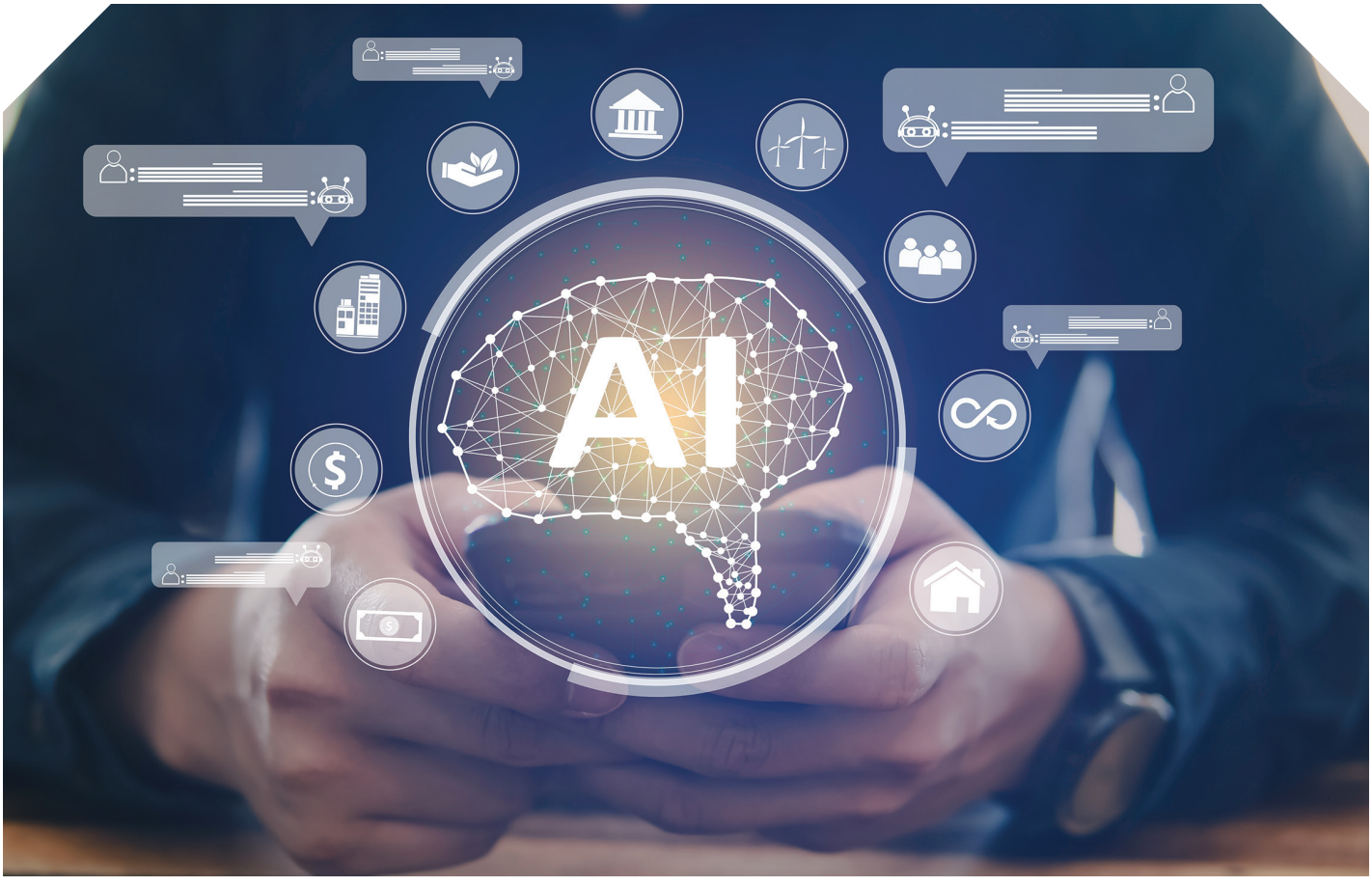

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Singapore's AI Applications in the Public Sector: Six Examples

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Steven M. Miller describes six instances in which Singapore has applied AI in the public sector, illustrating different ways of improving its engagement with the public by making government services more accessible, anywhere, anytime, and speeding its responses to public processes and feedback. He illustrates how its leaders made the city a living lab for AI use, and what they learned.

In November 2019, Singapore's Smart National and Digital Government Office (SNDGO) unveiled its National AI Strategy, stating its ambition that, by 2030, the country would be a leader in developing and deploying scalable, impactful artificial intelligence (AI) solutions in key economic and social sectors of high value and relevance, and that it would do so in ways that would serve the needs of its citizens and businesses.[1] These efforts would be concentrated in seven domains deemed crucial for a smart nation.[2]

Six of Singapore's applications of AI in the public sector illustrate different ways that AI an be used to enhance engagement with the public. Table 1 summarizes these efforts.[3]

The Six Examples

1. Managing Crowd Levels at Parks

Singapore's National Parks Board, known as NParks, oversees the city's various parks, gardens, and nature reserves, striving to make Singapore "a city in nature."[4] Providing and maintaining park access is an important public service that is especially appreciated in a small city-state with a high population density.

NParks needed to not only help its staff to manage this situation, but also encourage members of the public to make better and more informed choices about which park to visit and when.

In early 2020, COVID-19 restrictions drove more people to outdoor park areas. This sudden surge required that NParks staff be diverted from their regular work to count visitors and to patrol and enforce safe distance regulations in the more than 500 green spaces they managed. NParks needed to quickly come up with a solution that would not only help its staff to manage this situation, but also encourage members of the public to make better and more informed choices about which park to visit and when.

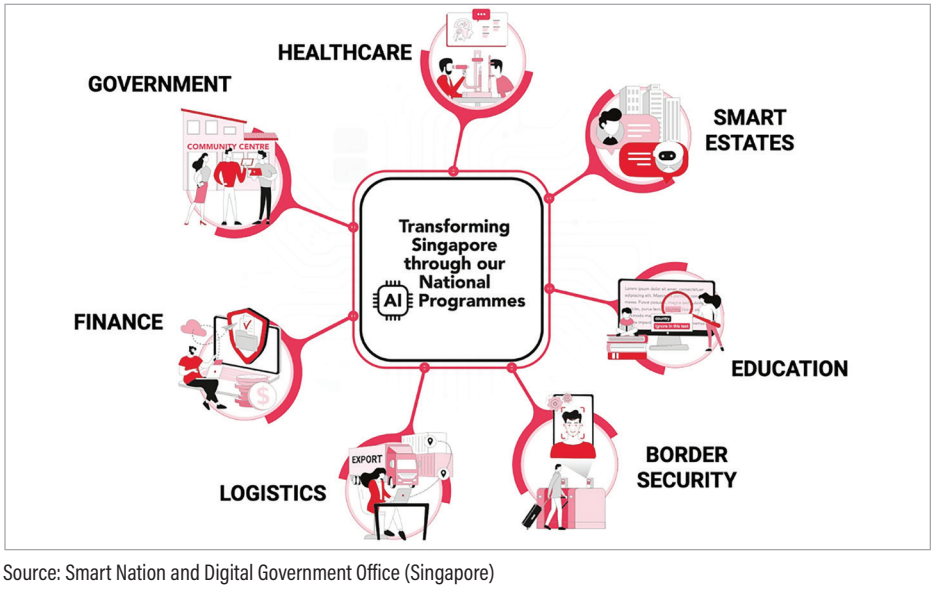
NParks worked with the Government Technology Agency of Singapore (GovTech) to create an AI-enabled system called Safe Distance @ Parks. The tool combines input from the parks' video streams with data about car park occupancy to determine how many people are in green spaces across Singapore in near real time (Figure 2).[5] However, not all of the video cameras already installed at parks were equipped to livestream to a central cloud platform for analysis. The video coverage was also insufficient to meet the operational needs of this new system. In addressing these deficiencies, NParks and GovTech decided to prioritize the more popular parks.

In just two weeks, GovTech deployed five video cameras, building on its ongoing projects and existing platforms. The team could then rapidly verify its methods for transmitting all images and other data back to a central cloud platform for analysis, its choice of models to achieve the necessary accuracy for counting people, and its methods for updating its numbers.

The rapid prototype also allowed the team to determine all necessary protocols and APIs (application programming interfaces), and to integrate the system with the Safe Distance @ Parks website and mobile app that would be used by NParks staff and the public.[6] The first version of the public website was launched a week after the technical demonstration, and then progressively refined by the team. Once all the technical issues were worked out, GovTech and NParks spent the next eight months refining the system and expanding its coverage to more park sites.

They also experimented with drones and mobile robots to safely give officers a better sense of visitor density in specific areas, allowing for more targeted safe distancing efforts. In a few park locations, especially during periods of heightened COVID-19 concern, the team used Spot, the robotic dog, to broadcast a recorded message

Figure 1: Seven domains for National AI projects

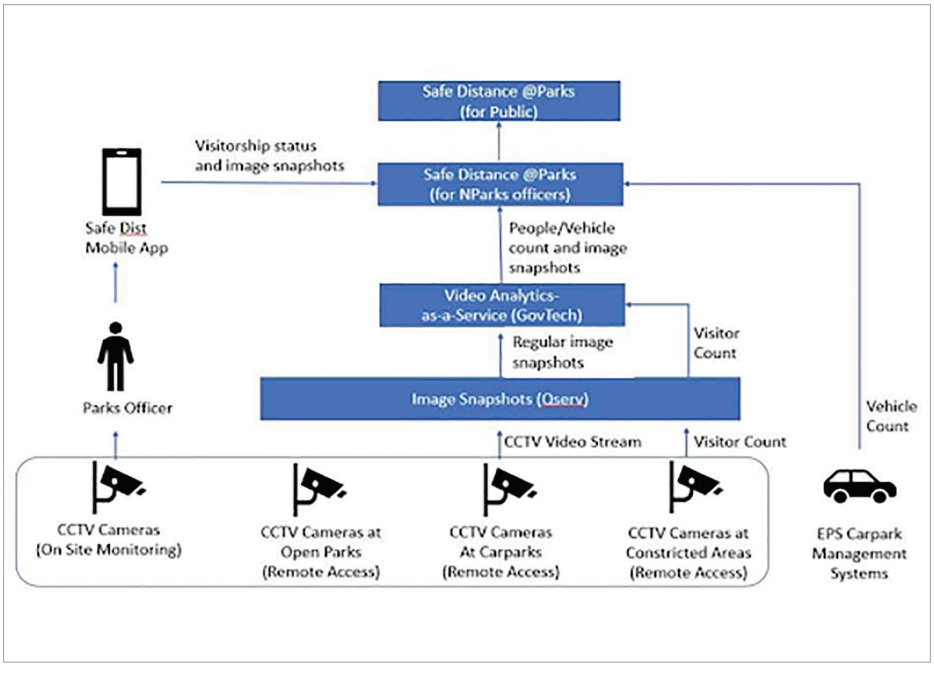


Source: Smart Nation and Digital Government Office (Singapore)

Table 1. Summary of Singapore's public sector AI applications			
	Public Sector	**AI Application**	**Impact on Public Engagement**
1	Government, Everyday Services	Managing the number of people in parks during COVID-19	▪ Eliminates tedious crowd-counting by National Park staff, frees them to do other park work and public engagement. ▪ Web portal lets the public check park crowd conditions.
2*		Job search and matching in support of future transformation of the economy	▪ Reduces job mismatches and missed matches for both local job seekers and potential employers, uses contextualized local labor market information and data. ▪ Expands the range of recommendations to include adjacent job options and educational courses to introduce new career possibilities.
3		Mass transit, urban rail system management with a customer-centric monitoring approach	▪ Faster and better response to service disruptions and crowded commuter conditions across the entire urban rail network.
4*	Smart estates, seamless and efficient municipal services	Municipal services office and the OneService chatbot	▪ Easier to submit complaint reports on municipal issues via a new chatbot system with a more flexible interface and more intelligent backend processing capabilities.
5*	Education, K–12	Adaptive learning and assessment for personalized public schools	▪ AI systems that personalize the education of each student in selected subject areas. ▪ Teachers can shift towards more customized and targeted engagement with both individual students and groups.
6*	Border Security	Contactless (breeze-through) immigration clearance at border control checkpoints	▪ Shorter wait times for travelers at immigration checkpoints; less physical contact with documents or equipment for travelers and checkpoint staff. ▪ More consistent, evidence-based approach to identifying travelers in need of special screening.

*Applications designated as National AI projects falling under the National AI domain areas in Figure 1.

Figure 2: Safe Distance @ Parks solution architecture overview



Source: GovTech (Singapore)

reminding visitors to observe safe distancing measures.[7,8]

Spot was also outfitted with cameras with GovTech video analytics to estimate the number of visitors it encountered (Figure 3). To allay privacy concerns and build public acceptance, the cameras and image analysis did not track or recognize specific individuals and no personal data was collected. NParks and GovTech continue to refine the behavior of the robotic dog to bring greater nuance to its interactions with humans in the park and to increase public acceptance of this approach.[9]

NParks made the Safe Distance @ Parks application accessible to the public and created a convenient way for anyone heading out to a park to see the crowd levels at that particular green space in advance.[10] People could then decide

where and when to go. Meanwhile the team continued to improve the public website to include real-time crowd heat maps of each park, seasonal crowd data, and other public leisure and recreational spaces.

At the height of COVID restrictions in 2020, monthly traffic to the Safe Distance @ Parks app peaked at 620,000 visits per month. Towards the end of 2021, this traffic had stabilized to around 400,000 visits per month. The app had automated people-counting, reducing the need for human enforcement staff by two thirds.

2. Local Job Search and Matching

Even before COVID-19, the Singapore government encouraged and supported working adults to upskill and reskill in response to technology changes, digital transformation, and ongoing industry changes.[11] All segments of the population were encouraged to adopt the habits and mindset of lifelong learners.[12]

The government, through Workforce Singapore (the former Workforce Development Agency under the Ministry of Manpower) launched the MyCareersFuture job portal to help residents find jobs, review career options and explore new job opportunities.[13] The self-help online portal also matches local job seekers with local employers.[14]

Workforce Singapore launched the first version of the jobs portal in April 2018, using machine learning and other AI methods to find the best job matches for each jobseeker's skills. Each match is quantified with a score from zero to one hundred; the higher the number, the closer the match. This score is drawn from an analysis of job descriptions and necessary skills, relative to the profile of the job seeker. The system also filtered results to include jobs with government training support schemes.[15]

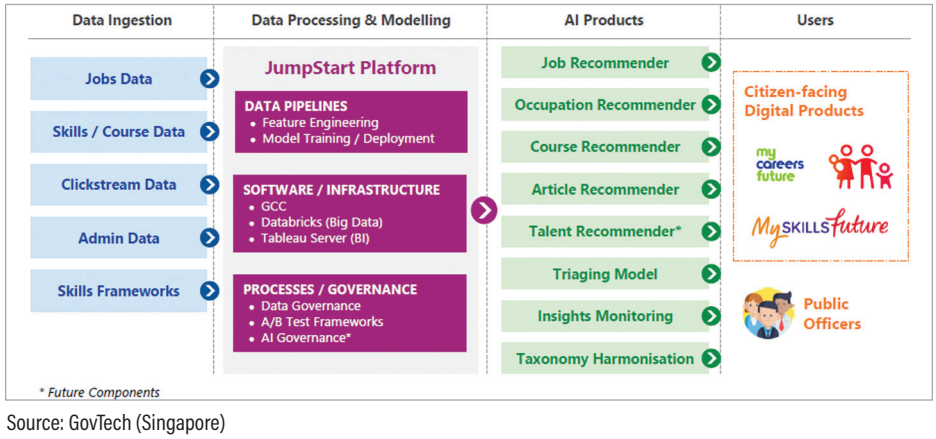
Figure 3: Field trial of Spot, the robotic dog, supporting enforcement of social distancing in a Singapore park during the early days of Covid-19

Source: Photo by Roslan Rahman/AFP via Getty Images from a Los Angeles Times story

A year later, the team enhanced the MyCareersFuture system to make it easier for employers to sort and list applicants, and to preview job seekers.[16] Machine learning enhancements allowed the system to recommend potential job candidates, including those who met the requirements but applied to jobs in other areas.

With the economic upheaval caused by COVID-19, the active job postings on the MyCareersFuture portal (both employers looking for workers and people looking for jobs) nearly doubled, from about 87,000 in November 2020 to about 150,000 in October 2021. This change reflected personnel shortages for both online services and frontline COVID support, as well as government train-and-place schemes intended to help workers move into the technology sector. In the ensuing months, job listings subsided to about 130,000. During the same period, the portal

Figure 4: Overview of the JumpStart platform used by MyCareersFuture and other government apps requiring job matching recommendations



Source: GovTech (Singapore)

received more than 560,000 job applications, making it clear that Workforce Singapore needed to improve the portal's capabilities. By creating a new AI job-matching platform called JumpStart (Figure 4),[17] the team improved MyCareersFuture in four keyways:

A. A more flexible, microservices-based architecture

JumpStart was designed as an independent, cloud-based, centralized job search and matching platform linked to MyCareersFuture. This architectural approach made it easy to reuse Jumpstart for other government applications that required a job search and matching engine. Applying the microservices architecture to the job portal also made it easier to integrate functions from commercial AI vendors into JumpStart's capabilities.

B. Better methods for filtering, matching, and recommending

An earlier version of MyCareersFuture deluged job seekers with as many as 1,000 openings while directing a torrent of applications at employers. JumpStart uses a more finely tuned AI that matches workers and employers more closely. The improved design also incorporates job openings that are highly or overly subscribed, more closely identifies adjacent occupations to which a worker did not apply, and prioritizes local jobs and industries with good growth prospects. JumpStart also suggests continuing education courses.

C. Seeing beyond the job seeker's stated preferences to implicit signals

Beyond using explicit data from the resumes and profiles of job seekers, JumpStart also analyzes implicit signals, including past job searches, job views, job applications, which job recommendations seekers viewed, and for which job opportunities they applied.

JumpStart uses this data to develop several models, including:

i. Skills-matching Model: A content-based filtering model that looks at how closely a jobseeker's skills match employers' requirements
ii. Views-based Model: A collaborative filtering model that uses singular value decomposition to evaluate a jobseeker's previous views
iii. Application-based Model: A collaborative filtering model built on jobseekers' previous applications that identifies potential jobs through similarity with other users

Because JumpStart's machine learning algorithms are trained on local data from the MyCareersFuture portal, its job search terminology, classifications, and recommendations reflect local labor market preferences, conditions, and trends. Singapore residents can also filter for listed job openings that are eligible for Workforce Singapore government support programs and easily link to the SkillsFuture listings of local training courses with government tuition subsidies.

D. Better support for using multiple data science models in parallel

JumpStart's job recommendations are generated using a hybrid approach in which multiple models (including the three mentioned above) are built and then mixed to work with one another to generate the eventual recommendations for the user.[18] The GovTech team did not want to build bespoke deployment solutions for each data science model. By integrating with the MyCareersFuture portal through a microservice architecture, the JumpStart team could experiment extensively with different ways of setting up a hybrid model and evaluating its performance without having to build and integrate bespoke deployments for each successive model change.

After GovTech deployed JumpStart, the clickthrough rate at the MyCareersFuture portal doubled from 4 percent to 5 percent to 10 percent to 12 percent. Seven months after JumpStart's launch, more than 5,000 job seekers had secured jobs through Jumpstart-enabled recommendations.

3. Mass Transit Urban Rail System Management

Singapore's state-of-the-art urban mass transit system makes extensive use of sensors to collect information, monitor operations, and gather data for AI models that predict disturbances. While the old system kept track of the current and predicted state of the rail network, it did not evaluate the experience of commuters. Singapore's Land Transit Authority (LTA) set out to monitor and improve the customer experience, using IoT sensing, situation assessment, and incident response planning.[19]

To monitor and manage these commuter-focused measures, which tracked how many passengers could not board because a train was too packed, the size of crowds on platforms and in trains, and the duration of delays, LTA and GovTech developed the Fusion AnalyticS for public Transport Event Response (FASTER) system, deploying it in mid-2018.

FASTER is an AI-powered data fusion platform that mines data from IoT sources, including video streams, WiFi and cellular signals, farecard data, train engineering and flow data, and taxi and other transport data to provide immediate warning of potential rail anomalies (Figure 5). The system makes the entire urban rail network visible around the clock, detecting unusual events and providing automatic alerts when it predicts impending disturbances.

Once a disturbance is predicted or occurring, FASTER gives rail operations staff enhanced real-time visibility at the micro and macro levels, allowing them to see how the event is affecting other rail stations so they can assess the impact system-wide. This visibility, combined with supporting real-time simulation abilities, lets the staff make thoroughly informed decisions.

FASTER also helps staff to quickly assess how various options would play out, whether adding trains to handle passenger backlogs, or, in more severe cases, deploying special buses to transport stranded passengers to unaffected rail stations.

FASTER has made the rail operations monitoring and response team more agile, productive, and efficient.

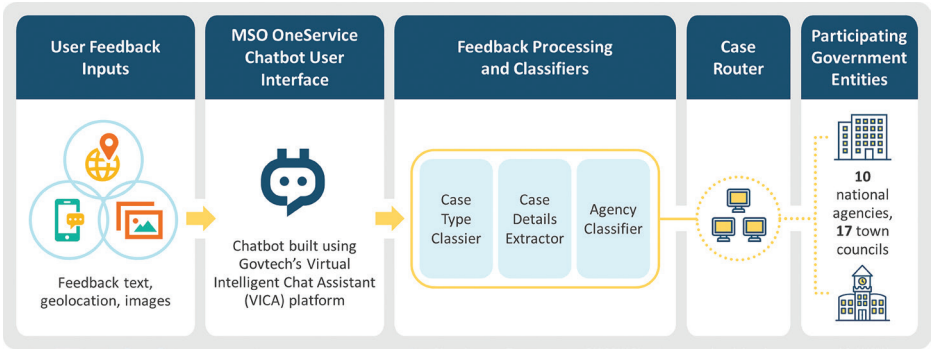
FASTER's outcomes are also fed into a broader LTA command, control, and communication (C3) system that draws status information and predictive insights about other land transport domains, such as roads and buses, to create a comprehensive view of the land transport network and coordinate fast and effective responses to large-scale disturbances.

When FASTER was first deployed, it was able to predict about 40 percent of impending incidents. By 2019, it had accumulated enough operating experience, fine tuning, and enhancement to predict 80 percent, and by the end of 2021 it approached 90 percent. This predictive ability allows rail operations staff to respond to most flow disturbances preemptively, usually minutes or more in advance.

Figure 5: Overview of the FASTER system

Source: Land Transport Authority of Singapore

Figure 6: Overview of the OneService chatbot



Source: GovTech (Singapore)

The FASTER system has also increased the productivity of the rail operations monitoring team. At the end of 2021, a team of four monitoring officers per shift were managing twice the number of stations monitored by their 2012 counterparts. FASTER has made the rail operations monitoring and response team more agile, productive, and efficient.

4. Municipal Services and the OneService Chatbot

In 2014, an infamous incident of a fishball stick discarded on a walkway highlighted the difficulties the public faced in reporting litter to the right public agency. In this case, three agencies fell to quibbling about their overlapping jurisdiction, none willing to remove the offending stick. That summer, the Prime Minister referred to the fishball stick incident in his National Day Speech as the driving force behind creating a new public agency called the Municipal Services Office (MSO). The MSO focused on improving the government's overall coordination and delivery of municipal and neighborhood services.[20]

MSO's hotline call center soon became the one-stop-shop for citizens to report municipal and neighborhood problems. The MSO would then figure out which government agency was responsible and coordinate various agencies when necessary. Ten public agencies and seventeen neighborhood councils now work closely with the MSO.

MSO's OneService mobile app was launched in 2015, a community platform for all things neighborhood, where residents can provide feedback on municipal issues, learn more about their neighborhood, and access government and town council e-services. The call center was eventually discontinued, leaving the app as the only form of communication until the MSO developed a chatbot.

While the OneService app is widely used, in certain ways, it did restrict public engagement with the MSO.[21] Some people did not want to

download and use the OneService app, preferring messaging apps like WhatsApp or Telegram. And submitting a case report could be complicated for users, especially for those who did not understand the app's pre-defined categories, whose complaint did not cleanly fit into those categories, or who had more than one issue.

Nonetheless, the app collected hundreds of thousands of case reports that formed a large, diverse dataset of complaints and the agencies that resolved them. This collection made it possible to use data-driven AI approaches, rooted in machine learning.

In July 2021, MSO unveiled its OneService chatbot, named Kaki (the local Singlish and Malay expression for 'buddy' or 'companion') (Figure 6).[22] Through live chat sessions, Kaki can identify the nature of a complaint and place it in the appropriate category (e.g., litter, illegal parking, broken toilet, dead animal, etc.). It can also extract the relevant details of the incident and automatically generate the case report.

After the chat session ends and there is more time for computational processing, the backend system predicts the right government agency and automatically routes the report there. The system uses all the text from the chat as well as any photos or videos uploaded to make this decision.

Kaki's initial accuracy rates were 80 percent for categorizing the problem and 85 percent each for generating the report with all required attributes and assigning it to the appropriate government agency. Accuracy rates stayed about the same in the following year, but Kaki expanded to handle many more types of complaints and many more users. Later, a more intelligent chatbot interface resulted in more than 90 percent of the cases being automatically routed to the right agency.

Nine months after deployment, Kaki was handling over 300 user sessions per day, serving over 4,000 people. Although these usage numbers were comparatively small, MSO and GovTech viewed them as evidence that the platform was effective. It was also seen as a successful application of GovTech's virtual intelligent chat assistant (VICA) platform, that standardized various government chatbots.[23,24]

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5. Adaptive and Personalized Learning for Public Schools

One of the projects highlighted by Singapore's National AI Strategy was the use of AI to provide personalized education through adaptive learning and assessment for primary and secondary level public school students. The goal is to allow all students to learn at their own pace, letting them better absorb lessons while supporting teachers in meeting the personal educational needs of each student.

Here, GovTech used two types of AI-enabled solutions. An adaptive learning system teaches mathematics, using machine learning to offer advice on solving problems and responding to errors that is customized for each student. By analyzing the student's responses to the system's content and questions, it infers how well the student understands a concept. The engine then makes recommendations about what content and assessment items the student should move on to next.

Meanwhile, a learning feedback assistant for English language writing gives students feedback on their grammar, sentence structure, and language errors. These two AI systems are delivered through the Ministry of Education's (MOE) Singapore Student Learning Space, the national online learning platform for grades 1 through 12.[25]

MOE piloted the AI adaptive learning system for primary and lower secondary school mathematics in cooperation with a few schools in 2022.[26] Two years earlier, MOE had shared the experiences of two secondary schools with a small-scale trial of commercial adaptive learning systems for some of their math classes.[27] Some teachers noted that they were able to use student performance and information from the adaptive learning system to encourage and facilitate peer teaching and learning.

Teachers could also more readily identify students who were struggling, offering them more attention and guidance. One teacher noted that some students responded to the different learning stages as if they were levels of a game and strove to keep climbing upward to the next level. These students appeared to enjoy the game approach, regardless of their math skill.

In August 2021, MOE called for bids for the development, piloting, and implementation of an AI system to provide feedback on English language writing. The system, to be deployed in 2023, will provide personalized feedback to improve students' English language writing skills by correcting their grammar, sentence structure, and expression.[28] An MOE official noted that it would later consider rolling out similar systems for other languages.

In November 2021, parliament questioned MOE about whether the use of this type of automated AI could make students' approach writing routine, undermining their ability to write and think with

creativity, cadence, personality, and flair.[29]

MOE responded that its use of educational technology, including this application, does not dilute, but complements the work of the teacher in guiding students to learn and master subjects, and especially high-level skills. By relieving teachers of the task of checking and correcting basic elements of writing, the system frees them to devote time with students to more complex aspects of language and advanced writing skills like creative expression, persuasiveness, and tone.

AI support for border security and crossing management is one of the designated national AI projects.

6. Contactless Clearance at Border Control Checkpoints

Singapore is deliberate about not only maintaining but always improving its image as a welcoming and safe destination for both tourists and businesses. The challenge is to insure that all inbound and outbound travelers can clear immigration quickly and without hassle without compromising border security.

AI support for border security and crossing management is thus one of the designated national AI projects; the 2019 National AI Strategy states, "We aim to deploy AI to achieve 100 percent automated immigration clearance for all travelers, including first-time social visitors. Singaporeans and departing visitors will experience 'breeze-through' immigration clearance, without the need to present their passports."

Contactless immigration clearance, using AI to analyze iris and facial scans to verify a traveler's identity, is currently in use at Singapore's land border checkpoints and at the airport (Figure 7). With a verified identity, backend systems can also verify passport status and other information relevant to crossing the border. Many countries perform facial matching using biometrics in the chip in the traveler's passport. Singapore chooses instead to use its own databases for biometric matching because it is more secure and not susceptible to forged passport chips.

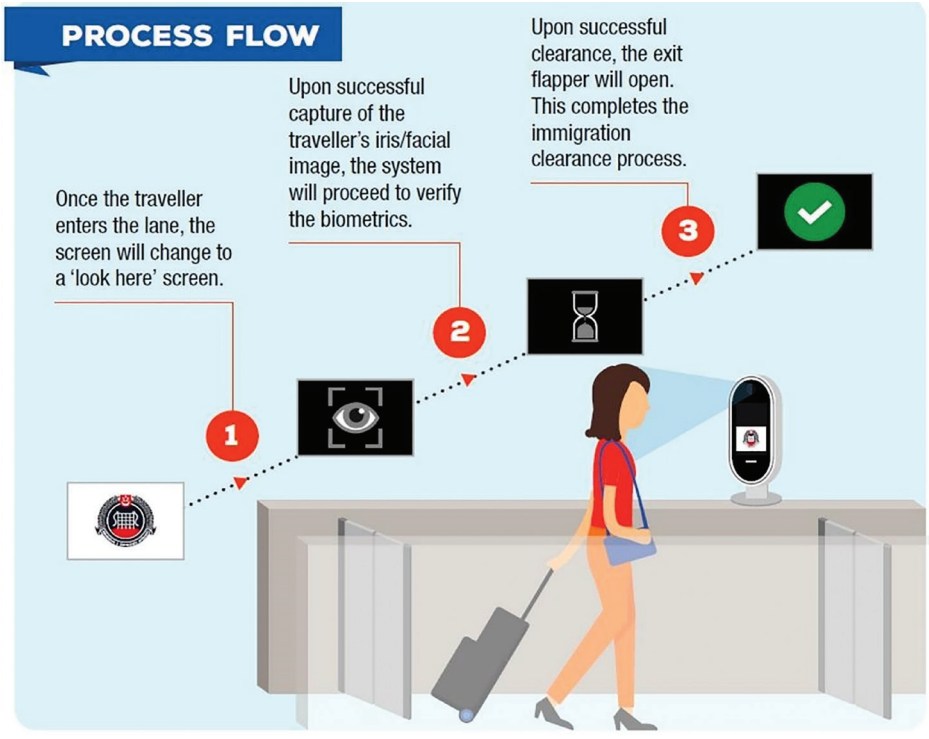
In order to function, this system must capture the necessary iris and facial scans. The Immigration & Checkpoints Authority (ICA), an agency under the Ministry of Home Affairs, started encoding the iris and facial images of Singapore citizens and permanent residents in January of 2017, as part of the process of issuing, renewing, or updating passports or national identity cards.

Singapore citizens, permanent residents, and long-term pass holders, as well as international travelers in ICA's frequent traveler program who have enrolled their iris and facial biometrics are eligible for the new breeze-through clearance.[30] First-time foreign visitors to Singapore can also use the breeze-through option if they enroll their entire set of biometrics at the border. If, for any reason, the system can't get an iris and facial scan, it prompts travelers to scan their fingerprint as a backup.

Breeze-through clearance makes it possible for ICA to handle the growing volume of travelers crossing Singapore's borders. After the rollback of many COVID-19 travel restrictions, border crossing volumes rapidly recovered. ICA kept pace by using AI-enabled technology to reduce the amount of time immigration officers spend on routine low-value tasks. These officers can instead focus on high value tasks such as interpreting analytics and following up with special interest travelers identified by ICA databases from international or domestic watchlists.

Home Team Science and Technology Agency (HTX), which is dedicated to supporting the needs of

Figure 7: Contactless breeze-through immigration clearance



Source: Immigration & Checkpoints Authority of Singapore

the Ministry of Home Affairs, used a combination of purchasing and internal development for iris and face detection systems. Within HTX, staff from the Immigration & Checkpoints Programme Management Center and the Biometrics and Profiling Center of Expertise worked together to create, deploy, and continually improve contactless border checkpoint solutions and their supporting technology.[31]

HTX's Biometrics and Profiling (B&P) Center of Expertise hopes to improve the system's ability to detect suspicious travelers through the automated detection of the behavior and physiological reactions characteristic of people with malicious intent. The system would then translate tell-tale indicators (TTI) into prediction algorithms to identify and point out such behavior.

TTIs are usually associated with a person's observable behavioral and non-verbal cues, such as fidgeting or excessive sweating. By developing an automated TTI detector, ICA expects to increase the consistency and objectivity of profiling at border checkpoints and of decisions about which travelers should be more intensely questioned.

Already travelers using breeze-through have a contactless way to provide their biometrics for verifying identity. Eliminating the need to check fingerprints or handle passports speeds up border clearance. Faster processing time reduces the time that travelers spend waiting in queues at the border checkpoint. And immigration officers using AI screening and profiling receive guidance on the very small subset of inbound and outbound travelers who are candidates for additional security measures.

Conclusions

These six examples of the Singapore government's digital and AI journey have important lessons to teach:[32]

A. Three important dimensions of public engagement are accessibility, responsiveness, and personalization. AI can improve public sector engagement with all three. While regular digital technologies can support 24/7 access, applying AI to these channels creates more intelligent retrieval, processing, and evaluation of large data from various sources, and also supports or automates the triaging of complex problems. This capacity results in more responsive and personalized interactions with customers. AI fueled personalization also improves public access to relevant information so people can make their own informed choices as they do with Safe Distancing @ Parks, and JumpStart/MyCareersFuture.

B. There is no single best AI solution for customer or public-facing situations because there are many different AI methods, all of which can be used in a range of use cases and domains. Early versions of an application often do not require the most sophisticated AI methods or delegate a great deal to the automated system.

Practitioners must learn to strike a very careful balance between the potential benefits of enhanced and automated accessibility, responsiveness, and personalization and the potential risks of losing public trust, overreaching, opacity, and excessive complexity.

The use of AI for consequential interactions with the public is in its infancy. Leaders must choose projects carefully, in part to persuade the public of the usefulness of AI. For now, we should focus on use cases that are not overly controversial and in which the machine is not solely responsible for high-impact decisions.

Over time, people will develop more trust and comfort with with AI-enabled systems. Meanwhile the solutions already deployed will gradually improve, prompting leaders to expand AI's range of uses and allow AI systems to take on bigger roles through closely monitored increase of both task automation and AI augmentation.

C. The key to success in each of these examples was a focus on solving a clearly identified problem in order to meet people's important everyday needs. None of these applications were motivated by the desire to use AI for its own sake. AI methods were employed because they were best suited to addressing the users' needs. It is more important to clearly define the use case than to use the most sophisticated AI methods. AI methods and supporting data that produce sufficient results at the outset can be improved over time.

D. Once leaders have a goal in mind, they should determine the broad types of AI functionality required for the initial minimum viable product and for updates over the initial eighteen months. Most projects will require one or more of the following families of functionality: prediction/recommendation, planning/optimization, modeling/simulation, natural language understanding, image or video understanding, or work process automation.

Once they have framed the problem, leaders will find their selection of AI methods influenced by i) data availability, ii) required degree and nature of transparency and auditability, and iii) the risks and consequences associated with AI errors and inaccuracies such as false positives, false negatives, and other output errors.

E. For an entity in the public sector, focusing on addressing the existing and common, even very basic, needs of residents is a good way to get started. It allows the agency to build internal AI capabilities while residents build experience with using AI systems.

The first step to becoming a smart city is to help residents to

do basic, everyday tasks more easily. This foundation will support future progress toward using more sophisticated AI methods and models to offer new services to residents.

Companies, especially those in the early stages of deploying AI tools, should follow this same pathway. Start simple; focus on basic customer needs.

F. The success of the latter five examples are the result of steady, iterative efforts spanning multi-year time periods. The designers needed this extended time to build up datasets, refine the performance of AI models, and integrate their outputs.

Organizational leaders must also plan and support a patient and iterative approach over a period of multiple years, as long as the system demonstrates a steady learning and performance curve at each step.

Example one demonstrates that once the organization has a strong capability base, it will be able to design and deploy targeted solutions very quickly in specific situations.

G. Working simultaneously to establish policies, governance, and technology platforms is essential if an organization hopes to move from an ad hoc approach to each AI project to a portfolio approach, deploying multiple AI solutions throughout the organization.

Being clear about using the commercial cloud, internal data-sharing, ownership and accountability for data quality, data and privacy protection, and use case review and approval is as important as AI technical competency.

Leaders must build internal infrastructure and software platforms that can capture, clean, curate, manage, and distribute data throughout the organization. They must also build the platforms for managing and executing development, security, and operations (DevSecOps) for machine learning.[33] All of these steps are necessary prerequisites for increasing the organization's efficiency in deploying and supporting an expanding portfolio of AI projects.

AI-enabled solutions for customer engagement, or for any application, involve a lot more than AI.

The technical aspects of choosing and implementing AI-models, while critical, are just a small part of creating, deploying and operating an AI-enabled solution. AI-enabled solutions for customer engagement, or for any type of application, involve a lot more than AI.

Building the City's Capacity to be a Lab for AI Deployments

Singapore's strategy is to rapidly test new ideas for AI applications in a city-scale field setting. Singapore can often move more quickly than larger countries to iteratively build a base of common understanding between the realms of technology, infrastructure, management, policy, and governance in order to build better and more complex public sector AI capabilities and services.

Singapore's government is therefore committed to encouraging responsible and innovative field trials and follow-on deployments of existing and emerging AI technologies. Despite the country's small size in terms of geography and population, its approach to field trials in carefully considered use cases with well-orchestrated deployments attracts leading global companies that provide AI solutions as well as AI-focused start-ups.

Uses of AI in the public sector have proven to be good starting points for interagency partnerships and for public-private partnerships. The Singapore government's approach to developing AI tools is a mix of home-building and using the most innovative vendors around the world.

Simpler – meaning no need for major customization – and less sensitive, smaller-impact projects are more receptive to the use of commercial products and open-source library modules to achieve quick wins (e.g., Safe Distancing @ Parks). More complex, highly integrated, and novel projects usually necessitate deeply contextual and custom approaches that require local knowledge and innovations (e.g., the JumpStart platform for the MyCareersFuture job search portal and the MSO chatbot, both internally developed by GovTech).

Some of these complex cases, like the AI learning assistants, the breeze-through system, and the FASTER system, also required joint development partnerships with local and global vendors and research institutions. The FASTER rail management system was achieved through a multi-year partnership with IBM and ST Engineering, a local firm.

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The government's learning how to steer relevant regulations, navigating public and societal protections, while supporting R&D, innovation, and learning-by-doing, was especially essential.

To build AI projects, governments must also be prepared to consider policies, regulations, and protections regarding access to public data, because data-driven

machine learning underlies most contemporary AI applications. Not long ago, Singapore was known for its unusually tight grip on government information; even data-sharing within the government was often cumbersome. Today, the situation has changed; access to both government and public data has become much more easy and open, though still with some notable exceptions.

Leadership

The Singapore government's AI journey, including AI for public engagement, has required leaders who have a judicious combination of the following four traits:

- **Progressiveness:** Senior leaders must support a dare-to-try spirit within government units, ministries, and agencies. This attitude is essential for digital and AI innovation for improving customers' engagement and experiences.
- **Pragmatism:** Leaders must make no-nonsense evaluations of whether an AI approach is even warranted. If the quality or quantity of data are insufficient, data-driven machine learning methods will not perform well. When addressing a new problem, choosing the simplest AI solution that best fits the situation will usually be an effective way to get started.

  The initial solution might even be good old-fashioned AI's rule- or logic-based approaches in defiance of the current common wisdom that says to always start with more complicated machine learning methods. Leaders also need hardheaded pragmatism to dismiss proposed projects that do not have a clearly defined purpose, or that are likely to be highly controversial or sensitive.
- **Patience:** Leaders and senior management must realize that, when deploying AI-based solutions, the system will be far from perfect at the outset. They must take a longer view and be willing to sustain the investments needed for the development team to keep iterating, improving the AI's performance over time as it collects more data and designers refine the AI and build supporting modules. These iterations, which build to the desired level of performance, can take several years.
- **Persistence:** Leaders who plan to introduce a new technology should be prepared to hold steady and persist in the face of internal and external public resistance. Like deploying any new type of technology, launching new types of AI-enabled systems and processes will disrupt established practices.

  The first AI projects of organizations will be opposed by internal and external stakeholders who may have a variety of concerns including privacy, job loss, and fairness. To deploy and adopt AI, leaders must have the conviction and the evidence necessary to responsibly address this inevitable opposition.

  Leaders will also need to be persistent in a way that is closely linked to patience. AI systems of all types require substantial monitoring, adjustment, and maintenance to ensure that their results remain reliable and responsible. Without this persistent support after deployment, the system's performance will drift as conditions change.

  Support teams will also have to address biases and errors in the system, both overt and subtle, that they did not initially detect or understand, but which emerge over time. Leaders must take responsibility for the organizational mechanisms that handle the lifetime requirements of AI systems and products. They cannot just be deployed and forgotten.

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In summary, the Singapore government's approach to building its AI capability and deploying AI applications across the public sector has been a national-level engagement effort across the whole government and its boundaries, the private sector, and local society.

The result is Singapore's steadily expanding portfolio of AI-enabled applications that have changed both how the government operates and how it engages with the public. So far, residents and businesses have responded positively to the government's digital and AI efforts. Singapore's annual survey on satisfaction with these services reflects that.[34]

On a scale of one to five, with five being 'very satisfied,' overall citizen satisfaction rose from 95 percent satisfied or higher and 73 percent very satisfied in 2016 to 99 percent satisfied or higher and 85 percent very satisfied in 2021. Satisfaction scores from businesses also rose: from 92 percent satisfied or higher, 64 percent very satisfied in 2016 to 98 percent satisfied or higher, 76 percent very satisfied in 2021. While the AI applications in these six examples are only a small part of a much larger government digital effort, the scores show that AI will play an increasingly important and expanding part in Singaporean life for years to come. ■

Author Bio

Steven M. Miller is Professor Emeritus of Information Systems at Singapore Management University. He served as founding dean of SMU's School of Computing and Information Systems for over thirteen years.[35] He also served as SMU's vice provost for research for eight years. He continues to advise several companies and government agencies in Singapore on AI applications and deployments, digital transformation, and organizational learning.

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