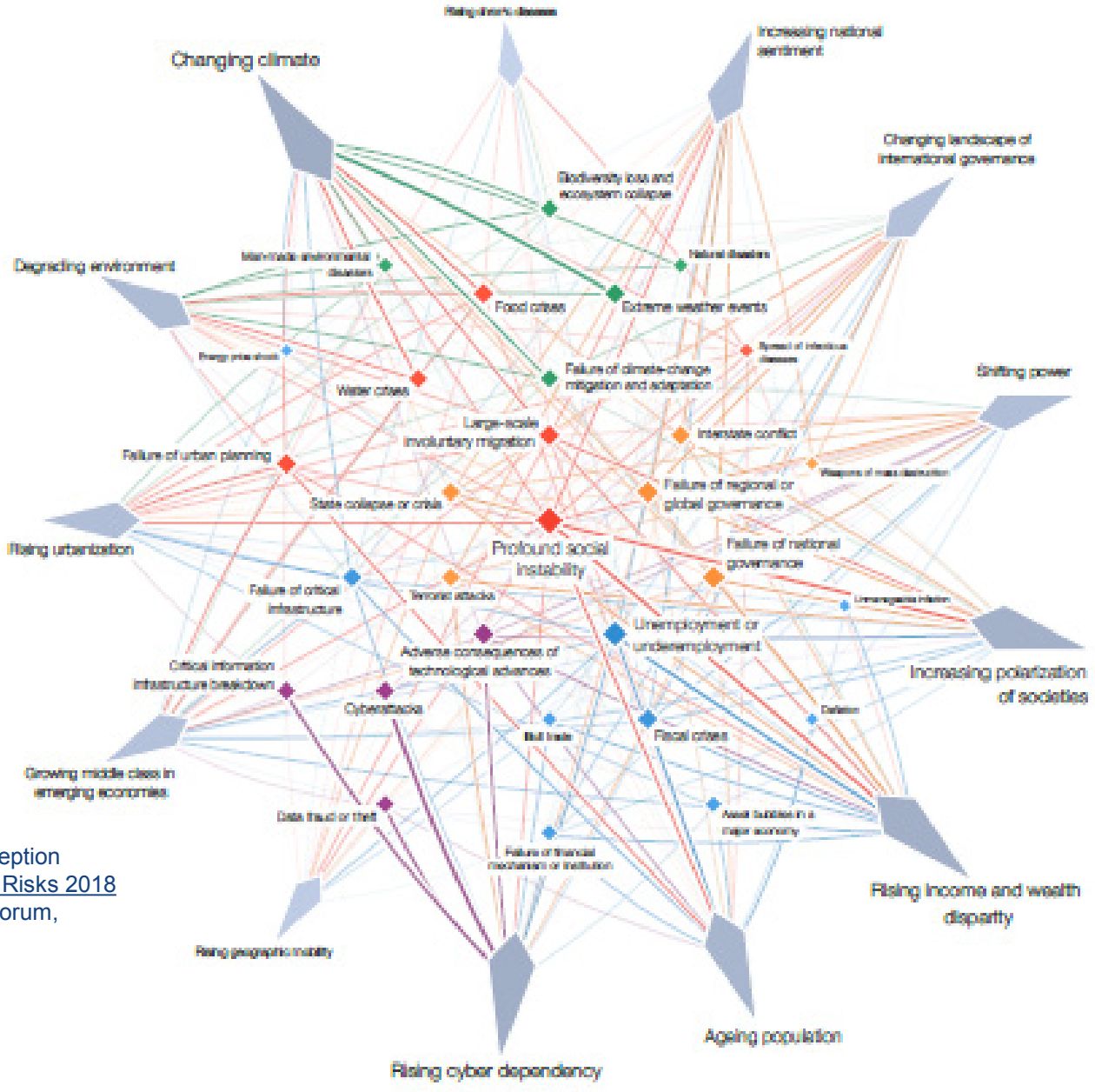
GAO United States Government Accountability Office

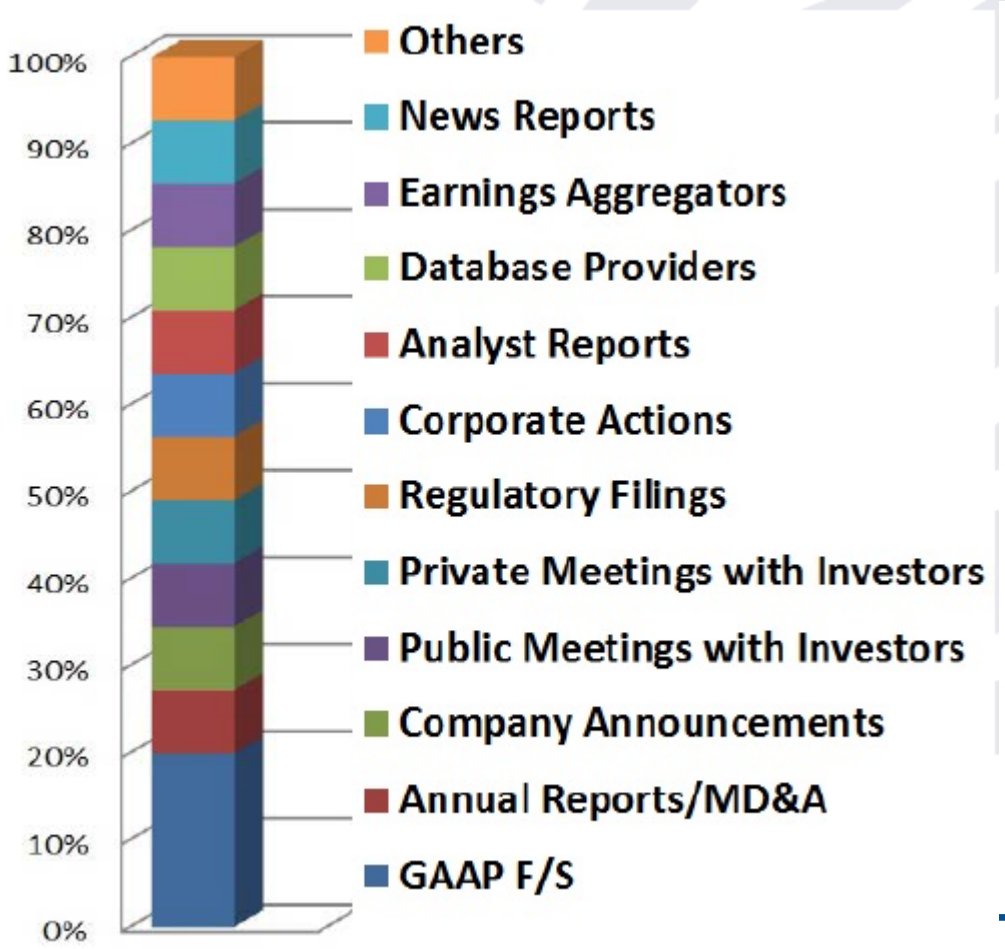
The Audit Renaissance: Transformational Considerations in the Era of Big Data, AI, and Digital Ledger Technology

Uncertainty & Complexity: Interconnected Risks



Source: Global Risks Perception Survey 2017-2018. Global Risks 2018 Report. World Economic Forum, Switzerland, 2018

Audit Relevance: Where Private Sector Decision-makers are Getting their Information



Source: CFA Institute

Major technological innovations in the last 150 years and their impact on productivity

FIGURE 1

From the printing press to the global internet, technology has evolved, and human societies with it

Source: Barclays

Key Trends

1

Trends in Internet access, use:

Ubiquitous U.S. access, mobile use, and increasing global coverage[a]

- Location data—movement of persons, vehicles—based on GPS,[b] other location sensors
- Communications—e-mails, voice communications, text messaging; tweets, social-media postings
- Purchases and sales—retail, ratings of products and services, selling (eBay, Etsy)
- Searches
- Online banking, billing and payment, use of budgeting apps
- Many new apps
- Digital photographs taken with smartphones
- Entertainment online (for example, Netflix, Pandora radio)
- The gig economy (online platforms through which individuals earn income[c])

2

Public area data collection:

Sensor-based developments create marketing, surveillance data

- Video-recording in malls or near stores; also airports, other locations (may connect to facial recognition software)
- Identifying individuals' presence in certain areas via signals from their devices (e.g., WiFi)
- Drones with cameras or other sensors

3

Extensive datafication:

Documents, records, maps that are searchable, analyzable[d]

- Electronic health records (EHR)
- Detailed maps for navigation
- Indexed documents and websites (to allow searches)
- Real-estate market information (Zillow, Trulia, etc.)

4

The open data trend:

Trend toward new releases of data to the public

- Pre-existing information (such as detailed weather data from Department of Commerce and crop-yield data from Department of Agriculture)
- Data from cities in areas such as public health and transportation, including real-time data (such as city data on open parking spots)

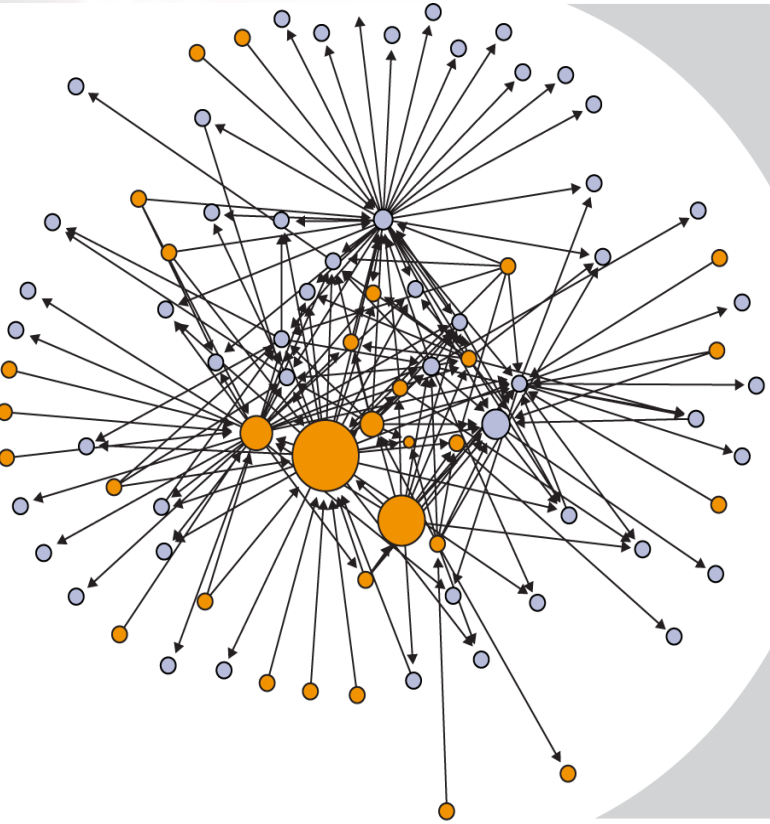
5

Connected sensors:

Internet of Things (IoT), Industrial Internet, and cyber-physical systems (CPS)[e]

- Consumer items—wearables such as exercise trackers; connected vehicles; connected home items, such as smart thermostats[f]
- Connected supply chains in manufacturing; connected sensors in agribusiness
- Connected government or public utilities—electricity, water
- Intelligent transportation—connected vehicles, smart traffic lights[g]

Credit Default Swap Market: A Network of Buyers and Sellers



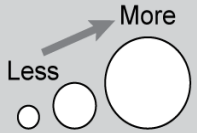
Potential benefits of big data

- Increases transparency
- Reveals:
  - Roleplayers (number and size)
  - Relationships (interconnectedness)
  - Systemic Risk
  - Transaction details (amounts and dates)
- Opens new modeling and analytical opportunities
- Provides regulators with more details/information

Potential challenges of big data

- Increases vulnerability
- Lacks standards/consistency
- Reveals:
  - Opportunities for manipulation
  - Potential targets
  - Weakest links
- Outpaces regulatory structure and/or resources
- Raises data privacy and security concerns
- Requires new models/analysis

Amount bought/sold



Net buyers of credit default swap protection

Net sellers of credit default swap protection

Source: GAO adaptation of graphic (network diagram) from Depository Trust and Clearing Corporation (DTCC 2013). Original figure appeared in Yellen 2013. GAO analysis (bulleted lists). | GAO-16-659

Blockchain: Solution to the Double-Spend

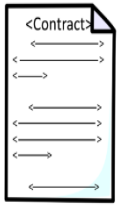
1. •**Public Key Cryptography** – Peer-to- peer transactions are made through cryptography (e.g., public-private key)

2. •**Distributed Public ledger** – Everyone "can" have a copy of the ledger creating a shared record of activity among all network participants

3. •**Timestamped Transaction History**– Transactions are timestamped and "append only," which are linked to every transaction record that came before it

4. •**Network Consensus** – Math and network participants validate transactions instead of a trusted third party

5. •**Programmable** – Transactions can be programmed (i.e., Smart Contracts)



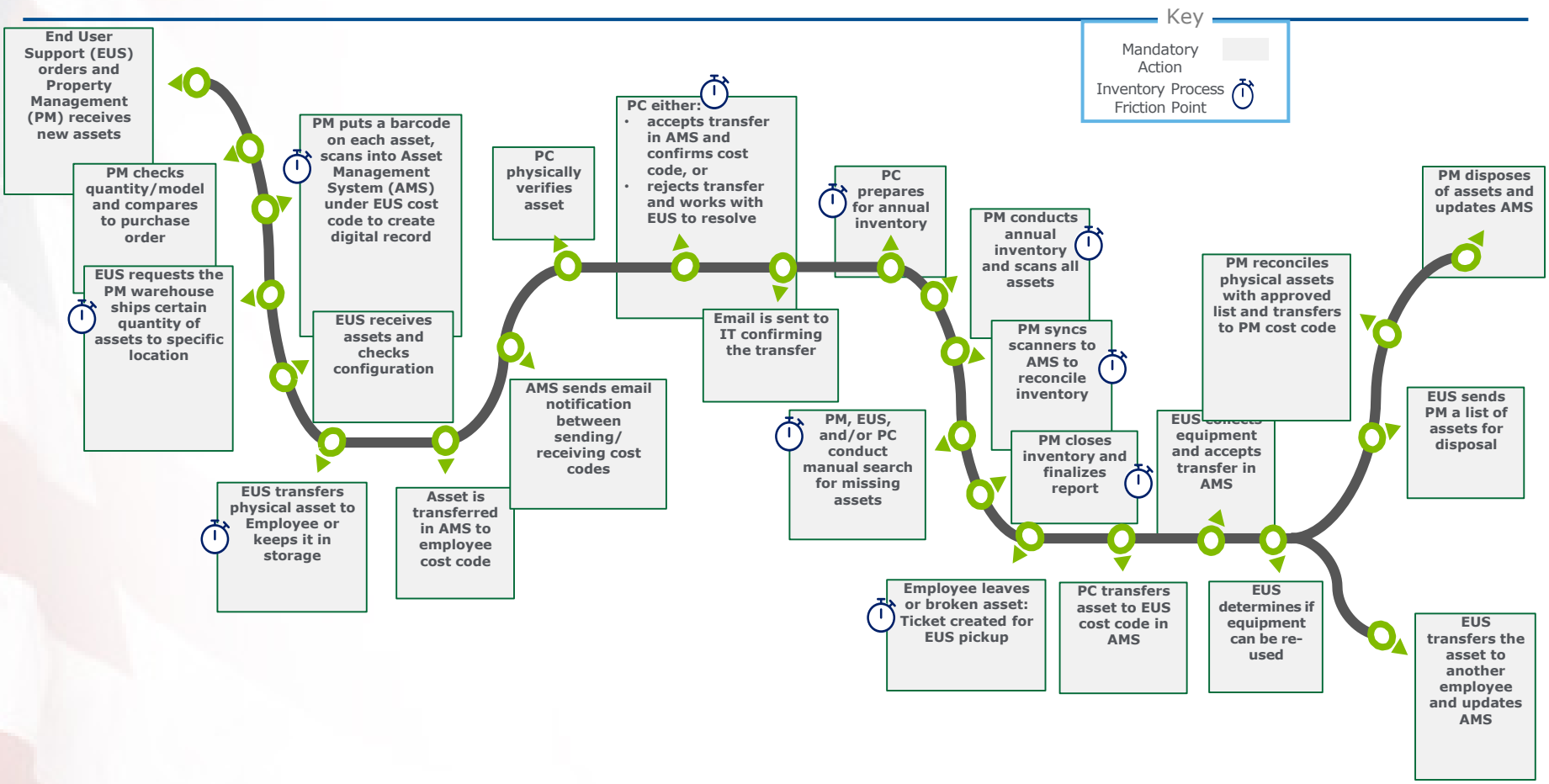
Source: U.S. Department of Treasury

Potential Benefits for Financial Management

	Feature	Original Purpose	FM Potential Benefits
1	**Public Key Cryptography**	Proof of Ownership	Secure Transactions
2	**Distributed Public ledger**	Transparency	Transaction Transparency Resiliency
3	**Timestamped History**	Order of Transactions	Robust Audit Trail Permanent Record of Transactions
4	**Network Consensus**	Validating Transactions	Efficiency Near Real-Time Transaction Clearing and Settlement
5	**Programmable**	N/A	Automation

Source: U.S. Department of Treasury

Asset Inventory Management (baseline)



Source: U.S. Department of Treasury

Asset Inventory Management (Blockchain)

End-to-end asset lifecycle transactions and state changes are recorded on a distributed ledger and shared among users, providing a single source of truth for asset information

Scan and tokenize assets

Electronic transfer of ownership between users

Automatic notifications to users sending and receiving asset transfers

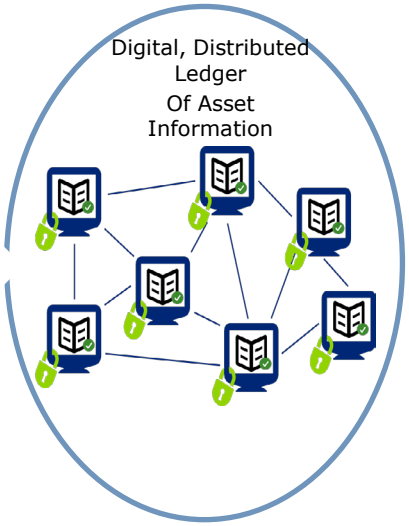
Automated initiation of inventory process

Electronic verification of asset ownership

Receiving and Distribution

Inventory Management

Disposal



Real-time Reporting

Fiscal Service Users

Property Management
IT Staff
Employees
Property Custodians
Bureau Leadership

Automated notifications when assets reach end of life

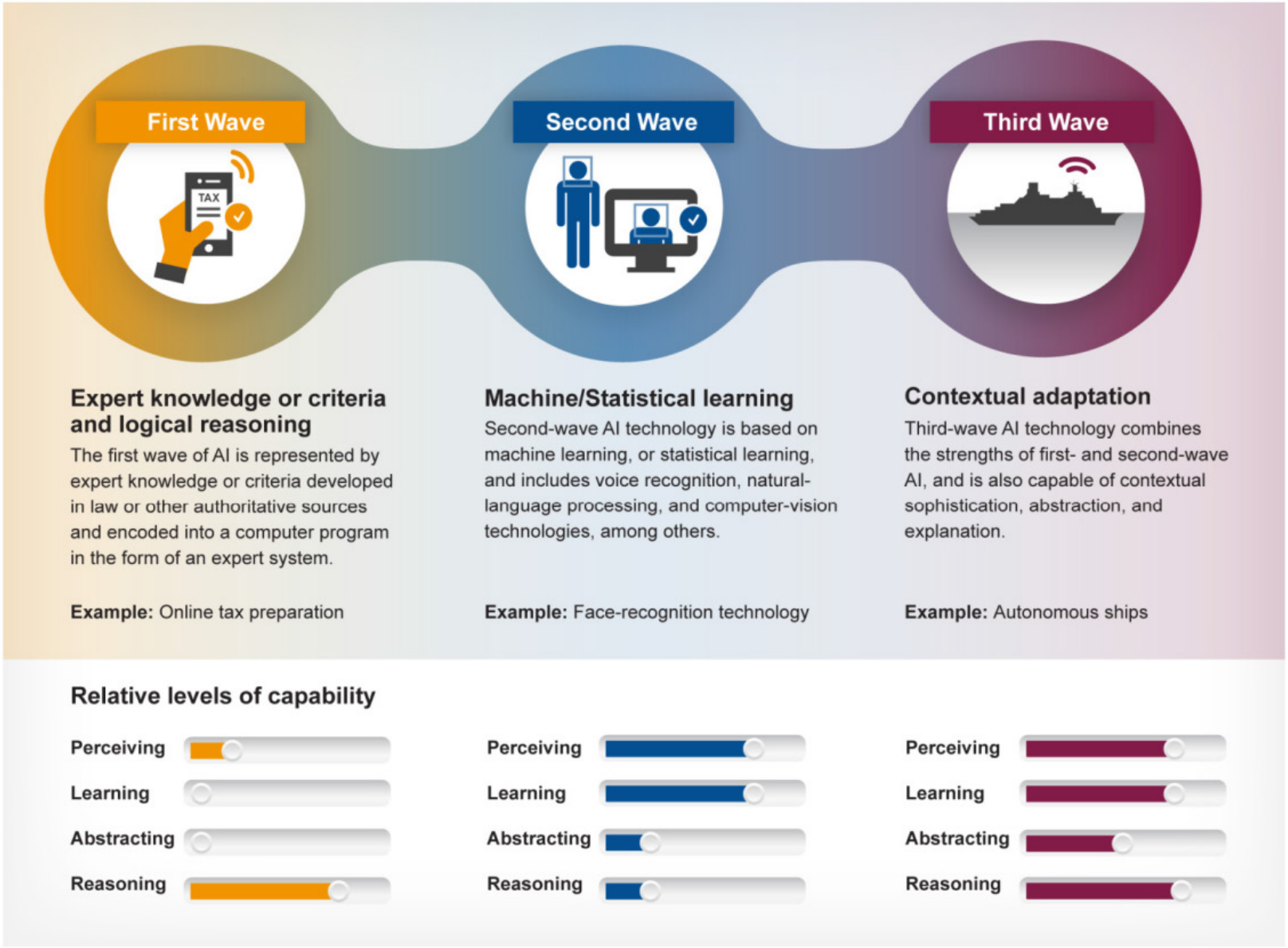
Electronic transfer of ownership between users

DESIRED OUTCOMES

- Complete, accurate, immutable records
- Real-time visibility of asset inventory
- Reduction in manual process time
- Trusted, efficient peer-to-peer transfers
- Understanding of DLT's applicability to financial management

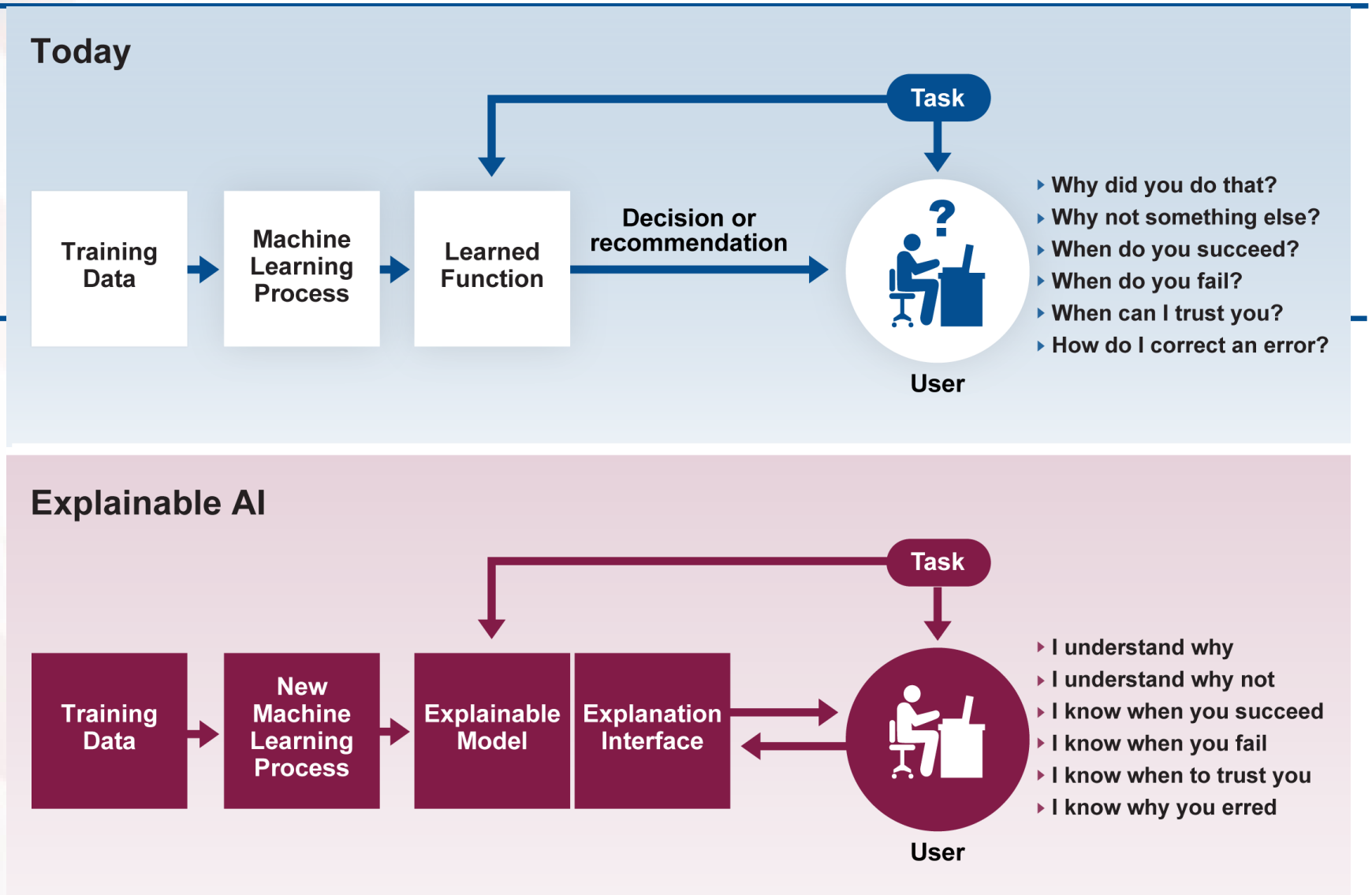
Source: U.S. Department of Treasury

Three Waves of AI



Source: Defense Advanced Research Projects Agency (DARPA) information; Art Explosion (art). | GAO-18-142SP

Key Issue: Explainable AI



Source: GAO and Defense Advanced Research Projects Agency (DARPA). | GAO-18-142SP

Risk of Counterintuitive Outcomes

GAO's Work on Cybersecurity

Establishing a national cybersecurity strategy and effective government-wide action and oversight

- Evaluate efforts to develop and implement a national cybersecurity strategy
- Assess federal efforts to address global cyber challenges, including cyber defense and response efforts
- Examine the implementation of government-wide cybersecurity initiatives

Ensuring the effectiveness of agency programs for the protection of federal information and systems

- Report to Congress on the effectiveness of federal agency cybersecurity
- Assess the effectiveness of security programs, policies, practices, and controls
- Evaluate the cybersecurity of major systems development and acquisition
- Assess agency preparedness for, an response to, breaches of sensitive government information

Strengthening the federal role in the public-private partnership for the protection of critical infrastructure and sensitive data

- Study cybersecurity implication of emergency technologies (IoT, Artificial Intelligence)
- Evaluate federal oversight of programs supporting the nation's critical infrastructure
- Examine federal efforts to oversee safeguarding of personal and other sensitive data shared with private-sector and other non-federal entities
- Examine federal response to security incidents with national ramifications, such as cyberattacks and data breaches at critical infrastructure components

How GAO Scopes Cybersecurity and Privacy Audits

- Frameworks for selecting audit work
  - NIST Cybersecurity Framework
  - NIST 800-37: Guide for Applying the Risk Management Framework to Federal Information Systems
  - Federal Information System Controls Audit Manual (FISCAM)
- Risk-based selection
  - Review prior agency reports (FISMA, IG, Financial, etc.)
  - Review significant information security incidents
  - Review third party assessments (Agency contracted work, legislatively mandated efforts, etc.)

NIST Cybersecurity Framework

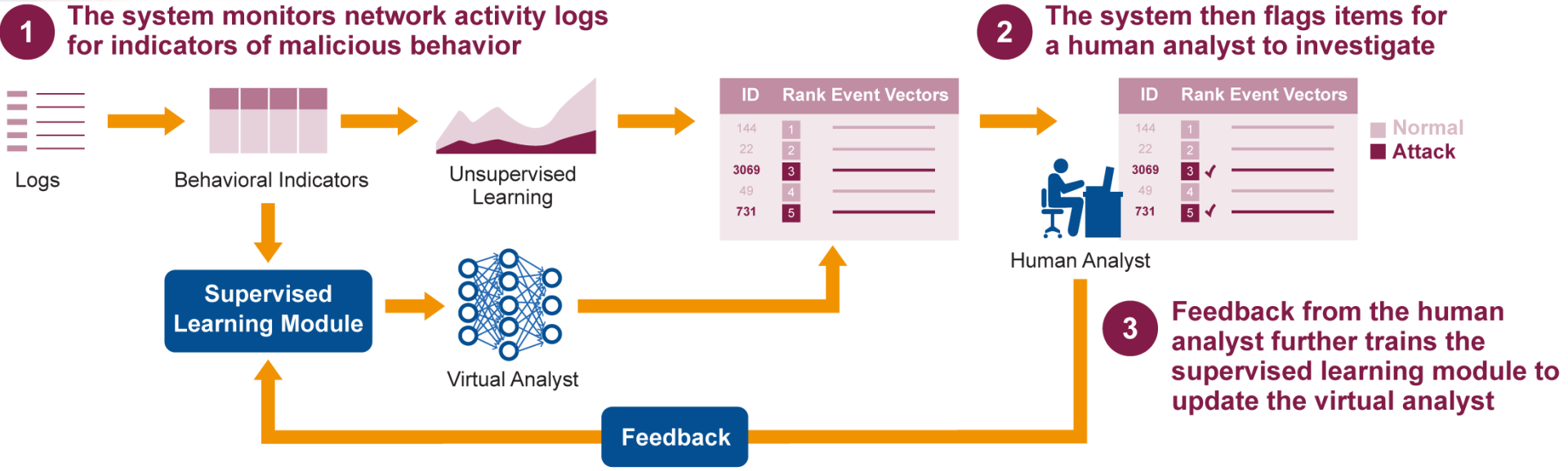
Function Unique Identifier	Function	Category Unique Identifier	Category
ID	Identify	ID.AM	Asset Management
		ID.BE	Business Environment
		ID.GV	Governance
		ID.RA	Risk Assessment
		ID.RM	Risk Management Strategy
PR	Protect	PR.AC	Access Control
		PR.AT	Awareness and Training
		PR.DS	Data Security
		PR.IP	Information Protection Processes and Procedures
		PR.MA	Maintenance
		PR.PT	Protective Technology
DE	Detect	DE.AE	Anomalies and Events
		DE.CM	Security Continuous Monitoring
		DE.DP	Detection Processes
RS	Respond	RS.RP	Response Planning
		RS.CO	Communications
		RS.AN	Analysis
		RS.MI	Mitigation
		RS.IM	Improvements
RC	Recover	RC.RP	Recovery Planning
		RC.IM	Improvements
		RC.CO	Communications

•Source: NIST

AI for Enterprise Risk Management

	Selected Questions
Cybersecurity AI applications face threats from cybersecurity attacks, but AI also may be used as a tool for detecting and defending against attacks.	▸ How can autonomous systems be made secure, without stifling innovation? ▸ How useful is a risk-based approach to determining if machine-learning algorithms adhere to legal requirements or ethical norms?
Financial Services The use of AI in financial services could improve client services and enhance surveillance monitoring, but also poses challenges to ensuring fair lending, attracting and retaining staff with requisite skills, and maintaining hardware and software.	▸ What are the mechanisms to address ethical considerations, tradeoffs, and protections? ▸ How can regulatory sandboxes be used to test new AI products, services, and business models?

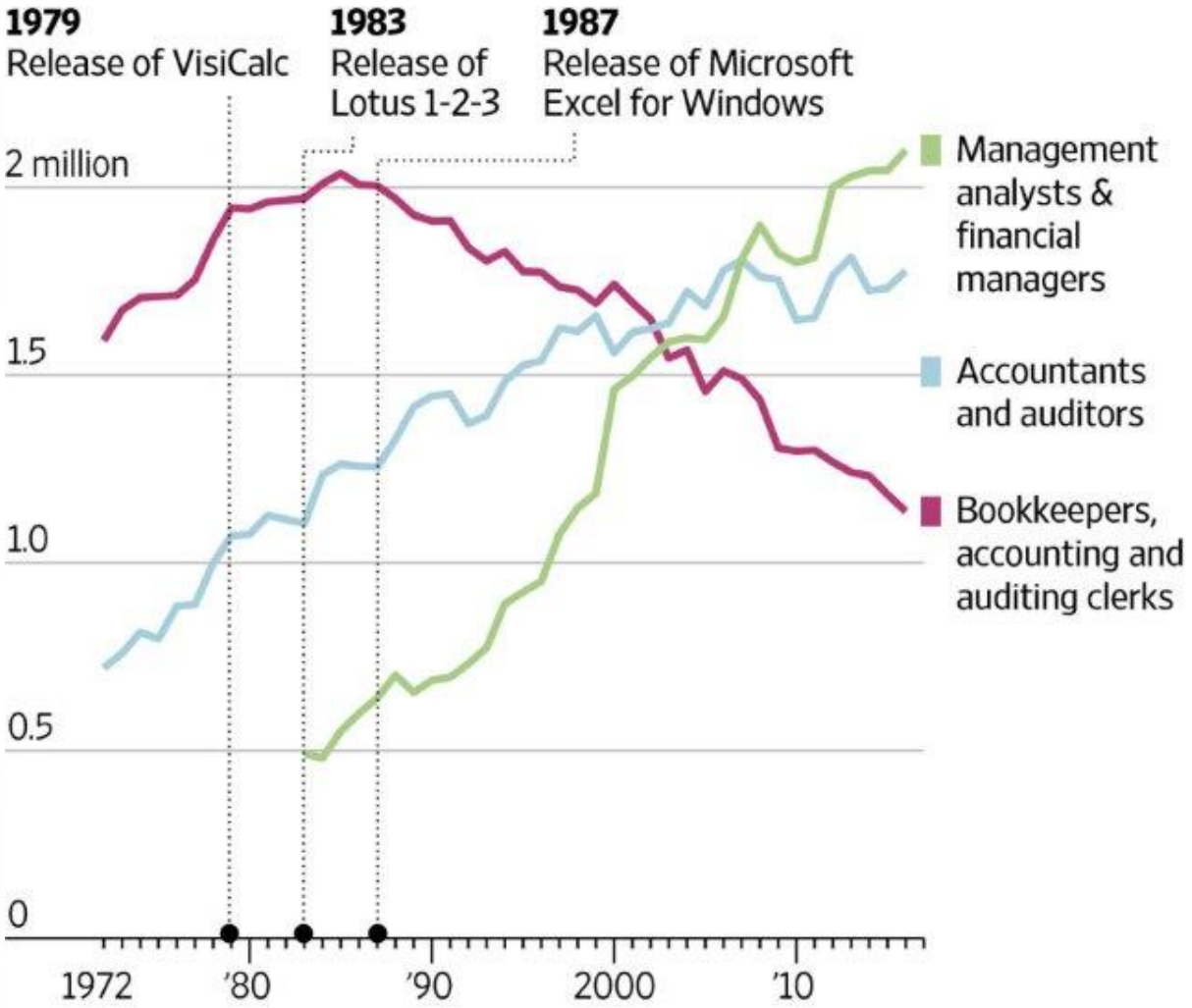
Machine Learning with Human Feedback for Cybersecurity



Source: GAO, adapted from video, Veeramachaneni, Arnaldo et al., *AI2: Training a Big Data Machine to Defend* (https://www.youtube.com/watch?v=b6Hf1O_vpwQ). | GAO-18-142SP

The Spreadsheet Apocalypse, Revisited

Jobs in bookkeeping plummeted after the introduction of spreadsheet software, but jobs in accounting and analysis took off.

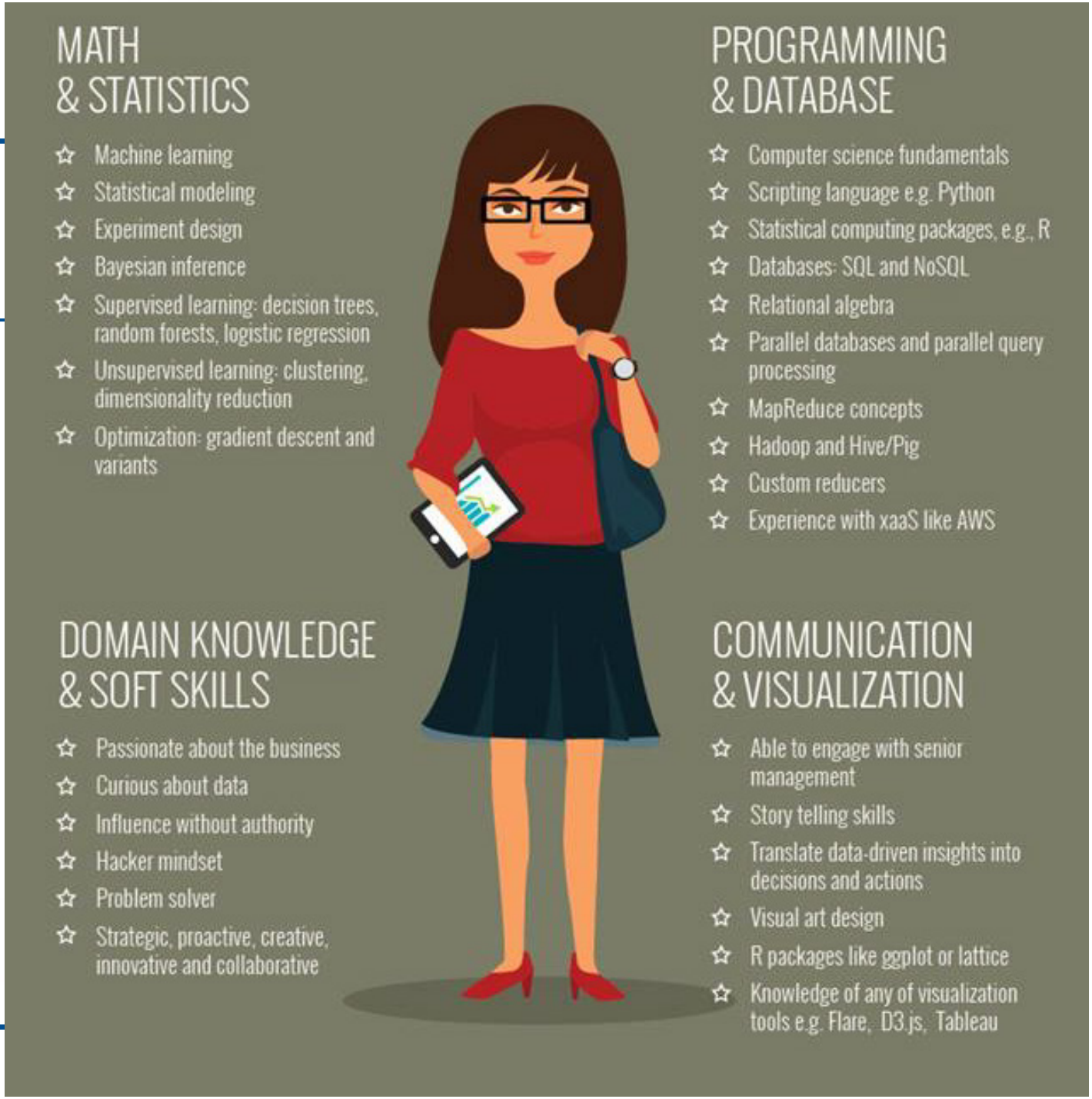


Notes: There is no data for 1982. Changes in occupational definitions in 1983, 2000 and 2011 mean that data is not strictly comparable across time. There was no category for management analysts or financial managers prior to 1983.
Source: Bureau of Labor Statistics

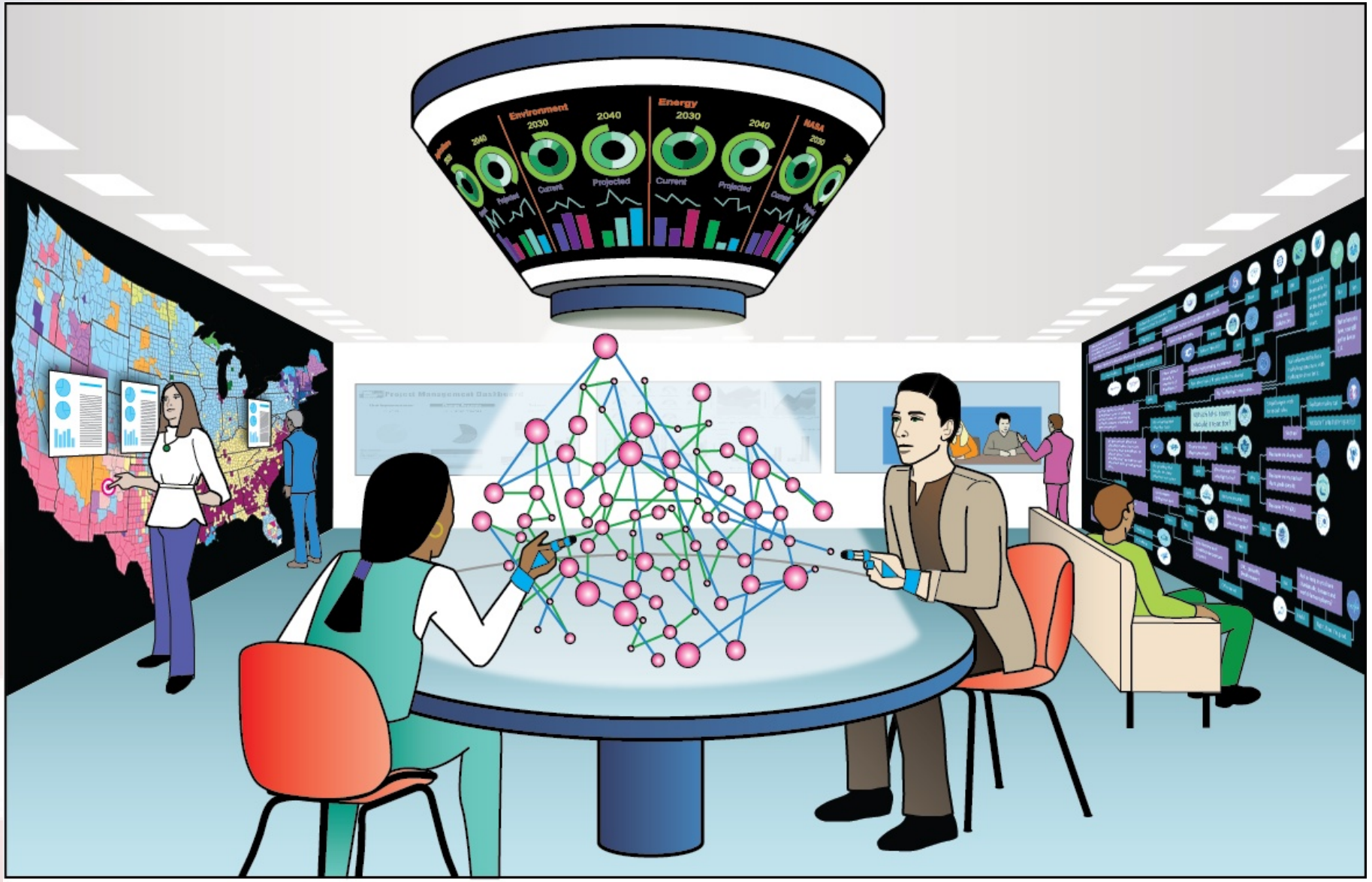
THE WALL STREET JOURNAL.

GAO

Re-Skilling and Up-Skilling for Auditors (Current and Future)



Audit Office of the Future Concept



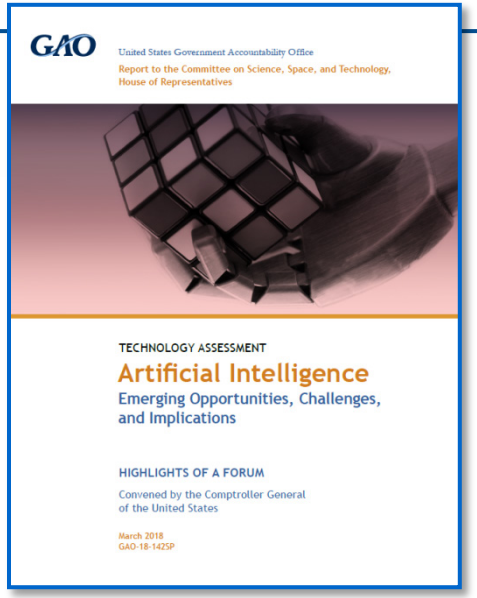
Source: GAO.

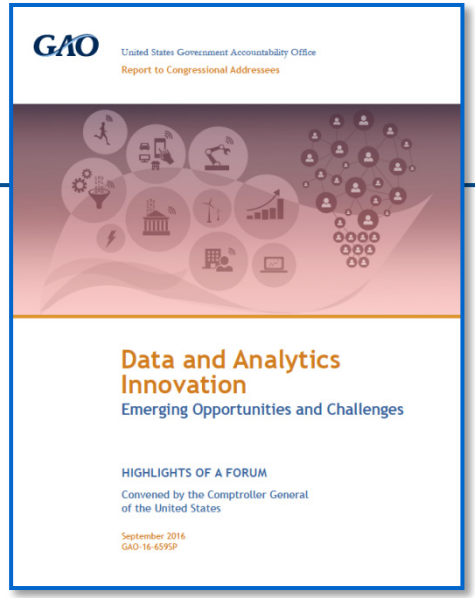
Considerations Going Forward

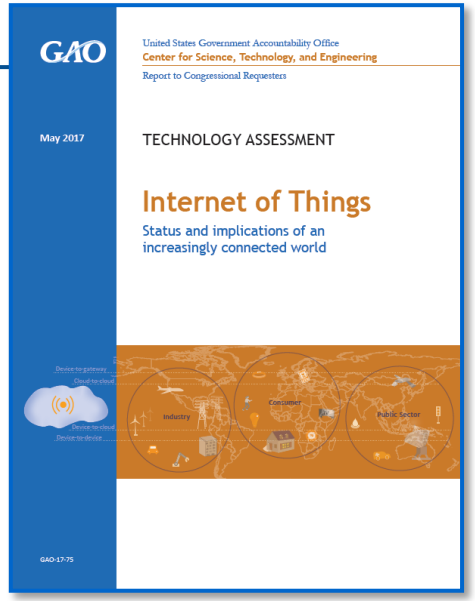
- "Data are the new oil" – tremendous opportunities exists for the accountability community to embrace key trends and shape them toward positive ends (*i.e.*, defining "reasonable assurance", dashboard auditing, quality metrics, and standards development, *etc.*)
- Audit innovation labs (i.e., "sandboxes") will be needed to identify issues and test the technologies in a realistic environment to determine the extent to which they enhance quality, timeliness, and ultimately, relevance.
- Rumors of the deaths of institutions and vocations are greatly exaggerated…jobs will be lost, but others gained (possibly a net gain)
- Human capital development will require fundamental reconsideration and will need transformation to meet the future demands of the profession
- Audit methodology needs to adapt to the probabilistic (vs. deterministic) paradigm and should yield more efficient and incisive audit findings even as core audit quality metrics remain the same
- The greatest challenges ahead are socio-cultural…not technical

("*culture eats strategy for breakfast*")

Thank you







personst@gao.gov
+1 (202) 512-6412
@GAOChfScientist
LinkedIn: “Timothy M. Persons”

http://www.gao.gov/technology_assessment/key_reports