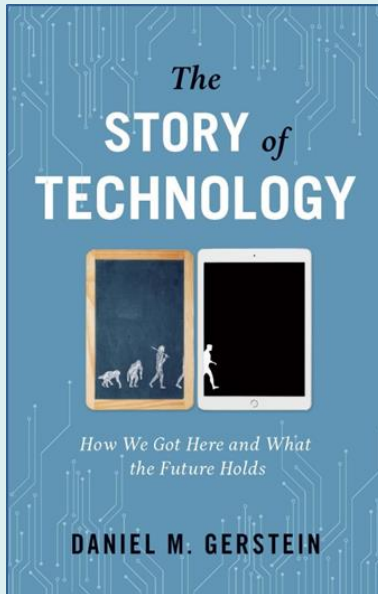# *The Story of Technology*
How We Got Here and What the Future Holds

What is technology and where does it come from?

Can technology be managed?

What is the appropriate balance discovery and prudence?

What does the history of technology tell us about the future?

**How can we shape a future that is hospitable – or at least not threatening – to humanity?**

…and what it means for US security and defense

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Some Conclusions About Technology

❑ **History of humankind and technology are inextricably intertwined**

❑ **Greater technological capacity and reach than ever before**

❑ **Convergence … technologies are collections of other technologies**

❑ **Technology is inherently dual use, increasingly disruptive and highly democratized**

❑ **The S-Curve provides a way to think about technology development**
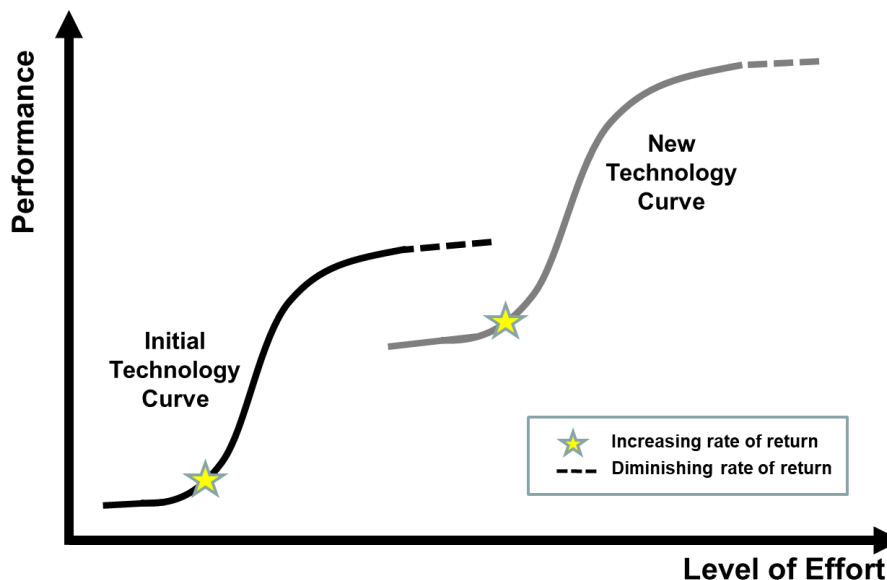
But does the S-curve still adequately capture convergent technologies?

Trend #1 -- Continuing Shifts in Technology Development

- ❑ **National R&D**
    - **The "modern" concept of R&D began in the World War II period**
    - **By 1960, government was funding ~65% of US R&D, while industry and academia accounted for ~35%**
    - **By 2015, the R&D expenditures, by source of funds were: industry ~67%, government ~24% and academia/other ~8%**
    - **By performer, the totals were: industry (72%), Federal Government (intramural and FFRDC) (11%), Academia/other (13%) other nonprofits (4%)**
- ❑ **Internationally**
    - **In 1960, the United States accounted for 70% of global R&D**
    - **As of 2015, US remained largest R&D-performing country, with R&D spending of $497 billion, a 26% share of global total, and R&D-to-GDP ratio of 2.7%**
    - **China was second at $409 billion (21% global share and R&D-to-GDP ratio of 2.1%**
    - **Japan and Germany were second and third at $170 billion (ratio of 3.3%) and $115 billion and ratio of 2.9%, respectively**
    - **Globally, R&D expenditures for the three largest regions are East and SE Asia (38%), North America (28%) and Europe (22%)**

Trend #2a -- Managing Technology Has Become Considerably More Challenging

Developing Technology

❑ **Technology development**
- **Focuses on solving operational problems**
- **Is being done within an increasingly globalized tech development ecosystem**

❑ **Some tools of technology development**
- **Horizon scanning**
- **Technology forecasting**
- **Capability development process (DOTMLPF-P)**
- **Technology Readiness Levels (TRL)**
- **Portfolio management**

❑ **Government (including DHS and DoD) must become better consumers**
- **Greater need for collaboration**
- **Can no longer dictate all the terms**
- **Government must gain greater technical expertise in many key areas**
- **Social responsibility increasingly important in industry**
- **Novel procurement approaches to develop capabilities more rapidly have emerged**
  - **Finding ways to get around the Federal Acquisition Regulation (FAR)**
  - **Venture capitalists such as In-Q-Tel**
  - **Other Transactional Authorities (OTA), Defense Innovation Unit (DIU), Strategic Capabilities Office (SCO)**

Trend #2b -- Managing Technology Has Become Considerably More Challenging

Controlling Technology

- ❑ **Can we (and should we) limit the advance of technology?**

- ❑ **Outpacing policymakers ability to place controls on tech development**

- ❑ **Can pre-digital age methods for managing technology work in digital age?**

  - – **Arms control (i.e., international laws)**
  - – **National laws**
  - – **International nonproliferation regimes**
  - – **Patents and Intellectual Property Rights**
  - – **Export controls**
  - – **Policies**
  - – **Regulations**
  - – **Standards**
  - – **Norms & ethics**

- ❑ **Must consider both the use and misuse cases …**

  - – **Simultaneously**
  - – **Early in a technology's lifecycle**

- ❑ **Balancing technological advancement with safety and security of society requires a technology risk framework**

  - – **Different measures are likely to be most effective for different technologies**
  - – **Should seek to avoid technological surprise and identify the point in a technology's lifecycle when dual use concerns are likely to arise**

Trend #3 – An Emerging Tech War is on the Horizon

❑ **Two near-peer competitors with an emerging China and recalcitrant Russia**

❑ *Russia Is a Rogue, Not a Peer; China Is a Peer, Not a Rogue* **(RAND Report, October 2018)**

> *China and Russia have begun to reassert their influence regionally and globally:*
>
> *"Today, they are fielding military capabilities designed to deny America access in times of crisis and to contest our ability to operate freely in critical commercial zones during peacetime. In short, they are contesting our geopolitical advantages and trying to change the international order in their favor."*

White House, National Security Strategy of the United States, December 2017

❑ **The competitive spaces …**

China	Russia
• **Determined to gain global dominance and leadership** • **East China Sea—changing facts on the ground** • **Belt and Road Initiative (BRI)** • **Made in China 2025 (lead in 10 key military and civilian technologies)** • **Great Firewall of China**	• **Restore near abroad** • **Challenge in key areas (Ukraine, Baltics)** • **Challenge in military technologies (air defense, hypersonics, nuclear weapons, cyber)** • **Putin is an opportunistic risk taker (with examples in Syria, and with Turkey and NATO)** • **Russia's 'sovereign' firewall**

"China and Russia want to shape a world consistent with their authoritarian model."
(2018 National Defense Strategy)

Trend #4 -- Growing "Competition" between Humans and Computers

❑ **"Direct competition" between humans and AI systems is on the near horizon**

– **Some might say already here**

– **What are the qualities and attributes that we define the human experience?**

– **Which of those do we wish to retain?**

❑ **As we think about the future of AI, perhaps certain tasks**

– **Remain predominantly human: tasks requiring creativity, compassion, judgment remain reserved for humans**

– **While others become largely the domain of AI systems: optimization, repetitive actions, precision (and calculations)**

– **And perhaps others can be shared through human-machine teaming**

❑ **What does that mean for:**

– **Future of Work?**

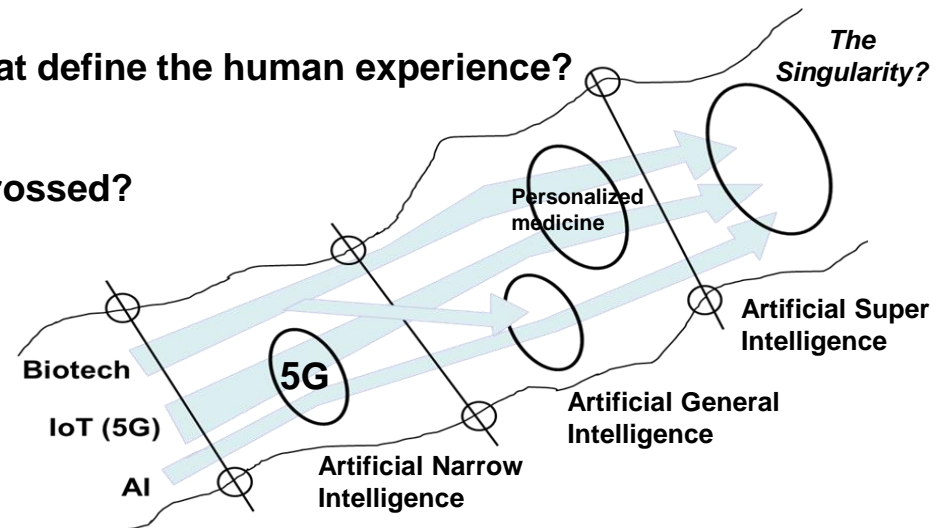– **Future of screening, security and law enforcement?**

– **Future of Warfare?**

Trend #5 -- Changing Expectations for Society … Privacy, Liberty, Freedom

❑ **Can privacy, liberty and freedom survive in this growing technologically convergent world?**

❑ **Someone will always be watching, listening and collecting**

❑ **What the American Civil Liberty Union (ACLU) says …**

– **Internet Privacy:** With more and more of our lives moving online, intrusions by governments and corporations have devastating implications for our right to privacy

– **Location Tracking:** Law enforcement is taking advantage of outdated privacy laws to track Americans like never before. New technologies can record your every movement, revealing detailed information about how you choose to live your life

– **Privacy at Borders and Checkpoints:** The government has repeatedly developed programs—increasingly involving new technologies—that subject travelers to unreasonable stops and searches at the border, violating the basic tenets of our Constitution

– **Medical and Genetic Privacy:** Medical and genetic information can reveal some of the most personal and private data about us, and maintaining control over that information is crucial. As medical records are increasingly digitized and genetic sequencing becomes faster and cheaper, threats to our privacy and autonomy intensify

– **Surveillance Technologies:** Companies and government agencies deploy new privacy-invasive technologies before subjects are aware that they exist—and certainly before we have consented to their use through our democratic political system

❑ **What does that mean for:**

– **Going off the grid?**

– **Using AI systems to "make" decisions?**

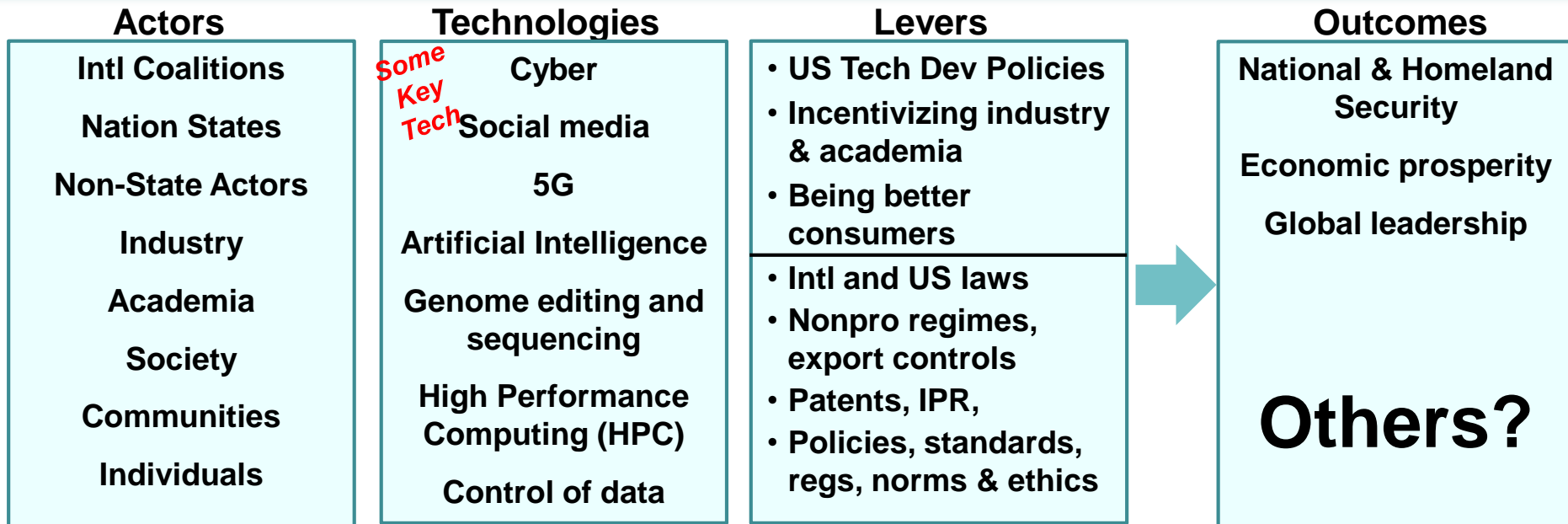– **Future of screening, security and law enforcement?**

Trend #6 – Increasing Risk to Humanity

❑ **Few controls on technology development, and normally after harm becomes apparent**

❑ **State-like capabilities in hands of non-state actors**

❑ **"What does the future look like at the intersection of artificial intelligence (AI)?", the Internet of Things (IoT) and biotechnology**

  – **Why biotech, IoT and AI?**

    • **AI … could alter how we see humans in terms of cognition, perception, judgment, creativity**

    • **IoT … creates an interconnected world with humans as nodes in the network**

    • **Biotech … potential to alter the human germline**

  – **Ask yourself**

    • **What are the qualities and attributes that define the human experience?**

    • **Which of those do we wish to retain?**

    • **Are there redlines that should not be crossed?**

Imperative to determine the principles that will be used to guide this development. Will they come from biotech, IoT, AI or some combination?
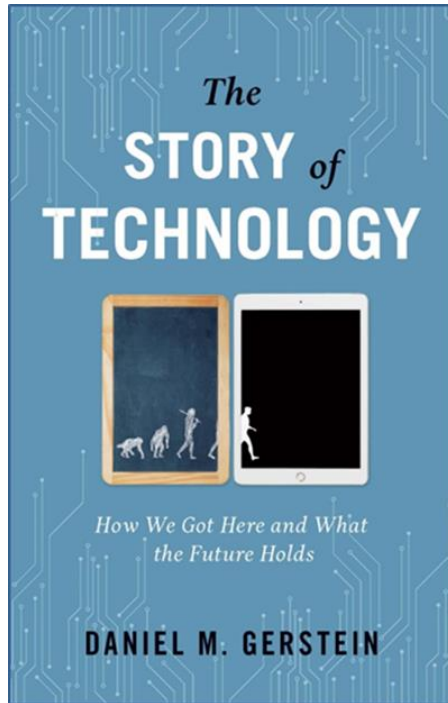

The Singularity?

Personalized medicine

Biotech

IoT (5G)

5G

AI

Artificial Super Intelligence

Artificial General Intelligence

Artificial Narrow Intelligence

What are the skirmish lines in our increasingly technology-enabled world?

Actors	Technologies	Levers	Outcomes
Intl Coalitions	*Some Key Tech* Cyber	• US Tech Dev Policies	National & Homeland Security
Nation States	Social media	• Incentivizing industry & academia	
Non-State Actors	5G	• Being better consumers	Economic prosperity
Industry	Artificial Intelligence	• Intl and US laws	Global leadership
Academia	Genome editing and sequencing	• Nonpro regimes, export controls	
Society	High Performance Computing (HPC)	• Patents, IPR,	**Others?**
Communities	Control of data	• Policies, standards, regs, norms & ethics	
Individuals			

- **5G:** Hinderances to US competitiveness include spectrum decisions and security concerns about Chinese hardware – will have vital impact on economic competitiveness

- **Social media and deep fakes:** Has become a free-fire zone – election hacking and fake news

- **Immigration:** Immigrant Nobel Prize Winners Since 2000 are 33 of 85 (39%)

- **Big Data Catch-22:** Need to consolidate vast amounts of data, but that creates vulnerabilities

- **Cyber:** Another free-fire zone … companies either know they have been hacked, or have been hacked and don't know it … most insecurities occur at the application layer … potential for physical destruction

- **Export control:** Changes likely needed given growing digital based economy

- **AI:** Goals for AI use are responsible, equitable, traceable, reliable and governable (DoD DIB 10/31/19)

Some DHS Tech Challenges

Final Concluding Thoughts

The STORY of TECHNOLOGY

How We Got Here and What the Future Holds

DANIEL M. GERSTEIN

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❑ As the capabilities of humankind have increased, the quest for gaining a fundamental understanding of the world has driven greater scientific study which has in turn has fueled greater technological achievements

❑ Where technology comes from is undergoing important shifts. Industry is now the largest funder of R&D. And multi-national corporations are complicating controls on science and technology proliferation

❑ Areas of science and technology that once were the exclusive domain of nations, such as global positioning systems (GPS), have become parts of our daily lives. Dual use technologies are allowing individuals to have state-like capabilities

❑ With the proliferation of science and technology, across the globe, the effectiveness of many of our historical institutions are being called into question

❑ In many areas, advances are so rapid, they are outpacing policymakers ability to place adequate control on research, development and behaviors with potentially devastating consequences, and certainly before treaties, laws, policies and regulations are in place

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