Lessons from Combating SARS in Singapore

E-GOVERNMENT CAPABILITIES AND CRISIS MANAGEMENT: LESSONS FROM COMBATING SARS IN SINGAPORE

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Executive Summary

The city-state of Singapore has been highly ranked for its e-Government services. Over the past two decades, it has leveraged its IT infrastructure for economic development and transformed its public services. The SARS outbreak in 2004 turned into a national health crisis because it spread rapidly and the medical community had little knowledge of how to treat the new mutation of the corona virus.

Yet, several Singaporean government agencies utilized the e-Government infrastructure and related resources to quickly bring the outbreak under control. In particular, the government’s IT infrastructure streamlined communications, information exchange, and data flow, and significantly eased collaboration among government agencies, private businesses, foreign agencies, and the public. By being able to coordinate crisis management activities, Singapore was able to keep the public up-to-date, enlist help from many sources, and rapidly develop innovative IT applications to contain the outbreak. Our findings illustrate the importance of IT in helping both public and private enterprises respond effectively to crisis situations, where leadership, speed, and coordination are paramount.

SINGAPORE’S E-GOVERNMENT INFRASTRUCTURE

Singapore’s e-Government systems have been highly rated for their extensive strategic and innovative use of information technology (IT) in delivering government services. Since the early 1980s, Singapore has continually introduced new information technologies to improve its government business processes. The result has been IT-knowledgeable human resources, as well as an IT infrastructure that provides citizens with a popular electronic channel for communicating and interacting with the government.

Modernizing its vast government infrastructure using IT has been difficult. The process has involved redesigning services, introducing over 1600 e-services, and learning how to tailor and deploy electronic services. The result has been transformed public services. These investments proved crucial in 2004 when Singapore was hit with the outbreak of SARS.

THE SARS OUTBREAK: A NATIONAL HEALTH CRISIS

Beginning in 2002, the World Health Organization (WHO) issued warnings of a spate of mutant viral infections that could rapidly spread around the world. One such mutation of the corona virus that causes atypical pneumonia is known as the Severe Acute


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1 Carol Brown was the accepting Senior Editor for this article.
3 Severe Acute Respiratory Syndrome (SARS) is a severe form of pneumonia and a highly transmissible disease that causes flu-like symptoms and respiratory problems in patients.
Respiratory Syndrome (SARS). SARS emerged in East Asia in early 2003 and spread globally soon after.

In most countries, including Singapore, the epicenters of infection were hospitals, where undiagnosed patients infected others. More than two-thirds of the cases involved visitors, healthcare workers, and patients in the vicinity of undetected SARS patients. The outbreak in Singapore began with regional travelers who fell ill after they returned from Hong Kong and were hospitalized with undiagnosed fever at Singapore General Hospital (SGH).

Three patients were soon diagnosed as having SARS, but not before they had unknowingly spread the infection to many people in Ward 58 of SGH, several family members, friends, and healthcare workers at SGH. Dealing with SARS was particularly difficult because there was then no information about the agent responsible for the infection, nor its mode of transmission.

The people infected by SARS displayed symptoms similar to the common flu: high fever accompanied by headache, dry cough, and shortness of breath. That is why early infections were often wrongly diagnosed as the common flu. To make matters worse, SARS was easily transmitted by close contact with an infected person. That’s why it spread so rapidly at the onset of the epidemic. This high initial infection rate also increased the number of deaths. By the end of March 2003, Singapore had more than 80 cases and four fatalities, all arising from just the three initial cases. Figure 1 shows the epidemic curve of SARS cases in Singapore.

**Singapore’s Response to SARS**

Singapore was the first Asian country to decisively tackle this public health threat. The rapid spread of SARS in Singapore alarmed the government, and caused much public concern, fear, and even paranoia. Wong Kan Seng, Minister for Home Affairs, explained Singapore’s three-prong strategy in his speech on April 16, 2003:

> Our national strategy against SARS has three prongs: First, to detect and isolate SARS cases as early as possible. Second, to ring-fence detected or suspected cases, hospitals and clinics and personnel treating SARS cases and adopt robust screening and infection control procedures. Third, to contain the spread of the virus and guard vigilantly against outbreak in the wider community.  

**Implement Widespread Contact Tracing.** To detect SARS cases, the Singaporean government extensively traced people who were either related to SARS patients or had possibly come in contact with these patients. This ‘contact tracing’ involved identifying all places a patient had visited, and then contacting every person who had visited each of those places, to monitor their health. The goal was to be cautious, and even quarantine large numbers of people, rather than risk suspected SARS patients slipping through the ‘ring fences.’

The government invoked the Infectious Disease Act, which directed all people who had come into contact

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with an infected person to be quarantined and monitored for possible signs of SARS for ten days, the virus’s incubation period.\footnote{Ministry of Health SARS Web site, www.gov.sg/moh/sars/ last accessed December 31, 2003.}

An important aspect of contact tracing was implementing ways to identify visitors to establishments, and also educating various establishments about SARS preventive measures. This process required the participation and coordination of many organizations in Singapore; Figure 2 shows those organizations. (See Appendix B for details about each agency.)

To coordinate with Singaporean schools and employers, the Ministry of Health (MOH) involved the Ministries of Education (MOE) and Manpower (MOM), respectively, to provide contact information and promote awareness. The Ministry of Community Development and Sports (MCDS) guided childcare centers on preventive and tracking measures where adults often escort their children. The National Environment Agency (NEA) was roped in to help manage the data on identifying and tracing contacts. A security service...
agency under the Ministry of Home Affairs (MHA) delivered quarantine orders. The Singapore Tourism Board (STB) launched a campaign to educate establishments on preventive measures. Several grassroots agencies, along with the Health Promotion Board (HPB), also campaigned to create awareness among residents of preventive measures.

Apart from the efforts within Singapore, the government set up fever-monitoring systems at air, sea, and land immigration checkpoints at its borders, and also regularly exchanged updates with its immediate neighbor, Malaysia, and other nearby vulnerable nations.

Centralize Treatment. To isolate and contain the disease, Tan Tock Seng Hospital (TTSH) was designated as the sole hospital to treat SARS patients. All employees, patients, and visitors to the hospital underwent tight screening measures (see Figure 3: Left). The hospital temporarily halted inter-hospital transfers of staff and patients. Healthcare workers were issued protective gear, such as masks, gloves, and gowns. On March 26, 2003, the Singaporean government even announced the drastic measure of shutting down all public schools for two days (see Figure 3: Right).

Residents were also advised against traveling to China and Hong Kong.

Coordinate Information. As the efforts to detect and contain the infection intensified, the numerous agencies needed a way to manage and communicate information with each other. The initial spreadsheet-based information management system from NEA proved insufficient to support the national effort, particularly as new infections continued to escalate. So, the Ministry of Health called on the Defense Science and Technology Agency (DSTA) because of its prior experiences developing and implementing e-Government projects. At the height of the crisis, the Ministry of Health asked DSTA to establish an operations center within two days’ time to support the 150 staff handling the operations.

DSTA went further. Within two weeks’ time, it developed and deployed an information system to support large-scale contact tracing and data management at the operations center to manage the crisis. The crisis management involved several agencies coordinating on a national basis to quickly clamp down on the spread of the SARS infections in Singapore.

SINGAPORE’S E-GOVERNMENT JOURNEY

Singapore was one of the first countries to develop an integrated and coherent approach to computerizing the government. Since the early 1980s, Singapore has considered IT the key enabler of its global competitive advantage. Figure 4 illustrates the major milestones of Singapore’s e-Government development from 1980 to 2006.

The 1980s. Singapore’s electronic government (e-Government) initiative began in 1980 with the Civil Service Computerization Program. This program set the underlying intention of the Singaporean government to become a world-class exploiter of IT.

Since its launch, this program has morphed into the National IT Plan, and has evolved with the changes in the country’s technological, business, and social climates. The government has changed how it operates, interacts, and services the public. And it has familiarized the civil service workforce with the purpose and potential of IT.


10 Singapore’s early IT adoption and technical support services to the
The 1990s. Through the 1990s, Singapore implemented its vision of building an intelligent island. It used the Internet to create a new communications channel, foster greater computer use, and popularize broadband use in homes, schools, and businesses. To support e-business activities, it also developed a support infrastructure, including legislation and sustained development of computer literacy among all sections of its society.11

One goal was to provide integrated services to the public through cross-agency links. The government was able to increase inter-agency collaboration by building a civil-service-wide network that consolidated its computing resources. However, policy coordination among the government agencies turned out to be extremely challenging, due to the diverse and intangible goals of the various agencies. So it used high-level agencies, such as the National Computer Board (NCB), to coordinate policy changes across the agencies. In all, the process of integrating resources took the government almost a decade, from the late 1980s to the late 1990s.

From 2000 to 2003. In 2000, Singapore launched the ‘InfoComm 21’ initiative to develop the country, by the end of 2003, into a global info-com capital with a prosperous e-economy and an info-com savvy e-society. Once the government had set its strategic objective of national IT adoption, it pushed implementation via various initiatives.

Public officers, ministries, and other government agencies have been essential in successfully implementing the e-Government strategy. Their buy-in played an important role in ensuring that the government benefited from the fresh opportunities of new technologies. One such initiative was the InfoComm Education Program, which ensured that public officers gained the IT competencies to revamp internal processes and external service delivery in their organization.

Singapore’s National Computer Services (NCS) provided the technical services to the civil services, and also played a role in policy-making through the National Computer Board. However, as management of IT and the support services became complex, the government decided to get out of the technical services business. It spun off IT services into a corporate body, still called National Computer Services (NCS). Today, several private companies compete with NCS to provide IT services to public agencies.

As the IT and telecommunications industries grew together, the National Computer Board’s role morphed into being an integrated agency with the Telecom Authority of Singapore (TAS). Its charge is to develop and coordinate information and communication policies in Singapore. The government formed the InfoComm Development Agency (IDA) as the nodal agency in developing and managing several e-
Government policies and services. IDA also was to prepare Singaporeans “for living and working in the New Economy,” where info-com plays a key role. Accordingly, several IDA initiatives have been to (1) educate the large elderly population in Singapore in the basic use of IT, (2) identify and develop next-generation technologies, and (3) formulate policies to provide e-services to all segments of the society.

From 2000 to 2003, the government began implementing Infocomm 21 via its e-Government Action Plan I. This S$1.5 billion project invested in complementary infrastructure components. It connected people and the government over the Internet, putting paperwork, information, and services online. Now, more than 1,600 services, or 97% of all government services, are online, from applying for business licenses to paying taxes. An example is the e-Citizen Portal, which is a customer-centric, one-stop, on-line portal for citizens to transact and interact with the government. Using this portal, citizens and businesses save time and money when transacting business with multiple agencies.

Several IT services are outsourced to the private sector, and several IT government agencies provide technical services, either with these private service providers or on their own. The Defense Science and Technology Agency (DSTA) is one such Singaporean agency. IT assists the Ministry of Defense (MINDEF) and its related agencies, and has played a lead role in developing several e-Government services.12 One such service was GeBiz, the large Singapore Government Electronic Business System that provides a single-stop service was GeBiz, the large Singapore Government Electronic Business System that provides a single-stop service to all public agencies can post their tender offerings and conduct purchasing.

From 2003 to the Present Time. The Singaporean government sees its network and information infrastructure as a platform for the country’s future IT growth. It has been moving its skill-intensive citizens to technology-intensive sectors, such as semiconductors and telecommunications, and is providing infrastructure support to maturing technology companies. It has also introduced major policy changes and promoted partnerships among public and private organizations to develop new and innovative services for citizens.

These government activities provided the IT foundation for responding to the SARS crisis. Classic risk management calls for contingency planning for activities, such as disaster recovery. However, it is not practical to anticipate all possible crises, and have a scripted response. Singapore’s sustained investment in its computing infrastructure and IT skills provided the country with the organizational capability to devise swift and effective responses to sudden and unexpected crises, just as the SARS outbreak demonstrated.

USING IT TO COMBAT SARS

Singapore’s uses of IT in the SARS outbreak were varied and widespread, and used a number of different technologies.

Personal Productivity Applications Initially Tracked Infection Patterns

Singapore realized only gradually that it had a healthcare crisis on its hands. Yet, the first responding agencies used IT in many ways to help them better manage their data. Several IT applications traced the movement of SARS patients, their contacts, and the health of relevant staff and in-patients. For example, Microsoft VisioTM, a diagramming program for documenting and organizing complex processes, was used to plot linkages between contacts at hospitals. In addition, some technology-savvy doctors used spreadsheets to set up their own contact tracing system, and shared it with MOH and NEA. Furthermore, DSTA explored modeling the viral outbreak to visually represent and study its spread. So, use of IT was both sporadic and widespread at the outset of the outbreak.

During the early stages of managing the crisis, MOH operated an operations center with the NEA. MOH and hospitals used the government’s e-mail systems to exchange data. NEA used spreadsheets to maintain lists of infected patients, and their potential contacts, who needed to be quarantined. A government security office used this list to issue the quarantine orders. This list, however, did not always contain up-to-date information, as it needed to be manually updated – a time-consuming effort. As the operations center’s job escalated, DSTA took an active role in proposing and developing an information system to manage the data exchange across agencies.

Case Management System developed for Crisis Management

DSTA began its case management system (CMS) work by forming a project team of specialists in networking technologies, database administration, system development, and testing. The team was given two weeks. DSTA had previously developed a casualty management system for the Singapore Armed Forces (SAF). It used that system as its basis.

As shown in Figure 5, the contact tracing system needed information from hospitals, MOE, MOH, gen-

eral practitioners, and Traditional Chinese Medicine (TCM) practitioners.

One of the most difficult challenges the project team faced was abrupt changes in system requirements, which sometimes occurred daily or even hourly. The CMS was designed to provide a long-term solution for similar crises, while catering to the immediate needs of managing the SARS outbreak.

The gathered information was entered into a database, which allowed the system to perform case management should someone be identified as a suspected or confirmed SARS patient. Link analysis associated confirmed cases with suspected and probable cases, so that the health status of potential SARS patients could be monitored. This SARS database could also be used to provide exit control for the immigration authorities (as a commitment of Singapore to regional safety) or with MOE to isolate students who might inadvertently attend schools when they should be quarantined.

To contact the Singaporean population quickly, DSTA created a reference database of simple contact information for the entire population.

During data collection, DSTA faced several obstacles. For one, the lack of established procedures at the operations center hampered its efforts to get the needed data. The team had to coax information from the spreadsheet owners, and then identify data sources, formats, and security issues associated with data. As its CIO recounted:

*I was told it might be impossible to gather such data, but I approached various government CIOs anyway, and they agreed. When one agency offered its data, they cautioned that it was at least one month old. But I was ecstatic because back then I had no data, and any data was better than that!*

The handling of such sensitive information also had to conform to strict procedures and guidelines that had been developed as part of the e-commerce infrastructure. For privacy protection, only the SARS crisis operations center and the data management group at MOH could access the CMS. The CIO explained:

*It was not a free-for-all as far as the data was concerned. We had to conform to certain norms when handling such data. All data exchange is guided by government policies to protect the privacy of individuals. Data access in the system is tiered into multiple layers and access to tiers is controlled by levels of authority.*

Other agencies were not even connected to the CMS for data input. Instead, they e-mailed their data to the operations center, where staff keyed it into the CMS.
One problem with this transfer was that the operations center used a different data format from the other agencies. These formats had to be standardized in the CMS.

The CMS’s data focused on patient information, infection status, and relation to other patients or contacts. The information helped Singapore better understand the spread of the infection, and gave it a way to identify and notify potential at-risk people through its link to the reference database.

Overall, though, data collection was greatly enhanced by Singapore’s mature e-Government infrastructure. The government and the people were already connected over the Internet. Citizens had access to 1,600 government services online, and some of these databases helped obtain or verify contact details. In fact, these databases became important sources of input to the CMS.

The project team worked on implementation and integration in parallel, and on data conversion and user training during breaks. The CMS gave the government the means to monitor the status of SARS across the nation, and it had accurate updates from the CMS’s data, including quarantine numbers and their status. Using the information on the daily CMS report, the Minister for Health briefed the nation at daily press conferences. The report also went to hospitals and other agencies. At the end of the crisis, the CMS was handed over to another agency for further development and maintenance.

Radio Frequency ID (RFID) Was Tested for Contact Tracing

During the early days of the SARS outbreak, many (undiagnosed) patients in hospitals came in contact with many people, causing the infection to spread rapidly. To effectively and quickly identify all the persons a patient came in contact with during their stay in a hospital, DSTA hosted a gathering of hospital CIOs to brainstorm an effective strategy. At that time, many hospitals were experimenting with Radio Frequency Identification (RFID), so using RFID was considered for tracing contacts. However, it was only deployed on a trial basis at one hospital during the crisis. Other hospitals had planned to implement it, but did not accomplish it before the crisis ended.

Using this system, every patient was tagged with the RFID. Every time the patient came in contact with a reader at various points in the hospital, the location and time of visit was recorded. This data was stored in separate databases not linked to the CMS, and stored only for the viral incubation period. When one of these people became identified as a potential SARS patient, the database could list everyone who had come in contact with that person, and they could then be quarantined to monitor their symptoms.

Videoconferencing Improved Coordination

At the outbreak of the epidemic, the Internet was already actively promoted as a new delivery channel, providing both information and transaction-based services to the public. The Singapore ONE broadband initiative catalyzed the delivery of interactive multimedia applications and services, and fostered inter-agency communications. Early on, videoconferencing became a critical communication tool linking MOH and MINDEF. Without the previously existing and fully integrated IT infrastructure, this videoconferencing system would not have been available so quickly after the outbreak.

In addition, because hospitals were such highly contagious zones, MOH also introduced videoconferencing to help patients interact with their visitors, where possible, without coming into contact with them.

Webcams were also installed in homes of quarantined people, simply by plugging the camera directly into a telephone line. MOH monitored the citizens it had served with Home Quarantine Orders by requiring them to appear before their in-home webcam on demand. That was part of the quarantine order.

Infrared Fever Scanning Detected Early Infection

DSTA also explored the idea of adapting readily available thermal imagers (used in the military as screening devices) for early SARS detection because fever was one of the earliest detectable symptoms for SARS. Within one day’s time, DSTA, Singapore Technologies Electronics, and Chartered Electro-optics developed a prototype of the Infrared Fever Screening System. In just one week’s time, the team was able to verify its effectiveness as a quick and non-intrusive way to screen people. The device was deployed at the nation’s various checkpoints, where probable patients were asked to go for a medical examination. The device did not require a nurse, so the nurses who had been stationed at checkpoints to screen travelers could return to work in their hospital.

The Infrared Fever Screening System addressed Singapore’s urgent need at the height of SARS for a fast, safe, and friendly means of mass screening people. As a person walked pass the system, an infrared camera captured the thermal emissions from the person’s skin, and the processed video images were displayed in real time with distinct colors indicating normal, feverish, or high fever. Being non-intrusive and easy to operate, the system was quickly deployed at airports across...
Asia as the first line of defense against the cross-border spread of SARS. In fact, the system received commendations from all over the world and contributed greatly towards the Singaporean government’s efforts to boosts its citizens’ confidence. A government official commented:

Many SARS affected countries requested that we supply them with the infrared scanners to help them detect inbound passengers who were suspected to have contracted the SARS disease.

The CIO of DSTA also commented:

The development of the Infrared Fever Screening System demonstrated how, as a community, we rose to the challenge and made the critical difference in a time of crisis. We are proud and honored that our innovation has contributed to the worldwide fight against SARS. Furthermore, the team developed the concept for the system into a working reality in the shortest possible time. The work was urgent and intense, a test not only of our technical knowledge but also of our innovativeness and responsiveness. It was both a thrilling and challenging time, and we are glad to have responded to the national call in the fight against SARS.

Singapore drew on several information technologies during the outbreak of SARS. Initially, the use of information technologies was sporadic, yet widespread. However, as the government realized the magnitude of the outbreak, it created a coherent strategy to effectively deploy its significant infrastructure.

**IT IMPROVED COLLABORATION**

While the use of information technologies proved crucial in fighting SARS, the government’s existing IT infrastructure provided the foundation for the crisis management effort, not just in terms of its technical underpinnings but its culture as well. Development of the e-Government infrastructure over the years engendered collaboration, coordination, and IT knowledge across agencies. That collaborative culture proved important in addressing SARS, and it spread countrywide during the crisis.

**Among Government Agencies.** Containing SARS required speed and synergy among many participants. Data from various government agencies was needed for the contact-tracing database. The Ministry of Finance, for instance, provided the information on Central Provident Fund contributors, which accounts for virtually everyone in the workforce in Singapore. Thus, almost everyone in the country could be identified from that single database.

Speed and flexibility – made possible, in part, by IT – prevented this national health crisis from going out-of-control, as it did in China, Vietnam, and other countries. The government introduced new policies, and rapidly identified and improved ineffective measures. For instance, NEA used spreadsheets and one hundred laptops to manage the initial contact-tracing operations. But when the scale grew, it quickly changed direction, and built a full-scale contact-tracing system in just two weeks’ time.

This schedule, in fact, turned out to be the most aggressive of all the actions that the Singaporean government undertook to prevent the spread of SARS. The fast results reaffirm the common belief in organizational studies that once a situation has been labeled a crisis, decision-makers do mobilize the necessary resources to manage it. Furthermore, the e-Government infrastructure significantly contributed to the government’s ability to coordinate the various crisis management activities.

The isolation, preventive, and containment measures that the government implemented proved highly effective because the various agencies could quickly cooperate and coordinate their efforts – due to the IT infrastructure. They were vigilant and pro-active in increasing surveillance and information sharing. The agency heads exchanged information, feedback, and suggestions for further actions. The CIO of DSTA commented:

Every night, I would go through the e-mails exchanged by various heads in the government and incorporate their suggestions into the system. It was an extremely useful communication mechanism.

**With Private and Other Organizations.** In collaboration with two major local broadcasting companies, MOH launched a channel that focused exclusively on SARS. It aired the latest updates, as well as re-runs of SARS programs, cable programs from foreign channel partners, and public education spots that gave tips on precautions people could take against SARS. Feedback Unit, a government agency that coordinates public feedback on government policies and measures, gathered feedback from citizens through its online forums and other surveys. This channel provided an

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important means for citizens to voice their opinions to the government through suggestions and comments.

To educate the public on the causes of SARS and preventive measures against it, the Singaporean government joined hands with community clubs and societies to launch campaigns to raise the level of public and personal hygiene. The COOL Singapore Award launched by the Singapore Tourism Board, the OK campaign launched by the Health Promotion Board, and the SARS Channel launched by the local broadcasters were some of the initiatives implemented during that period. The Singapore government ensured that corrective measures were openly communicated to all stakeholders because they were seen as part of an effective response strategy.15

With Foreign Agencies. The Singaporean government also collaborated extensively with foreign agencies, such as the U.S. Communicable Diseases Center and the World Health Organization (WHO), to better understand the nature of the disease, how it spread, how it could be contained, and how to help patients recover from it. This collaboration with foreign agencies through knowledge sharing and effective communication was crucial in handling the situation domestically.

With the Public. Controlling the SARS outbreak in Singapore took the combined effort of a determined government and a cooperative public. Collaboration with the public was essential, so the government encouraged two-way communication during the crisis, to provide accurate updates on the number of cases and to accurately gauge how the nation was reacting. MOH was the primary agency in charge of disseminating updates to all agencies (government agencies, the police, and grassroots organizations). The updates were meant to spur appropriate actions to contain new outbreaks.

Overall, the Singaporean government won the trust of its citizens, in part by assuring them that it was taking every possible action to make the nation SARS-free. The government fostered greater awareness and social responsibility among its citizens, encouraging them to help out in their own ways. People took extra care to safeguard their own health and the well-being of others around them by taking precautionary measures such as daily temperature checks and good hygiene.

Singapore also won acclaim from other countries for its swift and rigorous actions in implementing and maintaining precautionary measures above and beyond WHO’s recommendations. The government effectively used its infrastructure to continuously rein-

force the social responsibility of Singaporeans during the time of crisis.

In summary, the Singaporean government’s IT capabilities provided the platform on which it developed several initiatives to face the crisis. The platform enabled communications across agencies, so they could share relevant and current information to better manage the crisis. Furthermore, agencies could work as part of a coordinated national agenda to reinforce the national message to the nation and the region. Thus, an effective organizational capability yields not only appropriate use of information technology but also a culture of cooperation. Singapore was able to transcend the political quagmire of multiple agencies, each with a separate agenda. It created “telecooperation” through the use of information technology.

CONCLUSION

The overriding lesson from this study is that executives can view e-Government as an organizational capability that can play a strategic role in adopting, integrating, and deploying IT resources and capabilities in crisis situations. However, developing such a “national asset” requires sustained IT investment and development. It also requires creating a culture of cooperation.

These capabilities are applicable to both public and private sector organizations because both now operate in volatile situations and manage dispersed units, coordinated through IT infrastructures. IT infrastructure can be leveraged during times of crisis by both governments and private organizations alike. Businesses often deal with crises in rapidly changing and complex business ecosystems that include webs of partners, suppliers, and customers. Having already invested significantly in an infrastructure for operation, businesses, like a government, can leverage their infrastructure during a crisis to support collaboration and information exchange, to make effective, timely decisions.

The Singapore experience suggests that organizations need to think ahead about how they can adapt their existing IT resources and capabilities in times of crises. The SARS crisis illustrates the importance of coordination among agencies to bring coherence to crisis response. Efficient communication channels and a shared platform enhance decision-making and execution. Singapore’s experience also underscores the role of leadership in envisioning innovative measures to conduct relief operations.

Every crisis is inherently different. Hence, it is impractical to prepare for all eventualities. However, the IT infrastructure, technology resources, human IT tal-
ent, and collaboration capabilities are assets that will benefit crisis management activities. Organizations should develop their IT capabilities with these additional uses in mind. Organizations should develop new IT capabilities with these additional uses in mind.

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APPENDIX A: STUDY METHODOLOGY

This research aimed to answer two questions. First, how did Singapore’s prior investments in e-Government enable the development of the needed capabilities for SARS containment? Second, how did government agencies and ministries in Singapore coordinate their information activities and collaborate during the SARS crisis? Our goal was to determine how the government leveraged its existing IT resources and capabilities to respond effectively to the sudden outbreak of SARS. Our unit of analysis was the entire Singaporean government. By analyzing the actions the government took and the decisions it made in response to the outbreak, we better understand the issues, problems, and events that occurred over the course of combating SARS in Singapore.

To obtain a breadth of information, opinion, and accounts of experience, we interviewed 18 executives in the Defense Science and Technology Agency (DSTA) between August and November 2003. All the interviews, which were about one and one-half hours in duration, were transcribed and analyzed. The selected interviewees provided the full range of technological support during the crisis, and coordinated extensively with other agencies at all levels. The information collected during the personal interviews focused on the participants’ understanding of the crisis, and their contribution, experiences, and perceptions.

Secondary research included reading the extensive news coverage of the outbreak in Singapore, press releases from different government agencies, advisories for precautions against SARS, and articles from multiple newspapers and other SARS-related Internet publications in Singapore. This secondary research helped identify the key capabilities of e-Government that the government had developed over two decades.

We used the interview transcripts and meeting minutes to create a detailed history of the events, the IT resources used, the government’s decisions, and its actions during the SARS outbreak. We used Grant’s\textsuperscript{16} classification scheme for resources to identify the IT resources involved in the entire crisis management process. We verified our analysis by reviewing literature on e-Government and capabilities development.

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<th>Agency</th>
<th>Role</th>
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| **Ministry of Health (MOH)** | • Disseminate information and updates on SARS to all agencies  
• Issue advisories  
• Work/collaborate with all government agencies and statutory boards. Monitor overall responses. |
| **Ministry of Manpower (MOM)** | • Take care of compensation and benefits of workers affected by SARS  
• Take care of illegal immigrant issues  
• Inform foreign workers about SARS through packages in their native language  
• Work with employers and employees to help prevent the spread of SARS in the workplace  
• Guard against the import of SARS through the arrival of foreign workers |
| **Ministry of Education (MOE)** | • Distribute thermometers and information kits to school children  
• Clean schools and perform daily temperature checks  
• Manage education efforts on SARS, including introducing a SARS module in schools  
• Assure parents of a safe SARS-free environment for school children |
| **Ministry of Home Affairs (MHA)** | • Collaborate with Malaysian counterparts on SARS containment measures  
• Exchange timely and accurate medical information about SARS with Malaysia  
• Work hand-in-hand with MOH to disseminate information to the public; reassure the public to avoid panic; and encourage the public to cooperate |
| **National Environment Agency (NEA)** | • Ensure cleanliness and hygiene in public places, such as food centers, public restrooms, schools, condominiums  
• Distribute kits (thermometers, brochures) to hawkers  
• Assure the public of the safety of hawker centers and marketplaces  
• Handle initial contact tracing of index patients |
| **Singapore Tourism Board (STB)** | • Initiate the Singapore COOL Certification Award to encourage hotels and other tourism facilities to implement SARS preventive measures  
• Secure alternative accommodation (e.g., resorts) for visitors or students under quarantine |
| **Immigration and Checkpoints Authority (ICA)** | • Provide health declaration cards at all immigration points  
• Perform pre-departure and on-arrival passenger and crew health checks at all immigration points (land, sea, and air)  
• Work with Malaysia counterparts to develop a set of protocols to control the spread of SARS across land and sea checkpoints |
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<th>Agency</th>
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| **Civil Aviation Authority of Singapore (CAAS)** | • Issue directives to airlines  
• Conduct passenger/crew health checks  
• Provide health declaration cards at airports  
• Provide financial assistance to airport shop tenants and airlines affected by the SARS outbreak  
• Ensure compliance with SARS preventive measures at the airport |
| **Defense Science and Technology Agency (DSTA)** | • Provide the technology infrastructure for contact tracing, thermal scanners for detecting fever, and hospital patient tracking system  
• Design and deploy contact tracing applications at the MOH Operations Center |
| **Ministry of Community Development and Sports (MCDS)** | • Close childcare centers to prevent future spread of SARS  
• Implement measures to raise awareness and ensure high standards of precautions and hygiene at childcare centers  
• Provide public education via “advertorials” in the four official languages of Singapore to inform people about SARS |
| **Health Promotion Board (HPB)** | • Create awareness about SARS via posters, advertisements, etc.  
• Provide emotional support to the public |
| **Tan Tock Seng Hospital (TTSH)** | • Serve as the battleground for the SARS war  
• Isolate and house SARS patients, in-patients, and out-patients  
• Provide ambulance service for suspected SARS cases  
• Provide SARS screening  
• Implement preventive measures for hospital visitors, staff, and healthcare workers |
| **CISCO (a security service agency)** | • Deploy and install e-PIC cameras in homes of quarantined patients  
• Issue Home Quarantine Orders (HQOs) to prospective SARS cases  
• Call up and monitor people on HQOs |
| **Ministry of National Development (MND)** | • Check and repair sanitary pipes, and disinfect residential areas  
• Provide alternative supplies of vegetables on closure of the PPWC vegetable wholesale center following the discovery of SARS cases there  
• Provide financial assistance to those affected by the PPWC closure  
• Conduct surveys to assess the level of public confidence in fighting SARS |