of old paradigms, such as traditional policy/ops divides or organising around vertical domains. The need to work across government will become more vital than ever. This is also why the user journey mindset is so important, and why good user research is central to making good digital products. Understanding that needs and services do not occur in unrelated silos, governments around the world, including Singapore, are beginning to implement the "Tell Us Once" approach to providing citizen services.

The biggest challenge, however, are the implications of technology on **social transformation**: on inequality, social mixing and mental models. Much has been said about the digital divide further widening existing divides of class and income. [2,3] We need to be circumspect about this, and not inadvertently exacerbate extant issues. As public servants we should strive for deep, human understanding, by spending time talking to people and listening to their stories. Such an ethnographic approach has long been advocated by anthropologists and others, and have been applied both internationally[4] and in Singapore.[5,6] Our traditional analytic approaches should continue, but in tandem with these human stories: without them we cannot hope to say that we know how to bring Singapore into the digital future, or for whom.

WHITHER THE "DIGITAL SINGAPOREAN"?

Digitalisation will transform our lives. Our destiny as a nation, however, is up to us. How will we continue to remain essentially Singaporean, even as we blossom and transform into a digital nation, people and society? What must we retain, and how will we know that we have survived?

I think that the first step is for Singapore to come alongside on this journey together: by committing to be part of the Digital Readiness movement, whether as an organisation or as an individual, by being aware of digital developments and their impact on us as a country, and by helping one another tackle the challenges of daily digital life. The story of how Singapore thrives with technology is already being told internationally, but much of that story is still unwritten. Much depends on the willingness and readiness of every Singaporean to contribute to it.
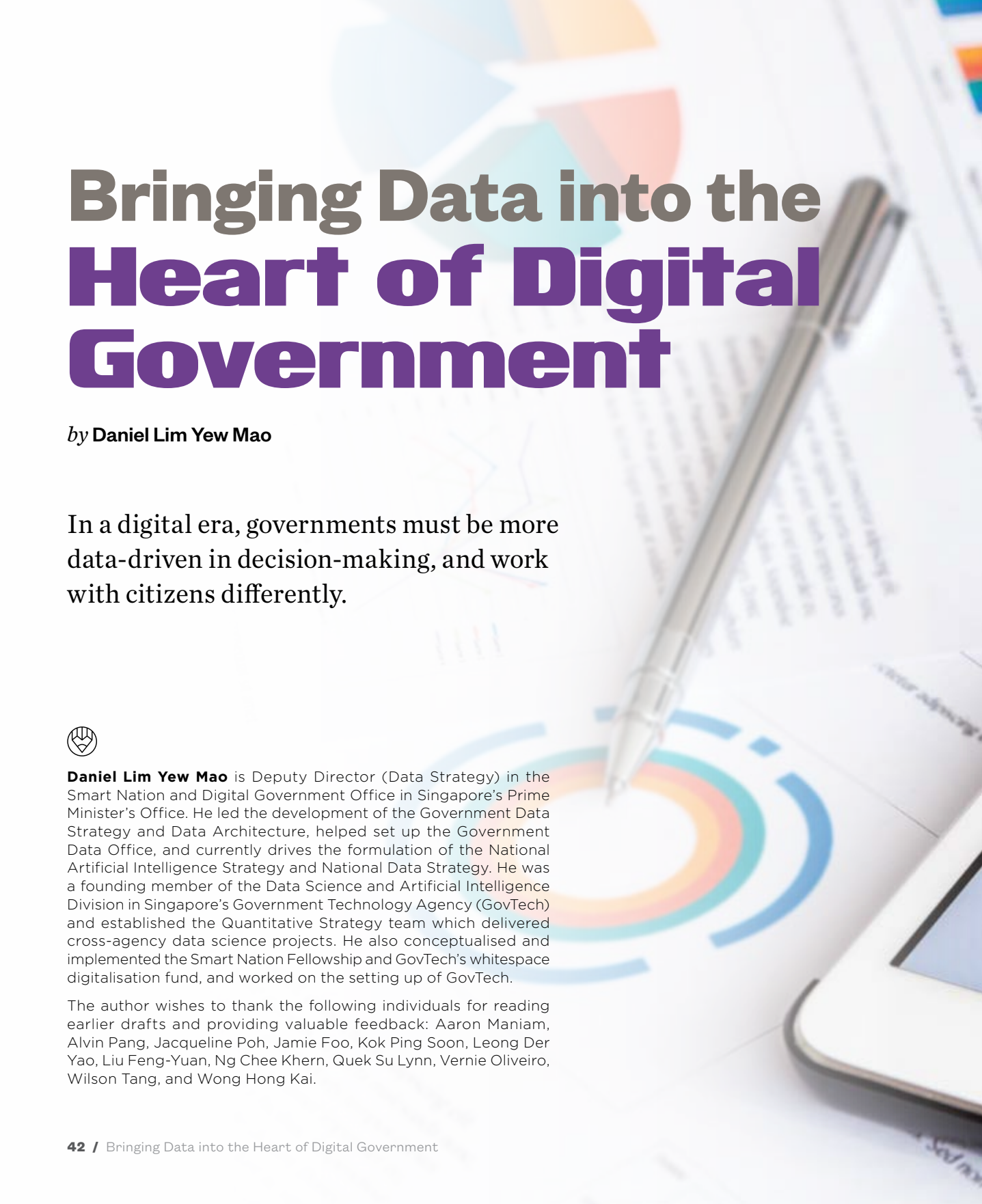
Throughout history, there has always been a desire for mankind to peer through the veils of time and predict the future. The oracles of ancient Greece, the prescient imaginations of polymaths like Leonardo da Vinci, writers such as Isaac Asimov, and modern-day savants such as Steve Jobs and Elon Musk, all speak of a deep human desire to know and leap into the future.

We now know that this future is digital. While once many viewed this future primarily with anxiety—Orwell writing about *1984*, or the dystopias of *Black Mirror*—we should also look at the myriad possibilities of our digital future and society with hope and excitement. We are not doomed to fall into the same spiral as Lacie on our Netflix screens—as long as we understand what the future holds, come together in our communities and work alongside one another, so that all Singaporeans can have the access, skills and perspectives needed to thrive in a digital society. ■

Notes

1. "Transcript of Speech by Prime Minister Lee Hsien Loong at Smart Nation launch, 24 November 2014", *Speech, Smart Nation Singapore,* accessed April 15, 2019, https://www.smartnation.sg/whats-new/speeches/smart-nation-launch.

2. "Regardless of Class", *Channel News Asia*, video, posted September 24, 2018, accessed June 7, 2019, https://www.channelnewsasia.com/news/video-on-demand/regardless-of-class/regardless-of-class-10751776.

3. Chua Mui Hoong, *Singapore, Disrupted* (Singapore: ST Press, 2018).

4. Clifford Geertz, *The Interpretation of Cultures*, 2nd ed. (New York, NY: Basic Books, 2000).

5. Teo You Yenn, *This Is What Inequality Looks Like* (Singapore: Ethos Books, 2018).

6. David Chan, ed., *How Working Together Matters: Adversity, Aspiration, Action* (Singapore: World Scientific Publishing, 2018).

Bringing Data into the Heart of Digital Government

by **Daniel Lim Yew Mao**

In a digital era, governments must be more data-driven in decision-making, and work with citizens differently.

Daniel Lim Yew Mao is Deputy Director (Data Strategy) in the Smart Nation and Digital Government Office in Singapore's Prime Minister's Office. He led the development of the Government Data Strategy and Data Architecture, helped set up the Government Data Office, and currently drives the formulation of the National Artificial Intelligence Strategy and National Data Strategy. He was a founding member of the Data Science and Artificial Intelligence Division in Singapore's Government Technology Agency (GovTech) and established the Quantitative Strategy team which delivered cross-agency data science projects. He also conceptualised and implemented the Smart Nation Fellowship and GovTech's whitespace digitalisation fund, and worked on the setting up of GovTech.

INTRODUCTION: WHY DIGITAL GOVERNMENT?

Singapore has a unique opportunity to harness digital disruption—often characterised as the fourth industrial revolution—and propel ourselves onto a new growth trajectory to sustain our future national competitiveness and liveability. We must build strategic capabilities in data and digitalisation, which are the foundational infrastructure upon which Artificial Intelligence (AI) and other digital technologies are being developed and deployed.[1] This is the broader strategic imperative for Smart Nation and why we are accelerating our collective effort to transform Singapore's government, economy, and society.

Singapore's Smart Nation aspirations hinge on Digital Government: the Singapore Government has traditionally set the agenda and pace for technology innovation and adoption across the nation. It has built the horizontal enablers that now sustain a vibrant technology ecosystem. In order to become a government that is "digital to the core", the Singapore public sector must be able to harness data as a strategic asset.

DATA IS THE HEART OF DIGITAL GOVERNMENT

Digital Government must go beyond digitising processes and offering government services online. These are essential digital plumbing to raise productivity and bring convenience to citizens. But much more needs to be done to fully harness the game changing potential of digital technologies—to bring data into the heart of government.

Digital Government is about fundamentally rethinking how government will work and

DIGITAL GOVERNMENT MEANS PURPOSEFULLY ORGANISING THE BUSINESS MODEL OF GOVERNMENT AROUND DATA.

engage with citizens in a digital era, and re-engineering it to be more data-driven in all aspects: be it policy and planning, operations, service delivery, or citizen engagement. It means recognising that data is a strategic asset that underpins digital transformation, and purposefully organising the business model of government around data. Policies will be iteratively tweaked and calibrated based on data instead of trial and error; operational responses will be proactive and coordinated instead of reactive and fragmented; services will be more anticipatory and personalised instead of one-sized fits all.

Realising this vision of Digital Government requires bringing data and digitalisation together.[2] Digitalisation is about using digital technologies to transform the way we work, and it gives us the infrastructure to strategically acquire and manage our data assets: the raw fuel that powers and sustains digital transformation. Data science and AI are tools that we can then apply to our data assets to further enrich their value and to improve digital infrastructure and services, which in turn generate more data that can be harnessed for digital transformation, thus creating a virtuous cycle.

If we can achieve this tight integration of data with digitalisation and mature as data-driven organisations (see figure on p. 45), the future digital government

Systems-Level Governance

Data and AI governance built into systems and products by design

Industrialising Data Science & AI

Products and micro-services to scale deployment of data and AI models

Experimenting with Data Science & AI

Small scale, one-off projects to demonstrate value of data science & AI. High-friction, manual deployments, solutions are not easily scalable

Business Intelligence

Visual dashboards to democratise access to data and deliver first-level insights

Raw Data

Digital systems and infrastructure to systematically acquire, process, and manage data assets

Data Maturity

Maturing as a Data-Driven Organisation

Source: Smart Nation & Digital Government Office

will be more user-centric and effective at delivering key outcomes.

- For **citizens and businesses**, this means engaging with a government that delivers end-to-end digital services on par with the leading digital companies, and communicates with a personal touch. They can expect more seamless and convenient options to transact with agencies, less red tape when resolving issues, and faster, more personalised and anticipatory services that address their pain points.

- For **public officers**, it means the opportunity to build a digital relationship with citizens that is anchored in a deeper understanding of their needs and aspirations. They will have ready access to data and information to better measure the effectiveness of policies and interventions. They will spend more time analysing and designing solutions to key challenges, instead of filling out paperwork. They will be able to coordinate with colleagues across different agencies and respond as One Government to solve complex problems, more effectively and at a lower cost than was previously possible.

For example, the Municipal Services Office (MSO) is leveraging data and digitalisation to transform the municipal feedback reporting process. Residents who encounter a municipal issue can snap a picture and submit their feedback on MSO's OneService App. AI is applied to the data collected from the app (text, images, and geolocation) and the

feedback is automatically routed to the relevant operational agencies. The data is also analysed to generate insights on municipal issue trends and hotspots, enabling agencies to proactively identify and resolve emerging issues. As a result, citizens experience a more seamless feedback and engagement process with One Government. Agencies have a better understanding of ground issues, spend less time re-routing cases among themselves, and are more efficient at resolving municipal concerns.

Further digitalisation will generate more data that can be harnessed to bring about greater improvements. Data collected from sensors and Internet-of-Things devices could be triangulated with municipal feedback to develop predictive maintenance models for infrastructure such as lifts. This will enable agencies to go upstream to address the root causes of municipal feedback, and for government and residents to co-create more liveable neighbourhoods for all.

This focus on data is what defines the Government's current transformation drive, which will put in place the policies, processes, systems and people that will enable the public sector to systematically acquire, manage, and exploit data at an industrial scale.

BIRTH OF THE GOVERNMENT DATA STRATEGY (2014 TO 2018)

Our journey towards the Government Data Strategy (GDS) began in 2014 (see side story) and is premised on three principles:

First, we plan and execute the GDS in an agile and iterative manner. Today,

BIRTH OF THE GOVERNMENT DATA STRATEGY

2014 to 2017: Rebuilding Engineering Capabilities and Demonstrating Value

In mid-2014, the Government Analytics Team was established as an experimental unit in the Infocomm Development Authority. This small multidisciplinary team of seven policy analysts, data scientists and software engineers was tasked to explore how data could be more effectively analysed for the public good. At that stage, many agencies were still unsure of the conditions under which the data they collected could be shared, and what value they could unlock from their own or fused datasets.

After some early successes in demonstrating the game changing potential of data science in the public sector, the unit evolved into the Data Science & Artificial Intelligence Division (DSAID) in GovTech and the team rapidly expanded to support the growing demand for data science and data engineering capabilities in public agencies. DSAID directly ran data projects across many agencies and conducted training in data analytics for public servants.

DATA SCIENCE PROJECTS: EARLY SUCCESSES

Policy: Understanding Citizen Archetypes

Since 2015, DSAID data scientists have applied clustering algorithms to cross-agency datasets to better understand citizen archetypes. These data-derived archetypes were validated through field interviews with actual citizens and have helped inform several government policy reviews.

Operations: Catching the Circle Line Rogue Train

In mid-late 2016, Singapore's MRT Circle Line was hit by a spate of mysterious disruptions. A team of three DSAID data scientists stepped up to support investigations. Analysing data from train operator SMRT, they pinpointed a rogue train, PV46, as the source of the breakdowns, in just three hours.

Operations: AI to Detect SSG SkillsFuture Fraud

In the aftermath of the S$40 million SkillsFuture (SSG) fraud case in October 2016, DSAID data scientists collaborated with SSG to develop an AI algorithm to automatically flag potentially anomalous SSG claims for review before the funds are disbursed.

Service Delivery: AI to Right-Site Hospital Frequent Admitters

In 2015, DSAID partnered with SingHealth to developed an AI algorithm to predict the likelihood that patients who had already been admitted twice in a given year would be admitted a third time. The pilot project demonstrated how AI could be used to augment hospital operations and improve patient outcomes.

2017 to 2018: Creating the Organisational Structures to Scale Data Transformation

In May 2017, the Smart Nation Digital Government Group (SNDGG) was established to drive digital transformation at the national level. The newly formed Data Strategy and Exploitation (DSE) team that evolved into the Government Data Office was tasked with developing policies to support data sharing and usage across the Public Service.

The DSE team worked closely with DSAID to understand the pain points of data science practitioners and seek their technical input on policies. The teams met regularly: the policy officers were attached to data science projects to learn how they are run. The data scientists and engineers attended policy discussions to hone their policy intuition and to shape thinking. Concurrent secondments helped formalise close engagement between the teams and to bridge the translational gap between policy officers and data scientists.

This deep policy/ops-tech integration between the policy and engineering teams was what gave birth to the Government Data Strategy and Government Data Architecture, and the target to share data in 7 days. DSAID's ground experience surfaced policy, process, and organisational issues that informed DSE's policies, which in turn helped amplify the impact of DSAID's work beyond individual projects.

it is no longer possible to develop one-off masterplans that guide multi-year transformation efforts. Instead government must, as both a user and regulator of digital technologies, adopt a more experimental, iterative approach. We will learn and develop expertise by implementing data projects, and must be deliberate about distilling lessons and insights to inform subsequent iterations of the GDS and our data policies.

DATA IS THE FUEL FOR DIGITAL TRANSFORMATION.

Second, we drive the public sector's data transformation through a dual emphasis on implementing use cases in the short term and building institutional enablers in the long term. Use cases are data projects anchored on real problems—they enable agencies to gain hands-on experience with data. Delivering on quick wins can also help demonstrate the value of data and generate momentum for deeper transformation. In the long run, institutional enablers crystallise learnings from use cases and are what ensure sustained success.[3]

Third, we adopt a hub and spoke model to scale public sector data transformation efforts. We started by growing a central team at GovTech—the Data Science & Artificial Intelligence Division (DSAID)—to pool scarce engineering talent resources and quickly execute on use cases to demonstrate value to stakeholders. However, a central team would eventually be limited by its lack of domain understanding, and agencies must eventually own their own data transformation efforts. The central team is supporting agencies through forward-deployed teams; the Smart Nation and Digital Government Office (SNDGO)

and GovTech are building centralised digital systems and infrastructure to offer scaled data capabilities.

DEVELOPING AND REALISING THE GOVERNMENT DATA STRATEGY (2018 TO 2019)

Challenges for Scaling Data Use in Government

Data is the fuel for digital transformation. A good Government Data Architecture (GDA) should provide public officers with access to quality data, quickly and securely—just as good water infrastructure should make clean drinking water available on demand from a tap.

Singapore's current GDA is based on the operating concept of "data sharing by default": individual agencies are asked to share data with one another when a legitimate request is made.

In practice, however, it takes many months for cross-agency datasets to be fused and shared, despite the best intentions.[4] Data sharing occurs through ad-hoc bilateral or multilateral arrangements, which have to be negotiated. Agencies collect data to serve their own needs, not cross-government uses. Many lack modern data systems for extracting and sharing data securely through Application Programming Interfaces (APIs). Nor is there a metadata catalogue or common data dictionary and format for government datasets. All this means that data users have to separately negotiate with source agencies to turn on the data tap. They then wait for several months for source agencies to manually extract the raw data, which needs to be cleaned and formatted to

be fit for use. Our inability to share data quickly prevents data exploitation from scaling across the government.

A New Government Data Strategy

In June 2018, the Government Data Strategy (GDS) was introduced to address issues with the current GDA. It is centred on the Public Sector reorganising itself around a new Integrated Data Management Framework (IDMF). The IDMF establishes a new operating concept for managing and using data across a 5-stage lifecycle: (1) Problem Statement, (2) Acquisition, (3) Fusion, (4) Access and Distribution and (5) Exploitation. It also identifies the horizontal enablers needed to manage data across its lifecycle. A Government Data Office (GDO) has been established to implement the GDS by 2023.

1 Problem Statement
2 Acquisition
3 Fusion
4 Access and Distribution
5 Exploitation

DATA LIFECYCLE

People & Capabilities
Technical Standards, Digital Systems & Infrastructure
Processes & Organisational Structures
Legalisation, Policies & Strategies

Integrated Data Management Framework

Source: Smart Nation & Digital Government Office
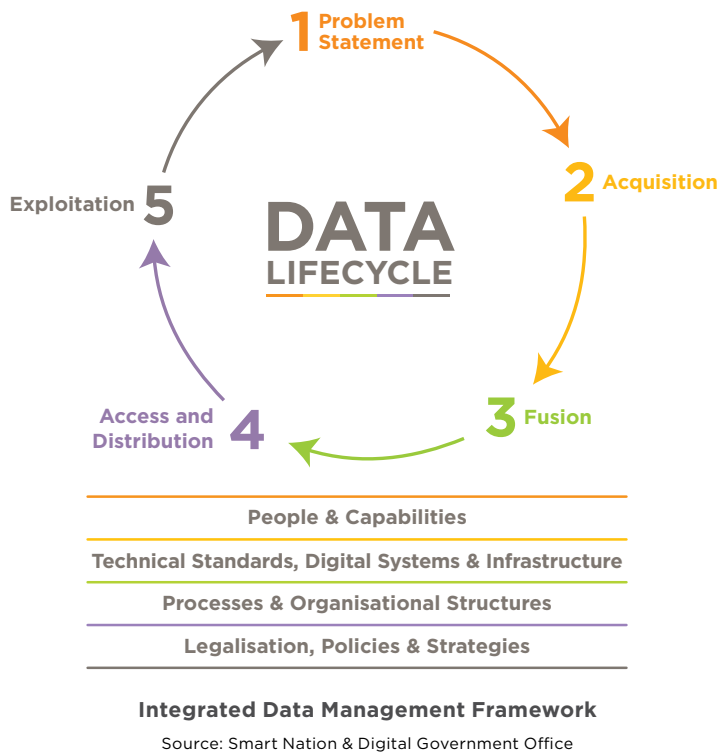
The GDS will be realised through four key thrusts:
Data Architecture, Digital Infrastructure, Data Education, and Use Cases.

1. Data Architecture

We will build a new GDA to enable quick and secure access to quality data. Core government data assets will be consolidated, and made discoverable and accessible within 7 working days. All core data fields must also be machine readable and API-ready.

The new GDA introduces two new organisational constructs: Single Sources of Truth (SSOTs) and Trusted Centres (TCs).
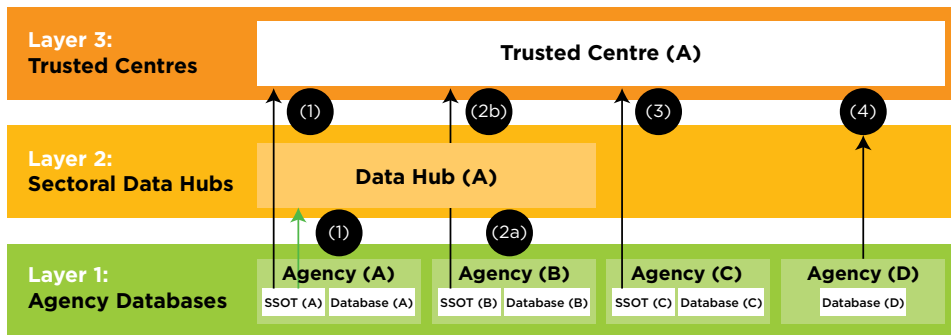
Overview of the new Government Data Architecture

Source: Smart Nation & Digital Government Office

SSOTs are authoritative sources for *core government data fields*. They are tasked with maintaining, cleaning, and distributing these data fields to requesting agencies within seven working days. For instance, there was previously no SSOT for family relationship data, which is a core government data field that many agencies require for policy analysis or service delivery. Agencies had to file separate requests to extract data from the marriage, divorce and birth registries, and manually construct the family relationship data field, a process that could take several months. Agencies used their own definitions which meant that data findings from different agencies' projects were often not comparable. The Ministry of Social and Family Development has since been designated as the SSOT for family relationship data and is mandated to maintain and distribute it to the rest of the government.

TCs aggregate data across the SSOTs and provide a one-stop-shop for users to access core government datasets. Users who need cross-sectoral datasets will not need to go individually to each SSOT to ask for data. Three TCs, sited in the Department of Statistics (individuals and businesses), Singapore Land Authority (geospatial) and Smart Nation and Digital Government Group (sensors), will be operational from end 2019.

2. Digital Infrastructure

We will develop the infrastructure to digitally industrialise the management, governance, and use of data, to support and scale data transformation initiatives. The aim is to achieve a quantum leap in the speed at which data can be harnessed for insights and data models deployed into products and integrated into business processes.

Some examples of this infrastructure include: (a) Vault.Gov.SG, a platform that lets all officers browse a meta data-catalogue, securely download sample datasets immediately for

CORE GOVERNMENT DATA ASSETS WILL BE DISCOVERABLE AND ACCESSIBLE WITHIN 7 DAYS.

exploratory analysis and then request full datasets from the TCs; (b) a code repository hosted on a common platform that enables data scientists to share their code with the public sector data community; (c) a whole-of-government analytics platform that enables the rapid development of data and AI models. Data security is built into these platforms by design.

3. Data Education

We will raise data capabilities across different levels and equip all public officers with the knowledge and skills to bring data into their everyday work.

For the majority of public officers, the emphasis is on developing data literacy: the ability to scope data use cases to address business needs and use simple data visualisation and analytics tools. For officers whose job functions require them to work with data, the emphasis is on deepening technical skills, sharpening their ability to link analytics solutions to business needs, and developing the software and data engineering skills to translate analytics insights into products that are integrated into business processes.

4. Use Cases

We will partner with government agencies and companies to identify use cases and facilitate access to data needed to deliver them. Many agencies lack experience working with data and have grown accustomed to slow, tedious processes for data sharing. Organisational cultures and memories are sticky: there needs to be a central push to help kickstart the data transformation process and generate momentum.

To this end, DSAID has published a data science project scoping guide and runs workshops with the Civil Service College; the GDO has partnered with agencies to identify data projects under their Ministry Family Digitalisation Plans and is working with researchers and companies to facilitate data sharing; the Strategy Group in the Prime Minister's Office works with agencies to commission data science projects.

FROM GOVERNMENT TO NATIONWIDE DATA TRANSFORMATION (2019 TO 2023)

The GDO is working with the relevant agencies to operationalise the GDA and digital infrastructure in phases. The first tranche of SSOTs, the Individual & Business and Geospatial TCs, and Vault.Gov.SG will be operational from Q4 2019. We aim to improve the user experience of working with data, to encourage and empower public officers to use data in their work. The findings from the Public Sector Data Security Review will also be published end 2019 and incorporated into the GDA.

The Singapore Public Service has also made significant changes to organisational structures, placing data at the front and centre of agency digital transformation efforts. The GDO is developing a guide for agencies to develop and implement data strategies as part of their digitalisation efforts. It is also developing a new competency framework for Chief Data

CREATING VAULT.GOV.SG

Vault.Gov.SG was a ground-up effort initiated in June 2018 by a small group of software engineers from DSAID's Open Government Products team and the GDO. They were keen to operationalise the new GDA and put data into the hands of users, to demonstrate that it was possible to achieve data sharing in days and not months. Using an agile development approach, they launched a basic product for user testing within three months.

Working closely together as a cross-functional, inter-agency team, GDO and DSAID officers formed a strong bond. This contributed to a virtuous cycle: as policy considerations changed, the engineers were sensitive to new technical requirements and adapted quickly. For example, the team was able to pivot and prioritise the development of new data security features in response to recent data breaches. This "Policy-Ops-Tech" integration has allowed Vault.Gov.SG to gain traction across a broad spectrum of data engineers, users and security experts.

The entrepreneurial team worked on the MVP as a side project and pitched the idea to senior management before gaining additional resources to scale the MVP into a government-wide product.

Officers (CDOs)—this professionalises the CDOs' roles and mandates them to drive data transformation in their agencies. DSAID has developed a data science competency framework, supporting structured training for raising the data capabilities of public officers.

At the same time, we are also preparing for the future, to extend the use of data as a strategic asset at the national level and to systematically apply digital technologies such as AI to enrich the value of our data assets.[5] SNDGO and the Infocomm Media Development Authority (IMDA) are jointly developing the National Data Strategy; SNDGO is also leading an inter-agency taskforce to develop Singapore's National AI Strategy. Through engagements with agencies, companies, and researchers, an initial tranche of data science and AI use cases has already been identified to anchor these strategies.

PUBLIC SERVICE IS ENTREPRENEURSHIP AT THE NATIONAL LEVEL

Over the past five years, Singapore has made progress towards our Smart Nation and Digital Government vision. The Public Service is now clearer about its transformation mission and what success would look like by 2023 (as reflected in the Digital Government Blueprint). We have built a core nucleus of in-house engineering talent to work with agencies, and are clearer about how Government needs to be reorganised to fully exploit the game-changing potential of data and digitalisation.

However, there is still a lot of work to be done. Many public officers still perceive their day-to-day work as removed from

digital transformation. This sentiment will gradually change as our digitalisation efforts kick into full swing, and when technology becomes an integral part of public officers' lived experience. The real drivers of change will be the groundswell of users and beneficiaries of data and digitalisation—we need to raise awareness and open minds to what is possible, by curating and publicising success stories. Enthusiastic users will be the ones demanding more; they will nudge their colleagues to deliver on digitalisation.

WE MUST VIEW PUBLIC SERVICE AS NOT JUST DOING A PRESCRIBED JOB, BUT AS ENGAGING IN ENTREPRENEURSHIP AT THE NATIONAL LEVEL.

Transformation will require all public officers to take ownership and drive innovation from within their own agencies, starting with their own immediate sphere of work. This will require a fundamental shift in mindsets: we must view public service as not just doing a prescribed job, but as engaging in entrepreneurship at the national level. There are no prescribed templates for digital transformation. Public officers must be proactive about identifying problems that need solving, engage with users to understand their ground challenges, rally support and marshal resources for their ideas, and leverage the digital-ready machinery of government to implement them. Like entrepreneurs, they must be willing to roll up their sleeves and do whatever it takes to accomplish the mission.

Ultimately, transformation is about problem solving, which will have to be a process of learning by doing, building and leveraging expertise from across Government, and delivering through cross-functional teams. The solutions will be found not in "policy", "operational", or "engineering" fields, but in bringing these together and taking collective ownership over successes and failures. Public officers will have to be "makers"—creative, innovative, and entrepreneurial—in the truest sense of the word. ■

Notes

1. This will involve (a) raising our digital maturity to ingest, process, productionise, and integrate data into decision making and business processes, at scale, (b) building the ops-tech capabilities to develop new operating concepts and redesign systems, processes, and jobs to exploit AI and digital technologies, and (c) building robust institutions that are effective in managing and governing digital technologies.

2. Adapted from Basis AI's slide deck on "Artificial Intelligence: Explainability and Governance".

3. This is akin to focusing on performance and health in sport. Performance may enable a team to win the league cup in any given year, but health is what enables teams to dominate the sport over a decade.

4. These figures were provided by DSAID based on their ground experience and were instrumental in shaping the Government Data Strategy.

5. Despite Singapore's small size, we are highly digitalised across the different sectors and have the ability to organise our national data assets. For example, we can leverage our unique common identifiers (e.g., National Registration Identity Card numbers for individuals, Unique Entity Numbers for businesses) to curate rich, cross-sectoral datasets.

HOW TO
Build Good
Software

by **Li Hongyi**

Software has characteristics that make it hard to build with traditional management techniques; effective development requires a different, more exploratory and iterative approach.

Li Hongyi leads a team of engineers, designers, and product managers who build technology for the public good. Projects they have worked on include Parking.sg—an app to replace parking coupons, Form.gov.sg—a web app for building online government forms in minutes, and Data.gov.sg—the government's open data repository. Prior to joining the public sector, Hongyi worked at Google on the distributed databases and image search teams. In his free time, he works on personal projects like typographing.com and chatlet.com.

WHY BAD SOFTWARE HAPPENS TO GOOD PEOPLE

Bad software is one of the few things in the world you cannot solve with money. Billion dollar airlines have flight search apps that are often inferior to those built by groups of students. Established taxi companies the world over have terrible booking apps despite the threat they face from ride-sharing services. And painful corporate IT systems are usually projects with massive budgets, built over the course of many years. Whatever the cause of bad software is, it does not seem to be a lack of funding.

Surprisingly, the root cause of bad software has less to do with specific engineering choices, and more to do with how development projects are managed. The worst software projects often proceed in a very particular way:

The project owners start out wanting to build a specific solution and never explicitly identify the problem they are trying to solve. They then gather a long list of requirements from a large group of stakeholders. This list is then handed off to a correspondingly large external development team, who get to work building this highly customised piece of software from scratch. Once all the requirements are met, everyone celebrates as the system is launched and the project is declared complete.

> **The root cause of bad software has less to do with specific engineering choices, and more to do with how development projects are managed.**

However, though the system technically meets specifications, severe issues are found when it is put in the hands of actual users. It is slow, confusing, and filled with subtle bugs that make using it an exercise in frustration. Unfortunately, by this time the external development team has been dismissed and there are no resources left over to make the necessary fixes. By the time a new project can be initiated years later, all knowledge of what caused these problems has left the organisation and the cycle starts over again.

The right coding language, system architecture, or interface design will vary wildly from project to project. But there are characteristics particular to software that consistently cause traditional management practices to fail, while allowing small startups to succeed with a shoestring budget:

- Reusing good software is easy; it is what allows you to build good things quickly;

- Software is limited not by the amount of resources put into building it, but by how complex it can get before it breaks down; and

- The main value in software is not the code produced, but the knowledge accumulated by the people who produced it.

Understanding these characteristics may not guarantee good outcomes, but it does help clarify why so many projects produce bad outcomes. Furthermore, these lead to some core operating principles that can dramatically improve the chances of success:

1. Start as simple as possible;

2. Seek out problems and iterate; and

3. Hire the best engineers you can.

While there are many subtler factors to consider, these principles form a foundation that lets you get started building good software.

REUSING SOFTWARE LETS YOU BUILD GOOD THINGS QUICKLY

Software is easy to copy. At a mechanical level, lines of code can literally be copied and pasted onto another computer. More generally, the internet is full of tutorials on how to build different kinds of systems using ready-made code modules that are available online. Modern software is almost never developed from scratch. Even the most innovative applications are built using existing software that has been combined and modified to achieve a new result.

The biggest source of reusable code modules is the open source community. Open source software is software in which code is freely published for anyone to see and use. Many of the largest contributors to the open source community are giant tech companies. If you want to use a state-of-the-art planet scalable database as Facebook does, just download the code for Cassandra that they open sourced in 2008. If you want to try out Google's cutting-edge machine learning for yourself, download the TensorFlow system published in 2015. Using open source code does not just make your application development faster, it gives you access to technology that is far more sophisticated than anything

you could have developed yourself. For the most popular open source code, it is even more secure as there are many more people paying attention and fixing vulnerabilities. This is the reason digital technology has made such rapid progress: even the newest engineers can build upon the most advanced tools our profession has to offer.

The advent of cloud services has taken reusability even further, offering the full use of even proprietary systems for just a subscription fee. Need a simple website? Just configure one in a few clicks using a website building service like Squarespace or Wix. A database? Subscribe to a virtual one from Amazon Web Services or Microsoft Azure. Cloud services allow developers to benefit from specialisation; the service provider handles the setup, maintenance, and continued development of a reliable, high-quality piece of software that is used by all its subscribers. This allows software developers to stop wasting time on solved problems and instead focus on delivering actual value.

You cannot make technological progress if all your time is spent on rebuilding existing technology. Software engineering is about building automated systems, and one of the first things that gets automated away is routine software engineering work. The point is to understand what

> Software engineering is about building automated systems, and one of the first things that gets automated away is routine software engineering work.

the right systems to reuse are, how to customise them to fit your unique requirements, and fixing novel problems discovered along the way.

SOFTWARE IS LIMITED BY COMPLEXITY

How useful a piece of software can be is usually limited by its *complexity* rather than the amount of resources invested in building it.

> Building good software involves alternating cycles of expanding and reducing complexity.

IT systems are often full of features but are still hated by users because of how confusing they become. In contrast, highly ranked mobile apps tend to be lauded for their simplicity and intuitiveness. Learning to use software is hard. Beyond a point, new features actually make things *worse* for users because the accumulated complexity starts to become overwhelming. For example, after serving as the hub of Apple's media ecosystem for almost 20 years, iTunes was split into three different apps (for music, podcasts, and TV shows) this year, as its features had grown too complex for one app to handle. From a usability perspective, the limit is not how many features can be implemented, but rather what can fit into a simple intuitive interface.

Even ignoring usability, engineering progress slows to a halt once a project becomes too complex. Each new line of code added to an application has a chance of interacting with every other line. The bigger an application's codebase,

the more bugs are introduced whenever a new feature is built. Eventually, the rate of work created from new bugs cancels out the rate of work done from feature development. This is known as "technical debt" and is the main challenge in professional software development. It is the reason why many large IT systems have issues that go unfixed for years. Adding more engineers to the project just adds to the chaos: they start running faster in place as the codebase keels over from its own weight.

In such cases, the only way forward is to take a step back to rationalise and simplify the codebase. The system architecture can be redesigned to limit unexpected interactions. Non-critical features can be removed even if they have already been built. Automated tools can be deployed to check for bugs and badly written code. Bill Gates once said "Measuring programming progress by lines of code is like measuring aircraft building progress by weight". Human minds can only handle a finite amount of complexity, so how sophisticated a software system can get depends on how efficiently this complexity budget is used.

> There is no such thing as platonically good engineering: it depends on your needs and the practical problems you encounter.

Building good software involves alternating cycles of expanding and reducing complexity. As new features are developed, disorder naturally accumulates in the system. When this messiness starts to cause problems, progress is

suspended to spend time cleaning up. This two-step process is necessary because there is no such thing as platonically good engineering: it depends on your needs and the practical problems you encounter. Even a simple user interface such as Google's search bar contains a massive amount of complexity under the surface that cannot be perfected in a single iteration. The challenge is managing this cycle, letting it get messy enough to make meaningful progress, but not letting it get so complicated that it becomes overwhelming.

SOFTWARE IS ABOUT DEVELOPING KNOWLEDGE MORE THAN WRITING CODE

In software development, most ideas are bad; this is not anyone's fault. It is just that the number of possible ideas is so large that any particular idea is probably not going to work, even if it was chosen very carefully and intelligently. To make progress, you need to start with a bunch of bad ideas, discard the worst, and evolve the most promising ones. Apple, a paragon of visionary design, goes through dozens of prototypes before landing on a final product. The final product may be deceptively simple; it is the intricate knowledge of why this particular solution was chosen over its alternatives that allows it to be good.

This knowledge continues to be important even after the product is built. If a new team takes over the code for an unfamiliar piece of software, the software will soon start to degrade. Operating systems will update, business requirements will change, and security problems will be discovered that need to be fixed. Handling these subtle errors is often harder than building the software in the first place, since it requires intimate

knowledge of the system's architecture and design principles.

In the short term, an unfamiliar development team can address these problems with stopgap fixes. Over time though, new bugs accumulate due to the makeshift nature of the additional code. User interfaces become confusing due to mismatched design paradigms, and system complexity increases as a whole. Software should be treated not as a static product, but as a living manifestation of the development team's collective understanding.

> Software should be treated not as a static product, but as a living manifestation of the development team's collective understanding.

This is why relying on external vendors for your core software development is difficult. You may get a running system and its code, but the invaluable knowledge of how it is built and what design choices were made leaves your organisation. This is also why handing a system over to new vendors for "maintenance" often causes problems. Even if the system is very well documented, some knowledge is lost every time a new team takes over. Over the years, the system becomes a patchwork of code from many different authors. It becomes harder and harder to keep running; eventually, there is no one left who truly understands how it works.

For your software to keep working well in the long term, it is important to have your staff learning alongside the external help to retain critical engineering knowledge in your organisation.

3 PRINCIPLES FOR GOOD SOFTWARE DEVELOPMENT

1 Start as Simple as Possible

Projects that set out to be a "one-stop shop" for a particular domain are often doomed. The reasoning seems sensible enough: What better way to ensure your app solves people's problems than by having it address as many as possible? After all, this works for physical stores such as supermarkets. The difference is that while it is relatively easy to add a new item for sale once a physical store is set up, an app with twice as many features is more than twice as hard to build and much harder to use.

> **Software projects rarely fail because they are too small; they fail because they get too big.**

Building good software requires focus: starting with the simplest solution that could solve the problem. A well-made but simplistic app never has problems adding necessary features. But a big IT system that does a lot of things poorly is usually impossible to simplify and fix. Even successful "do it all" apps like WeChat, Grab, and Facebook started out with very specific functionality and only expanded after they had secured their place. Software projects rarely fail because they are too small; they fail because they get too big.

Unfortunately, keeping a project focused is very hard in practice: just gathering the requirements from all stakeholders already creates a huge list of features.

One way to manage this bloat is by using a priority list. Requirements are all still gathered, but each are tagged according to whether they are absolutely critical features, high-value additions, or nice-to-haves. This creates a much lower-tension planning process because features no longer need to be explicitly excluded. Stakeholders can then more sanely discuss which features are the most important, without worrying about something being left out of the project. This approach also makes explicit the trade-offs of having more features. Stakeholders who want to increase the priority for a feature have to also consider what features they are willing to deprioritise. Teams can start on the most critical objectives, working their way down the list as time and resources allow.

We followed a similar process for all our most successful apps. Form.gov.sg started out as a manual Outlook Macro that took us six hours to set up for our first user but today has processed about a million public submissions. Data.gov.sg started out as a direct copy of an open source project and has since grown to over 300,000 monthly visits. Parking.sg had a massive list of almost 200 possible features that we never got around to building but still has over 1.1 million users today. These systems are well received not in spite of their simplicity but because of it.

2 Seek Out Problems and Iterate

In truth, modern software is so complicated and changes so rapidly that no amount of planning will eliminate all shortcomings. Like writing a good paper, awkward early drafts are necessary to get a feel of what the final paper should be. To build good software, you need to first
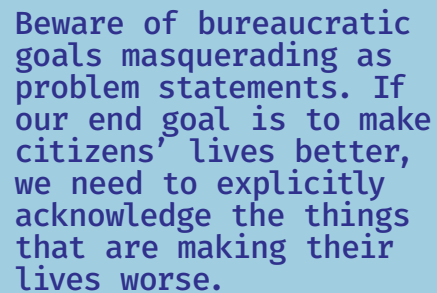
build bad software, then actively seek out problems to improve on your solution.

This starts with something as simple as talking to the actual people you are trying to help. The goal is to understand the root problem you want to solve and avoid jumping to a solution based just on preconceived biases. When we first started on Parking.sg, our hypothesis was that enforcement officers found it frustrating to have to keep doing the mental calculations regarding paper coupons. However, after spending just one afternoon with an experienced officer, we discovered that doing these calculations was actually quite simple for someone doing it professionally. That single conversation saved us months of potentially wasted effort and let us refocus our project on helping drivers instead.

Beware of bureaucratic goals masquerading as problem statements. "Drivers feel frustrated when dealing with parking coupons" is a problem. "We need to build an app for drivers as part of our Ministry Family Digitisation Plans" is not. "Users are annoyed at how hard it is to find information on government websites" is a problem. "As part of the Digital Government Blueprint, we need to rebuild our websites to conform to the new design service standards" is not. If our end goal is to make citizens' lives better, we need to explicitly acknowledge the things that are making their lives worse.

Having a clear problem statement lets you experimentally test the viability of different solutions that are too hard to determine theoretically. Talking to a chatbot may not be any easier than navigating a website, and users may not want to install yet another app on their phones no matter how secure it makes the country. With software, apparently

obvious solutions often have fatal flaws that do not show up until they are put to use. The aim is not yet to build the final product, but to first identify these problems as quickly and as cheaply as possible. Non-functional mock-ups to test interface designs. Semi-functional mock-ups to try different features. Prototype code, written hastily, could help garner feedback more quickly. Anything created at this stage should be treated as disposable. The desired output of this process is not the code written, but a clearer understanding of what the right thing to build is.

> Beware of bureaucratic goals masquerading as problem statements. If our end goal is to make citizens' lives better, we need to explicitly acknowledge the things that are making their lives worse.

With a good understanding of the right solution, you can start work on building the actual product. You stop exploring new ideas and narrow down to identifying problems with your particular implementation. Begin with a small number of testers who will quickly spot the obvious bugs that need to be fixed. As problems are addressed, you can increasingly open up to a larger pool who will find more esoteric issues.

Most people only give feedback once. If you start by launching to a large audience, everyone will give you the same obvious feedback and you'll have nowhere to go from there. Even the best product ideas built by the best engineers will start out with significant issues. The

aim is to repeatedly refine the output, sanding down rough edges until a good product emerges.

Even after all this iteration, after launch is when problems with a product matter the most. A problem that happens only 0.1% of the time may not get noticed during testing. But once you have a million users, every day the problem goes unresolved is a thousand more angry people you have to deal with. You need to fix problems caused by new mobile devices, network outages, or security attacks before they cause substantial harm to your users. With Parking.sg we built a series of secondary systems that continuously check the main system for any discrepancies in payments, duplicate parking sessions, and application crashes. Building up an "immune system" over time lets you avoid being overwhelmed as new issues inevitably come up.

Overall, the approach is to use these different feedback loops to efficiently identify problems. Small feedback loops allow for quick and easy correction but miss out on broader issues. Large feedback loops catch broader issues but are slow and expensive. You want to use both, resolving as much as possible with tight loops while still having wide loops to catch unexpected errors. Building software is not about avoiding failure; it is about strategically failing as fast as possible to get the information you need to build something good.

③ Hire the Best Engineers You Can

The key to having good engineering is having good engineers. Google, Facebook, Amazon, Netflix, and Microsoft all run a dizzying number of the largest technology systems in the world, yet, they famously have some of the most selective interview processes while still competing fiercely to recruit the strongest candidates. There is a reason that the salaries for even fresh graduates have gone up so much as these companies have grown, and it is not because they enjoy giving away money.

Both Steve Jobs and Mark Zuckerberg have said that the best engineers are at least 10 times more productive than an average engineer. This is not because good engineers write code 10 times faster. It is because they make better decisions that save 10 times the work. A good engineer has a better grasp of existing software they can reuse, thus minimising the parts of the system they have to build from scratch. They have a better grasp of engineering tools, automating away most of the routine aspects of their own job. Automation also means freeing up humans to work on solving unexpected errors, which the best engineers are disproportionately better at. Good engineers themselves design systems that are more robust and easier to understand by others. This has a multiplier effect, letting their colleagues build upon their work much more quickly and reliably. Overall, good engineers are so much more effective not because they produce a lot more code, but because the decisions they make save you from work you did not know could be avoided.

This also means that small teams of the best engineers can often build things faster than even very large teams of average engineers. They make good use of available open source code and sophisticated cloud services, and offload mundane tasks onto automated testing and other tools, so they can focus on

the creative problem-solving aspects of the job. They rapidly test different ideas with users by prioritising key features and cutting out unimportant work. This is the central thesis of the classic book *"The Mythical Man-Month"*[1]: in general, adding more software engineers does not make a project go faster, it only makes it grow bigger.

> **Building software is not about avoiding failure; it is about strategically failing as fast as possible to get the information you need to build something good.**

Smaller teams of good engineers will also create fewer bugs and security problems than larger teams of average engineers. Similar to writing an essay, the more authors there are, the more coding styles, assumptions, and quirks there are to reconcile in the final composite product, exposing a greater surface area for potential issues to arise. In contrast, a system built by a smaller team of good engineers will be more concise, coherent, and better understood by its creators. You cannot have security without simplicity, and simplicity is rarely the result of large-scale collaborations.

The more collaborative an engineering effort, the better the engineers need to be. Problems in an engineer's code affect not just his work but that of his colleagues as well. In large projects, bad engineers end up creating more work for one another, as errors and

poor design choices snowball to create massive issues. Big projects need to be built on solid reliable code modules in an efficient design with very clear assumptions laid out. The better your engineers, the bigger your system can get before it collapses under its own weight. This is why the most successful tech companies insist on the best talent despite their massive size. The hard limit to system complexity is not the quantity of engineering effort, but its quality.

CONCLUSION

Good software development starts with building a clear understanding of the problem you want to solve. This lets you test many possible solutions and converge on a good approach. Development is accelerated by reusing the right open source code and cloud services, granting immediate access to established software systems and sophisticated new technology. The development cycle alternates between exploration and consolidation, quickly and messily progressing on new ideas, then focusing and simplifying to keep the complexity manageable. As the project moves forward, it gets tested with successively larger groups of people to eliminate increasingly uncommon problems. Launching is when the *real* work ramps up for a good development team: layers of automated systems should be built to handle issues quickly and prevent harm to actual users. Ultimately, while there are infinite intricacies to software development, understanding this process provides a basis to tackle the complexities of how to build good software. ■

Note

1. Frederick P. Brooks, Jr., *The Mythical Man-Month: Essays on Software Engineering, Anniversary Edition*, 2nd ed. (Boston, MA: Addison-Wesley Longman, 1995).

Attracting Tech Talent: Start with Culture Redesign

by **Karen Tay**

A Singaporean in Silicon Valley argues for new work structures, principles and practices, and incentives that will appeal to the top tech talent we want.

Karen Tay works in Silicon Valley for the Smart Nation and Digital Government Group as well as the Singapore Global Network Department in the Economic Development Board. She is building an international tech talent attraction strategy and machinery for Singapore, among other roles. She also edits www.techandpublicgood.com, is faculty at Singularity University, and is a certified executive coach for tech professionals.

The views expressed in this article are the author's own.

Singapore's tech ecosystem has accelerated rapidly in the past five years. Tech start-ups have blossomed, Venture Capital has poured in, global and regional tech firms like Google, Stripe, Grab and GoJek have set up significant engineering operations, and even traditional organisations like Singapore Power, Singtel, DBS and the Singapore Government have charged ahead with ambitious digital transformation plans.

I currently work in Silicon Valley where one of my roles is to engage, cultivate and recruit tech talent for opportunities in Singapore. Hardly a day goes by without a Singaporean employer reaching out to me to discuss the tech talent shortage. One gets the sense that the ambition and speed of tech development in Singapore is being held back only by a talent shortage.

To be fair, the shortage of tech talent is a global phenomenon: even hiring managers at Silicon Valley giants like Google and Facebook have complained about talent scarcity! This is also why countries like Canada, Israel, Thailand, Vietnam, New Zealand and many others have come up with strategies to enhance their attractiveness to tech talent.

The rate of technological development and its relevance to all sectors of society is accelerating faster than people can be trained: the talent shortage is here to stay for a while yet.

If you are leading a large, traditional organisation and want to attract technical talent, what can you do?

Answering the Million Dollar Question

In an attempt to answer this question, my team has engaged over a thousand Singaporean tech professionals living in the Silicon Valley. We have software engineers, product managers, data scientists, cybersecurity specialists, cloud architects and hardware engineers, just to name a few common roles. They range from junior engineers to Senior Vice Presidents in top companies like Google, to Chief Technology Officers and founders of start-ups. I feel a sense of pride when I see Singaporeans excelling—Silicon Valley employers I've spoken to recognise the Singapore brand.

What are these Singaporeans up to? When and why did they move to Silicon Valley? Would they be open to moving back home at this critical juncture, to take on leadership roles and help build our own tech ecosystem?

My team seeks to understand these issues as we run large events like the Singapore Tech Forum (which drew 850 attendees this year), host domain and expertise-specific engagements, and conduct one-on-one conversations. We have also validated our findings with U.S., Southeast Asian, Chinese, Indian and other global tech talent.

Here, I want to focus on one critical insight that has arisen from our many interactions with tech talent: the importance of engineering culture.

The importance of "engineering culture"

When we speak to overseas Singaporeans about tech in Singapore and Southeast Asia, they are at once surprised at the growth of the tech sector, and sceptical about how hospitable the place will truly be to tech talent in the long run. "What's the engineering culture like? Has it truly changed?" is a question that dwells beneath the surface of most of our conversations. Tech talent in their 30s and older remember vividly the Singapore tech scene they left in the 2000s: one where they felt unvalued because less technically skilled managers were telling them what to do (even if unfeasible or sub-optimal), their salary scales would always be lower than managers, and they were at risk of having their work "outsourced" to cheaper vendors.

They contrast this mindset with Silicon Valley employers, who respect engineers as the true engines of the company's growth. For example, Google is famous for valuing engineers who directly solve problems, eschewing the whole concept of "managers"—until the company grew to a size where appointing management was unavoidable.

How to enable a healthy engineering culture

So, what is a proper engineering culture and how have Silicon Valley companies gone about creating it?

My conversations with hundreds of tech talent and Silicon Valley companies suggest that there are four elements to a healthy engineering culture:

1 An ethos of user obsession

In your average Silicon Valley company, software product development teams are empowered to make decisions based on users' needs, pain-points, and intuitive interactions with the product. They carefully observe how their design and engineering decisions impact the user's experience, engagement and utility, and then iterate quickly to boost these metrics.

This ethos of user obsession means that regardless of rank and seniority, there are no "super users" who can dictate product decisions from outside the team. Managers give product development teams broad objectives and boundaries: but when it comes to the specifics of what is developed, how it is developed, the features to include and metrics to measure success, managers are regarded as just some of many "users", whose inputs the team are not obliged to take.

> If you are leading a large, traditional organisation and want to attract technical talent, what can you do?

This need not be taken to the extreme. There are some great use cases for centralised, top-down planning: for example, when creating data sharing platforms or common infrastructure that many departments can share.

However, managers seeking to enable a healthy engineering culture should be very deliberate about: (a) balancing top-down plans with space for ground-up initiatives which respond to user needs, (b) remembering that they are not "super users" in the product development process, and (c) empowering the team to say "no" to them.

2 Technical expertise is respected and rewarded

A healthy engineering culture recognises and respects technical expertise. Coding, design, cryptography—these are disciplines that demand mastery. Some talented tech workers do not want to give up on their path of mastery in order to become managers.

In Silicon Valley companies, it is possible for individual contributors to be compensated as much as C-suite executives as long as they drive big, complex, technical projects with their skills. Some individual contributors are highly esteemed for designing the architecture of the company's systems or platforms, or developing algorithms to optimise matching of supply and demand in a marketplace. It is not that they are lone wolves or have no social skills—many of them are happy to provide technical advice, mentorship, and even coordinate technical projects. But they do not want to be a "reporting officer".

Good HR and compensation design rewards technical expertise well relative to managers. Most Silicon Valley companies have parallel tracks in their engineering organisations for engineering managers and individual contributors. Their pay bands are equivalent, level-for-level, with the same pinnacle points. Most individual contributors I spoke to acknowledged that they might not rise up the compensation ladder as fast as managers—it's difficult for one person's impact to match the scope of a ten-person team. However, they felt it was important to have that possibility clearly defined.

Pay is only one way that deep technical expertise is rewarded and recognised. Softer elements can also convey respect for technical expertise. Whose opinions are sought and valued in key company decisions? Whose profile, projects and stories are mentioned in the company's newsletters and all-hands meetings? These are subtle signals of what types of expertise and experience are valued, and traditional organisations would do well to pay close attention to them. A culture is built on thousands of such micro-decisions every day.

3 Respected engineering leadership supported by new HR capabilities

When tech talent considers working in a traditional organisation without a "tech" brand, they often base their decisions on the strength of the tech leadership team. They cannot be sure that the organisation has a good engineering culture, no matter what senior management or tech recruiters tell them. The best proxy is

> **Some talented tech workers do not want to give up on their path of mastery in order to become managers.**

whether the organisation has strong engineering leaders whom they can trust to champion a good (and constantly improving) engineering culture.

Hence, a traditional organisation seeking to attract good technical talent has to first focus on recruiting its top tech leadership. Ideally, some of these leaders should be from companies recognised for their brand and culture. They must be given the mandate to optimise for a vibrant engineering culture, which includes (but is not limited to) deviating from organisational rules about the tools they use, their office spaces, dress codes, work-from-home guidelines, and even the procurement process.

Since talent begets talent, these tech leaders must be the face of recruitment. Senior tech leaders in Silicon Valley unicorns have told me that they spend more than 50% of their time recruiting: reaching out to candidates; cultivating them; negotiating attractive packages and job scopes. In some cases, tech leaders have been allowed to hire their own talent partners separate from the existing HR machinery, giving them maximal flexibility in process, pay bands

and titling when building the founding team. Of course, this is not to be done lightly: companies that tried this have also expressed some regrets. Proper metrics are still needed to ensure accountability.

Finally, an oft-overlooked but critical factor to attracting top talent: building new capabilities in your corporate functions.

For example, tech talent has told us that actions and attitudes of HR professionals during the talent cultivation and recruitment process implicitly communicate an organisation's engineering culture. Are they committed to long-term cultivation of talent, or are they transactional? Are they empowered to be flexible and quick in the recruitment process, or are they bogged down by bureaucracy? Are they transparent and willing to explain the process and considerations, or are they elusive? If you are a potential job candidate, do they make you feel that they are acting in your best interests? Or—as one candidate interviewing with a traditional organisation recounted—does it feel like "they are trying to squeeze every last drop of blood out of you"?

If you are serious about bringing in tech talent, you need People Operations and HR leaders who see this as a fierce competition for scarce resources: people who cultivate longer-term relationships with talent, are willing to push the boundaries on what the organisation can offer talent, and have the ability to drive new workflows between tech leaders, HR, and senior management to drive results and make risky calls. This is a stark contrast to process-driven recruitment which is more commonplace in HR functions today.

Why is Singapore a great place for tech talent? Hear from Singapore Tech Forum speakers at
go.gov.sg/sgtechcareer

Thirty top tech leaders from Google, Stripe, Bigo, Indeed.com, GovTech, Cybersecurity Agency, Zopim, Grab, Carousell and many others shared about exciting engineering and product work in Singapore. Singapore is no longer just a marketing, sales or corporate services hub—cutting-edge tech products are being built out of Singapore for the region and the world.

Source: Photos courtesy of EDB and SNDGO

850 tech talent in the Silicon Valley showed up in full force at the Singapore Tech Forum in April 2019, up from 350 last year. We had a waiting list of over 200. As opportunities grow and culture transforms, interest will increase.

Global tech talent want to see breadth and depth of opportunities in a tech ecosystem. This means that we need to work whole-of-goverment, and across public and private sectors, when pitching Singapore. Pictured here is the whole-of-government team that worked seamlessly to showcase Singapore's tech scene at Tech Forum 2019.

4 Flexibility to experiment, pivot, and even stagnate

A healthy engineering culture is built on a good understanding of tech talents' aspirations. As a group, tech talent is less interested in climbing career ladders in a single organisation. A study we did found that the average time overseas Singaporean tech talent stayed in a job was only three years. A combination of their user obsession and their desire for mastery and growth drives them towards the next most impactful and interesting problem to solve, or a role where they can optimise for learning.

What does this mean for traditional organisations seeking to attract tech talent? Don't assume that traditional career progression incentives are attractive. Instead, continually seek new incentives and structures that appeal to their needs and motivations.

One important perk is the flexibility to experiment, pivot, or even stagnate within the organisation.

One of the value propositions of smaller Silicon Valley companies vis-à-vis tech giants (where roles are much more specialised) is the flexibility they can give people to experiment and pivot across different roles and fields. For example, some allow tech talent to experiment with different proportions of management versus individual work (50-50? 80-20?). They also provide opportunities to pick up new skills within the organisation. An employee may move from pre-sales engineering to product management, while picking up software engineering skills along the

> " Don't assume that traditional career progression incentives are attractive. Instead, continually seek new incentives and structures that appeal to their needs and motivations. "

way. As one interviewee from a Series C start-up puts it: "I don't want to be pigeonholed right now, I want to learn."

Offering the flexibility to *stagnate*—temporarily or permanently—can be a surprising benefit. Googlers talk about a "respectable Level 5", the point in a Googler's career where they can choose to tap out of further promotion and not run the risk of being let go (Google's scale runs from about 3 to 11 for engineers). For one employee, a mother of two in her 30s, this was a relief as she could still make a good base salary and potentially a large bonus for good performance at a scope she was comfortable with. It's a win-win for the organisation, as she is still doing good work for them. Traditional organisations should think about how to change their "up or out" culture, especially when it comes to tech talent.

Conclusion

In light of global tech talent shortages, it is clear that organisations must step up their game to compete for the tech

talent they need to deliver impactful digital products, services and platforms.

However, attracting tech talent is not a simple recruitment game. The goal cannot just be to bring top tech talent in, only have them leave because of "organ rejection"— a costly and ineffective path.

Attracting and retaining top tech talent demands that organisations take a hard look at their inherited cultures and start to redesign them to better suit the attitudes, needs and aspirations of talented tech workers. Organisational design, reward structures, the quality of tech leadership and HR, and how management sees their role vis-à-vis product development teams are all factors that contribute to culture redesign. The good news, I believe, is that most talented people—not just those in tech—find these principles and guidelines attractive, and organisations that can implement them become more attractive cultures overall.

While building a healthy engineering culture is an important start, the end point of cultural transformation is not yet clear. There is a messy in-between, which is the phase most organisations are in right now. Some split up or form separate entities with different cultures; others stay as a single organisation with bi- or even tri-modal cultures. Change takes time, and perhaps it is too early in the journey to determine what is the "right" end-point—we have to keep experimenting, learning, and embracing the uncertainty.

While challenges remain, I am optimistic about Singapore's ability to attract tech talent and transform our nation with technology. I have witnessed in so many Singaporean organisations—including GovTech—the ability and willingness to adapt and experiment, make difficult decisions, and collaborate such that we are more than the sum of our parts. I believe this is the same spirit that brought Singapore to where we are today. With it, we can build the culture we need to carry us into the future. ■

{ If you are a singaporean employer seeking to attract tech talent, Karen would be happy to share insights on overseas tech talent and discuss collaborations which enable you to reach global tech talent. }

If you work in tech and are looking for your next challenge, consider one of the fastest growing tech ecosystems in the world — Singapore and the broader Southeast Asia: get in touch with Karen at
✉ **karen_tay@pmo.gov.sg**

The Agile Way of Working

by **Abhilash Anselm and Tiana Desker**

An approach borrowed from software development could help public service teams take faster and more adaptive action in complex, volatile conditions.

Abhilash Anselm is a Lead Delivery Manager in Government Digital Services (GDS) at GovTech. He has over 10 years of product development experience, managing agile development and global operations for products in the gaming industry, with companies like LucasArts, Ubisoft and Blizzard Entertainment.

In GDS, he oversees agile development for products such as the Sensor Data Exchange that is part of the Smart Nation Sensor Platform. He also supports efforts that contribute to the Singapore Government Tech Stack and is the Delivery Manager Chapter Lead under the Apps Development team.

Tiana Desker is Deputy Director (Digital Workplace) in the Public Sector Transformation Group at the Public Service Division. She leads an agile cross-functional team that works to provide a more digitally-enabled workplace to officers of the Singapore Public Service.

Tiana was previously Deputy Head of the Centre for Strategic Futures, a think tank within the Singapore Government that researches emerging issues at the intersection of technology and public policy. She began her career at the Ministry of Defence in a policy role focused on Southeast Asia.

Agile is an approach, commonly used in software development, which has been widely adopted by tech organisations to deliver their products to consumers more efficiently.

The public sector, which has traditionally not used Agile ways of working, can benefit from adopting Agile in many areas, including strategy, policy, communications, HR, and IT. In our own teams, we use Agile as a methodology to enable our teams to keep work organised and productive whilst being able to adapt to change rapidly.

WHAT IS AGILE?

Originally based on the principles published in the Agile Manifesto,[1] the Agile approach encourages a culture of working based on the values of autonomy, collaboration, communication, iterative working, user-centricity and competence:

1. Autonomy

Agile is an alternative to the traditional silo, hierarchical way of working based on a "top-down" decision-making process. Agile organisations comprise networks of self-organising, cross-functional teams that are guided by a shared purpose. Team members commit to a prioritised set of deliverables and are accountable for delivering these in alignment with their stakeholders. They do not wait for tasks and instructions to be handed to them.

2. Collaboration

Agile organisations typically have flat structures with clear roles; any lack of role clarity that would impede collaboration is flagged up early and worked through by the people involved. Teams work out amongst themselves how their decision rights should be structured. Collaboration between teams is fluid and persistent.

3. Communication

Agile teams are encouraged to communicate regularly to share each member's progress and to speak up if there are risks or obstacles in getting the job done. Communication is usually face-to-face or through collaboration tools where every member participates in the conversation.

4. Iterative Working

Agile teams work in an iterative way, delivering concrete outcomes at regular cadences ("sprints"). Typically, sprint periods are between one to three weeks depending on the scale and complexity of the project. This lets teams reflect on their processes regularly, identify areas for improvement and adjust their activities accordingly.

A key principle is to get something in front of the customer or citizen as soon as possible for feedback, rather than wait to consult them at the end.

5. User-Centricity

A key principle is to get something in front of the customer or citizen as soon as possible for feedback, rather than wait to consult them at the end. Every team member should have line-of-sight to the user and know how they, personally, are delivering value to citizens. Working iteratively, teams place early designs and prototypes into users' hands early in the process and implement changes or improvements more frequently based on feedback received. The regular feedback loop lets the team focus on delivering high quality work while building confidence that they can meet users' requirements.

6. Competence

Agile emphasises decision-making that gives weight to the views of those with relevant professional expertise, rather than those most senior in the hierarchy. This is where cross-functional teams with a mix of technical and non-technical skillsets work together as one. "Agile organisations do not seek consensus decisions; all team members provide input, the perspectives of team members with the deepest topical expertise are given greater weight, and other team members, including leaders, learn to respectfully and openly raise their concerns if there is a disagreement on the decisions being made to enable the team to move forward."[2]

Agile emphasises decision-making that gives weight to the views of those with relevant professional expertise, rather than those most senior in the hierarchy.

WHY AGILE?

The main argument for pursuing an Agile approach is to achieve swifter decision-making on complex projects within a volatile and uncertain operating environment. Hierarchy-based organisations were designed for the industrial era—routine work, efficiencies through standardisation, and a compliant workforce. Agile organisations are designed for our post-industrial era—work that requires creative problem-solving, collaboration across functions, and a high degree of responsiveness to changing circumstances.

As managers, we find that Agile provides a sense of momentum for our teams and gives us a clearer picture of what everyone is doing. We save time otherwise spent "managing" so that we can "get work done". As team members, we have found that the Agile way of working has kept us motivated and focused. For our teams, who grapple with uncertainty and unexpected challenges, the consistency of our Agile practices—daily habits—provides a sense of stability. In our experience, working in Agile teams reduces our stress levels and allows us to be more productive.

Agile is well-suited to highly skilled, self-motivated teams who value their autonomy; culturally, it fits the work styles of many millennials.

Agile provides a sense of momentum for our teams and gives us a clearer picture of what everyone is doing.

Agile is a way of working well-suited to highly skilled, self-motivated teams who value their autonomy; *culturally*, it fits the work styles of many millennials. Our personal experience working in Agile teams is that it *feels* like we work in progressive organisations. We feel respected as professionals: trusted to get our work done and to be accountable for it—the opposite of being micro-managed.

Indeed, organisations that practise Agile methodologies have been found to have a 70% chance of being in the top quartile for organisational health: the most reliable indicator of performance over the long run.[3]

HOW TO PRACTICE AGILE

How might you apply Agile techniques in your own team or department? Each team will need to find its own tempo and adapt these processes to suit its unique context.

The team at the Public Service Division's Digital Workplace Programme Office

(DPWO) uses Scrum,[4] which is the most widely-used Agile methodology. Scrum project teams have roles and "rituals"—i.e., the processes used to organise a team's work. For these processes to be effective, the team must be relatively small (i.e., fewer than ten people). There must also be considerable inter-dependencies between the tasks that the various individuals in the team are doing.

ROLES

Product Owner

This is typically the Director or department head who is accountable for the success of the programme. The Product Owner sets the vision for the project and signs off on the priorities the team needs to deliver. Accountable for meeting the required outcomes, the Product Owner also engages the project's users and stakeholders and is responsible for translating the team's output into value for the organisation. The Product Owner must be experienced enough to be able to get alignment from stakeholders and have the confidence to manage stakeholder demands so that the team can stay focused on the most high-value tasks.

Scrum Master

The resident problem-solver, the Scrum Master facilitates the relationship between the team and the Product Owner. This can be any member of the team: preferably a senior with relevant experience and Scrum Master certification.[5] The person in this role facilitates the Scrum processes and ensures that meetings are adhered to and productive in achieving team outcomes. The Scrum Master is responsible for the productivity of the team and must remove any impediments to team progress: by improving inefficient organisational processes and ensuring the team has the resources they need, for instance. This includes protecting the team from external influences (e.g., unplanned work requests) to avoid impacting their velocity. The Scrum Master also provides guidance to less experienced team members in understanding Scrum and how it is being applied. The Scrum Master must have enough clout in the organisation to deal effectively with any obstacles the team may face.

A Typical Task Board

Setting the vision (usually before the start of each Sprint)

The team convenes with the Product Owner to discuss the outcomes to be achieved over the next Sprint, with a focus on concrete deliverables. Through this discussion, the team develops a prioritised list ("Product Backlog") of the outcomes they will pursue in the sprints.

For this session to be effective, the Product Owner must have consulted stakeholders and users beforehand to gather requirements towards the Product Backlog.

Planning our work (every Sprint)

The team comes together at the start of the Sprint for a "Sprint Planning" meeting where they review the Product Backlog and see if it needs to be changed according to the priorities set by the Product Owner. Then they determine what to work on in the coming period (the "Sprint") and highlight if the committed work has dependencies externally or internally within the team.

Work can be tracked using a physical Task Board or using tools such as Atlassian's Jira. With a physical Task Board, each task (or, in product development terms, a "user story")[6] is written on a sticky note and pasted on the Task Board. These sticky notes are then organised in order of priority. Team members mark their initials on the tasks for which they opt to be responsible over the coming Sprint.

The team should be clear on what each task's "definition of done" is. For example, the proposal must be sent to the Director, or a draft circulated for comments, before the task can be considered complete.

The team estimates in man-hours (or "story points" as an indication of time required) how much effort each task will need and indicates this on the sticky label. A regular practice is to use the 80/20 principle in committing to work during a sprint. For example, for a one-week sprint, the team should aim for 32 out of 42 (80%) hours of activities per person per week; the remaining 20% allows for time spent doing "baseline work": e.g., answering emails, attending external meetings or training.

Keeping updated (every day)

Every morning, each team member shares: what they are doing today; what they completed yesterday; any obstacles they are facing. It can be done face-to-face or using chat apps like Slack or WhatsApp.

This "Daily Stand-up" encourages transparency on the work being done and the individual's accountability to fellow team members in dealing with any potential obstacles that could impact the Sprint progress.

Doing the work (every day)

As tasks are completed, team members move their sticky notes from the "Doing" column to the "Done" column. This is very satisfying! Everyone gets to see the progress that the team is making on a daily basis.

One principle of Agile is that we are accountable to our fellow team members—not only to our boss—and the Task Board makes the work visible.

Reviewing the work (every two weeks or at the end of the Sprint)

The team holds a Sprint Review meeting every two weeks to review progress with the Product Owner and key stakeholders.

This meeting should include people who represent the users of the product or service we deliver. For example, for a team developing training for leaders in the Public Service, this meeting should include officers who are the target of the training interventions.

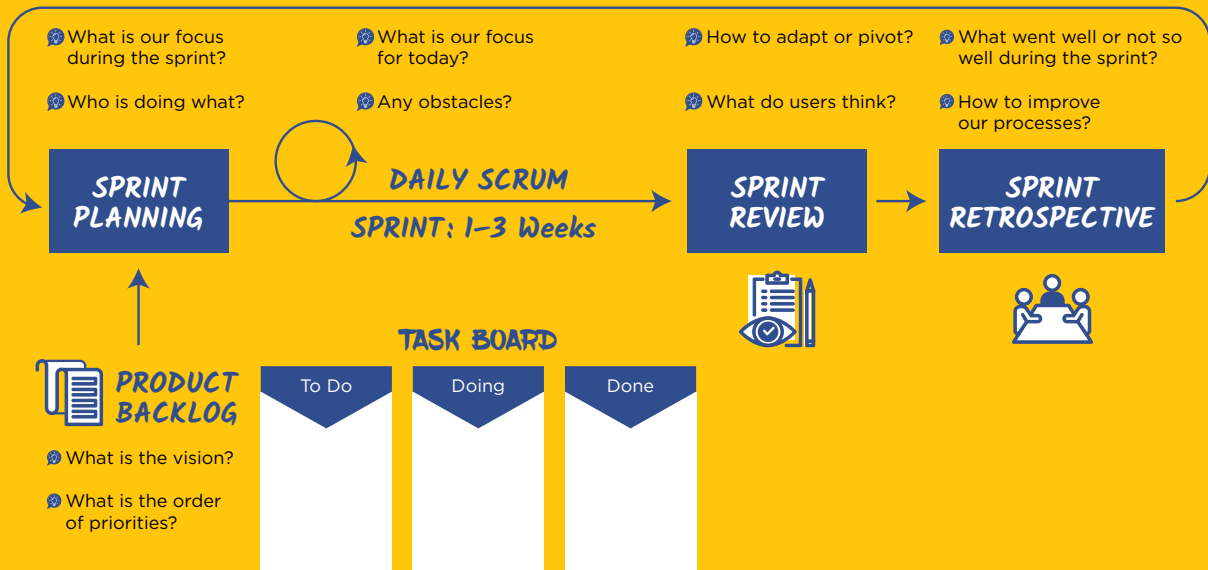## Reflecting on our processes (every two weeks or at the end of the Sprint)

Scrum requires the team to be outcome-focused but also to regularly improve its processes.

The "Sprint Retrospective" is a session that ensures the team is constantly reviewing its processes and the relationships within the team and with the Product Owner or stakeholders. It is where the team comes together to talk about what went well over the past Sprint, what did not, and how to improve our processes. Team members should be free to express their feelings.

This needs to be an open conversation where issues can be aired without prejudice and the team collectively works on a resolution. In our experience, if there is a good measure of psychological safety within the team, then these sessions can be very illuminating. They can be a powerful outlet for team members to surface what management or the organisation is doing that is getting in the way of their productivity and effectiveness.

OVERVIEW OF THE SCRUM PROCESSES

- 🗨 What is our focus during the sprint?
- 🗨 Who is doing what?

- 🗨 What is our focus for today?
- 🗨 Any obstacles?

- 🗨 How to adapt or pivot?
- 🗨 What do users think?

- 🗨 What went well or not so well during the sprint?
- 🗨 How to improve our processes?

SPRINT PLANNING

DAILY SCRUM

SPRINT: 1–3 Weeks

SPRINT REVIEW

SPRINT RETROSPECTIVE

PRODUCT BACKLOG

- 🗨 What is the vision?
- 🗨 What is the order of priorities?

TASK BOARD

To Do	Doing	Done

A Week in the Life of an Agile Team

Monday, 5 p.m.

The Scrum Master calls us to the Task Board for Sprint Planning. Looking at our "Done" column, we each share high points from the last week. The Product Owner shares the big priorities for the upcoming Sprint, looking to the "To Do" column. Then we start writing sticky notes and pasting them into the "Doing" column. Someone "over-commits", putting their initials on too many sticky notes. We readjust and share the work. We close by sharing how we are each feeling generally on a '1 to 100' scale.

Tuesday, 10 a.m.

We start to share in our team chat the sticky notes we are working on today. Someone raises an issue in the team chat—a key stakeholder has not replied to a request for inputs. The Scrum Master reaches out to this stakeholder to remove the obstacle.

Thursday, 2 p.m.

Sprint Review for a project where the team presents the latest iteration of its work to the Deputy Secretary and various other stakeholders.

Friday, 4 p.m.

The team heads out to a nearby café for Sprint Retrospective. The Scrum Master asks each of us to share what we thought went well or did not go so well during the past Sprint. We talk about how we need better governance for a project and what to do about that. We reflect on what we learnt in the past Sprint, like realising we need to bring a new stakeholder into one of the projects. And then we break for the weekend!

MINDSET SHIFTS FOR THE AGILE ORGANISATION

Agile is ultimately not about following a set of processes; it is about a mindset and daily habits of working. It takes a lot of conscious effort to switch from a traditional "bureaucratic" public sector work style towards a more Agile way of working.

TRADITIONAL	AGILE
Unless leaders apply pressure to them, most employees will slack off	Employees are empowered to achieve their best to get things done and achieve the mission
As a leader, I should know what must be done for all issues under my purview	As a leader, I trust that my staff will take ownership of their work
The leader knows best, so try to interpret their meaning; avoid challenging them even if you disagree	The leader sets the direction, then leaves professionals to make decisions on issues within their domain
Everything is urgent, and let's do it all at the same time	Focus only on what delivers greatest value; maximise the work *not* done
Managers assign tasks to their staff	Individuals propose the tasks they need to work on; managers set priorities
It is my right as a manager to expect my staff to be responsive to me	It is my team members' right to say, "not in this Sprint, let's do it next Sprint"
As a manager, seeing a detailed Gantt chart covering what we need to do over the next six months is very reassuring	Things change fast, let's do just-enough planning and adjust along the way
Managers send chasers via email and WhatsApp to check on progress	Task Board makes visible what has been achieved on a day-to-day basis
Managers chair long and draggy coordination meetings	All meetings are "time-boxed"; we discuss what we can in the allotted time
I focus on my vertical reporting line upwards and downwards	I focus on building tight collaboration with other teams, laterally
It is unprofessional to give bosses "half-baked" work	Bosses give comments on early drafts and prototypes, to avoid wasted work
I can only engage people at my level, so my Director must help me engage their counterpart about my project	For my project, I will engage relevant stakeholders at all levels of the organisation and in partner agencies
When two teams cannot agree on their roles and responsibilities, this must be escalated up the hierarchy for decision	As we collaborate, teams work out for themselves how to split roles and responsibilities, then update bosses on their resolutions
For cross-agency issues, I will staff my recommendation up the approval chain, then "surprise" my partners in other agencies with our position	I will work out a sensible solution with my agency counterparts, then we jointly staff up this position, using a cross-agency approval chain[7]

CHALLENGES AND LIMITATIONS

Agile methodologies work best for complex, non-routine work in an environment of rapid change. They may not be suited where work processes are standardised and stable, proceeding sequentially in phases that are dependent on previous phases, and where the scope has been clearly defined before work begins and changes would be costly (such as "waterfall" projects, commonly seen in construction).

Agile methodologies work best for complex, non-routine work in an environment of rapid change.

The fluid nature of Agile approaches is typically more suited to work that requires creativity and where there is some appetite for failure. However, there is some evidence that Agile can work even where risk tolerance is low: Saab used Agile methodologies for developing fighter aircraft.[8]

One serious challenge for practitioners is how to make Agile work when the wider organisation is still run on traditional command-and-control principles. Stephen Denning observes of such situations in *The Age of Agile*: "Either the Agile teams will take over the organisation, or more likely, the bureaucracy will crush the Agile teams."[9] This would be a pity—as Li Yiyang, a Manager in the Digital Workplace team of Singapore's Public Service Division puts it: "Scrum organises work so much more efficiently, I hope I will never have to return to the old way of working."

Given Agile's benefits, it is important that leaders in traditional public sector organisations learn how to manage Agile teams. Here, Low Xin Wei, Director of Strategy and Masterplanning at Singapore's National Research Foundation, has some advice: "For a Director whose team is embarking on an Agile journey, there is a learning curve involved, but it is worthwhile to stay the course. For directing passionate young officers on dynamic and complex issues, this is a way of working that keeps them engaged and brings about a sense of ownership not possible with traditional management forms." ∎

One serious challenge is how to make Agile work when the wider organisation is still run on traditional command-and-control principles.

Notes

1. Manifesto for Agile Software Development (website), accessed July 1, 2019, www.agilemanifesto.org.

2. Wouter Aghina et al., "The Five Trademarks of Agile Organizations", *McKinsey Quarterly*, December 2017.

3. Michael Bazigos, Aaron De Smet and Chris Gagnon, "Why Agility Pays", *McKinsey Quarterly*, December 2015.

4. Jeff Sutherland, *Scrum: The Art of Doing Twice the Work in Half the Time* (London: Random House, 2014).

5. Certified ScrumMaster (CSM) certification courses are widely available in the market, for e.g., by ScrumAlliance (www.scrumalliance. org).

6. Tasks are the smallest unit of work, and usually assigned to a single team member of the team to complete. In product development, "user stories" help the team group and track these tasks as an outcome driven by user requirements. So a feature (e.g., login on a webpage) may be one of the main deliverables of a user story in addition to areas like user-experience, security, compliance and so on.

7. For example, for issues involving both PSD and SNDGO, the relevant PSD and SNDGO Directors are cleared jointly on one email chain, then the issue is staffed up to PS(PSD) and PS(SNDG) jointly.

8. Darrell Rigby, Jeff Sutherland & Hirotaka Takeuchi, "Embracing Agile", *Harvard Business Review*, May 2016.

9. Stephen Denning, *The Age of Agile: How Smart Companies Are Transforming the Way Work Gets Done* (New York: American Management Association, 2018).

FORMSG

From Idea to Hit Platform in a Year

by **Leonard Loo**

A leading member of the team that created FormSG shares his seven steps to building a breakthrough software application, fast.

Leonard Loo is a GovTech scholar who holds a double Bachelor's degree in Business and Computer Science from the University of Pennsylvania and a Master's degree in Data Science from Harvard University. In July 2017, he joined GovTech's Data Science and AI Division as a Software Engineer before shifting to a new role as a Product Manager.

The FormSG project would not have been possible without the contribution of Li Hongyi, Abby Ng, Nguyen Viet Nam, Arshad Samad, Hafizah Husin, Kevin Chu, Sarah Salim, Ryan Ang, Ian Chen, Alwyn Tan, Liang Yuanruo, Jean Tan, Gary Ang, Pearly Ong, Louiz Kim-Chan and Foo Yong Jie. The team had three to six people at any one time and the names are listed in the order that they joined the project.

FormSG began in August 2017 as an idea discussed by a few of us at GovTech, for which we were trying to find potential users. One of our earliest users was the Municipal Services Office (MSO), for which we were digitising a pigeon inspection form. MSO staff were complaining that they were spending tens of hours doing manual data entry. I thought it would be a weekend side project to solve this problem. What my team and I ended up with, one-and-a-half years later, was something that tens of thousands of officers now use to digitise thousands of forms filled in by millions of Singaporeans. And despite not having a policy mandating its use, our platform is now used by just about every single government agency in Singapore.
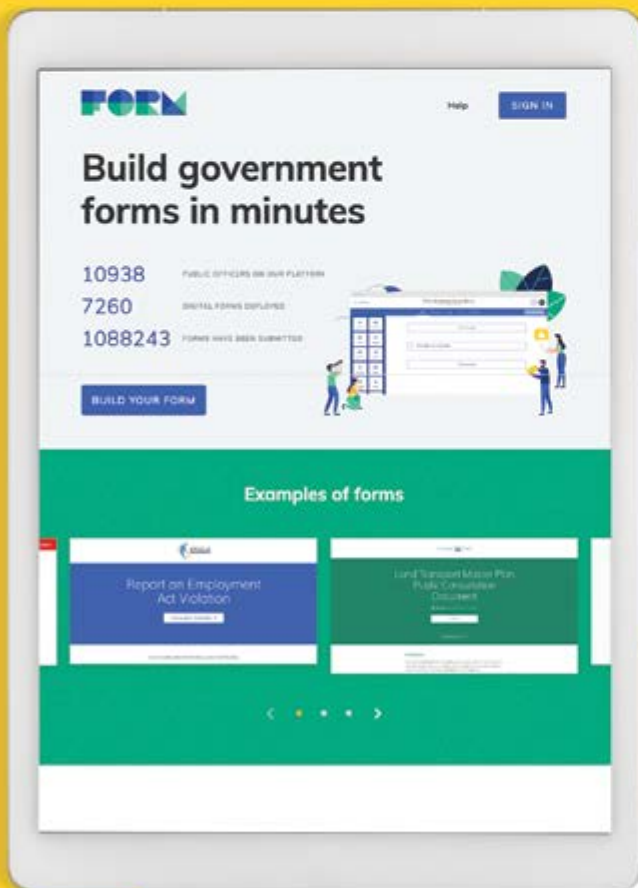
How did we get this far this quickly? I believe it was a combination of luck, hard work, and the deliberate approach we took to development. Here's how we did it:

1 UNDERSTAND THE SCALE OF THE PROBLEM

We realised we were solving an Everest-scale problem. Ask yourself—how many paper forms do you fill in a year? If the average Singaporean fills in six a year, this means over 30 million paper submissions each year! All this data then has to be manually entered or digitised, which calls for an army of data entry staff. Paper submissions are usually also stored for some time. If you do the math, all this paper stacks up to a mountain almost the size of Everest. And this happens every year.

2 START BY REALLY SOLVING ONE PERSON'S PROBLEM

We didn't start by building a rocket to scale Everest. But neither did we make a "minimal viable product" (MVP) either. No one is going to remember or bother using an MVP that barely satisfies them. The first product we build should be a complete product that precisely solves one person's problem. Our Version 1 wasn't a form builder tool with two fields. It was a full-fledged form with all the fields that MSO needed. I was manually coding each and every field. Once we solved MSO's problem, they started sharing our good work with their peers from other agencies, which earned us some traction. When our supply of forms couldn't keep pace with demand, we decided to build a form builder.

3 LISTEN TO USERS' PROBLEMS, NOT THEIR SOLUTIONS

We listened to users for their problems, but not their solutions. In the late 1800s, a rider on a slow horse would have asked for a faster horse, not a car. Sometimes a user doesn't know what they need until you put a solution in front of them. Our initial users, such as MSO, asked us to build something like Google Forms, but for sensitive data. A sensible solution might have been to code something like Google Forms, then host it on government data centres. But computing cores on self-hosted data centres could cost S$5,000 per month or more, compared to S$50 per month from commercial cloud services. So instead we hosted the platform on the cloud, but did not store the data there. Each time someone submits a form, data is emailed directly to a public officer's secure Government email. Users loved that there were no concerns over data governance, privacy or security with our product. A meeting with the Ministry of Manpower (MOM) was shortened from 1.5 hours to 15 mins, after I told them: "We don't store your data"!

"

No one is going to remember or bother using a minimal viable product that barely satisfies them.

4 FOCUS ON GETTING THE WORK DONE, NOT HOW IT IS DONE

We did not spend much time on processes. When a user asked how we were able to ship useful features so rapidly with just a team of three, I told him we focused on two things: talking to users and writing code. The Agile method to running software development might make sense for larger teams, but for a small team like ours it adds too much overhead. If we did sprint planning, story pointing and retrospectives, we would have 40% less time to write code. Hence as the product manager, it was just me writing the stories, estimating development effort needed and then assigning them. If we find a process that takes up 20% of our time but increases productivity by only 10%, then it makes sense to remove that process. For example, we started with daily stand-ups—meet-ups of 15 minutes or less where the team literally stands—but ditched it because it made more sense to talk to each other only when there was a need to.

5 MAKE SURE IT'S GOOD, THEN LET SUCCESS MARKET ITSELF

We focused on growth only after we were sure we had a good product. First, a good product is going to sell itself. Elon Musk has highlighted never having spent a single dollar on marketing for his Tesla cars. Steve Jobs advocated the importance of product people and not sales people running tech companies. The biggest reason FormSG grew to serve the entire government was because we built a product that people loved. And people share products they love with those around them. Second, if we focused on marketing our product or pushing for a mandate too early, we might end up shoving a bad product down the throats of our users. That's a quick way to destroy user trust. Because our users loved FormSG, it was easier to introduce other products we've built, such as by.gov.sg, a government link shortener.

6 KILL YOUR DARLINGS

We were very willing to dismantle old features. No one likes to undo their work. Or admit that their feature or product has failed. Which is why it's not hard to find examples of failing products that still get resourced. Once we realise a feature or even an entire model is not working well, we remove them. In the early days, we had progress trackers to give users a sense of how far they were into the form. But on user testing we realised users weren't gauging progress from the "23 of 40 questions answered" label, but the position of the scroll bar! Their eyes never once looked at our label, and continually moved back and forth from the scroll bar to the questions. So we removed progress tracking. And there were many other examples of us undoing things we had done.

Even today with thousands of officers already using our product, we are thinking of revamping our email model. Users dislike the email model because they have to manage email

> ## " No one likes to undo their work. Or admit that their feature or product has failed.

space, and have to manually run a script to collate emails into Excel. We are thinking of a way to store data so submissions can be downloaded directly from our website. But what about not wanting to store data on the cloud? We are now thinking of doing end-to-end encryption, similar to how WhatsApp stores its messages in its servers but does not actually have access to the content of those messages. The idea is that when you create a form, you'll receive a password that is not seen by our server. When a user submits your form, the data is encrypted before being sent to our server. And when you want to view responses, that encrypted data is downloaded but you must provide the password to decrypt them. Even if our database were to be compromised, only the encrypted version of the data will be leaked, with no way to decrypt them unless the attacker has the passwords as well.

7 TAKE THE INITIATIVE, DON'T WAIT FOR THE STARS TO ALIGN

We did not wait for others, but acted immediately to solve user problems. When we first started FormSG, some policy folks said that if Google Forms could handle classified data then that could be used to digitise government forms. But we built FormSG anyway

because we didn't want to wait for that to happen. We were also not confident that Google Forms, a tool best meant for quick and dirty surveys, could have all the features public officers need for official government applications.

There were also plans for a digital signature module. But instead of waiting for that module, we pushed for digitisation of forms with signatures. The Electronic Transactions Act does not prescribe a specific format for an electronic signature. Hence, something as simple as a SingPass login or a checksum-validated NRIC field could suffice as an electronic signature. These digital measures are likely harder to tamper than a wet ink signature. There were also plans for the Government Commercial Cloud to provide Intranet access to our Cloud hosted apps. Instead of waiting for that, we pushed for digitisation of Intranet forms. Although our form is on the Internet, a QR code of the form link can be emailed to officers for them to fill forms from their phones.

We consistently had a bias for action and made the most of the resources we had at hand. We never once delayed work just because we were waiting for someone else to build something.

Looking back, we never once took FormSG offline and said we needed to have a "build phase". We launched from Week 2, and it has stayed online ever since. ∎

> ## " We never once delayed work just because we were waiting for someone else to build something.

# *ARTIFICIAL INTELLIGENCE:*
Impact on Public Safety & Security

by **Rahul Daswani and Jevon Tan**

An integrated and nuanced approach, deploying both humans and machines, will be needed to counter the emerging technology's potential for malicious abuse.

Rahul Daswani leads the Futures team at the Ministry of Home Affairs. Previously a Senior Strategist at the Centre for Strategic Futures, he has also served at SkillsFuture Singapore.

Jevon Tan is part of a team from the Defence Science & Technology Agency (DSTA) embedded in National Security Coordination Secretariat (NSCS), where he identifies risks and threats relating to emerging technologies. Prior to joining NSCS, he was involved in telecommunications acquisition projects and master-planning in DSTA.
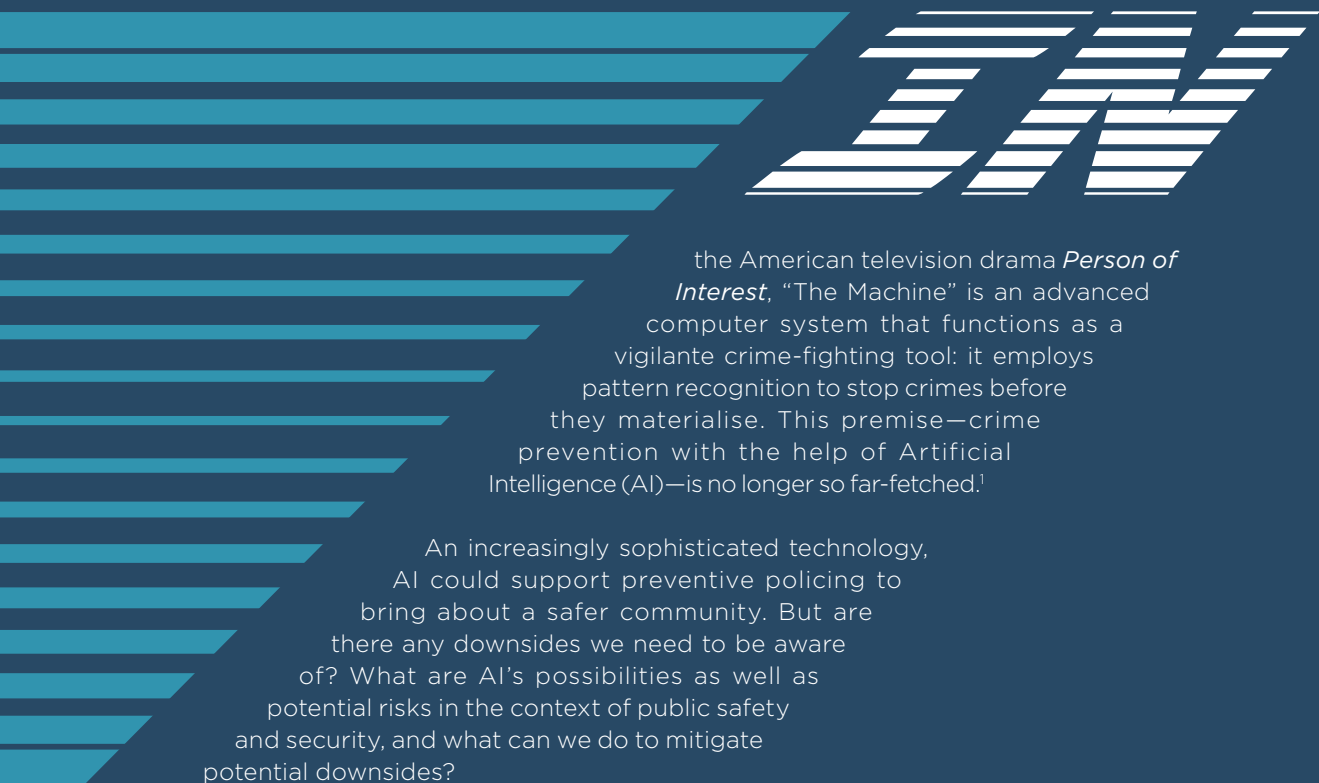
the American television drama *Person of Interest*, "The Machine" is an advanced computer system that functions as a vigilante crime-fighting tool: it employs pattern recognition to stop crimes before they materialise. This premise—crime prevention with the help of Artificial Intelligence (AI)—is no longer so far-fetched.[1]

An increasingly sophisticated technology, AI could support preventive policing to bring about a safer community. But are there any downsides we need to be aware of? What are AI's possibilities as well as potential risks in the context of public safety and security, and what can we do to mitigate potential downsides?

AI ENHANCES OPERATIONAL EFFECTIVENESS

As a set of technologies that simulate human traits such as knowledge, reasoning, problem solving, perception, learning and planning,[1] AI can enhance operational effectiveness through **automation** and **augmentation**. When combined, they complement human expertise, producing faster and better results. While AI can spot patterns that may escape the naked eye, humans can contextualise data insights and decision-making with intuition and experience.

The automation of data-heavy processing tasks, from visual inspections of public spaces to interpreting security video footage, can help to overcome resource constraints. This frees up scarce human capacity for higher-value work and more complex problem-solving, boosting workplace productivity and engagement.

Machine self-learning capabilities have predictive and prescriptive uses. AI creates new sense-making possibilities by quickly generating insights through deeper analysis of data.

AUTOMATING THE HOME TEAM'S OPERATIONAL CAPABILITIES

In Singapore, AI has already found its way into a variety of Home Team[2] border security and homeland security applications. AI-driven perception, processing, and analysis are essential for collecting, sorting, and interpreting data to better inform human decision-making. A leading AI technology now being deployed is machine-learning computer vision technology. AI-backed biometric systems have also become more powerful than ever in spotting patterns in human physiology.

AI—at the intersection of machine learning and robotics—has also given rise to autonomous systems that can tackle more challenging tasks in a wider range of environments. While sensors can provide data inputs to systems, the AI element helps to filter and make sense of data, and can recommend particular actions. Unmanned Aerial Vehicles (UAVs) are robotic autonomous systems that give our officers a bird's-eye view of a situation, so they can make better ground decisions. In the future, the UAVs could incorporate AI in the following forms:

a. "Computer Vision & Learning"— the ability to analyse visual input;
b. "Machine Perception"—the ability to processing input from a variety of sensors; and
c. "Motion Planning"—the ability to break down a desired path into smaller, more manageable segments.

The Singapore Civil Defence Force (SCDF) has deployed UAVs in monitoring activities outdoors and in public spaces, such as fire tracking, surveillance, and Search and Rescue missions. The integration of these systems complements current operations and aims to improve operational effectiveness. An example is SCDF's use of a Red Rhino Robot (or 3R) for autonomous fire detection, with an auto heat-seeking mechanism to help find heat sources. This robot can

WHILE AI AUGMENTS CAPABILITY, IT CANNOT ENTIRELY REPLACE HUMANS.

ICA officers at the Automated Biometrics & Behavioural Screening Suite (ABBSS) Command Centre at Woodlands Checkpoint. With more than 280,000 travellers passing through every day, technology is a key enabler in keeping the Checkpoint secure. Similar capabilities will soon be deployed at other border crossings.

ABBSS can quickly identify Persons of Interest, allowing officers to deal with potential security threats swiftly.

The Sky ARC vehicle carries various types of UAVs and communications equipment that relay information back to ground commanders in real time.

Unmanned Aerial Vehicles (UAVs) can fly up to a few hundred metres in altitude, and can be equipped with different payloads such as thermal imaging and high zoom cameras. Footage can also be live-streamed for viewing by ground commanders and police command centres, providing valuable intelligence to enhance decision-making.

Source: Photos courtesy of the Ministry of Home Affairs

AI Integration in Singapore's Border Security Operations

Iris scans were introduced on a trial basis at the Woodlands Checkpoint in July 2018, enhancing the existing network of cameras with the facial recognition capabilities of the Automated Biometric and Behavioural Screening Suite. The Immigration & Checkpoints Authority plans to roll out the Suite progressively at all checkpoints.

Video analytics and screening capabilities identify suspicious objects and individuals, and conduct quick biometric identity verification. This reduces manpower requirements and also increases operational effectiveness. Since its introduction, the system has swiftly detected foreigners wanted for offences such as overstaying.

potentially reduce a traditional four-man crew to a team of three, and penetrate far deeper into the seat of fire without risking a human firefighter.

AUGMENTING THE HOME TEAM'S OPERATIONAL CAPABILITIES

UAVs also augment police neighbourhood patrols. The UAVs can transmit a live aerial video feed to a Police Operations Command Centre (POCC), facilitating their dispatch to the crime scene. Advanced sensors, intelligent autonomous navigation and mapping algorithms may be progressively added to these UAVs to improve obstacle detection and avoidance.

The Home Team is well aware that AI is not a magical silver bullet that will solve all problems: different operations call for different degrees of technological intervention. While AI augments capability, it cannot entirely replace humans. The use of UAVs, for example, enhances the present force's capabilities and effectiveness, with the same manpower resources. But our frontline officers remain relevant to the community they serve in. Officers bring a human touch, and an assuring sense of safety and security to the community. Human touchpoints that communities value cannot easily be replaced by AI.

POTENTIAL FOR EXPLOITATION

Any emerging technology is a double-edged sword, with potential for abuse by malicious actors. Automation and augmentation through AI have contributed to such widely reported abuses as cybersecurity breaches and

HUMAN TOUCHPOINTS THAT COMMUNITIES VALUE CANNOT BE EASILY REPLACED BY AI.

Case Study: Emergency Management

The Ministry of Home Affairs uses UAVs (also known as drones) to conduct aerial surveillance for forested operations, fire management and crowd monitoring for mass public events such as the New Year's Eve Countdown. Equipped with high-definition cameras that transmit clear images of people and objects on the ground, the drones use thermal-imaging capabilities to help identify human heat signatures—a boon for spotting suspects in densely-forested areas, especially at night.

Since December 2016, the drones have helped police to nab three criminals conducting illegal activities in the forest; they have also monitored major pipelines, and even traffic congestion at checkpoints. In October 2018, police officers caught 125 illegal immigrants via night-time drone operations in the western and northern parts of Singapore.

fake news distribution. Understanding how malicious agents can manipulate AI technologies to their advantage is crucial in mitigating potential threats.

The "Thinking" Malware

In 2017, 62% of the attendees at Black Hat USA 2017—the world's leading information security conference—said they believe artificial intelligence will be used for cyberattacks in the near future.[3] In fact, this has already happened. IBM security researches have uncovered a new breed of AI-powered cyber-attacks that can automatically target vulnerabilities with greater speed and accuracy.[4] Deep Locker, a recent product of IBM Research, demonstrates how AI-powered malware is highly successful at evading traditional detection.[5] Automated to attack with peak effectiveness and with self-learning capabilities, each attempt becomes more effective than the last.

The first observed example of an AI-backed malware hack was executed in 2017, on an India-based company.[6] Embedded algorithms allowed the software to first observe and figure out the typical user's network behaviour, and then mimic their digital footprints to evade surveillance detection long enough to complete the hack. Data breaches may now go undetected for

ANY EMERGING TECHNOLOGY IS A DOUBLE-EDGED SWORD, WITH POTENTIAL FOR ABUSE BY MALICIOUS ACTORS.

longer as AI-powered attacks emulate this detection-evading mechanism.

ONLINE FALSEHOODS SUGGEST HOW AI COULD BE MANIPULATED TO FOOL PEOPLE MORE EFFECTIVELY AND QUICKLY.

AI's Role in Fake News

The ease of access to emerging technologies means AI is as readily available for use by malicious actors as by proper authorities. Deliberate online falsehoods, the online proliferation of false stories often embedded with social, economic and political biases with the malicious intent of misleading audiences for gain, are becoming increasingly common. The generation of these increasingly realistic falsehoods suggest how AI could be manipulated to fool more people more effectively and quickly.

Neural networks underpinning AI technologies have augmented multimedia editing. Almost perfect image and video manipulations are now achievable, creating photo-realistic images and mimicking voices seamlessly. These are known as "Deep Fakes".[7] Discerning between what is real and fake online is no longer straightforward. A viral video of Barack Obama, where the former US President is seen and heard using expletives, was made using Adobe's After Effects software and the AI face-swapping tool FakeApp. The fake footage was swiftly disseminated across many virtual platforms, garnering over 3.7 million views within a week.[8] This shows just how attention-grabbing and persuasive fakes can be.

> "
> At present, even an AI of tremendous power will not be able to determine outcomes in a complex social system, the outcomes are too complex—even without allowing for free will by sentient agents...
>
> Strategy that involves humans, no matter that they are assisted by modular AI and fight using legions of autonomous robots, will retain its inevitable human flavor.[9]
> "
>
> — Kareem Ayoub and Kenneth Payne

STRENGTHENING OUR RESILIENCE FOR THE FUTURE: AI AND BEYOND

Cybersecurity

For all the inherent risks AI presents in self-mutating malware, the answer might ironically lie in harnessing the power of AI itself to strengthen existing cybersecurity setups. SparkCognition, a US-based company, developed an entirely AI-based solution called Deep Armor in 2017.[10] It is the first cognitive antivirus software that leverages AI to identify mutating online viruses and

MITIGATION MEASURES MUST GO BEYOND TECHNOLOGY: THE RESPONSE NEEDS TO BE ALL-ROUNDED, INVOLVING CITIZENS AND PUBLIC-PRIVATE COLLABORATIONS.

detect malware approaches, including advanced malware masking techniques, and stepping up against more sophisticated cyberattacks. AI can therefore be tapped to upgrade cybersecurity capabilities not only in detection and response, but also preventive defence.

In parallel, a deliberate talent strategy will be important, to recruit and deploy those with the expertise to work with AI to boost cybersecurity. For example, Thailand's government agencies have begun deploying sensors running AI algorithms, incorporating predictive analytics in cyber network monitoring systems.[11] At the same time, a new digital forensics team is being developed to specifically investigate digital evidence from cyber-attacks.[12] These projects accompany plans to raise existing employees' digital literacy, while looking overseas to recruit experts. Such a move aims to combine AI-enabled prevention and protection systems' algorithmic decision-making, with flexible human interaction and supervision.

Dealing with Fake News

Research is already being carried out on how to deploy AI in detecting falsehoods. The machine can be trained to analyse text and determine how likely it is that a particular message is a real communication from an actual person, or a mass-distributed solicitation.[13] Building on a similar type of text analysis to spam-fighting, AI systems are also trained to evaluate how well a post's text, or a headline, compares with the actual content of an article someone is sharing online. Another method could examine similar articles to see whether other news media have differing facts. Similar systems can identify specific accounts and source websites that spread fake news.

However, mitigation measures must go beyond technology: the response needs to be all-rounded, involving citizens and public-private collaborations. To inoculate the community against falsehoods, Singapore government agencies such as MCI[14] and IMDA have begun efforts to promote better media literacy[15] through educational forums, training users to critically evaluate and independently report suspicious information.[16]

A Broader Perspective

From the security perspective, a multi-agency effort is needed to establish a framework so that agencies understand the appropriate responses to different risks. Relevant agencies are also working together to anticipate and identify emerging security risks linked to such technology adoption, and to build up capabilities to address these risks.

As we gain a better understanding of AI, we will be better at mitigating its dangers. Exciting times are ahead—we have entered a brave new world. ■

Notes

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REGULATING DIGITAL TECHNOLOGY:

REAL WORLD CHALLENGES AND OPPORTUNITIES

by **David Hardoon and Shameek Kundu**

David Hardoon from MAS and StanChart's Shameek Kundu offer perspectives on the implications of emerging innovations, on and beyond the financial industry.

David Hardoon was Chief Data Officer and Head of the Data Analytics Group at the Monetary Authority of Singapore (MAS). He is now Special Adviser (Artificial Intelligence) at MAS.

Shameek Kundu is Chief Data Officer at Standard Chartered Bank (StanChart).

David Hardoon

Shameek Kundu

1 WHAT ASPECTS OF EVOLVING SOCIAL NORMS SHOULD BE TAKEN INTO CONSIDERATION AS THE USE OF DIGITAL TECHNOLOGIES BROADENS?

Hardoon:

I will discuss digital technology in the context of financial services, i.e., FinTech, which broadly refers to the application of technology to financial services. FinTech has been an important theme in financial regulation over the past two decades, and it continues to evolve.

Digital disruption can potentially transform the financial industry for the better. But these same technologies can also potentially be misused. For this reason, MAS has partnered with the industry to encourage innovative use of these technologies while putting in place the right conditions for their ethical usage.

The aim is two-fold. We want to encourage financial institutions to innovate and experiment using the latest technologies. At the same time, we want them to bear in mind a set of principles that promote *Fairness, Ethics, Accountability and Transparency* (FEAT) in their use of Artificial Intelligence and Data Analytics.

Kundu:

A number of areas will need to be handled judiciously. One is privacy: the individual's right to their own data should be recognised. Another is the need to treat both consumers and employees *fairly.* This includes avoiding unintended bias—it may be fine if there are legal, appropriate and purposeful reasons for certain kinds of bias (e.g., intentionally

not lending to those who may not have the means to pay back), but not if such bias has crept in unintended due to an opaque, poorly-understood algorithm.

We have to watch for *predatory pricing*, such as practices that may produce positive surplus for consumers in the short term but which destroys competition or are not in customers' interest in the medium to long term.

Using disruptive technology is no different from any other business decision. Just as companies are held *accountable* for the environmental impact of their actions, they should also expect to understand, track and ultimately own up to the impact of their technology use—e.g., on consumers' health, stoking of conflict in society, and so on.

> Companies should expect to understand, track and ultimately own up to the impact of their technology use.

Companies should also take care to not remove *human agency* altogether through the introduction of disruptive technologies, at least until such time as the particular technology and its applications have matured fully.

Finally, disruptive technologies and the innovations they bring should more clearly demonstrate their *broader positive impact on society* (e.g., enhancing financial inclusion is arguably a much bigger "call to arms" for FinTech innovation than new services or user interfaces).

> *Enhancing financial inclusion is arguably a much bigger "call to arms" for FinTech innovation than new services or user interfaces.*

2. WHAT IS THE RIGHT APPROACH TO REGULATING DIGITAL TECHNOLOGIES?

Hardoon:
As a regulator, MAS views regulation as playing a central role in promoting innovation and technology. In fact, achieving continued innovation means that we must get regulation right. Fundamentally, it is about ensuring that risk is managed, while facilitating innovation.

> *Achieving continued innovation means that we must get regulation right.*

As a starting point, this sometimes means not rushing to regulate. Introducing regulation prematurely may stifle innovation and potentially derail the adoption of useful technology. Materiality is key here. This means we want to allow regulation to kick in only when the risk posed by the new technology becomes material, and arrive at regulation that is proportionate to the risk posed.

Where appropriate, we have different regulatory levers and approaches to support the industry's adoption of FinTech. First, since technological innovations create new opportunities as well as new risks, MAS strives to provide timely clarification to the industry on where the risks could lie, and how existing regulations could apply to such new technologies. Second, we regularly review our regulatory framework to ensure it is fit for purpose. An example of where we are taking such steps is in the payment services area, where we are experiencing a surge in innovation. The new Payment Services Act, which will come into force early next year, is an *activity-based regulatory framework* that allows MAS to more effectively regulate all relevant segments of the payments ecosystem in Singapore, including new services enabled by evolving technologies.

The potential benefits of FinTech are immense. While our story of FinTech regulation is still unfolding, there are three areas where good progress has been made in the last ten years: in the setting of standards for distributed ledgers, in making cloud computing services safer, and in the area of artificial intelligence. FinTech developments are forcing regulators to review the way regulation is done. If FinTech is unbundling the financial services value chain, then regulators may have to, where appropriate, "unbundle" or "re-calibrate" their regulations too.

Regulators must run alongside innovation.

Regulators must run alongside innovation, keeping pace with developments, assessing the risks, evaluating whether it is necessary to regulate or leave things to evolve further and where appropriate, provide monetary incentives to support the development of an innovative ecosystem. MAS regularly engages the ecosystem to learn and understand about new technologies. MAS also conducts and participates in proof-of-concept projects with the industry to better understand certain technologies. We will continue to calibrate our response, whilst maintaining the ethos that regulation should not front-run innovation, and having regulation that facilitates innovation.

Kundu:

Regulations need to strike a balance: between the freedom to experiment and explore, and the certainty of not falling foul of rules inadvertently, particularly as early experiments become mainstream. They should establish a level playing field between incumbents and challengers (both within and outside the industry). Regulatory requirements should be commensurate with the potential material impact of a breach or level of risk. There should be alignment—between different regulations in a country (such as banking and privacy regulations), and also where possible between countries: which is particularly relevant for MNCs.

In some countries, banks are struggling with increasing restrictions on accessing data across borders. The rationale for "data sovereignty" rules is well understood, but to the extent that these might impede innovation and stifle other government objectives (e.g., enabling cross-border investment and trade, and preventing money laundering and terrorism financing through data sharing), there may be room for refinement.

The FEAT (Fairness, Ethics, Accountability and Transparency) principles for the use of Artificial Intelligence in Financial Services by MAS illustrate much of what industry would like to see in the regulatory space. FEAT principles were preceded and followed by meaningful industry *consultation and co-development;* are *principle-based* instead of *rule-based*, with practical illustrations of how the principles should be interpreted; recognise the need to balance risk and innovation; *offer a level playing field* for both incumbents and new entrants; are *flexible* on how the principles can be implemented (e.g., creating a new AI governance framework or embedding into existing risk frameworks); they allow industry response to be *calibrated* based on materiality of impact.

> Regulatory requirements should be commensurate with the potential material impact of a breach or level of risk.

3 HOW SHOULD A GOOD REGULATORY SANDBOX BE DESIGNED TO ENCOURAGE USEFUL EXPERIMENTATION AND INNOVATION WITH DIGITAL TECHNOLOGY?

Hardoon:

To date, there are at least two distinct models of sandbox: (1) product testing sandboxes and (2) policy testing sandboxes.

The sandbox by MAS takes the second approach. The sandbox facilitates live experimentation of innovative financial services and business models within pre-defined boundaries. It is a mechanism to evaluate whether particular rules of regulations should be changed on specific use cases. This helps MAS identify regulations that may no longer be relevant due to the use of new technologies in the financial sector.

Operating and maintaining a sandbox is not without cost. In one developing economy, the process involved extensive public consultation and market landscaping. It also involved significant internal consultation, estimated at around six days each for 10 to 15 members of senior management and a three-day workshop for around 18 staff members. One regulator in an advanced economy has the equivalent of 10 full-time staff supporting the sandbox function. Another has just one full-time staff member running the sandbox, consequently resulting in significant bottlenecks. Given this constraint, jurisdictions should not rush into creating sandboxes. There are clear cases where sandboxes have slowed down or impeded innovations because of limited manpower to support its operations.

Kundu:

A good regulatory sandbox needs to provide a meaningful platform for the industry to prove or disprove technologies or business models. It should have a number of features, such as having *clear objectives* (not "solutions looking for a problem"). Ideally, it should focus on opportunities that involve *multiple players* in the industry (including a partnership between incumbents and new entrants) and/or government, and involve real-world rather than hypothetical or synthetic data.

> A good regulatory sandbox needs to provide a meaningful platform for the industry to prove or disprove technologies or business models.

A good sandbox should be appropriately *scaled*: if it is too small, for instance, the experiment could have very little value outside the sandbox. There should be clear *supervisory and regulatory guidance* throughout the sandbox trial, based on continuous communication and partnership between the regulator and sandbox participants.

Finally, the sandbox should focus not just on proving concepts but on creating confidence about the *ability to scale up* and "productionise" the new technology application or business model.

4 WHAT DO INDUSTRY AND REGULATORS NEED TO UNDERSTAND ABOUT EACH OTHER'S RESPECTIVE STANDPOINTS IN THE DIGITAL ECONOMY?

Hardoon:

MAS is in a unique position. It is not only a regulator, but also an industry developer. Deepening innovation and digital transformation for the financial industry remains important, as is the consideration of risks when adopting new technologies.

As a regulator, we continuously strive to deepen our understanding of emerging technologies, including the risks and opportunities they present. I view regulatory sandboxes as a means to enhance collective understanding of such new technologies that impact the future of financial services. Therefore, working jointly is important especially when we do not have all the answers in advance. One of my favourite adages is particularly apt here: "when in doubt, ask".

> Working jointly is important especially when we do not have all the answers in advance.

Kundu:

In some ways, regulators may benefit from staying true to their original objectives even when looking at digital disruption. For example, in the financial services context, this would have historically included: stability of, and trust in, the financial system; safety and soundness of firms; financial inclusion, fair treatment for customers; (responsible) growth of the industry in the country.

But while there is value in staying firm on the objectives, regulators will need to think about some additional factors as well. This includes such factors as a dramatically greater pace of change, with increasing complexity and concentration of risk.

Indeed, the very definition of who should be regulated in a given "industry" have changed completely. Sectors like media and retail are already unrecognisable compared to a decade ago; others like automobiles and transport are being rapidly transformed.

In this environment, networks and platforms have become vital. This means we need to go well beyond individual firms to looking at an entire ecosystem of partnerships, for instance.

Needless to say, data has become central to the business. Policymakers and regulators will need teams with a different set of skills, including a manifold increase in competencies related to technology and data.

On the tech front, there is a risk of good intentions papering over an inadequate risk culture—many digital innovators may have limited experience working in regulated industries; while their approaches may be good for challenging or disrupting old assumptions, some can also be naive about the risks they are creating for themselves and society.
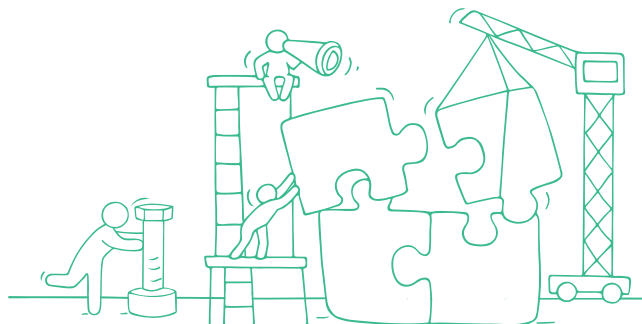
> There has to be as much thought on supporting those left behind and correcting for the negative impact of disruption.

5. IN AN ENVIRONMENT OF RAPID DIGITAL DISRUPTION, HOW CAN GOVERNMENTS CREATE POLICIES THAT DELIVER BOTH STABILITY FOR ECOSYSTEMS AS WELL AS RESPONSIVENESS TO CHANGE?

Hardoon:

This question captures succinctly, the "new" model regulators operate in. My view, as I've explained, is that: One, *that regulation should not front-run innovation*: introducing regulation prematurely may stifle innovation and potentially derail the adoption of useful technology. Two, *regulators must run alongside innovation*, keeping pace with developments, assessing the risks, evaluating whether it is necessary to regulate or leave things to evolve further and where appropriate provide monetary incentives to support the development of an innovative ecosystem. Three, *accepting that we do not have all the answers in advance.* Therefore, keeping abreast with developments, engaging the industry and staying nimble are key to operating in this new normal.

Kundu:

Looking beyond individual industry regulators, some additional "whole-of-government" considerations would be useful.

First, within a country, regulators across industries may need to work much more closely. The same companies will enter, and perhaps seek to dominate, multiple industries. Cross-cutting concepts around ownership and custodianship of data will become more critical. The pool of skill-sets available to regulators will become smaller. As a result, cross-agency collaboration will become key.

There will also be much greater need for cross-border alignment and cooperation (though this is easier said than done!). It is particularly important for small open economies like Singapore.

There has to be a willingness to make, accept and then correct mistakes. Regulators are likely to end up making decisions that become irrelevant or even counter-productive over time due to changes in technology. In this light, regulators could look to provide guidance in the first instance, rather than impose binding regulation.

Finally, it is important to recognise that digital disruption *will* have a negative impact in some areas (the most obvious being the destruction of existing jobs). "Win-Win" situations will not always be possible. There has to be as much thought on supporting those left behind and correcting for the negative impact of disruption. In this, governments may even need to make the (largest) disruptors take a share of the responsibility. ■

What DIGITAL SUCCESS Looks Like:
Measuring & Evaluating Government Digitalisation

by **Aaron Maniam**

Seven indicators could offer a more comprehensive and useful overview of how well the public sector is doing in going digital.

Aaron Maniam is currently Senior Principal Researcher at the Institute of Governance and Policy, Civil Service College, while he works on a PhD on digital transformation of governments with the Blavatnik School of Government, Oxford University. Previously Senior Director (Industry) at the Ministry of Trade and Industry and Institute Director of the College's Institute for Public Sector Leadership, he was the first Head of the Centre for Strategic Futures, and has also served with the Singapore Foreign Service. He has published two collections of poetry and is a Fellow of the Royal Society for the encouragement of Arts, Commerce and Manufactures (RSA).

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n adage often attributed to management guru Peter Drucker goes: "What gets measured gets done". This is probably easier to understand in its converse form: "What we cannot measure, cannot be managed".

Despite Drucker's insight, a growing number of governments are claiming to "go digital" by incorporating digital technology into their internal administration and service delivery—but measure their efforts woefully imprecisely. For every government that is aiming to "digitalise", one can find a different and often competing definition of what that means. Consequently, measures of digitalisation are often patchy and poor.

MEASURING DIGITALISATION

It is not that measurement is being ignored. There are many frameworks assessing e-governance, including efforts by the United Nations, Organisation for Economic Co-operation and Development (OECD), World Bank, European Union, Waseda University's International Academy of Chief Information Officers, the Fletcher School of Law and Diplomacy at Tufts University, the World Wide Web Foundation, and the Open Knowledge Network.

The problem is that existing measurements are flawed and insufficient. Take, for example, the UN Department of Economics and Social Affairs (UNDESA)'s E-government Development Index (EGDI) and the World Bank's Digital Adoption Index (DAI)—the most comprehensive measures currently available. They cover all countries, unlike other regional or sector-focused frameworks.

The EGDI includes three sub-indices:

I. an Online Services Index (OSI) indicating how far public services are delivered digitally;

II. a Telecommunication Infrastructure Index (TII) assessing a country's number of internet users, mobile subscribers, telephone subscriptions, and wireless/fixed broadband subscriptions; and

III. a Human Capital Index (HCI) measuring adult literacy, enrolment ratios in primary, secondary and tertiary education, as well as expected and average years of schooling.

The DAI also includes three sub-indices:

I. a Business Indicator measuring Third Generation (3G) mobile coverage, download speeds and server security;

II. a People Indicator measuring Internet and mobile access in homes; and

III. a Government Indicator measuring the extent of online public services, digitalisation of core administrative systems and the presence of a digital identity (ID) system.

Both indices are problematic on several counts. In some ways, they include too much to precisely reflect government performance: the EGDI's TII and HCI indicators cover much more than government or even business digitalisation, even if issues like mobile infrastructure and measures of education system quality are important in a broader sense. The DAI assigns a very high weightage to digital ID systems, ignoring how some advanced digitalised systems do not have one. This leads to the anomalous situation where the UK, the 2016 EGDI's top ranked country, has a mediocre showing on the DAI with an index score of 0.59 on the government indicator.

In other respects, the indices include too little. They focus on numerical measures of the *presence* of digital technology in government (output measures), but do not evaluate the *quality* of digitalised government (outcome measures). To be fair, most scholarly work has not done this either, and only one 2006 study, by Patrick Dunleavy, Helen Margetts, Jane Tinkler and Simon Bastow,[1] has attempted a rigorous evaluation.

In that study, three particular aspects of digitalisation in seven governments (Australia, Canada, Japan, the Netherlands, New Zealand, the United Kingdom and the United States) were examined:

I. the success rate of government IT (measured inversely by how often key IT projects are scrapped);

II. the price comparability between public sector and private sector IT; and

III. the relative modernity of government IT systems, including hardware, software and network speed (compared to private sector systems).

Thirteen years on, countries now offer a richer empirical set of digitalisation experiences to test whether these three measures of success have proven relevant. Singapore's own Digital Government Blueprint, for instance, suggests several key performance indicators by which Smart Nation policies and programmes should be evaluated—these include and expand on the major indicators suggested so far by both policymakers and scholars.

I suggest seven measures that can be used to evaluate public sector digital efforts, both in Singapore and more broadly. I argue that:

- the first two indicators in Dunleavy et al. (i.e, success and price) should be retained;

- the third needs to be rephrased, since a system's modernity is not an unqualified good; and

- four new variables are needed: usage, usability and usefulness of government digital platforms to citizens, businesses and other stakeholders; security of government data; timeliness of completion for major government IT projects; the use of data and data analytics for broader policy purposes.

My seven suggested measures are as follows:

The indices focus on numerical measures of the *presence* of digital technology in government (output measures), but do not evaluate the *quality* of digitalised government (outcome measures).

1 Success of digital projects

Following Dunleavy et al., a digital system's success can be measured inversely, by the number of projects scrapped. This indicator matters because of the loss of investments involved during such write-offs. Project scrappage is likely to be affected by factors including:

- size, scale and specificity (modularity) of projects;

- existence of rigorous techniques and/or institutional processes for IT sector planning;

- whether projects proceed in well-defined stages;

- whether projects are backed by senior leadership (either political or from key central agencies like Finance Ministries);

- whether there is internal IT expertise to assess and implement digital projects;

- whether there are meaningful contractual controls at the project selection stage; and

- use of pilot studies and phased rollouts, rather than moving immediately to implement new platforms at scale.

Two nuances are worth noting. First, non-scrappage of projects may not always be positive, e.g., Japan has a culture of not publicly admitting project failure due to fear of reputational damage; instead, additional resources are channelled to fix problematic projects, and success is

not purely externally determined. Such instances will have to factor into any assessment of different projects' success. Governments should be measuring genuine project *success*, not merely project *survival*.

Second, instances of scrappage should be of full-fledged projects, not pilots or beta-versions, which are intended to be more iterative and adjustable, in line with more agile approaches that are increasingly the hallmark of digital systems.

Governments should be measuring genuine project *success*, not merely project *survival*.

2 Price competitiveness of government digital projects

This measure refers to the money cost of government projects, compared with similar efforts in other governments and other sectors. It measures whether governments are overpaying or obtaining value for money in their expenditure. Price competitiveness is likely to be influenced by:

- the presence of incentives for civil service leaders to secure defensible prices (e.g., "value for money" audits or requirements for smart commissioning);

- the degree of focus on modular, medium-sized projects instead of large-scale behemoths;

- government tendering processes and contract scrutiny within government, public scrutiny, and potential contractual challenges for losing firms. Onerous

processes can lead to erosion of joint profits and returns, causing firms to be highly circumspect about bidding for a government project, unless the price is sufficiently high;

- whether and to what extent successful price dampening mechanisms like call-off contracts, electronic marketplaces and open-market purchases exist;

- the occurrence of forced outsourcing (creating a closed and concentrated market);

- the nature of relationships between firms and governments;

- firms specifying contractual terms in ways that protect them from future market changes; and

- long-term contracts that lead to only incumbent firms being able to deliver mid-contract modifications.

One nuance to watch for is to avoid simplistic quantitative comparisons between public and private sector projects. Government projects could be large, more complex and differently structured from those in the private sector, which can result in price premiums (e.g., IT for some government agencies may require helpdesk support 24 hours a day, 7 days a week, throughout the year). The key question is whether these premiums are justifiable, or merely the result of excessive risk-averse behaviour by commissioners of government IT projects.

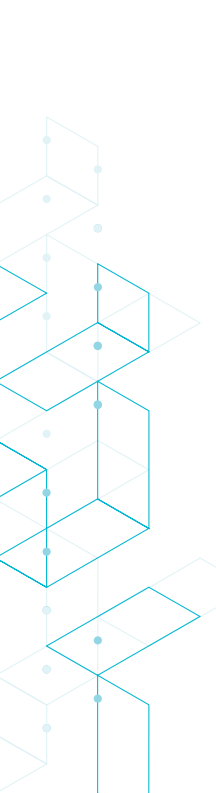## Avoid simplistic quantitative comparisons between public and private sector projects.

3 Relative effectiveness of government IT systems

Dunleavy et al. consider the "relative modernity" of government IT systems, compared to private sector adoptions. This includes the quality of back office systems, large databases, front-office software, desktop systems, web-compatible systems, network speed and bandwidth, the development level of e-government services (compared to e-commerce, fintech and other Web-oriented services), existence of legacy problems, recency of transition to fully Web-enabled networks, pace of generating government websites, support to citizens in navigating e-bureaucracy, and adoption of up-to-date technical standards.

Such elements make sense as indicators of how successfully a digital system meets its aims, but the term "modernity" is unnecessarily loaded and problematic. Modernity is not an unqualified good: there can be many reasons why governments and even companies might avoid recent software or hardware, including the desire to avoid bugs in early versions. This is why many organisations, both public and private, ask employees not to download new versions of apps until they have been tested by IT departments. Nevertheless, the spirit of the modernity argument is correct, in the sense that IT systems cannot be so old that they become unwieldy and inefficient—as the email client Lotus Notes was for many governments by the late 1990s.

Whether systems are old or new, their capacity to deliver output and outcomes

is key. Hence my suggestion that we should focus on the "effectiveness" of a system. This involves several aspects:

- Effectiveness as a digital system: including hardware reliability, software efficiency, bandwidth sufficiency;

- Effectiveness as a specific system: e.g., a digital tax system might focus on results like higher revenue collection, higher compliance levels and lower evasion/fraud, higher tax morale, reduced costs, increased audit efficiency, reduced occurrence of activities like money laundering, more expeditious license and identification etc; and

- Dynamic effectiveness: e.g., through the use of technology-neutral approaches and regular reviews, to "future-proof" systems and mitigate against over-reliance on particular platforms (ICAEW 2016).[2]

Whether systems are old or new, their capacity to deliver output and outcomes is key.

This variable is likely to be affected by the fiscal resources needed to purchase quality systems, and whether there is a clear strategic process to move services and platforms online. It will also be influenced by provisions for change management and business process re-engineering as agencies move to new systems, and the extent a government is willing to overhaul systems or apply efficacious software patches.

In some cases, there may be trade-offs in different dimensions of effectiveness.

For instance, the customisation of digital systems for government needs might also create structural "lock in", which could impede future flexibility and system effectiveness.

Usage, usability and usefulness of government digital platforms

Usage, usability and usefulness of government digital systems signify the difference between "white elephant" systems and those genuinely serving citizen needs. They are measured by the number of users of government digital platforms, the proportion of such users relative to the total number for a particular service (if the service has an "offline" delivery option), and user experiences of the systems (including time spent on particular functionalities and the ease of use of web services). Usage, usability and usefulness will be determined by how personalised, simple, consistent, intuitive and real-time a system is. The ways in which these aspects are manifested include:

- the existence and prevalence of "digital by default" platforms;

- whether, and how easily, citizens and government officials can circumvent digital processes;

- reduction or eradication of time delays in operational processes like form-filling;

- the possibility of pre-populated forms and real-time information provision to government agencies;

- the presence or absence of digital accounts for government services

Usage, usability and usefulness of government digital systems signify the difference between "white elephant" systems and those genuinely serving citizen needs.

that allow citizens and businesses to have a "single view", e.g., of their tax position;

- provision of support services by digital platforms like online billing and refunds, e-invoicing, and Helpdesk facilities via webchats, webinars, chatbots, secure messaging, social networking sites, YouTube videos and other digital means;

- sufficient support for users with a range of disabilities (e.g., difficulties seeing websites) and other provisions for those unable to access online platforms like older citizens or those in areas with poor Internet coverage (e.g., a continuation of at least minimal provisions for paper-based filing, and/or a network of accessible and affordable tax agents who can file returns on behalf of taxpayers);

- ability of citizens and businesses to choose how they receive services;

- transparency and regular updates on government decisions about queries or particularly complex cases;

- the extent to which government is anticipatory rather than reactive, initiating recommendations or actual service delivery to citizens/businesses rather than waiting for requests or queries;

- platforms and provisions for co-created service delivery;

- the degree of data integration among government agencies, and between government and other bodies (e.g. banks, building societies, pension administrators, mortgage providers, and unions); and

- extent of digital system adoption by government employees themselves, e.g., mobile, apps, social media for more flexible and agile customer support.

The extent of internet penetration critically determines these outcomes. These use-related variables are important proxies for digital access, which is neither uniform nor universal in most countries. In Estonia, for instance, there are already documented instances of older, rural dwellers being left out of national digital frameworks, despite the country's high level of aggregate digitalisation.

5 Security of government data

As concerns over individual privacy and collective data integrity rise, the overall security of such data will be a key new dimension of any successful digitalisation—as Singapore has experienced with health data in the past two years. We can measure the security of government data by the number of security breaches in the period under study, and the time taken to respond to them. Breaches could include phishing, man-in-the-middle
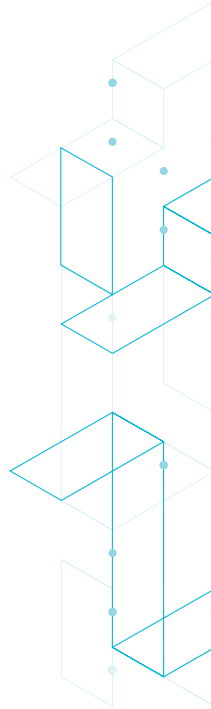
attacks, identity theft, spearfishing, social engineering and other forms of cyber-security breaches (ICAEW 2016).

This indicator measures the quality of governments' internal data governance processes, not just their citizen-facing delivery capacity. Observable dimensions include: the existence of protocols for data governance (e.g., classification, extraction); the use of stewardship models, change-control mechanisms, enhanced encryption, increased identification, identity and rights management, secure ID, and multi-factor authentication, including biometrics; and how effectively a government uses platforms like cloud computing or hybrid cloud.

6 Timeliness of completion for major government IT projects

This measure indicates governments' capacity to translate an initial idea for a digital project into tangible outcomes within a reasonable timeframe. It is likely to be influenced by the size of each project, as well as the presence of expertise able to anticipate and pre-empt potential obstacles early. Such expertise could be internal or outsourced to contractors with a direct link to internal decision-makers.

7 Data use in policy, strategy formulation, organisational design and delivery

Where earlier measures consider the use of digital systems by citizens and businesses, this measure indicates how government agencies themselves use the opportunities created by digitalisation. This includes harnessing digitally collected and synthesised data to understand broad fiscal patterns and generate insights specific to companies and key citizen segments. For instance, when digital technology is applied to taxation:

- data analytics platforms could be treated as predictability models based on taxpayer information from e-invoices, and used to identify taxation deviations that determine pre-populated tax returns and generate broad-based "fiscal intelligence";

- tax agencies could make appropriate data available as building blocks for other government agencies, like Ministries of Finance; and possibly third parties, to integrate broader service offerings (Microsoft and PWC 2017)[3]. Current examples include the OECD's use of (i) consolidated databases and analysis of i-extensible Business Reporting Language (iXBRL) tagged company accounts, and (ii) Standard Audit File for Tax (SAF-T) requirements to standardise tax reporting by businesses, and generate mutually comparable data streams;

- the use of artificial intelligence (enabled by data-driven machine learning) to combat corporate tax evasion e.g., work by the Computer Science and Artificial Intelligence Laboratory, at the Massachusetts Institute of Technology, to develop

As concerns over individual privacy and collective data integrity rise, the overall security of such data will be a key new dimension of any successful digitalisation.

the AI "STEALTH" (Simulating Tax Evasion and Law through Heuristics);

- cash registers at any commercial establishment could be directly linked to a tax agency, facilitating more accurate estimates of revenues from Value Added / Goods and Services taxes; and

- a combination of tax payment data combined with behavioural nudges reminding taxpayers to make payments, as was done in a project by the Danish Nudge Unit.

Potential responses to such data include restructuring an agency, crafting strategies or developing key performance indicators (KPIs) around citizen and business needs, rather than supply-driven factors (e.g., by function or region).

Such data analytics and data matching could contribute to increasing compliance and refining audit efforts. Continuing with the taxation-related examples, Bas Jacobs' 2017 chapter in an International Monetary Fund publication identifies several ways in which tax agencies might use data to enhance their "tax enforcement technology"[4]: higher quality data on individual consumption (through digital platforms), better linked data on wage and capital income, better cross-border linkages of data on wages and capital, enabling financial institutions to be third party reporters on capital income and wealth, and enabling consumers as third-party reporters.

This variable is likely to be strongly influenced by the quality of the technological system in use by each agency, the complexity of the tax regime, and the presence of expertise to collect, connect, curate and communicate the data such that it is relevant to policy, strategy and organisational design.

CONCLUSION

Alone, none of these proposed indicators sufficiently capture the quality of a digitalisation effort. Together, however, they paint a rich composite picture, and could contribute to filling the substantial measurement gap in the literature on government digitalisation. As Singapore's Smart Nation project develops and deepens, measures like this help to ensure that its outcomes are truly meaningful: not just by helping us to manage the process better, á la Peter Drucker, but also by enabling us to scrutinise our efforts honestly, as we continually refine them. ■

Notes

1. Patrick Dunleavy, Helen Margetts, Simon Bastow, and Jane Tinkler, *Digital Era Governanance: IT Corporations, the State and E-Government* (Oxford University Press, 2006).

2. International Chartered Accountants of England and Wales (ICAEW) Information Technology Faculty, *Digitalisation of Tax: International Perspectives* (ICAEW, 2016).

3. Kuralay Baisalbayeva, Eelco Van Der Enden, Rita Tenan, and Raúl Flores, *The Data Intelligent Tax Administration* (Microsoft and PriceWaterhouseCoopers, 2018).

4. Bas Jacobs, "Digitalization and Taxation", in *Digital Revolutions in Public Finance*, eds Sanjeey Gupta, Michael Keen, Alpa Shah, and Genevieve Verdier (International Monetary Fund, 2017), chap. 22.