Passengers in Mexico City wear protective masks to combat the effects of the Swine flu.

Governing for the Future
What Governments Can Do

BY PETER HO AND ADRIAN W. J. KUAH

On 25th February 2003, the Severe Acute Respiratory Syndrome (SARS) virus entered Singapore through three women who had returned from Hong Kong with symptoms of atypical pneumonia.[1] The virus then spread with alarming speed through the hospital system, confounding doctors and healthcare professionals with its aggressiveness. The fatality rate was shocking: by the time the SARS crisis was declared over in Singapore, 33 people had died out of the 238 who had been infected.[2]

Nicholas Nassim Taleb describes a "black swan" as a hard-to-predict event with a large impact.[3] SARS was such a black swan for Singapore. Indeed, the impact of SARS on Singapore was profound and multifaceted, not only in the severity of the infection but psychologically in terms of public fear and stress. Overnight, visitor arrivals plunged, paralysing the entire tourism industry. SARS severely disrupted the Singapore economy, leading to a contraction and a quarter-long recession that year. While many lessons were learned from the SARS crisis of 2003, for the purposes of this paper one central insight stands out. It is simply this: other black swans will continue to surprise us, as much as, if not more than, the SARS crisis.

Recent years have seen a succession of strategic and catastrophic shocks including 9/11, the 2008 Global Financial Crisis, the 2011 Tōhoku earthquake and tsunami and Fukushima nuclear meltdown, July 2011 Thailand floods, and the Eurozone crisis, just to name a few. The frequency of such shocks seems to be increasing, with the amplitude of their impact growing. The question is, why? More importantly, what can governments do about them?

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Complexity: It Ain't Rocket Science – Pity

From the middle of the 20th century – a period that is sometimes called the "Great Acceleration" – change has accelerated at a pace and on a global scale that is unprecedented in history. The "Great Acceleration" has seen huge leaps forward in technology – in telecommunications, the internet, and transportation – leading to vastly increased trade and the movement of people around the world. Population growth has surged. Combined with rapid urbanization, it has generated enormous consumer demand. The effort to meet this demand through industrialization and mass production has had a huge but unpredictable impact on the earth's ecosystem. Globalization resulting from and combined with technological innovation has, in turn, accelerated change on all fronts – political, economic and social.

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Much of this change has followed unpredictable trajectories. The reason for this is "complexity."[4] And it is no small irony that there are different types of complex systems that include physical complexity, biotic complexity and conscious complexity.[5] This paper argues that the public policy challenge of our times lies at the intersection of the physical, the biotic and the conscious.

Simply put, the complex is not the same as the complicated: it is something fundamentally different. The natural world is complex. In comparison, an engineering system – be it an airplane or a telecommunications satellite – is merely complicated. Its inner workings may be hard for a layman to understand, but it is designed to perform certain pre-determined functions that are repeatable. In other words, it embodies the Newtonian characteristics of predictability, linearity and reducibility to mechanistic causes and effects. A complex system does not necessarily behave in a repeatable and pre-determined manner. Cities are complex systems, as are human societies. Countries and political systems are complex. Indeed, the world as a whole is complex and unordered. In all likelihood, a complicated world has not existed for a very long time – if it ever did. Many of the catastrophic shocks mentioned above have their roots in the interlocking of human behaviors and the dynamics of the planet's natural systems. In other words, such shocks are a consequence of an anthropocentric planet in which the human, far from being a detached actor in the natural system, is increasingly and inextricably enmeshed.[6] And as Geyer and Rihani put it, the continued inability to move beyond the Newtonian clockwork paradigm, in the socio-political milieu at least, has resulted in "both the continued failure of social scientists to capture the 'laws' of social interaction and policy actors' continual frustration over their inability to fully control and direct society."[7]

The ancient Chinese philosopher Lao Tzu instinctively grasped the complex nature of the world that we live in when he wrote in the "Tao Te Ching" (or "The Way") that "everything is connected, and everything relates to each other."[8] But connections and interactions

within a complex system are extremely difficult to detect, inexplicable, and emergent. Efforts to model complex systems, such as the Club of Rome's famous model of economic and population growth, have not proven very useful.[9] Unlike in a complicated system, the components of a complex system interact in ways that defy a deterministic, linear analysis. As a result, policymakers continue to be surprised and shocked by black swans and other unknown unknowns. If only we were still doing rocket science.

Wicked Problems and Retrospective Coherence

Unfortunately, complexity not only generates black swans, but also gives rise to what the political scientist Horst Rittel calls "wicked problems."[10] Wicked problems have no immediate or obvious solutions. They are large and intractable issues, with causes and interlocking factors that are not easily defined ex ante, much less predicted. They are highly complex problems because they contain many agents interacting with each other in often mystifying and conflicting ways. Finally, they have many stakeholders who not only have different perspectives on the wicked problem, but who also do not necessarily share the same goals. Often they are problems where either no single agency owns them, or where many agencies own a piece of the problem, in which case they fall through the cracks of the bureaucracy.

The public policy enterprise is littered with wicked problems. Climate change is a very good example of a wicked problem: it is a problem that exists at the global level, and yet precisely because it transcends national boundaries and has implications for state sovereignty, the solutions that must necessarily involve the supra-national and the

sub-national are continually still-born. State-bound perspectives can only go so far in solving global problems; indeed, sometimes they exacerbate them. Pandemics are another. In the developed world, the problem of aging populations is emerging as a critical wicked problem. Sustainable economic development, which is not unconnected to the triangular problem of food, water and energy security, is an enormously wicked problem.

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Tackling one part of a wicked problem is more likely than not going to lead to new issues arising in other parts. Satisfying one stakeholder could well make the rest unhappy. A key challenge for governments therefore is to move the many stakeholders towards a broad alignment of perspectives and goals. But this requires patience and a lot of skill at stakeholder engagement and consensus building.

One of the hallmarks of wicked problems is their tendency to "pop into existence."[11] The linkages between wicked problems and complexity theory become extremely compelling, especially through the idea of "retrospective coherence."[12] In a sense, the Danish philosopher Søren Kierkegaard anticipated the notion of "retrospective coherence" through his observation that, "Life is understood backwards, but must be lived forwards."

The current state of affairs always makes sense (even if only apparently) when viewed

retrospectively. But this is more than saying that there is wisdom in hindsight. It is only one of many patterns that could have formed, any one of which would have been equally logical. That an explanation for the current state of affairs exists does not necessarily mean that the world is a complicated and knowable world; rather, often it only seems that way.

Taken together, the concepts of emergence and retrospective coherence suggest that in a complex system, even if the same decisions are faithfully repeated, there is no certainty that the outcomes can be replicated. Put another way, it simply means that understanding and applying the lessons of history are no sufficient

guide into the future. The past is clearly no prologue.

Indeed, the notion of "past as prologue" is a dangerous assumption if the operating environment is complex. At the same time, though, the assumption that the world is an orderly and rational place has long informed the public policy enterprise, to say nothing of being reassuring to the policy maker. However, complexity theory suggests that the internal dynamics of a system "create complex outcomes that are not amenable to precise prediction," and that any coherence is only apparent or retrospective, or both.[13]
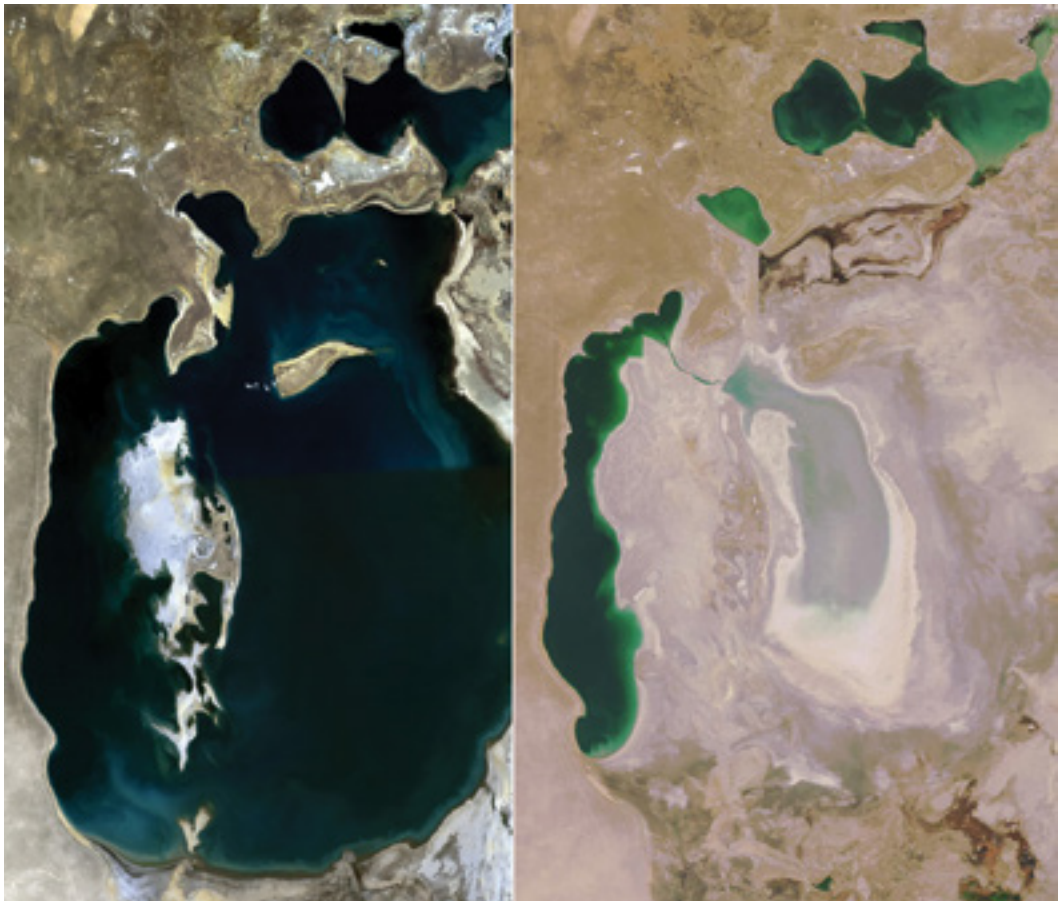
The Aral Sea in 1989 (left) and 2008 (right). A complex phenomenon with multiple stakeholders.

Governments that do not understand retrospective coherence will often assume that the operating environment is merely complicated – and not complex – one in which cause and effect are linked such that the output can be determined from the input, in which one step leads predictably to the next. A failure to appreciate and apply complexity theory appropriately creates a messy contradiction and stressful situation for policy makers "caught between the demands of orderly, rational central criteria and the messy reality of day-to-day local conditions and contradictions."[14]

Governments and Complexity

If we accept the central message of complexity theory, that the broad range of socio-political and economic phenomena are simply not amenable to prediction and therefore control, then how can we justify the strategic foresight enterprise? Is futures work simply "future babble", as Dan Gardner puts it?[15]

In Singapore, a strong futures orientation has always been an integral part of policy making. In a 1979 speech titled Singapore into the 21st Century, S. Rajaratnam, the then Minister for Foreign Affairs and one of the founding fathers of modern Singapore, not only dispelled the charge that futures-oriented speculations were not proper concerns of the policymaker, but also argued that futures thinking was integral to Singapore's long-term prospects:

> There are practical men who maintain that such speculations are a waste of time and they have no bearing at all on solutions to immediate day-to-day problems. This may have been so in earlier periods of history when changes were few and minute and were spread over decades and centuries...

> [Because] we are not only living in a world of accelerating change but also of changes which are global in scope and which permeate almost all aspects of human activity...only a future-oriented society can cope with the problems of the 21st century.[16]

There in 1979 lay the philosophical (but overlooked) foundations of Singapore's foresight enterprise. From the outset, there was no doubt that foresight would be an integral part of public policy. The only question was how competently and effectively foresight could be practised.

The Singapore Government has tried to reconcile a strong futures orientation with an appreciation of the complexity inherent in public policy. It has realized that when governments ignore the complexity of their operating environment, they are at risk of assuming that policies that succeeded in the past will continue to work well in the future. In other words, governments would rather be doing Newtonian rocket science. This results in policymakers dealing with wicked problems as if they are amenable to simple and deterministic policy prescriptions. To be sure, the temptation to take this approach is understandable: it seems intellectually and cognitively easier, requires fewer resources, and in the short run may actually lead to positive outcomes. However, government policies that do not take complexity into account can, and often do, lead to unintended consequences, with a real danger of national failure in the long run.

Unfortunately, the evidence suggests that many governments will opt to take this path, either out of political expediency, or because of cognitive failures, or simply because they lack an understanding and the tools to deal with complexity. Those governments that learn

to manage complexity, and how to govern in a complex operating environment, will gain a competitive advantage over those that do not. But to manage complexity requires fundamental changes to the mind-set, capabilities and organization of government.

Professor Yaneer Bar Yam, a complex systems scientist, writes that "the most basic issue for organizational success is correctly matching the system's complexity to its environment."[17] In other words, the complexity of the government developing the policy should match the complexity of the system that will be affected by the policy.

Fighting a Network with a Network

What then does it mean for the complexity of government to match the complexity of the problem? Singapore's counter-terrorism effort provides a useful illustration of this concept in practice. On December 7, 2001, the authorities announced the detention of several Singaporeans who were members of a previously unknown network of extremists, the pan-Southeast Asian *Jemaah Islamiyah* (or JI). The JI had been plotting acts of mass terror against several targets in Singapore. Singaporeans were preparing to kill fellow Singaporeans in pursuit of demented ideological goals.

This was a black swan for Singapore that overnight produced a wicked problem for the Government – how to deal with the threat posed by extremists who were members of a larger Southeast Asian network, and who lived and worked within the community, like ordinary Singaporeans.

The insight that a network was needed to fight a network[18] was a critical element in Singapore's counter-terrorism strategy. The observation that the JI, as a sprawling, multi-layered network, was a complex organization led to Singapore's response, both in terms of organization as well as policy, that matched the JI's complexity.

Given its organic and diffused nature, it was not possible to destroy the JI network by just hunting down the leadership and decapitating it. To do so would be to deny the JI's essentially complex nature. Thus, Singapore adopted a similarly organic whole-of-government – perhaps even a whole-of-nation – approach to the threat posed by the JI. The traditional approach, of delineating the boundaries between agencies so that each would be responsible for a particular area, clearly would not work. No government agency had the full range of competencies or capabilities to deal completely with this complex threat.

In contrast to the American solution of creating a centralized agency, its Department of Homeland Security, Singapore opted to strengthen coordination and integration among existing agencies, leveraging the diverse strengths of existing agencies. This entailed coordinating the counter-terrorism efforts of the line agencies and ministries at the operational level, while integrating strategy and policy at the whole-of-government level. This approach called for a small but active node – the National Security Coordination Secretariat – at the heart of the broader network with the capacity to drive the strategic national agenda in counter-terrorism, but which would not interfere with the accountabilities of each agency.

Such an approach called for many agencies for the security, economic and social sectors to be networked, and at different levels. Needless to say, it was not without problems. The classic problem of inter-agency rivalries

and parochialism had to be managed. For example, the non-security agencies felt that this was a matter to be dealt with by the security agencies, whereas the security agencies in turn felt that their mandate was being impinged on by interlopers.

Lessons for Whole-of-Government Approach to Policymaking

The logic behind the whole-of-government approach to policymaking is a compelling one. A complex and multi-layered network of government agencies and non-governmental organizations had been created. In turn, the policies that were generated and implemented were complex – both defensive and offensive, employing both hard and soft power. The counter-terrorism enterprise has since formed the template that the Singapore Government has applied to other wicked problems like population and climate change.

More generally, governments will need to consider how they should be organized to deal with black swans, unknown unknowns, and the wicked problems that complexity generates. Creating new departments to deal with new wicked problems can be wasteful and ultimately ineffective if these creations do not contain enough organizational complexity.

Developing policies and plans to deal with such wicked problems requires the integration of diverse insights, experience and expertise. People from different organizations, both from within and outside government, have to come together and pool their knowledge in order to discover potential solutions. Cooperative mechanisms need to be set up to enable the sharing of information and to strengthen collective action.

The whole-of-government approach injects diversity and complexity into the policy process, crucial elements identified by Scott Page for success in the public policy enterprise.[19] It recognises that in complex situations, and when dealing with wicked problems, insight and good ideas are not the monopoly of single agencies or of governments acting alone. An integrated and networked approach strikes a balance between strength and stability of the formal vertical government structure, and the diversity from different perspectives and solutions derived from a larger and more varied horizontal network of government and other national resources.

While the case for a whole-of-government approach may be intellectually compelling, it is not easily achieved. Governments, like any large hierarchical organization, tend to optimize at the departmental level rather than at the whole-of-government level. Furthermore, in a traditional hierarchy, the leader at the top receives all the information and makes the decisions. But, under stress, hierarchies can be unresponsive — even dangerously dysfunctional — because there are in reality decision-making bottlenecks at the top.

Finally, complexity stresses hierarchies. The world that governments operate in today is too complex and too fast changing for the people at the top to have the full expertise and all the answers to make the requisite decisions. Indeed, it has become increasingly unclear where "the decision" is taken.

A whole-of-government approach requires that vertical departmental silos be broken down so that information can flow horizontally to reach other departments. The old "need-to-know" imperative must give way to "knowing enough" so that each component of the larger organization can respond to issues and challenges as they arise. An environment that encourages the spontaneous horizontal

flow of information will enlarge and enrich the worldview of all departments. This in turn improves the chances that connections hidden by complexity, as well as emergent challenges and opportunities, are discovered early.

The concept of *auftragstaktik* may hold clues for what the structures and processes for a whole-of-government approach might look like. The German military adopted with great success (at least at the operational level) a concept of military command called *auftragstaktik*, essentially a philosophy of command that acknowledged the complexity and the chaos of war. [20]

In *auftragstaktik*, even the most junior officers were empowered to make decisions on the spot, because they had a better and more direct feel for the situation on the ground. It meant that down the line, every officer had to understand not just the orders, but also the intent of the mission. In turn he was empowered to make decisions to adjust to the situation as he judged it, in order to better fulfil the intent of the mission.

Whole-of-government implicitly contains the central idea of *auftragstaktik*, which is that in complexity, it is not possible for everything to be centrally directed. Not unlike *auftragstaktik*, whole-of-government depends critically on people at all levels understanding how their roles fit in with the larger national aims and objectives. Agencies must have a strong and shared understanding of the challenges that the nation faces, and the underlying principles to guide responses. Furthermore, leaders of each agency must ensure its own plans and policies are aligned with the national imperatives, to the point that they instinctively react to threats and opportunities as they arise, knowing that what they do will advance the larger national, rather than departmental interests.

Whole-of-government is a holy grail – an aspiration. In countries like Singapore, it remains very much a work in progress. It requires emphasis, support and constant attention from the top.

Dealing with Cognitive Biases

In addition to the limitations, even flaws, of the traditional bureaucratic structures that define modern government, the cognitive limitation and biases that plague the human condition also constitute a significant obstacle to the more effective management of complexity.

In April 2010, the Icelandic volcano Eyjafjallajökull erupted.[21] When a huge cloud of volcanic dust started to spread over Europe, air traffic authorities grounded thousands of aircraft as a safety precaution. Europe was almost paralyzed. It caused travel chaos around the world and disrupted global supply chains for weeks. It has long been known that volcanoes erupt from time to time, and that it is risky to fly through volcanic ash clouds. Yet why, despite this knowledge, was the world so surprised and unprepared for the impact of this eruption?

First, although the risk of eruption is known, it is very difficult to assess its probability of occurrence. Behavioral economists point out that we underrate the probability of an event when it has not happened recently and overrate the probability of an event when it has. As a result of this cognitive bias, the risk of an eruption was underrated in this case, as the Icelandic volcano had been quiescent for a long time. This tendency to place less emphasis on future risks and contingencies, and to emphasize present costs and benefits is a

common cognitive bias known as hyperbolic discounting.[22]

Second, the effect of the eruption on aircraft flights was the result of complex interconnectivities and therefore highly unpredictable. When the Icelandic volcano erupted, aviation authorities depended on the predictions of analytical models and reacted with caution by shutting down all flights.[23] But as the commercial impact grew, the industry began to question the reliability of these models and proposed doing experimental flights to probe whether it was safe to fly. In the event, the experimental flights proved to be a better indicator for action than reliance on the models. This is a clear demonstration of the value of exploration and experimentation when confronted with complex phenomenon, as opposed to depending solely on the predictions of analytical models.

Cognitive biases and the extreme difficulty of estimating the cumulative effects of complex events make preparing for unforeseen situations an exercise fraught with difficulty. It also adds to the challenges of governments operating in complex situations.

Finally, the reluctance to grapple with game-changing issues – be they volcanoes, financial crises or terrorist attacks – stems from an unwillingness to face the consequences of an uncertain and unpredictable future. These consequences interfere with long-held mental models, thereby creating cognitive dissonance. By extension, cognitive dissonance speaks of

Flight disruptions at Leeds Bradford International Airport in 2010 after Icelandic volcano, Eyjafjallajökull, erupted leaving a huge cloud of volcanic dust.

denial: the inability to acknowledge uncertainty, the unwillingness and recalcitrance in accepting the need to adapt to a future that is not a straightforward, linear extrapolation from current reality.

Managing and Organizing Complexity

In such a complex operating environment, governments should be adaptive in navigating situations characterized by emergence, multi-causality and ambiguity. Governments often have to make big decisions, and develop plans and policies, under conditions of incomplete information and uncertain outcomes. It is not possible to prepare exhaustively for every contingency. Instead, a "search and discover" approach should be adopted. The deployment

Lean systems that focus exclusively on efficiency are unlikely to have sufficient resources to deal with unexpected shocks and volatility, while also having the bandwidth to make plans for an uncertain future filled with wicked problems.

of experimental flights to check out the real risk of flying into a cloud of volcanic ash exemplifies this approach. The military calls this approach the OODA loop (Observe, Orient, Decide, Act), which is a recurring cycle of decision-making that acknowledges and exploits the uncertainty and complexity of the battlefield.[24]

Scenario planning is a linear method of carrying out the OODA loop, in the sense that it projects futures based on our understanding of the operating environment today. Used intelligently, it can be a very important tool for planning, and can help overcome cognitive biases by challenging our mental models. But it is insufficient in a complex unordered environment.

In this regard, non-linear methods should be part of the government complexity toolbox. One of the more innovative methods has been policy-gaming, which is akin to military war-gaming. Applied to the civilian policy context, policy-gaming helps to condition policy-makers to complex and uncertain situations, thereby allowing them to confront their cognitive biases. At Singapore's Civil Service College, Applied Simulation Training (AST) was introduced in 2012, after being successfully piloted in a series of policy-gaming sessions held in leadership milestone programmes.[25] Far from being an exercise in validating current policies and practice, the central aim of policy-gaming is the "expansion of participants' comfort zones…"[26]

Governments must also be able to manage the risk that is a natural result of operating in complexity. There will always be threats to national interests, policies and plans, because no amount of analysis and forward planning will eliminate the volatility and uncertainty that exists in a complex world. These threats constitute strategic risk.

But there is little by way of best practice to systematically address or ameliorate the threats to national goals that these risks pose. In Singapore, the government is developing a unique Whole-of-Government Integrated Risk Management (WOG-IRM) framework – a governance chain that begins with risk identification and assessment at the strategic level, to monitoring of risk indicators, and finally to resource mobilization and behavioral changes to prepare for each anticipated risk.[27] WOG-IRM also plays an imperfect but important role

in discovering the inter-connections among risk factors. This in turn helps to reduce some of the complexity. The WOG-IRM framework is a work-in-progress, and we have started using it for strategic conversations on risks that occur at the whole-of-government level.

The WOG-IRM framework is also critical to building resilience, which is the ability to cope with strategic shock by adapting to, or even transforming with, rapid and turbulent change. Resilience, defined as the ability to "bounce back" and distinct from the "imperviousness," is a prerequisite for governments to operate effectively in a complex environment.

Resilient governments must also go beyond an emphasis on efficiency. Lean systems that focus exclusively on efficiency are unlikely to have sufficient resources to deal with unexpected shocks and volatility, while also having the bandwidth to make plans for an uncertain future filled with wicked problems.

This is not an argument for establishing bloated and sluggish bureaucracies; rather, it is to reiterate the importance of a small but dedicated group of people to think about the future. The skill-sets needed are different from those required to deal with short-term volatility and crisis. Both are important, but those charged with thinking about the future systematically should be allocated the bandwidth to focus on the long-term without getting bogged down in day-to-day routine. They will become repositories of patterns that can be used to facilitate decision-making, to prepare for unknown unknowns, and perhaps to conduct policy experiments through policy-gaming or other simulations. A few examples will suffice to illustrate this point.

In 2004, the Singapore Government initiated its Risk Assessment and Horizon Scanning (RAHS) program. A major development in Singapore's broader strategy to scan for complex risks, RAHS uses a computer-based suite of tools to identify and interpret weak signals that can evolve into sudden shocks. The primary rationale of RAHS is sense-making, used in the technical sense as articulated by pioneers in the field such as Karl Weick and Dave Snowden.[28] Ultimately, sense-making is not about the "truth" or "getting it right;" rather, it consists in the continuous drafting (and redrafting) of an emerging story so that it becomes more comprehensive and comprehensible, and becomes more viable than alternative stories so that it can form the basis of present actions. Given the emergence of ubiquitous (and often equivocal) big data, coming in from multiple sources such as climate information, posts on social media sites, digital pictures and videos, financial transaction records, mobile telephony GPS signals and so forth, RAHS's sense-making work has become ever more salient to Singapore's risk management enterprise.

In going beyond the detection of weak signals to engendering strategic and meaningful shifts in thinking, the Singapore Government set up the Centre for Strategic Futures (CSF) in 2009.[29] It is a think tank that promotes a whole-of-government approach to strategic planning and decision-making. It works on leading-edge concepts like complex systems science, WOG-IRM, and resilience. It promotes fresh approaches for dealing with complexity like policy-gaming, encouraging experiments with new computer-based tools and sense-making methods to augment the current horizon scanning toolkit. Although a small outfit,

the CSF is a catalyst for strategic change in the government and its agencies.

The setting up of the CSF at the heart of government – within the Prime Minister's Office – is itself highly instructive. Its location within the establishment as well as its mandate of challenging dogma and orthodoxy speaks to how government futures work cannot be conducted in isolation, yet at the same time must be insulated and protected from the day-to-day machinations of government. This calls to mind noted futurist Wendell Bell's example of General Matthew B. Ridgway, who in the mid-1950s served as the U.S. Army Chief of Staff:

> *When asked what he thought was his most important role as the nation's top soldier, he answered, "To protect the mavericks." What Ridgway meant was that a future war might be completely different from the currently dominant beliefs on which plans were being made...He was counting on the mavericks to be looking at the future in ways different from the dominant views, thinking beyond the orthodox beliefs and school solutions.*[30]

Conclusion

The future promises ever more complexity, carrying in its train more black swans and unknown unknowns. Governments must learn how to operate and even thrive in this complexity, and to deal confidently with strategic shocks when they occur. The first step is to acknowledge the inherent complexity of the operating environment. Then they should consider the imperative of a whole-of-government approach, and the adoption of new non-linear tools for managing complexity, and strategic risk. These will not eliminate shocks. But by improving the ability to anticipate such shocks, governments might actually reduce their frequency and impact. In turn this will help make governments and nations more resilient as their leaders govern for the future. PRISM

Notes

[1]   Goh Lee Gan, "Reflections on the Singapore SARS Outbreak," *Singapore Medical Association News*, Vol. 35, No. 3, (March, 2003), p. 5. http://www.sma.org.sg/sma_news/3503/commentary.pdf (accessed 15th August, 2012).

[2]   I.H.G. Escudero, M.I.Chen and Y.S. Leo, "Surveillance of Severe Acute Respiratory Syndrome (SARS) in the Post-Outbreak Period," *Singapore Med* J, Vol. 46, No. 4, (April, 2005), p. 165. http://www.sma.org.sg/smj/4604/4604a2.pdf (accessed 15th August, 2012).

[3]   See Nassim Nicholas Taleb, *The Black Swan: The Impact of the Highly Improbable*, (New York: Random House Publishing Group, 2007).

[4]   For a good discussion of complexity science, please see Melanie Mitchell, *Complexity: A Guided Tour*, (Oxford [UK];New York: Oxford University Press, 2009); Neil Johnson, *Two's Company, Three is Complexity – A Simple Guide to the Science of all Sciences*, (New York and London: One World Publications, 2007); Thomas Homer-Dixon, *Ingenuity Gap: Facing the Economic, Environmental, and Other Challenges of an Increasingly Complex and Unpredictable Future*, (New York: Vintage Books, 2002).

[5]   For examples and discussions of the different types of complex systems, see Fritjof Capra,

The Web of Life, (New York: Flamingo, 1996); Murray Gell-Man, *The Quark and the Jaguar*, (Boston: Little Brown, 1994).

6   James Lovelock, *Gaia: A New Look at Life on Earth* (Oxford University Press, 1979)

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10   Horst W.J.Rittel and Melvin M. Webber, "Dilemmas in a General Theory of Planning," *Policy Sciences*, Vol. 4, No. 2, (June, 1973), pp. 155 – 169.

11   Private communication with Riel Miller (September 2013).

12   Dave Snowden, "Complex Acts of Knowing: Paradox and Descriptive Self-Awareness," *IBM Global Service*, (July 2002). http://www.imamu.edu.sa/Scientific_selections/Documents/IT/complexity_of_knowing.pdf (accessed 15th August 2012).

13   Robert Geyer and Samir Rihani, *Complexity and Public Policy*, p. 4-6.

14   Ibid.

15   Dan Gardner, *Future Babble: Why Expert Predictions Are Next To Worthless and You Can Do Better* (London: Dutton, 2011).

16   Speech by Mr. S. Rajaratnam, Minister for Foreign Affairs, *Singapore into the 21st Century*, at a seminar organised by the Singapore Association for the Advancement of Science at the Singapore Science Centre on 20 December 1979. Reproduced in Kwa Chong Guan, ed., *S. Rajaratnam on Singapore: From Ideas to Reality* (Singapore: World Scientific and the Institute of Defence and Strategic Studies, 2006), 238-48 [additional terms and italics mine].

17   Yaneer Bar Yam, *Making Things Work: Solving Complex Problems in a Complex World*, (Boston, Mass.: Knowledge Press, 2004), p. 91.

18   John Arquilla, "How to Build a Network," PRISM V.5,N.1

19   Scott E. Page, *Diversity and Complexity*, (Princeton, NJ: Princeton University Press, 2011).

20   *Auftragstaktik* is defined as mission-type or task-oriented tactics. *Auftragstaktik* essentially encourages greater initiative by leaders at all levels of command.

21   Valur Gunnarsson, "Iceland Volcano: Hundreds Evacuated After Eruption," *The Guardian*, 15 April, 2011.

22   Daniel Kahneman, *Thinking, Fast and Slow* (New York: Farrar, Straus and Giroux, 2013 reprint).

23   These were essentially outdated analytical models more than two decades old and that were furthermore derived from small data sets from Indonesian volcanic activities, a geological region with fundamentally different characteristics.

24   See David Fadok, who wrote one of the earliest studies on Boyd and on the concept of the OODA loop. He also distilled many of the critical points of Boyd's theories. David S. Fadok, 'John Boyd and John Warden: Air Power's Quest for Strategic Paralysis,' in Col. Phillip S. Meilinger (ed.), *The School of Advanced Airpower Studies – The Paths to Heaven: The Evolution of Airpower Theory*, (Maxwell Air Force Base, Alabama: Air University Press, 1997), p. 366.

25   See the Singapore Civil Service College's Annual Report 2012/13. https://www.cscollege.gov.sg/About%20Us/Annual%20Report/CSC_AR_FY12_1Oct13.pdf (accessed 15th January 2014)

26   Aaron Maniam, "Preparing Public Officers for New Modes of Governance," *Ethos*, Issue 10, October 2011, p. 71.

27   Ben Nadarajan, *Close Watch – A Nation's Resolve to Secure Singapore*, (Singapore: National Security Coordination Secretariat and Straits Times Press, 2012), p. 110.

28   For example, see Karl Weick, *The Social Psychology of Organizing*, (New York: McGraw-Hill, 1979); D. J. Snowden and C. F. Kurtz, "The New Dynamics of Strategy: Sense-making in a Complex and Complicated World", *IBM Systems Journal*, Volume 42, Number 3.

29   For more information on the Centre for Strategic Futures, please see its website, http://www.csf.sg.

30   Wendell Bell, Foundations of Futures Studies: History, Purposes, and Knowledge, Volume 1, (New Jersey: Transaction Publishers, 2009), p. 77.