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Anticipating and Navigating Strategic Technological Surprise

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The many technological advances underway in artificial intelligence, bioengineering, quantum technologies, energy innovations, and space capabilities are accelerating the pace and scale of change and introducing a new era of outsized possibilities and uncharted risks. New discoveries and technologies have always been disruptive, and some have been broadly transformative, from the wheel and the printing press to the automobile and the internet. However, today's convergence of advancing technologies and strong economic incentives is leading to new technological applications and disruptions at breathtaking speed. Many important aspects of human life are being altered, forcing individuals, societies, institutions, and governments to adapt.

These technological disruptions are strategically significant when they overturn prevailing assumptions, dramatically alter the course of events, empower actors and shift advantage, and require significant responses at the societal, national, and/or international level. For example, China's unveiling of DeepSeek last year was a strategic shock to the U.S. policy community because it overturned the assumption that China could not produce advanced, globally competitive AI at scale.[1] With the rapid pace of technological development and diffusion, it is increasingly risky for governments, industries, and communities not to anticipate and prepare for how new discoveries and capabilities will be used and how they will impact their interests, security, and daily lives. Once new technologies are unleashed, it may be too late to shape their applications or adequately prepare for likely implications. Strategic warning of their potential emergence, unintended applications, and unanticipated implications is increasingly essential.

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To help leaders navigate this era of rapid innovation, Hoover's Tech Futures Lab offers a provisional framework for thinking about future strategic technological surprises. Our framework offers criteria for defining strategic surprise, identifies different categories of technological surprise across the innovation lifecycle, widens the aperture beyond traditional military contexts, and suggests multiple approaches to better anticipate and prepare for disruptions. Rather than being definitive, we provide this framework as a starting point for conversations about the risks and opportunities of technological disruptions. Protecting and maintaining U.S. security and prosperity in the years ahead requires consistent efforts both to reduce the element of 'surprise' and to make our societies, economy, and country more resilient and adaptive.

TRADITIONAL DEFENSE AND SECURITY FRAMING

Strategic surprise traditionally has been defined in the defense or national security arena as occurring when adversaries or rivals act in a way that defies expectations and overturns long-held assumptions, forcing an actor to alter how it protects itself and its interests.[2] These strategic surprises have fallen into a few categories, including unexpected attacks (timing and location), the acquisition and revelation of new weapons systems or capabilities, unconventional military tactics, and other behaviors that contravene historical patterns. Renowned military strategists, such as Sun Tzu and Von Clausewitz, encouraged the use of unexpected tactics as a means to gain initial advantage.[3] Modern academics, such as Michael Handel, Richard Betts, and Albert Mannes and Don Moore, and intelligence organizations have conducted postmortem reviews of strategic surprises to help understand the causes and to anticipate and prepare for future such events.[4]

These academic and government reviews demonstrate that several conditions can contribute to the surprise effect. First, the perpetrator may have employed denial and deception techniques to mislead about their real intentions—the easiest way to achieve surprise.[5] For example, an attacking military may disguise actions to resemble training exercises, as Russia did in the run-up to the 2022 invasion of Ukraine.[6] Second, an event may be surprising because observers assume it cannot or will not occur and thus dismiss available warning signs. This was the case in the 1968 Tet Offensive, when U.S. analysts detected evidence of a Communist buildup, but did not expect a major offensive during Tet, making

the scale and timing of the attack surprising.[7] Third, decision makers may be occupied with current events and therefore do not focus on what is deemed a low probability, high impact event, such as the numerous warnings of a global pandemic prior to COVID-19.[8] Finally, bureaucratic obstacles within and between organizations can make it difficult to connect fragmentary pieces of information as well as to get the information to the right decision makers in a timely manner. Prior to the September 11th attacks, legal and cultural barriers prevented the timely sharing of information between and within foreign-focused intelligence agencies and domestic law enforcement.[9]

Surprise attack. (Pearl Harbor, September 11th attacks, 1973 Arab-Israeli War, Oct. 7 HAMAS attack) The term 'strategic surprise' for most people conjures memories of the September 11th attacks or Pearl Harbor. These devastating attacks occurred in unexpected places, at unexpected times, and in novel ways, and each time led to a major military response and war. Both militaries and non-state organizations have conducted such surprise operations to gain an advantage. In many cases, these actors did not expect to keep the operation hidden.

New or newly acquired technological capability. (Nuclear breakout and testing, Cuban Missile Crisis) The development or acquisition of a new weapon or technological capability becomes a strategic surprise when decision makers are not expecting it and when the capability alters the balance of power. The discovery of Soviet nuclear-armed missiles in Cuba in 1962 is an example of strategic surprise, not because of the existence of this missile capability but because the USSR dared to send the weapons to Cuba within range of the continental United States, changing the effective range and thus the threat posture of Soviet nuclear weapons overnight.[10] Similarly, India's nuclear weapon tests in 1998 surprised the world as India became the sixth country in the world to publicly demonstrate nuclear weapons capability, altering power dynamics in the region and raising the country's stature globally.[11]

New, unconventional applications of existing weapons. (Kamikaze planes, drones, Improvised Explosive Devices (IEDs) in Iraq and Afghanistan) From the German use of tanks and radios to conduct blitzkrieg operations to Ukraine's use of First Person View (FPV) drones for kamikaze attacks against Russian artillery, existing technologies have often been used in novel and unconventional ways to shock the opponent and create battlefield advantage.[12] In the Middle East, the

Houthis' technologically sophisticated and logistically complex multi-drone attacks against ships in the Red Sea surprised the international community and shut down transit through the Suez Canal, forcing allied navies to take action.[13] Likewise, IEDs are not new, dating back hundreds of years, but their innovative application in Iraq and Afghanistan shaped the war significantly, temporarily shifting the balance of power on the ground, extending U.S. engagement arguably by years, and forcing the U.S. military to develop new resource-intensive approaches to countering IEDs.[14]

Uncharacteristic or unexpected behaviors. (Iraq WMD, Arab Spring, Sputnik, DeepSeek) Sometimes strategic surprises occur because the surprised party expected or assessed the opposite. For instance, in a 2002 National Intelligence Estimate, the U.S. Intelligence Community (IC) assessed that Iraq "has continued its weapons of mass destruction (WMD) programs in defiance of the United Nations' (UN) resolutions and restrictions," recognizing Saddam Hussein's history of using them, his previous use of denial and deception, and his repeated efforts to obstruct UN inspectors.[15] After the invasion, U.S. forces on the ground found no evidence of this program, surprising analysts and policymakers alike.[16]

The Arab Spring is another example. Few regional experts expected the people and the security services in Egypt and Tunisia to turn on the autocratic regimes, which had been in power for decades, but a single person's act of defiance ignited an undercurrent of frustration and unmet expectations that led to their downfalls.[17] The Soviet Union's launch of Sputnik in 1957 was a surprise to the United States, not because it demonstrated a phenomenon previously thought impossible, but because the seemingly 'backward' Soviet Union achieved it first.[18] This surprise prompted major U.S. policy and institutional responses, including the creation of the Advanced Research Projects Agency (ARPA) (later Defense Advanced Research Projects Agency (DARPA)) in 1958.[19]

WHAT MAKES A SURPRISE *STRATEGIC*?

From our review of historical cases of strategic surprise, we identified several criteria for a development to be considered strategic, including the actors involved, the level of disruption, and the need for a response to the surprise.[20]

The Perpetrator. Who or what perpetrates the surprise or develops, acquires, and/or controls the new capability can make it a *strategic* concern. For the United States, if a state rival or adversary develops or acquires a power-altering capability—even if the United States has achieved the capability first—this development could be strategic. In most cases, the perpetrator intended to catch the rival unaware or off guard and had malicious intent. Historical examples include Japan (Pearl Harbor), the USSR (Sputnik), al-Qa'ida (September 11th), HAMAS (October 7), and China (DeepSeek).

The perpetrator may also unintentionally surprise allies and partners who had not recognized or had misperceived changes in intentions and capabilities. For instance, Ukraine's resilience and creativity in response to Russia's 2022 invasion surprised most outside observers, including European allies, who failed to take into account Ukraine's preparation since the 2014 invasion.[21]

The Surprised Party. By definition, the word 'surprise' indicates an actor or actors who are surprised and unprepared for the development. To be a *strategic* surprise, the surprised party must be a decision maker responsible for shaping overarching policy related to the development. Even if they have been warned, individual decision makers can be surprised for a variety of reasons, including that the warnings came too early, the development was deemed low probability, they were more focused on immediate threats, or they had cognitive biases. They also may have simply ignored the experts who tried to warn them because the possibility did not fit their agenda or because of their own hubris.

Level of disruption. To be a strategic concern, the surprise must have deep and widespread disruptive capacity within at least one domain, overturning the existing equilibrium, standard practices, and existing norms. Weapons of mass destruction (WMD) are the clearest case. Their strategic weight comes from their mere existence; even the threat of deployment forces adversaries to restructure their planning, alliances, and deterrence postures.[22] Lower costs and open-knowledge ecosystems are enabling smaller states, non-state actors, and individuals to access an expanding universe of capabilities to produce strategic effects. The September 11th attacks—perpetrated by non-state actors with modest means—produced strategic consequences that no one anticipated and that have reverberated for decades.[23]

Context and Response. A surprise rises to the level of strategic if it warrants a major response or policy shift to manage the impact.[24] In other words, the context of the surprise determines whether it is strategic or not.[25] The response may be at the societal, national, or international level and may require significant reallocation of resources, institutional changes, or policy reforms. This aspect of the definition implies that 'surprise' is controlled not only by the scope and nature of a development, but also by the reaction of policymakers, implying that, to a certain extent, whether or not a surprising new development is strategic is a somewhat discretionary decision.

A FRAMEWORK FOR STRATEGIC *TECHNOLOGICAL* SURPRISE

Taking into account the parameters of strategic surprise, we define strategic *technological* surprises (STS) as developments regarding or relating to technology that significantly and unexpectedly invalidate core planning assumptions, alter a strategic domain, and thereby require a major response. (An illustrative STS is described in the text box at the end of this paper.) Technology can produce strategic surprises at any point along its life cycle, from development to application to the appearance of additional long-term effects, and a surprise in one domain may lead to additional surprises downstream. In this context, a technological surprise rises to the level of strategic when it catches key decision makers unprepared for the emergence, timing, application, diffusion, and/or implications of a technology. In contrast to traditional defense or military-related strategic surprises—which historically involved a perpetrator with intent—a technology may be so transformational that the actors matter less, and the impact matters more. These disruptions can occur without human intention or direct involvement at all.

Going forward, the greatest risks of technological surprise may not be failing to forecast the specific technological advancements, but being unable to anticipate the unplanned ways new and existing technologies can be applied and their longer-term systemic disruptions. As with the printing press, the automobile, and the internet, broader, strategic effects often emerge years or decades after development.[26] These disruptions can have both negative and positive implications for U.S. interests, influence, and long-term security. For example, transformational effects can include improvements in efficiency and productivity while at the same time disrupting livelihoods and economies.

The framework below offers categories of potential strategic technological surprise along the lifespan of a technology. Actual cases may span multiple categories or shift among them as they unfold.

Emergence of revolutionary science or technology. Although rare, scientific breakthroughs that fundamentally alter accepted scientific understanding and open new lines of inquiry and development can constitute strategic technological surprise. As noted above, the strategic dimension comes into play when a breakthrough overturns long-held assumptions and forces affected parties to alter behavior and policies. A very good counterfactual example might have been cold fusion; had low-energy nuclear reactions proved reproducible and scalable under ordinary conditions, it would have been revolutionary in many senses of the term, upending the conventional wisdom in physics that fusion requires extremely high temperatures, while dramatically transforming energy-production economics.[1] In real life, the discovery of penicillin in 1928—followed by its widespread medical application in the 1940s—produced a dramatic shift in healthcare outcomes and, over time, contributed to the transformation in mortality patterns, demographic structure, and economic productivity, along with other public health innovations like sanitation.[27]

On a smaller, sectoral scale, the 1982 discovery of prions challenged the then-dominant view that infectivity and replication required DNA or RNA, and eventually forced major operational changes in domains such as food safety, blood safety, and infection control/health security.[28] At the moment of discovery, however, reports of scientific breakthroughs can be difficult to distinguish from error and often provoke pushback within the scientific community before their implications are recognized and absorbed. Note also that a nontrivial number of early, high-profile scientific claims advertised as 'revolutionary breakthroughs' in the media and in institutional science communication are, in fact, forms of hype that exaggerate the positive implications, generality, or robustness of the underlying evidence, and do not survive subsequent scrutiny or independent testing.[29]

The timing of the emergence of an innovation. A technological or scientific breakthrough could rise to the level of a strategic surprise if the timing of its

[1] Alas, the scientific consensus after three decades is that cold fusion mainly demonstrated the perils of bypassing peer review processes intended to weed out error.

emergence is not anticipated or appreciated. For example, the Soviet Union detonated its first atomic bomb in August 1949, at least five years earlier than intelligence estimates had anticipated.[2] This event was one of several influences that drove the United States towards the development of thermonuclear weapons.[30] Looking forward, examples of strategic technological surprise from the timing of an innovation could be cryptographically relevant quantum computing or nuclear fusion in the next couple of years.[31]

Unintended and novel applications. While surprise from the emergence of a technology itself is less likely given today's information environment and open innovation system, both existing and emerging technologies can be used in surprising, unintended, and transformative ways. Technology designed and intended for one use may be applied in unexpected, non-obvious ways in other places and contexts, sometimes transforming other domains. For example, consumer quadcopter drones were originally developed as inexpensive platforms for aerial photography and hobby use.[32] However, recent conflicts—especially in Ukraine—have demonstrated that off-the-shelf models, like DJI's Mavic, can be repurposed for real-time reconnaissance, artillery spotting, and grenade or small-munition delivery, effectively giving small units and non-state actors precise and ubiquitous 'airpower,' and forcing militaries to rethink tactics, force protection, and electronic-warfare priorities.[33]

Unexpected diffusion and adoption. Technological innovations can produce surprising effects when they diffuse quickly, spread widely, or are adopted at scale before norms and standards can catch up. Early transformational technologies spread slowly and did not become widely used for decades. For example, it was almost 70 years after Edison developed his lightbulb—not the first—before most American households had electric lights.[34] More recent innovations, such as smart phones and LLMs, have moved quickly across countries, regions, and the world to change how we live and work.

Even when a technology and its applications are anticipated, the speed and scale of adoption can produce outsized disruptions across multiple domains,

[2] See, for example, CIA Director R.H. Hillenkoetter, "Estimate of the Status of the Russian Atomic Energy Project, Memorandum to the President." Central Intelligence Agency, July 6, 1948. https://nsarchive.gwu.edu/document/19576-national-security-archive-doc-05-document-3. (verified)

affecting daily life, domestic stability, geopolitics, and national security. For example, Facebook originally was just a system for college students to communicate, but a decade later, it became a global source of information and news in many countries.[35] For many, Facebook is now the primary source of news.[36] Similarly, in developing countries without modern infrastructures, the smartphone not only enabled communication, but provided women a form of identification, facilitated banking and payment systems, and gave millions access to education, disrupting societal norms and traditional practices.[37]

Long-term, unanticipated secondary implications. Sometimes an initial disruption is quite small and could go unnoticed, but over time, that initial disruption may catalyze a larger, unforeseen reaction. A well-known historical example is the printing press, which Johannes Gutenberg first invented in the 1430s.[38] It required 15 years to print the first full book and another 50 years for the printing press to be used across Europe.[39] When it was widely adopted, the printing press revolutionized education and the spread of information, promoted progress in other fields, and finally overturned power structures within societies.[40]

Alternatively, an invention could prove highly effective at solving the problem for which it was created, but then cause problems in a different area. Examples of these unintended implications are numerous, including asbestos, which had many industrial uses but was later discovered to cause cancer, or plastic, which has a wide range of applications but has created a host of complications for human health and the health of the planet.[41] These unforeseen problems, which occurred in sectors other than the one in which technology was deployed or designed, forced major policy responses, including new regulations and norms of behavior.

Compounding and cascading effects. The most challenging strategic surprises to forecast are those that are contingent on the emergence of other technologies or societal dynamics. This convergence pattern can produce unexpected and outsized impact, both positive and negative. Consider, for example, the rapid proliferation of the Internet and its numerous applications. Originally designed to network timesharing mainframe computers, it has evolved in a relatively short time into the backbone of our modern world.[42] However, for the internet to be accessible to ordinary citizens required the development and proliferation of personal computers and smartphones (and

wireless data networks).[43] Today, ubiquitous high-speed internet service provides a myriad of opportunities to improve daily life and increase productivity while simultaneously hosting platforms that have fragmented and polarized our communities.[44]

MORE STRATEGIC TECHNOLOGICAL DISRUPTIONS ON THE HORIZON

Looking ahead, the accelerating development, diffusion, and application of new technologies are likely to produce more and more frequent surprising, disruptive, and strategic effects in multiple, different domains. These disruptions—both positive and negative—will be increasingly systemic and potentially more consequential to our stability, security, and prosperity than more traditional strategic surprises in the military domain. In many cases, we have only begun to explore how they will play out over the longer term.

Scientific and methodological. Technological advancements increasingly are catalyzing other scientific and technological advancements, creating an accelerating cycle of innovation, advancement, and more innovation. Historical examples of enabling and catalyzing technologies are numerous. From the compound microscope to the electron microscope, mass spectrometry, CRISPR, and many others, these technologies supported the conduct of scientific research and had an enormous impact on scientific progress. CRISPR-Cas9 enabled precise, programmable gene editing, making genome engineering more accessible to more researchers, thereby accelerating advancements in biotechnology, agriculture, and therapeutic development.[45] Computation is another example of a virtuous, accelerating cycle. Improvements in computing beget new applications, and semiconductor companies then invest profits in the next generation of chips and computation, which has, for decades, created multiple cycles of advancements.

Social and cultural. Existing and emerging technologies already are straining the very fabric of our societies, producing strategic challenges for U.S. stability, security, and ability to project power. Medical breakthroughs, social media, AI, and many other innovations have catalyzed political debate and fostered societal divisions. Social media content—both real and fake—can motivate political behavior (Arab Spring 2011), erode trust in institutions (Covid-19), polarize societies, undermine national resolve and sense of common purpose, and weaken public support for international action, including military

operations.[46] Without domestic support, even the most technologically sophisticated military will struggle to maintain operations over the long term.

Economic and commercial. Technological innovations are disrupting long-standing market patterns, from supply chains to labor forces to consumer markets, and creating new winners and losers. Historically, when an innovation disrupted job markets, new opportunities for work emerged. For example, the invention of automobiles eliminated jobs related to horse-drawn carriages, such as stable hands, farriers, and street cleaners, but it also spawned a broad range of complementary industries with new career options at all levels.[47] However, there is no guarantee this pattern will continue. In the future, technological disruptions to the economy are likely to be faster, more uneven, and may not spawn new employment opportunities.

Defense and intelligence. In the defense domain, surprise, large-scale kinetic attacks, like September 11th, will remain possible but probably infrequent. In contrast, the application of civilian technologies by both state and non-state actors has the potential to lead to more frequent, smaller-scale national security surprises that cumulatively have strategic implications. The production and dissemination of deep fakes and other AI-enabled disinformation campaigns are well-recognized examples of how civilian technologies can have significant defense and intelligence implications.[48] These information campaigns can create a series of surprising challenges with implications for U.S. security. Moreover, both new and evolving technologies are enabling the application of a greater range of gray zone tactics.[49] Such tactics—coercive actions carried out below the threshold of open war to pressure or influence another state while avoiding direct military escalation—are important because they can be used to create a near-constant state of below-threshold confrontation between great power rivals and can enable smaller countries and non-state actors to punch above their weight.

Geopolitics. Technology has become a central and arguably the most important element of strategic competition, with many new civilian technologies having unexpected geopolitical significance. Some of these technologies will alter the balance of power between countries, giving one an unexpected advantage over another, or extending a country's global reach. In some cases, being the first mover in creating a new technology provides an outsized strategic advantage, while in other cases, scaling these technologies to sell to others provides greater

influence. For example, China's rapid development, adoption, and scaled production of electric vehicles (EVs) and renewable energy sources are making China a global leader in climate-friendly technologies, providing the country with an expanding global market as well as new types of soft power.[50]

MITIGATING THE ELEMENT OF SURPRISE

Although eliminating surprise is impossible, applying a variety of foresight techniques can help identify a range of possible disruptions, arming decision makers with the information and time to prepare to mitigate or take advantage of them. Academic papers, patents, and international commercial activity provide ample early warning about new technologies in development. The fundamental challenge is sorting through this data to identify what developments are likely to produce the most consequential disruptions for societies, institutions, and governments.

A variety of approaches may help identify blind spots and anticipate potential surprises.

Learn from previous strategic surprises. Lessons-learned exercises help organizations see what has and has not worked. Some organizations call this approach an after-action report or a post-mortem, while the military calls it a "hot wash". The actual name is less important than the intended effect: to identify what worked and what didn't, and then apply the lessons for future use. The U.S. Intelligence Community has utilized such exercises in the wake of the September 11th attacks and the search for weapons of mass destruction in Iraq to revamp training, create and apply better methodologies, and increase analytic rigor.[51]

Recognize uncertainty. Experts in any field almost always want to demonstrate their expertise, but to prepare for potential shocks, we need to admit where uncertainties lie. This requires significant humility and willingness to ask fundamental questions, exploring both the 'known unknowns' and the 'unknown knowns'.[52] In the category of known unknowns, we may know something is possible in the future, but we fail to continuously scan for indicators and explore the implications. In the category of unknown knowns—things that we know that we ignore or have forgotten about—we fail to take advantage of hard-won experience.[53]

Identify assumptions and biases. Strategic surprises often emerge from flawed assumptions about capabilities and intentions, both our own and our competitors.[54] The hardest assumptions to catch are the most deeply embedded because they don't feel like assumptions. Human nature is to assume that the future will resemble the past, or that if something hasn't happened yet, it probably won't. These are the types of cognitive defaults that new technologies are challenging and increasingly exposing as wrong. Surfacing them requires asking not just what we know, but what we have stopped questioning. This dialectical thinking requires time and patience to unpack the analytic process.

Explore and imagine. Structured and unstructured scenario exercises help planners imagine and engage with the types of surprises they could face in the near and long term. Examining the origin, trajectory, and consequences of technological surprises during a period of calm gives planners a chance to identify bureaucratic weaknesses, establish protocols, acquire resources and capabilities, and develop various responses. President Dwight D. Eisenhower's famous quote, "plans are worthless, but planning is everything," highlights that the value is in the preparation, not the document.[55] In the context of strategic technological surprise, modeling combinations of technologies, investment patterns, and unconventional applications could shed important light on the technology pathways. Moreover, planning equips decision makers with intimate knowledge of the foundational building blocks—resources, constraints, contingencies, and decision points—to enable rapid reorientation when unforeseen disruptions render the original plan obsolete. Such pre-familiarization accelerates adaptive replanning and clarifies core priorities.

Think like the adversary/competitor. Red teaming, a military practice that simulates adversaries to identify vulnerabilities and test responses, offers an instructive approach that could help anticipate technological surprise.[56] Red teaming in a combat context helps anticipate enemy tactics. In the context of a geopolitical technology competition between the United States and China, the approach expands the technological aperture of analysis to include how innovations diffuse through markets and industry ecosystems. This approach tasks scientists and engineers with putting themselves in the competitor's shoes and asking how they might act under the constraints that the rival faces. This red-team-inspired approach is intended to move beyond observation toward

scenario-based laboratory experimentation to forecast possible technological trajectories of concern.

Such Red Teaming efforts also could include prototyping how others might adopt and apply technologies in new ways or how they could develop new variations of technologies. The focus would be on identifying capabilities that others might attempt to develop and then explore how they could attain this capability, given real-world constraints. The most useful Red Teaming would incorporate public and private resources to combine the knowledge of intentions, culture, and capabilities with deep expertise in the foundational sciences and emerging technologies. Red Teaming is not easy because of the need for a deep, nuanced understanding of the motivations and capabilities of the competitor. Red Teaming exercises fail when participants lack detailed knowledge of the mindset and culture of the other actors, and as a result, play other actors like themselves. Robert Jervis reminded us repeatedly of the dangers of mirror imaging in conducting such analytic exercises.[57]

Scan widely. We all exist in information silos because we frequently engage with like-minded groups and other experts in our fields. Moreover, it is human nature to explain away anomalies and discount weak signals of change. Overcoming those tendencies requires breaking down bureaucratic barriers and engaging across disciplines and organizational structures. Systematic monitoring of academic publications, patents, international commercial activity, and other open sources can help detect emerging capabilities and novel applications before they produce strategic effects. Such scanning also needs to be continuous, given the rapid pace of innovation.

Apply tech against tech. AI, including current LLMs, can be applied to all of the above approaches to improve the speed, breadth, and depth of these efforts. AI can assist in identifying the potential for technological surprise by generating a larger set of plausible scenarios, running and rerunning wargames and simulations, and by analyzing across these exercises for common themes, risks, and opportunities. AI can accomplish these tasks in minutes rather than days, weeks, or even months for humans, providing more time to prepare decision makers.

Reframe accountability. In addition to post-mortems of intelligence failures, reviews of strategic technological surprises also should examine the dynamics

that prevented adequate contingency planning. Reviews should ask why warnings were not heeded, why contingency plans were not developed, and what costs followed from inaction. Policymakers themselves may bear some responsibility for insufficient preparation, yet an emphasis on failures of warning allows them to avoid accountability and deflect blame for their own inaction. Identifying the real-world costs of insufficient preparation can help hold decision makers accountable for failing to act and incentivize preparation for the future.

IMPROVING RESILIENCE AND BUREAUCRATIC FLEXIBILITY

In addition to better forecasting of disruptions, effective foresight requires adopting policies and taking concrete steps to improve resiliency, flexibility, and response when the surprises unfold. As Warren Buffett lamented in his 2001 report to shareholders, "Predicting rain doesn't count; building arks does".[58]

To be positioned to take advantage of surprising developments for growth and positive change, large and often rigid bureaucracies—including governments and international corporations—need to go beyond forecasting and heed Buffett's Noah rule.

Here are several steps to take ahead of time.

Build trusted, expert teams. Being prepared for rapidly evolving developments requires assembling a diverse, expert team that can anticipate and respond to strategic surprises. Surprises can present opportunities, but taking advantage of those opportunities often is time sensitive. A trusted team needs to be prepared to move quickly to determine risks and advantages of the evolving situation.

Institutionalize a *Policy* Devil's Advocate. For decades, intelligence organizations in various countries, including the United States and Israel, have had contrarian units to challenge conventional thinking and argue the opposing analytic position, and for centuries, the Catholic Church maintained an *advocatus diaboli* in the canonization (sainthood) process to argue against the candidate and to uncover any character flaws or misrepresentation of the evidence.[59] Similarly, decision makers should have an institutional contrarian voice to compel consideration of and active preparation for seemingly low probability events and trends, like the fictitious 'tenth Man' who had to adopt the opposing view in the

movie version of World War Z.[60] At a minimum, such a mechanism would encourage the development of contingency plans in case the disruption occurs.

Develop response plans. Creating and rehearsing response plans that can be deployed quickly can help manage a surprise when it occurs. Such plans would need to be domain-specific and should include potential surprises and their implications. Several Nordic countries have drafted and disseminated various types of crisis handbooks with detailed instructions for their citizens for how to prepare and what to do when a crisis unfolds.[61] For potential technological surprises, response plans could be formulated in advance in areas such as quantum computing and its potential to break encryption. Given the widespread belief that the feasibility of quantum computing for decryption is a matter of when rather than if, government agencies could perform pre-mortem exercises now to prepare for the inevitable future exposure of yesterday's and today's secrets.[62]

Establish protocols and norms for technologies before they emerge. Proactive development of governance frameworks, regulatory approaches, and response protocols before technologies reach maturity can reduce the window of vulnerability when surprises occur. This requires sustained engagement with scientific communities, scenario planning exercises, and iterative policy development that anticipates multiple technological trajectories.

Prepare communication plans and procedures. If a strategic surprise triggers a crisis, people will be eager for information and guidance, and are likely to struggle to know whom to trust. Having pre-established communication channels, trusted messengers, and clear procedures for information dissemination can reduce confusion, prevent panic, and enable more effective coordination during rapidly evolving situations.

CONCLUSION

In the years ahead, the increasing pace, scale, and variety of strategic technological surprises are likely to strain our communities, institutions, and governments in ways we have only begun to imagine. Meeting this challenge demands not just better information or more innovation, but a fundamental rethinking of how we identify, assess, and prepare for technological disruptions across all domains of national life. With this paper, we hope to provoke a

structured, ongoing conversation among policymakers, technologists, and strategic planners to think more rigorously about technological disruption. The framework presented here should be treated as a foundation for further development rather than a complete solution—a way to organize thinking about an inherently uncertain future while remaining humble about our predictive capacities. Protecting and maintaining American security and prosperity will require consistent application of foresight methods to reduce the element of 'surprise,' and the adoption of strategies to make our societies, economy, and country more resilient and adaptive to the inevitable disruptions.

MOVING FORWARD WITH THE TECH FUTURES LAB

Here are some questions we hope to answer in TFL over time:

Technology Futures

- What is a big problem in any domain that could be solved by technology in the next ten years?
- What problem or challenge do you hope technology will help solve in the next decade?
- What critical, but controversial, assumptions about technology need to be challenged?
- What is common now that will be rare or nonexistent in ten years because of technology?
- What is rare or nonexistent now that will be common in ten years because of technology?
- What is a taboo topic about technology?

First-Mover and Fast-Follower Strategy

- What potential breakthrough has the most first-mover advantage?
    - Why does that advantage exist?
- What technology characteristics indicate the existence of a first-mover advantage?
- Under what circumstances is it better to be a fast follower?
- What resources and cultural habits are needed to sustain a fast-follower strategy?

Strategic Blind Spots

- What aspects of technology development, or of the society in which technology is embedded, are not getting enough attention given their potential impact?

Box 1: DeepSeek AI - An Instructive Case Study of Strategic Technological Surprise

China's launch of DeepSeek AI's R1 model last year is a significant, recent example of strategic technological surprise, offering us lessons for how to think about and avoid future such surprises.[63] As noted earlier, the announcement of DeepSeek's R1 was a strategic shock to the U.S. policy community, but it **was not a shock** to most in the AI research community.[64] The surprise was not due to a lack of information about how Chinese researchers were likely to advance their models. To the contrary, academic publications, patents, and international commercial activity offered real-time, observable indicators of China's efforts and progress.[65] Here, policymakers' surprise stemmed from **a lack of frequent engagement** between government officials and researchers in academia and industry who had a more accurate overall picture of China's progress in AI.

In addition, this surprise showcases **a failure of imagination**. China watchers did not consider that the country's scientists and engineers might adopt different approaches to achieve their goals. Faced with diminished access to state-of-the-art computational hardware (advanced chips well-suited to machine learning tasks) due to U.S. export controls, China's scientists and engineers focused on developing and deploying hardware-aware software that helped to circumvent the specific roadblocks caused by the lack of the most advanced hardware.[66] Hardware-aware software—the deliberate tailoring of software to exploit the specific characteristics of the underlying hardware—had been known for decades but fell out of favor as Moore's law delivered exponentially cheaper, abundant computing power. This assumption that more advanced hardware is always the answer shaped how outside observers assessed what China could and could not achieve, and it was wrong.

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