Economic Research and Analysis of the National Need for Technology Infrastructure to Support the Internet of Things (IOT)

Presentation to the NIST IoT Advisory Board

STRATEGY OF THINGS

December 12, 2023

DRAFT

Introductions

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Study Research Team

- Renil Paramel, CEO, Strategy of Things (Principal Investigator)
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- David Duncan, Consultant (Researcher)

Source: Strategy of Things

Table of Contents

- NIST IoT Infrastructure Gaps Research Study
- Key Findings: Industry Challenges and IoT Infrastructure Gaps
- Draft SoT Recommendations

Source: Strategy of Things

NIST IoT Infrastructure Gaps Research Study

Scope of Research

- Assess the current state of the IoT technology infrastructure covering research, development and adoption across industries

- Analyze these findings and identify technology gaps

- Perform an economic analysis to understand the industry impact of addressing those gaps

- Recommend potential areas for federal IoT-related research investments that will enhance U.S. competitiveness and national and economic security

- Communicate these findings across the federal government, academia and industry through a variety of channels, including publications, speaking engagements, journals, online and digital means

- Project Funding: NOFO - 2019-NIST-TPO-IOT-01 ("Economic Research and Analysis of the National Need for Technology Infrastructure to Support the Internet of Things (IOT)")

Approach to identifying IoT infrastructure gaps

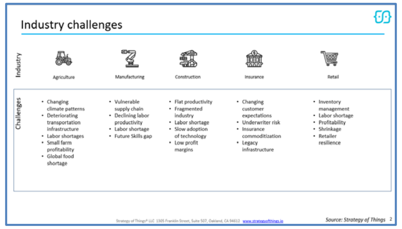
A Industry Review

Agriculture IoT Primer

[illegible]

- Industry Overview
- Challenges
- Value chain
- Use case opportunities
- Industry conferences
- Industry associations
- IoT vendors
- Top businesses
- Use cases

B Identify top industry challenges



Industry challenges

	Agriculture	Manufacturing	Construction	Insurance	Retail
Challenges	• Changing climate patterns • Deteriorating transportation infrastructure • Labor shortages • Small farm profitability • Global food shortage	• Vulnerable supply chain • Declining labor productivity • Labor shortage • Future Skills gap	• Flat productivity • Fragmented industry • Labor shortage • Slow adoption of technology • Low profit margins	• Changing customer expectations • Underwriter risk • Insurance commoditization • Legacy infrastructure	• Inventory management • Labor shortage • Profitability • Shrinkage • Retailer resilience

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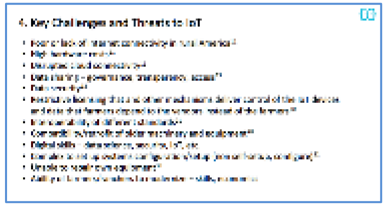
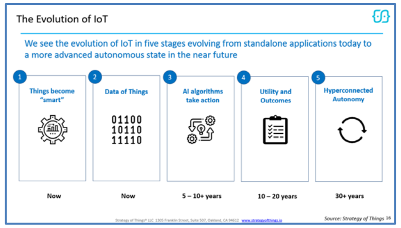
Source: Strategy of Things 2



4. Key Challenges and Threats to IoT

- Poor or lack of internet connectivity in rural America
- High hardware costs
- Disrupted cloud connectivity
- Data sharing – governance, transparency, access
- Data security
- [illegible]
- Interoperability of different standards
- Compatibility/retrofit of older machinery and equipment
- Digital skills – data science, security, IoT, etc.
- [illegible]
- Unable to repair own equipment
- [illegible]

C Identify IoT challenges



The Evolution of IoT

We see the evolution of IoT in five stages evolving from standalone applications today to a more advanced autonomous state in the near future

1	2	3	4	5
Things become "smart"	Data of Things	AI algorithms take action	Utility and Outcomes	Hyperconnected Autonomy
Now	Now	5 – 10+ years	10 – 20 years	30+ years

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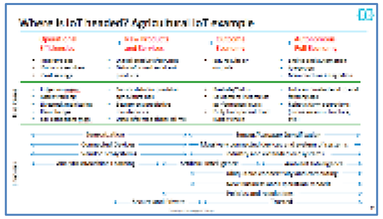
Future IoT

D Identify IoT Use Cases to solve top industry problems

E IoT Technology Infrastructure Gaps Initial Hypotheses



Where is IoT needed? Agriculture IoT example

Translate into Enablers

F Validate and Refine

Interviews

Surveys

Industry Reports

- Industry Associations
- Select industry vendors
- IoT vendors
- Tech and infrastructure

G

Top technology gaps

H

Economic Impact Assessment

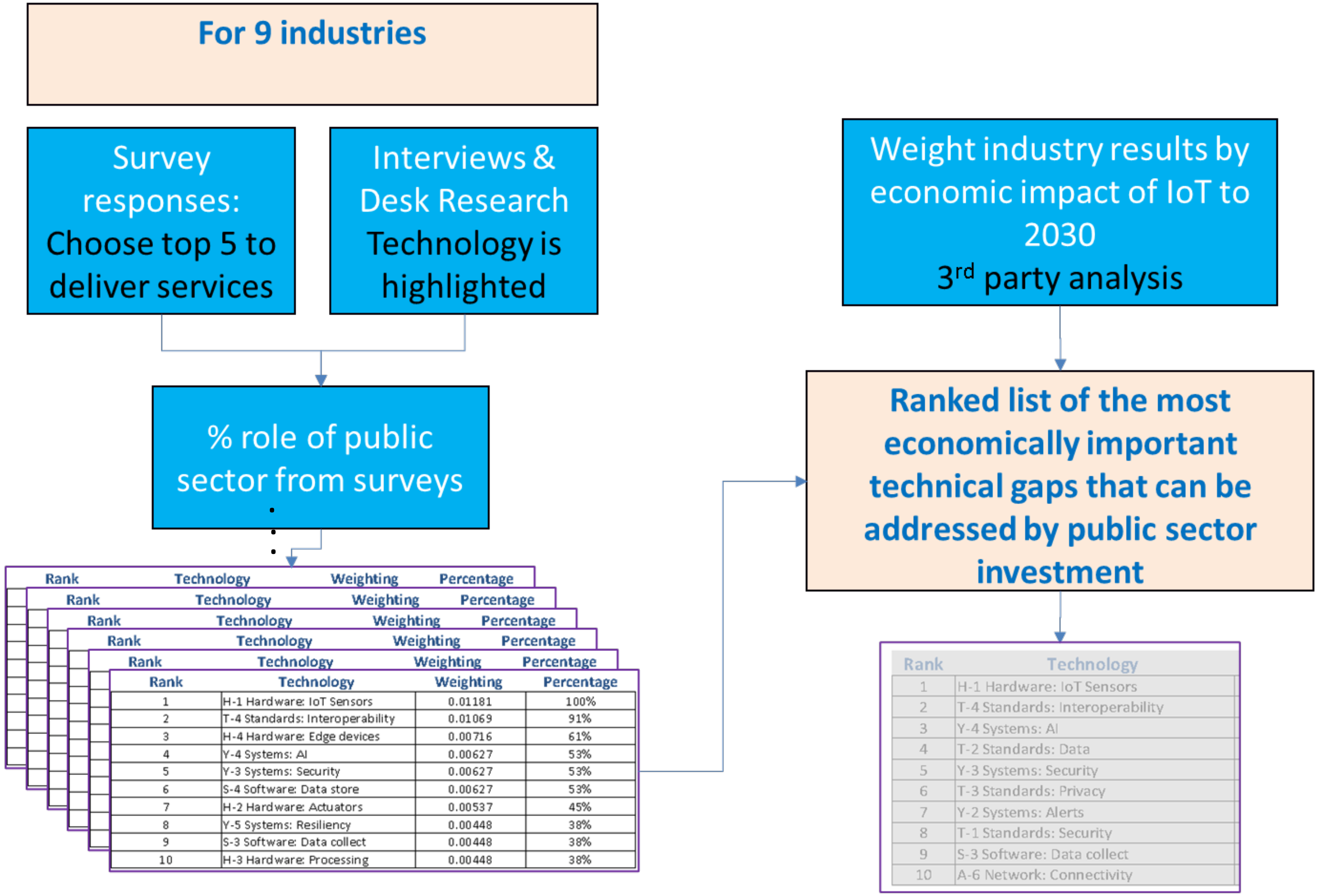
Source: Strategy of Things

Economic Approach

Ranking the most important IoT technology infrastructure gaps addressable by public sector investment

25 possible technology gaps

Hardware	IoT Sensors
	Actuators
	Processing
	Edge Devices
Software	Sensor Firmware
	Edge Firmware/OS
	Data Collection/Ingestion
	Data Storage
Networkin	Gateways
	Connectivity
Applicatior	Device Management
	Network Management
	Data Management
	Data Analytics
	Data Visualization
	User Interaction/Usability
Systems	Middleware/Integration
	Alerts and Notifications
	Security Management
	Artificial Intelligence
	System Resiliency
Standards	Security
	Data
	Privacy
	Interoperability



For 9 industries

Survey responses: Choose top 5 to deliver services

Interviews & Desk Research Technology is highlighted

% role of public sector from surveys

Rank Technology Weighting Percentage
Rank Technology Weighting Percentage
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Rank Technology Weighting Percentage
Rank Technology Weighting Percentage

Rank	Technology	Weighting	Percentage
1	H-1 Hardware: IoT Sensors	0.01181	100%
2	T-4 Standards: Interoperability	0.01069	91%
3	H-4 Hardware: Edge devices	0.00716	61%
4	Y-4 Systems: AI	0.00627	53%
5	Y-3 Systems: Security	0.00627	53%
6	S-4 Software: Data store	0.00627	53%
7	H-2 Hardware: Actuators	0.00537	45%
8	Y-5 Systems: Resiliency	0.00448	38%
9	S-3 Software: Data collect	0.00448	38%
10	H-3 Hardware: Processing	0.00448	38%

Weight industry results by economic impact of IoT to 2030
3rd party analysis

Ranked list of the most economically important technical gaps that can be addressed by public sector investment

Rank	Technology
1	H-1 Hardware: IoT Sensors
2	T-4 Standards: Interoperability
3	Y-4 Systems: AI
4	T-2 Standards: Data
5	Y-3 Systems: Security
6	T-3 Standards: Privacy
7	Y-2 Systems: Alerts
8	T-1 Standards: Security
9	S-3 Software: Data collect
10	A-6 Network: Connectivity

Source: Strategy of Things

Key Findings: Industry Challenges and IoT Infrastructure Gaps

Findings – Top Industry challenges, IoT Technology and Non-Technology Gaps

	1. Agriculture	2. Manufacturing	3. Construction	4. Insurance	5. Retail
Industry	▪ 5.4% of GDP (dir+indir) ▪ 2.6 million workers ▪ 2.05 million farms	▪ 24% of GDP (dir+indir) ▪ 12.8 million workers ▪ 243,687 businesses	▪ 4.1% of GDP (direct) ▪ 7.2 million workers ▪ 753,000 businesses	▪ 2.9 % of GDP (direct) ▪ 2.8 million workers ▪ 181,309 businesses	▪ 6.0 % of GDP (direct) ▪ 32.1 million workers ▪ 3.61 million businesses
Industry Challenges	▪ Changing climate patterns ▪ Deteriorating transportation infrastructure ▪ Labor shortages ▪ Small farm profitability ▪ Global food shortage	▪ Vulnerable supply chain ▪ Declining labor productivity ▪ Labor shortage ▪ Future Skills gap	▪ Flat productivity ▪ Fragmented industry ▪ Labor shortage ▪ Slow adoption of technology ▪ Low profit margins	▪ Changing customer expectations ▪ Underwriter risk ▪ Insurance commoditization ▪ Legacy infrastructure	▪ Inventory management ▪ Labor shortage ▪ Profitability ▪ Shrinkage ▪ Retailer resilience

IoT Gaps

	1. Agriculture	2. Manufacturing	3. Construction	4. Insurance	5. Retail
IoT Tech Gaps	▪ Connectivity ▪ Edge computing & processing ▪ Interoperability	▪ Interoperability ▪ Cybersecurity ▪ Low cost sensors ▪ Connectivity	▪ BIM-IoT data integration ▪ Data standards and interoperability	▪ AI model accuracy & explainability ▪ Data privacy ▪ Cybersecurity	▪ Low cost sensors ▪ Privacy enhancing technologies ▪ AI trust and explainability
Non-Tech Gaps	▪ Right to repair ▪ Digital skills ▪ Adoption resistance ▪ Data privacy	▪ Slow adoption ▪ ROI skepticism ▪ Resistance to change	▪ Fragmented industry structure ▪ Lack of asset owner requirement ▪ Adoption resistance	▪ Uncertain regulatory treatment ▪ Digital skills	▪ Legacy technology infrastructure ▪ Digital skills

Source: Strategy of Things

Source: Strategy of Things

Findings – Top Industry challenges, IoT Technology and Non-Technology Gaps

(Continued)

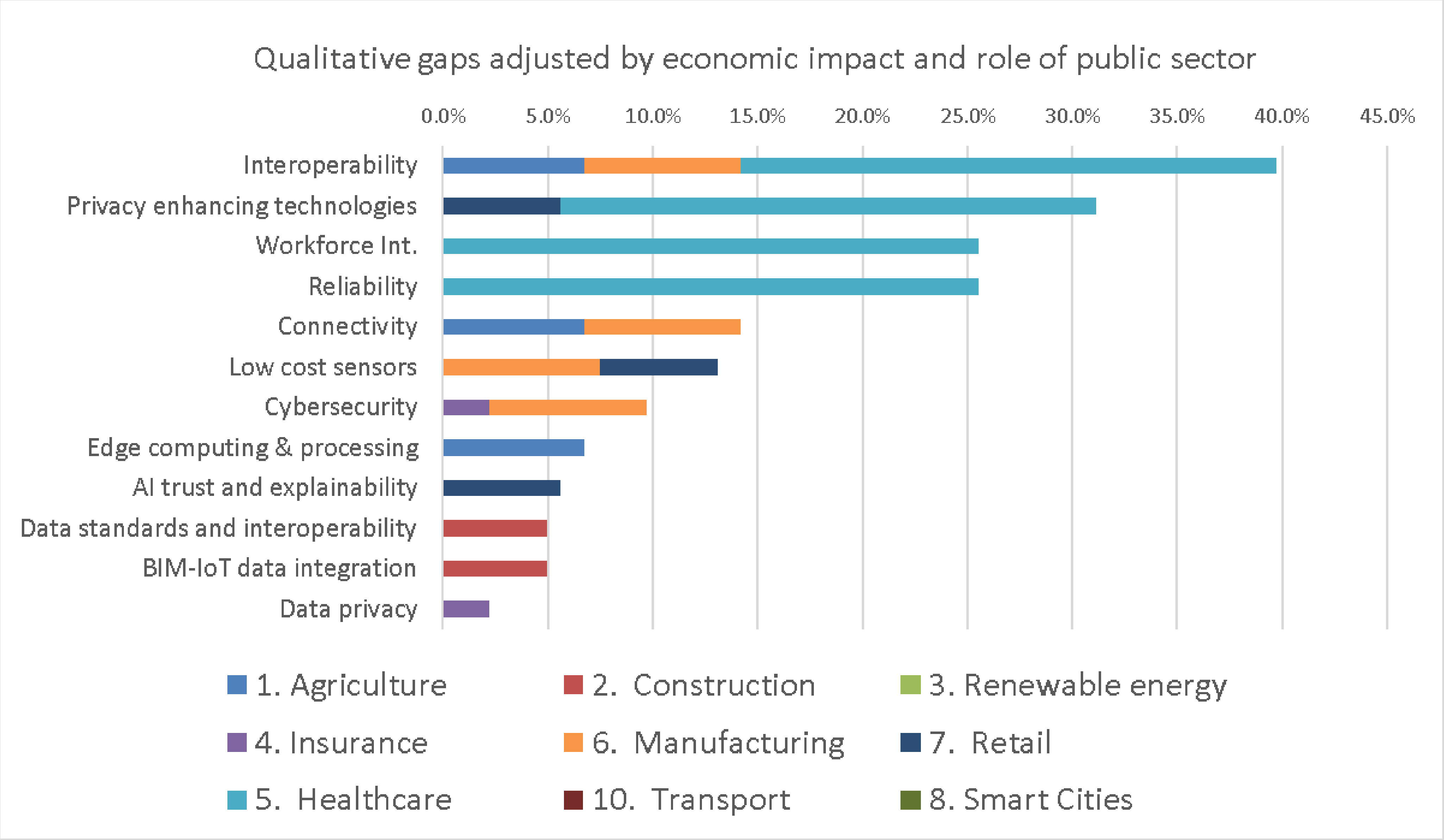
	6. Cities/Local Govt	7. Transport/Logistics	8. Healthcare	9. Renewable Energy
Industry	19,495 cities Metro → 91.1% GDP Metro → 88% of jobs	2.96% of GDP (dir+indir) 5.7 million workers 257,785 businesses	19.6% of GDP (direct) 21.2 million workers 928,174 businesses	2.9 % of GDP (direct) 620,000 million workers 1,673 RE generators
Industry Challenges	Deteriorating infrastructure Budgets Digital ops and services Public safety	Supply chain resilience Aging infrastructure Environment and sustainability Labor shortage Fuel costs	Rising care costs Access to healthcare Workforce shortage Chronic disease management	Renewable energy output variability/duck curve Aging and outdate grid infrastructure Labor shortage Lengthy development review and permitting

IoT Gaps

IoT Tech Gaps	Interoperability Spectrum Data management Privacy Cybersecurity	In Progress	Interoperability Cybersecurity Privacy AI accuracy and explainability	DER cybersecurity Interoperability (inverters, storage, grid)
Non Tech Gaps	Lack of funding Lack of trust Skills Adoption resistance Legacy systems	In Progress	Digital skills Adoption resistance Regulatory approval Uneven payer coverage	Digital skills Regulatory

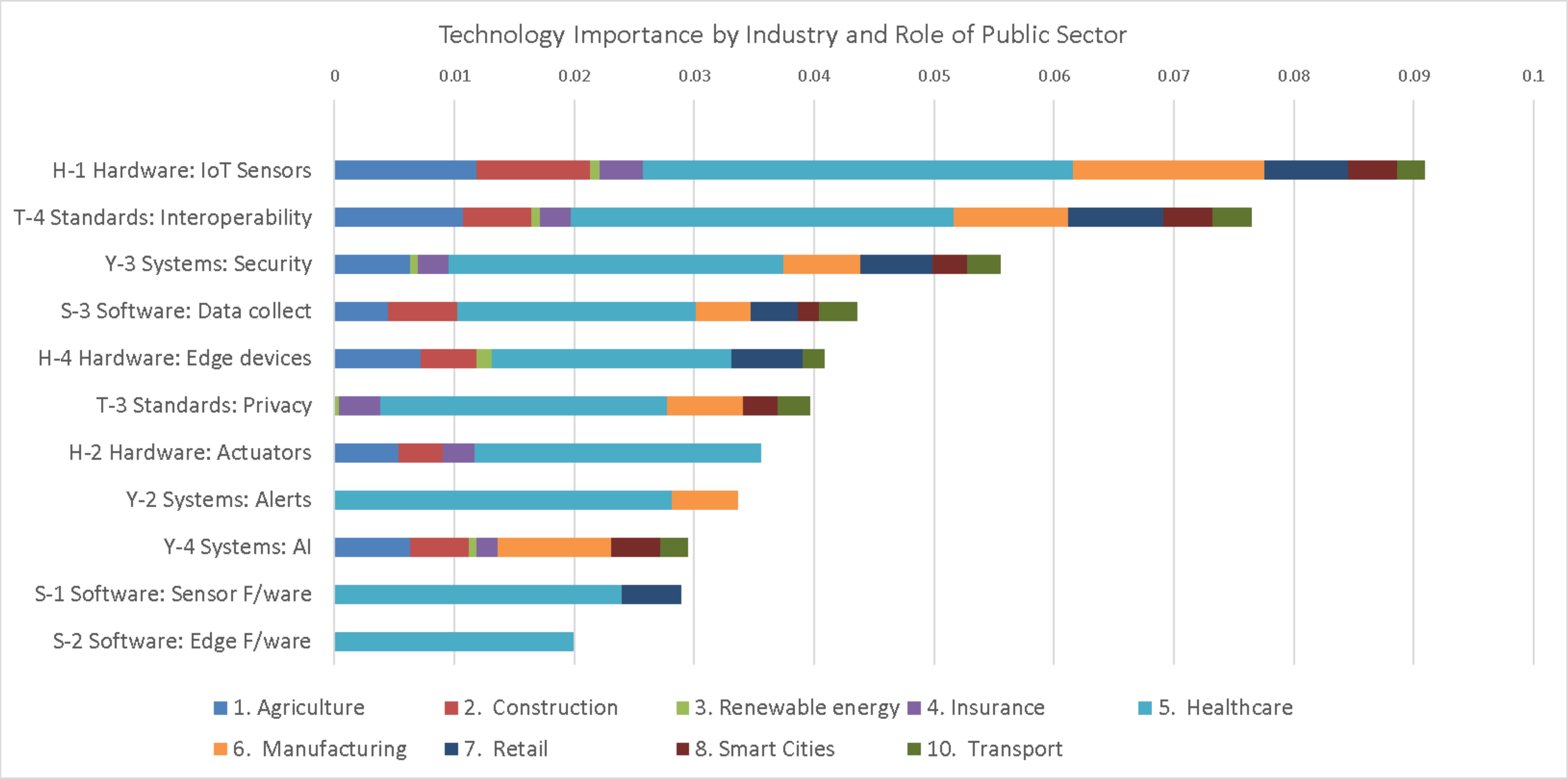
Source: Strategy of Things

All Industries: Integration of qualitative analysis into narrative



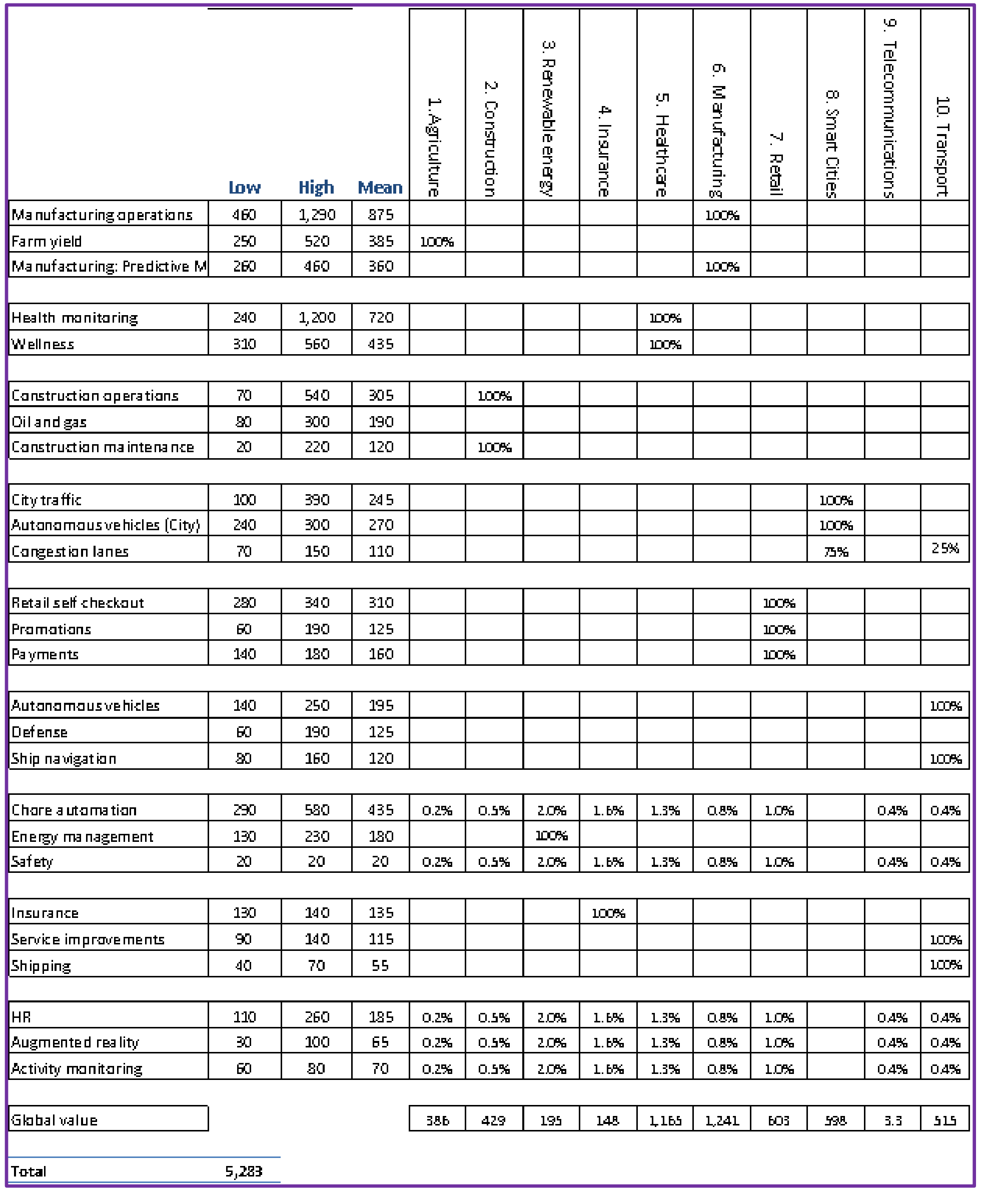
Source: Strategy of Things

All Industries: Economically adjusted gaps – by technology



Source: Strategy of Things

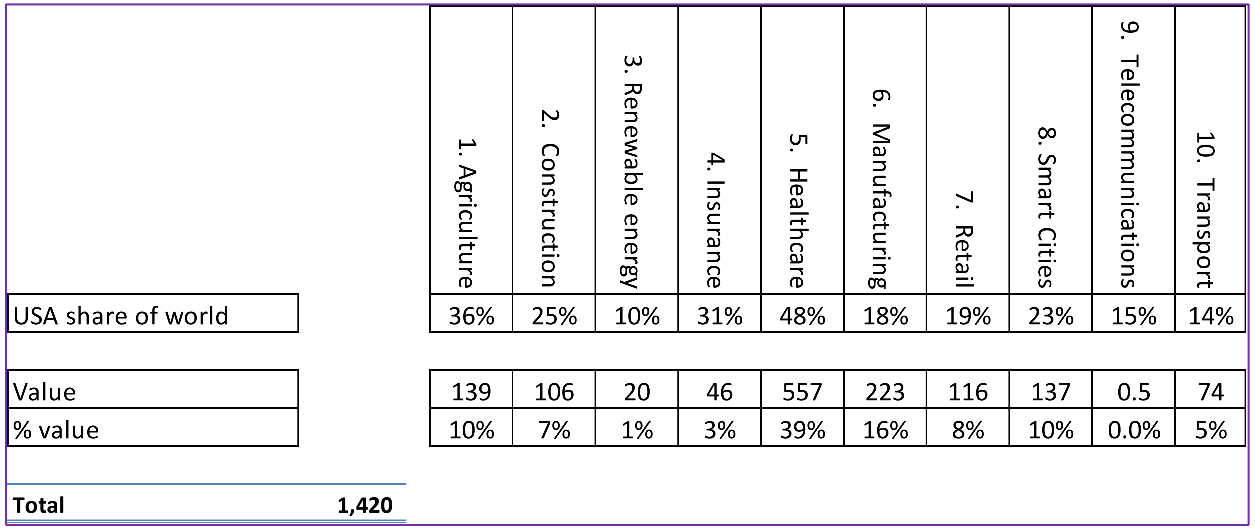
There is significant value for IoT in the USA from 2025 to 2030 ($ 1,420 bn)



	Low	High	Mean	1.Agriculture	2. Construction	3. Renewable energy	4. Insurance	5. Healthcare	6. Manufacturing	7. Retail	8. Smart Cities	9. Telecommunications	10. Transport
Manufacturing operations	460	1,290	875						100%				
Farm yield	250	520	385	100%									
Manufacturing: Predictive M	260	460	360						100%				
Health monitoring	240	1,200	720					100%					
Wellness	310	560	435					100%					
Construction operations	70	540	305		100%								
Oil and gas	80	300	190										
Construction maintenance	20	220	120		100%								
City traffic	100	390	245								100%		
Autonomous vehicles (City)	240	300	270								100%		
Congestion lanes	70	150	110								75%		25%
Retail self checkout	280	340	310							100%			
Promotions	60	190	125							100%			
Payments	140	180	160							100%			
Autonomous vehicles	140	250	195										100%
Defense	60	190	125										
Ship navigation	80	160	120										100%
Chore automation	290	580	435	0.2%	0.5%	2.0%	1.6%	1.3%	0.8%	1.0%		0.4%	0.4%
Energy management	130	230	180			100%							
Safety	20	20	20	0.2%	0.5%	2.0%	1.6%	1.3%	0.8%	1.0%		0.4%	0.4%
Insurance	130	140	135				100%						
Service improvements	90	140	115										100%
Shipping	40	70	55										100%
HR	110	260	185	0.2%	0.5%	2.0%	1.6%	1.3%	0.8%	1.0%		0.4%	0.4%
Augmented reality	30	100	65	0.2%	0.5%	2.0%	1.6%	1.3%	0.8%	1.0%		0.4%	0.4%
Activity monitoring	60	80	70	0.2%	0.5%	2.0%	1.6%	1.3%	0.8%	1.0%		0.4%	0.4%
Global value				386	429	195	148	1,165	1,241	603	598	3.3	515
Total	5,283												

3rd Party worldwide value allocated to 9 industries along with high and low estimates

USA share allocated by proxy indicators



	1. Agriculture	2. Construction	3. Renewable energy	4. Insurance	5. Healthcare	6. Manufacturing	7. Retail	8. Smart Cities	9. Telecommunications	10. Transport
USA share of world	36%	25%	10%	31%	48%	18%	19%	23%	15%	14%
Value	139	106	20	46	557	223	116	137	0.5	74
% value	10%	7%	1%	3%	39%	16%	8%	10%	0.0%	5%
Total **1,420**										

Provided a value of $1.4T from 2025 to 2030, including consumer surplus, and weightings for US industries

Source: Strategy of Things

Impact of a $10m investment in H-1, T-4

The table on the right is an example of our economic model showing the impact of a public investment of $10 million in the IoT sub category of Hardware Sensors (H1)

Industry	H-1 Hardware: IoT Sensors Weighting	Public R&D investment ($m)	R&D to Revenue	Revenue ($m)	Gross margin	Surplus from Revenue ($m)
5. Healthcare	0.052655	$4.91	8.3%	$59	52%	$31
6. Manufacturing	0.015967	$1.49	2.3%	$65	35%	$23
1. Agriculture	0.011809	$1.10	0.8%	$141	14%	$19
2. Construction	0.009477	$0.88	0.8%	$113	23%	$26
7. Retail	0.006976	$0.65	0.8%	$83	24%	$20
8. Smart Cities	0.003656	$0.34	2.3%	$15	29%	$4
4. Insurance	0.003587	$0.33	0.8%	$43	31%	$13
10. Transport	0.002308	$0.22	2.3%	$9	21%	$2
3. Renewable energy	0.000855	$0.08	0.8%	$10	40%	$4
		$10.0		**$539**		**$143**

The table on the right is an example of our economic model showing the impact of a public investment of $10 million in the IoT sub category of Standards Interoperability (T4)

Industry	T-4 Standards: Interoperability Weighting	Public R&D investment	R&D to Revenue	Revenue ($m)	Gross margin	Surplus from Revenue ($m)
5. Healthcare	0.026640	$2.48	8.3%	$30	52%	$16
1. Agriculture	0.010690	$1.00	0.8%	$128	14%	$17
6. Manufacturing	0.009532	$0.89	2.3%	$39	35%	$14
7. Retail	0.007972	$0.74	0.8%	$95	24%	$23
2. Construction	0.005752	$0.54	0.8%	$69	23%	$16
8. Smart Cities	0.003656	$0.34	2.3%	$15	29%	$4
10. Transport	0.003318	$0.31	2.3%	$13	21%	$3
4. Insurance	0.002609	$0.24	0.8%	$31	31%	$10
3. Renewable energy	0.000667	$0.06	0.8%	$8	40%	$3
		$10.0		**$428**		**$106**

Source: Strategy of Things

Impact of a $10m investment in S-3, Y-3

The table on the right is an example of our economic model showing the impact of a public investment of $10 million in the IoT sub category of Software Data (S3)

Industry	S-3 Software: Data collect Weighting	Public R&D investment	R&D to Revenue	Revenue ($m)	Gross margin	Surplus from Revenue ($m)
5. Healthcare	0.036005	$3.36	8.3%	$41	52%	$21
2. Construction	0.005752	$0.54	0.8%	$69	23%	$16
6. Manufacturing	0.004504	$0.42	2.3%	$18	35%	$6
1. Agriculture	0.004477	$0.42	0.8%	$54	14%	$7
7. Retail	0.003986	$0.37	0.8%	$48	24%	$12
10. Transport	0.003232	$0.30	2.3%	$13	21%	$3
8. Smart Cities	0.001567	$0.15	2.3%	$6	29%	$2
4. Insurance	0.000870	$0.08	0.8%	$10	31%	$3
3. Renewable energy	0.000334	$0.03	0.8%	$4	40%	$2
		$10.0		**$262**		**$72**

The table on the right is an example of our economic model showing the impact of a public investment of $10 million in the IoT sub category of Systems Security (Y3)

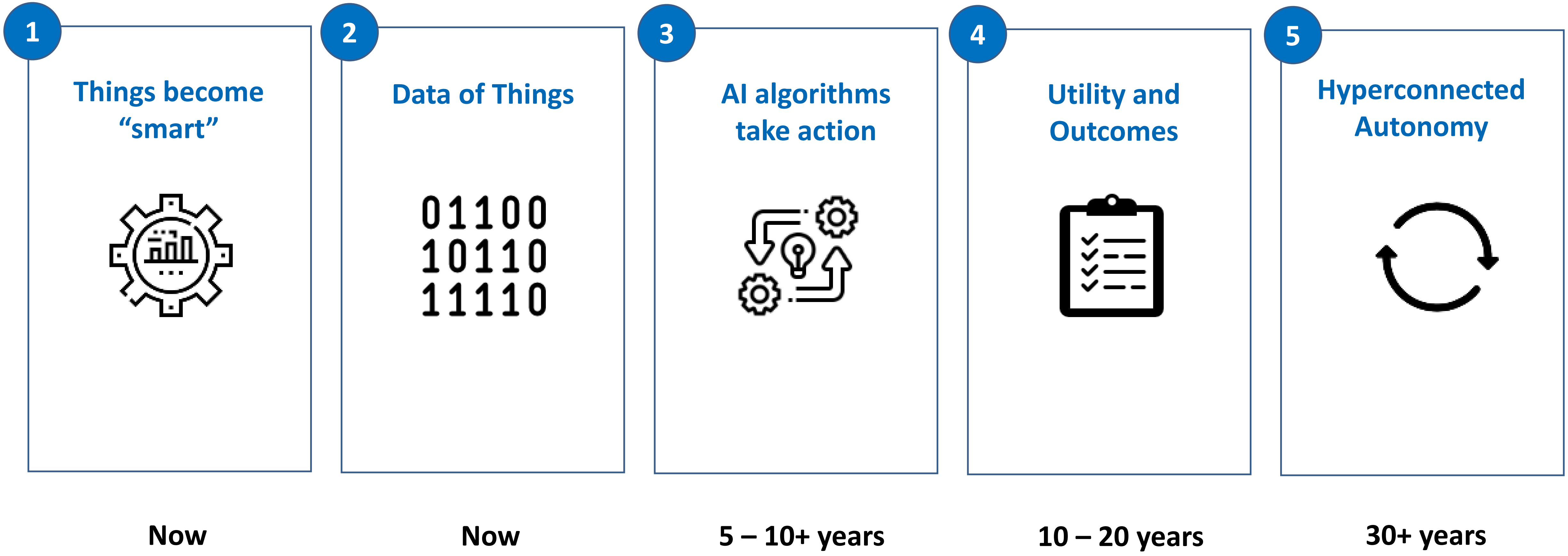
Industry	Y-3 Systems: Security Weighting	Public R&D investment	R&D to Revenue	Revenue ($m)	Gross margin	Surplus from Revenue ($m)
5. Healthcare	0.023310	$2.17	8.3%	$26	52%	$14
6. Manufacturing	0.006435	$0.60	2.3%	$26	35%	$9
1. Agriculture	0.006268	$0.58	0.8%	$75	14%	$10
7. Retail	0.005979	$0.56	0.8%	$71	24%	$17
10. Transport	0.002770	$0.26	2.3%	$11	21%	$2
8. Smart Cities	0.002611	$0.24	2.3%	$11	29%	$3
4. Insurance	0.002609	$0.24	0.8%	$31	31%	$10
2. Construction	0.001569	$0.15	0.8%	$19	23%	$4
3. Renewable energy	0.000667	$0.06	0.8%	$8	40%	$3
		$10.0		**$278**		**$73**

Source: Strategy of Things

Evolution of IoT and Draft SoT Recommendations

The Evolution of IoT

We see the evolution of IoT in five stages evolving from standalone applications today to a more advanced autonomous state in the near future



1 Things become “smart” — Now

2 Data of Things — Now

3 AI algorithms take action — 5 – 10+ years

4 Utility and Outcomes — 10 – 20 years

5 Hyperconnected Autonomy — 30+ years

Source: Strategy of Things

Key factors driving or hindering evolution of IoT

1. Things become "smart"
2. Data of Things
3. AI algorithms take action
4. Utility and Outcomes
5. Hyperconnected Autonomy

Key evolution drivers

- Interoperability and standards
- Ubiquitous connectivity
- Ubiquitous computing
- Trustworthy IoT
- Analytics and intelligence
- Convergence of IT, OT and enterprise systems
- Policies and regulations
- Innovative businesses and operating models

Emerging Trends

- Emergence of "edge"
- "low code" and "no code" tools
- Increasing open source IoT ecosystem
- Cybersecurity standards and regulations
- Next gen satellite connectivity
- 5G rollout
- AI and ML capable IoT devices
- Energy harvesting technologies
- Multi-sensor data fusion
- Digital twin adoption

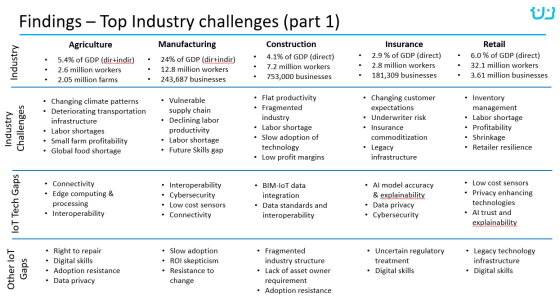
Future Research Areas to Enable Evolution

- More capable and intelligent edge devices
- Robust infrastructure to support increasingly large number of IoT systems
- Usable AI for IoT
- Hyperconnected communication and networks at scale
- Massive data ecosystem
- Interoperability and standards
- Human centric ambient intelligence IoT systems
- Trust architectures and ecosystems

Source: Strategy of Things

Hypothesis: Gaps exist and may vary depending on the evolution stage of IoT

Master gaps list



Findings – Top Industry challenges (part 1)

	Agriculture	Manufacturing	Construction	Insurance	Retail
Industry	• 5.4% of GDP (dir+indir) • 2.6 million workers • 2.05 million farms	• 24% of GDP (dir+indir) • 12.8 million workers • 243,687 businesses	• 4.1% of GDP (direct) • 7.2 million workers • 753,000 businesses	• 2.9 % of GDP (direct) • 2.8 million workers • 181,309 businesses	• 6.0 % of GDP (direct) • 32.1 million workers • 3.61 million businesses
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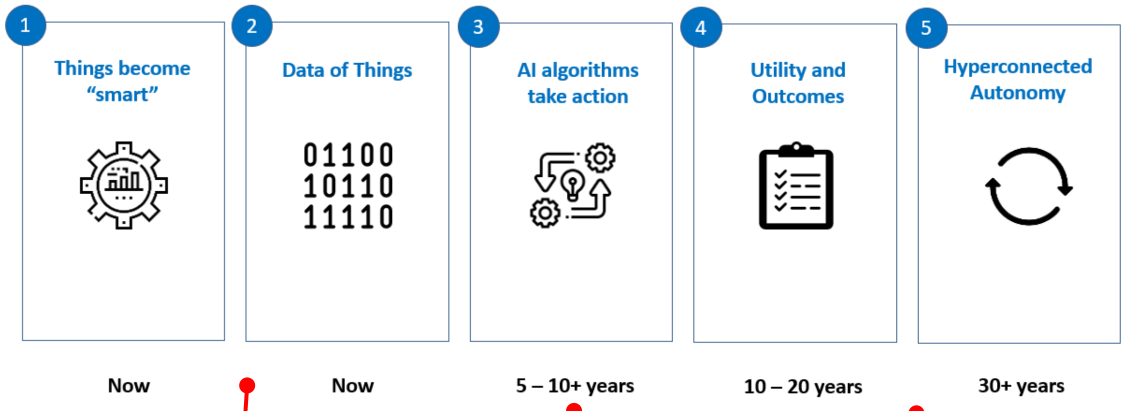
IoT Tech Gaps	• Connectivity • Edge computing & processing • Interoperability	• Interoperability • Cybersecurity • Low cost sensors • Connectivity	• BIM-IoT data integration • Data standards and interoperability	• AI model accuracy & explainability • Data privacy • Cybersecurity	• Low cost sensors • Privacy enhancing technologies • AI trust and explainability
Other IoT Gaps	• Right to repair • Digital skills • Adoption resistance • Data privacy	• Slow adoption • ROI skepticism • Resistance to change	• Fragmented industry structure • Lack of asset owner requirement • Adoption resistance	• Uncertain regulatory treatment • Digital skills	• Legacy technology infrastructure • Digital skills

Future Research Areas to Enable Evolution

- More capable and intelligent edge devices
- Robust infrastructure to support increasingly large number of IoT systems
- Usable AI for IoT
- Hyperconnected communication and networks at scale
- Massive data ecosystem
- Interoperability and standards
- Human centric ambient intelligence IoT systems
- Trust architectures and ecosystems

"Illustrative Gaps"



- Interoperability
- Cybersecurity
- Privacy

- AI explainability
- Usable AI

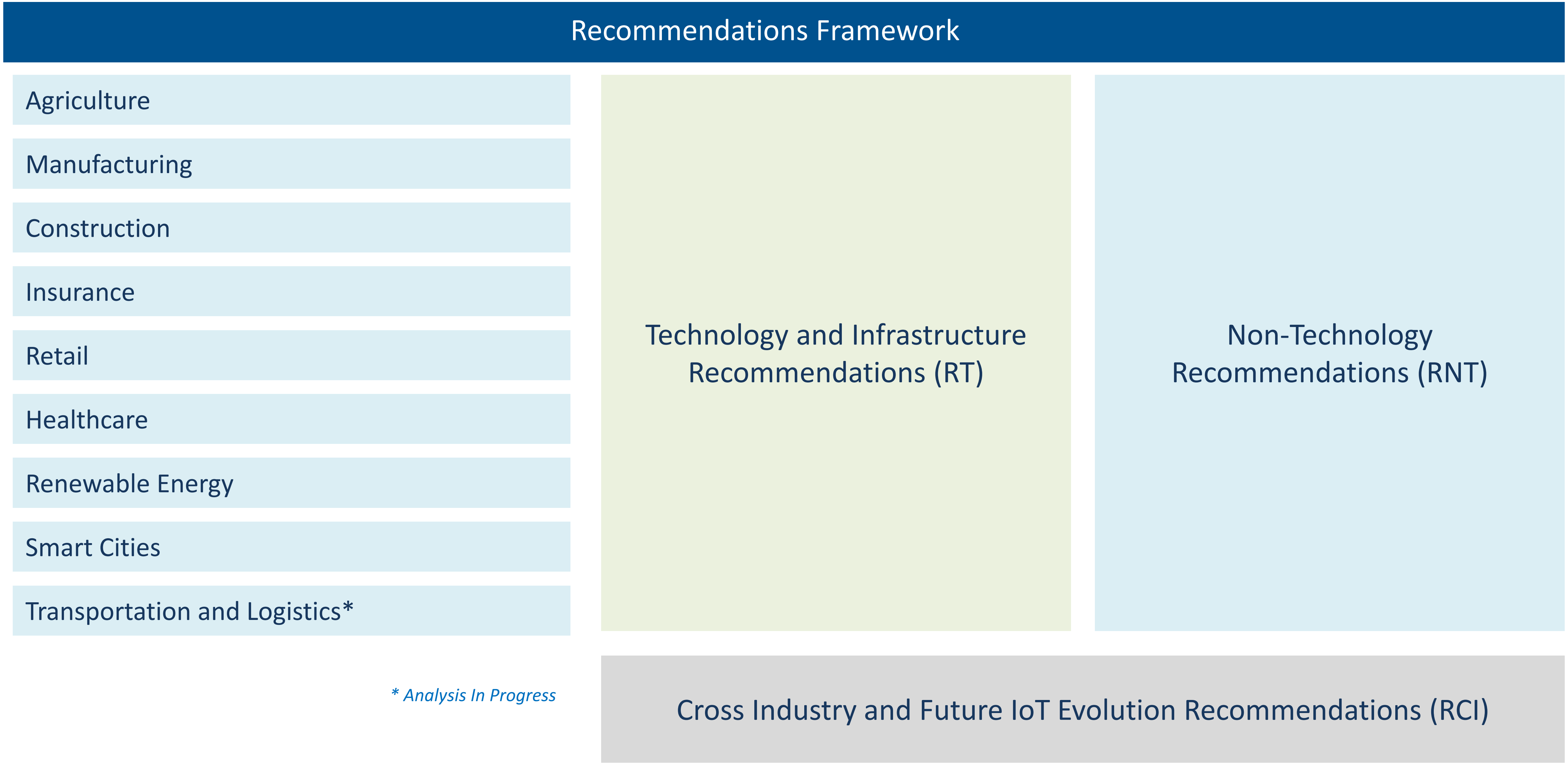
- Network infrastructure
- Interoperability

Draft Recommendations

Source: Strategy of Things

Source: Strategy of Things

Draft Recommendations Approach and Framework



Recommendations Framework

- Agriculture
- Manufacturing
- Construction
- Insurance
- Retail
- Healthcare
- Renewable Energy
- Smart Cities
- Transportation and Logistics*

Technology and Infrastructure Recommendations (RT)

Non-Technology Recommendations (RNT)

Cross Industry and Future IoT Evolution Recommendations (RCI)

** Analysis In Progress*

Source: Strategy of Things

Recommendations Breakdown by Industry and Technology Areas

	Technology Recommendations (21)	Non-Tech Recommendations (32)
Agriculture	Connectivity (AG1), Interoperability (AG2)	Small farm adopt (AG3), Workforce (AG4), Right to repair (AG5), Data confidentiality (AG6), IoT awareness (AG7)
Manufacturing	Rural broadband (MFG1), Interoperability (MFG2), Cybersecurity (MFG5)	Small manufacturer adoption (MFG3), Workforce (MFG 4)
Construction	Interoperability (CON2), Cybersecurity (CON5)	IoT specification in federal funded projects (CON1), Small contractor adoption (CON3), Workforce (CON4),
Insurance	AI explainability (INS1,3), Cybersecurity (INS5)	AI data usage and privacy policy (INS1,2), Privacy framework/regulation (INS2), AI Workforce (INS1,3), Workforce (INS4), Federal Insurance Office (INS5)
Retail	Low cost sensor research (RT1), Privacy enhancing technologies (RT2), AI explainability (RT3), Cybersecurity (RT6)	AI trained workforce (RT3), Workforce (RT4), Small retailer adoption (RT5)
Healthcare	Interoperability (HC1), Cybersecurity (HC2), Privacy enhancing technologies (HC4), AI explainability (HC8)	Federal healthcare adoption (HC3), Privacy (HC4), Rural adoption (HC5), Small practice adoption (HC6), Workforce (HC7), Data and privacy for AI, AI workforce (HC8)
Renewable Energy		
Smart Cities	Interoperability (SC4), Cybersecurity (SC7), Privacy (SC8)	City adoption of IoT (SC1), Rural community adoption (SC2), Use of IoT by federal (SC3), Small/medium city adoption (SC5), Workforce (SC6), GCTC (SC9), Equity of access and benefits (SC10), National IoT strategy (SC11)
Transportation and Logistics*		

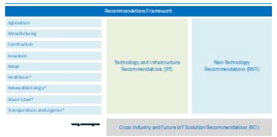
** Analysis In Progress*

Cross Industry and Future IoT Evolution Recommendations (7)

IoT device capability (RCI1), Interoperability (RCI2), Infrastructure (RCI3), Usable AI for IoT (RCI4), Hyperconnected communications networks (RCI5), Human centric IoT (RCI6), Model Refresh (RCI7)

Source: Strategy of Things

Draft Recommendations: Agriculture



Recommendations Framework

Agriculture

Manufacturing

Construction

Insurance

Retail

Healthcare*

Renewable Energy*

Smart Cities*

Transportation and Logistics*

Technology and Infrastructure Recommendations (RT)

Non-Technology Recommendations (RNT)

Cross Industry and Future IoT Evolution Recommendations (RC)

Agriculture: Technology and Infrastructure Recommendations

AG1: Facilitate development of connectivity policies and programs that support:

- Broadband service at the farmhouse greater than 25/3 Mbps
- Symmetric connectivity of at least 100/100 Mbps that supports high bandwidth precision agriculture use cases (video, imagery, automation and control, etc.)
- Last acre IoT connectivity service that addresses coverage, terrain diversity, evolving use cases, and foliage interference

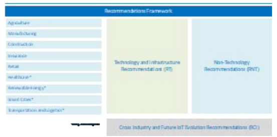
- Today's broadband and connectivity infrastructure and capabilities are insufficient to support current and future precision agriculture needs.
- Future needs include the processing of low latency, real time data, support automation applications, and high bandwidth applications

AG2: Support and promote industry and SDO efforts to address interoperability of agricultural systems and machinery

- Farms have a variety of equipment and machinery that can't talk to each other. Ag industry model is to develop s/w and devices in proprietary formats.

Source: Strategy of Things

Draft Recommendations: Agriculture



Recommendations Framework

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Agriculture: Non Technology Recommendations

AG3: Facilitate small farm/ranch (< $350,000 GCFI) adoption:

- Subsidies and tax credits for purchase
- Use of Cooperative Extension Offices and resources for IoT data analytics and other technical support

- Small farms are 90% of all US farms, 49% of farmland, 20% of production.
- They operate with <10% margins.
- They do not have cash flow to buy IoT or smart equipment.

AG4: Facilitate policies and programs that support the key education and digital skills development across vocational schools, community colleges and four year universities for the current and future agriculture workforce, including:

- Data analytics and management
- IoT technologies
- Machine vision and robotics
- Networking and systems integration
- Cybersecurity and Installation
- Maintenance and servicing of IoT systems

- Technology will automate manual activities and low skill repetitive work will shift to work requiring technical, cognitive and people skills.
- Agricultural workers lack the needed skills to succeed in the new environment.

Source: Strategy of Things

Draft Recommendations: Agriculture

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Agriculture: Non Technology Recommendations

AG5: (Precision Ag) Enactment of federal “right to repair” legislation to address the inability of agricultural producers to service their smart equipment

- Smart equipment cannot be fixed by farmers.
- It is expensive and may take a long time to get fixed.
- These may occur at sensitive times for farmers who can’t afford the wait.
- Farmers turned to “hacked” software from Eastern Europe or buy older equipment.

AG6: Facilitate development of IoT data confidentiality guidelines for agricultural IoT systems, and manufacturers of “smart” and IoT enabled agricultural machinery and systems [Linkage to privacy recommendations]

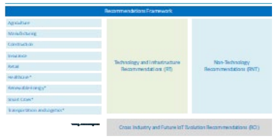
- Producers are concerned with who and how their data is used. 77% of producers are concerned about who accesses data, 67% will consider how their data is used when making purchase decisions, and 61% are concerned that companies use their data to influence market decisions.

AG7: Increase awareness and education of agricultural IoT technologies through government funded programs, cooperative extension programs, publications, and other means. [linkage to Ranveer university demo centers]

- Producers are slow to adopt (7 year adoption cycle) for several reasons, including “nature vs. technology”, poor experiences with technology previously and less education than larger producers.

Source: Strategy of Things

Draft Recommendations: Manufacturing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Manufacturing: Technology and Infrastructure Recommendations

MFG1: Facilitate and prioritize the rollout of broadband infrastructure in rural parts of the country with manufacturing facilities.

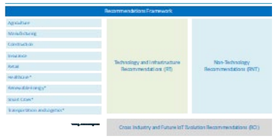
- Lack of broadband threatens rural based manufacturing companies to compete against others using Industry 4.0 technologies.

MFG2: Support and promote industry and SDO efforts to address interoperability of manufacturing systems and machinery

- Interoperability challenges are a major barrier to IoT adoption and value realization in manufacturing.
- Factories have a variety of equipment, from new industrial equipment with current technology to legacy equipment with limited technology and connectivity.
- Many of the machines employ a variety of proprietary and incompatible protocols that make sharing information from MES, ERP systems, and SCADA and DCS difficult or impossible.

Source: Strategy of Things

Draft Recommendations: Manufacturing



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Manufacturing: Non Technology Recommendations

MFG3: Facilitate small manufacturer adoption of “smart manufacturing”:

- Subsidies and tax credits for purchase
- Expand Manufacturing Extension Partnership and CESMII and resources for IoT data analytics, technical support, promote “smart manufacturing” benefits and successes, change resistance and cultural issues
- Increase awareness and education of smart manufacturing technologies through government funded programs, cooperative extension programs, publications, and other means.
- Facilitate workforce development to support smart manufacturing

- Labor productivity fell 4% (2010-19) compared to 41% increase (2001-10)
- Small manufacturers < 500 people are 98.3% of all US manufacturers. 74.3% are < 20 people.
- ROI skepticism
- Change resistance issues (IT/OT silos, culture)

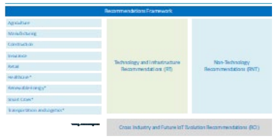
MFG4: Facilitate policies and programs that support the key education and digital skills development across community colleges and four year universities for the current and future manufacturing workforce, including:

- Technology and computer skills
- Digital skills (analytics, cybersecurity, IT, networking, etc.)
- Robotics and automation programming
- Working with tools and technology
- Critical thinking

- Manufacturing jobs are no longer low skilled jobs, but require new skills.
- Automation will require people to work alongside robots and machines.
- A labor shortage and skills shortage will leave 2.4 million unfilled jobs between 2018-2028.
- This leads to a loss of $454 B of manufacturing value by 2028 and makes the US less competitive in manufacturing.

Source: Strategy of Things

Draft Recommendations: Manufacturing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Manufacturing: Technology and Infrastructure Recommendations

MFG5: Facilitate cybersecurity in IoT applications for smart manufacturing

- Expand cybersecurity trust mark program to include IoT devices and modules used for smart manufacturing and industrial applications
- Facilitate workforce development programs to increase pool of IoT cybersecurity trained resources in smart manufacturing

- Manufacturing industry was #1 industry targeted in 2021.
- Creation of new attack surfaces into a former “protection by air gap” environment
- Integration of resource constrained IoT devices with limited cybersecurity capabilities
- Exposure of air gapped legacy equipment, industrial control systems and OT infrastructure vulnerabilities
- Security operations, such as updates and patches, limited to machine downtime periods

Source: Strategy of Things

Draft Recommendations: Construction

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Construction: Non Technology Recommendations

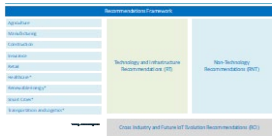
CON1: Specify the use of IoT and other technologies (e.g. BIM, etc.):

- In the design, construction and maintenance of federally owned, leased and operated properties, buildings and facilities.
- In the design of construction projects funded fully or partially by federal grants and funds (e.g. state and local highway projects, infrastructure projects, etc.)

- Contractors will not add IoT or other technologies unless the customer (federal government) specifies the use of it. No contractor will add anything on their own without a customer requirement.

Source: Strategy of Things

Draft Recommendations: Construction



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Construction: Technology and Infrastructure Recommendations

CON2: Support and promote industry and SDO efforts to address interoperability of data from IoT sources with other construction and asset sources. [some linkage to transportation recommendation on interoperability]

- Data from IoT devices do not integrate with BIM software, nor do they integrate with the data sets in that software.

Source: Strategy of Things

Draft Recommendations: Construction

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Construction: Non Technology Recommendations

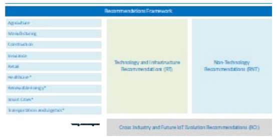
CON3: Facilitate small contractor adoption of “smart construction” tools and technologies:

- Subsidies and tax credits for purchase for tools and machinery
- Increase awareness and education of smart construction technologies through government funded programs (e.g. SBA), cooperative extension programs, publications, and other means.
- Facilitate workforce development to support smart construction

- Industry labor productivity is flat from 2007-2020
- Small contractor firms < 5 people are two-thirds of all US contractors. Half the workforce is in firms between 20-250 people.
- Low profit margins
- Adoption resistance of IoT due to status quo, risk aversion, workforce readiness

Source: Strategy of Things

Draft Recommendations: Construction



Construction: Non Technology Recommendations

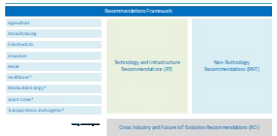
CON4: Facilitate policies and programs that support the key education and digital skills development across vocational schools, community colleges and four year universities for the current and future construction workforce, including

- Technology and computer skills
- Digital skills (analytics, cybersecurity, IT, networking, etc.)
- Software tools - BIM
- Working with tools and technology
- Critical thinking

- The construction industry is behind the curve in digitalization.
- 43% of U.S. civil engineers and contractors reported the use of digital tools and innovations, compared with 66% of non-U.S. counterparts.
- 43% of U.S. civil contractors had low digital capabilities, compared with only 23% of non-U.S. construction companies.
- In contrast, 45% of non-U.S. construction and engineering companies reported high digital capabilities, compared with just 20% for U.S. companies.

Source: Strategy of Things

Draft Recommendations: Construction



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Construction: Technology and Infrastructure Recommendations

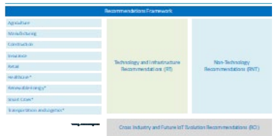
CON5: Facilitate cybersecurity in IoT in smart construction

- Expand cybersecurity trust mark program to include IoT devices and modules used for smart construction and industrial and construction operations, and in IoT equipped construction machinery and equipment
- Facilitate workforce development programs to increase pool of IoT cybersecurity trained resources in smart construction

- Construction systems do not have the same level of digital sophistication as other industries.
- Construction IoT technologies need to be secure if they are to be integrated into construction monitoring, operations platforms, BIM and other software tools.

Source: Strategy of Things

Draft Recommendations: Insurance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Insurance: Non Technology Recommendations

INS1: The Federal Insurance Office should undertake a study of the impacts of IoT and adjacent technologies like AI, in order to understand its potential impact on the insurance industry, the products produced, and its impact on the markets served, and the role of the FIO.

- With few exceptions, insurance is regulated at the state level. However, each state has a different treatment, policies and regulations of IoT.
- This inconsistent treatment limits the development of IoT-enabled products, the benefits realized and the growth of the industry.
- Data collected from IoT enabled products and services may be used to discriminate at a personal level to create a class of “uninsurables” whose members are unable to get coverage or have limited coverage.

Source: Strategy of Things

Draft Recommendations: Insurance

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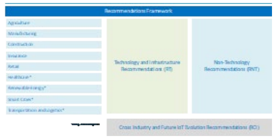
Insurance: Non Technology Recommendations

INS2: The federal government should study and take into consideration the data privacy challenges of IoT enabled insurance products in its development of data and privacy frameworks, policies and regulations.

- IoT enabled insurance products offer the potential for personalized policies that reduce underwriting risk, align policies and premiums to customer needs, and create new value and revenues.
- However, these products collect data that could be used for other purposes now or in the future.
- In addition, the data collected from IoT enabled products and services may be used to discriminate at a personal level to create a class of “uninsurables” whose members are unable to get coverage or have limited coverage.

Source: Strategy of Things

Draft Recommendations: Insurance



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Insurance: Technology and Infrastructure Recommendations

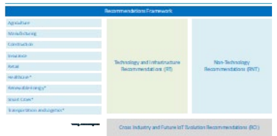
INS3: Facilitate the adoption of AI in IoT in insurance through

- Support research in the development of trustworthy AI algorithms and tools, including AI explainability
- Facilitate the development of IoT data usage and privacy policies that support the development of AI algorithms [linkage with Debbie recommendation]
- Support workforce development efforts to increase the pool of workers trained in data analytics and AI

- While AI can help automate the analysis of massive amounts of IoT data, and other data collected from insurance companies, its ability to create beneficial outcomes that are fair, equitable, ethical, and explainable is a challenge.

Source: Strategy of Things

Draft Recommendations: Insurance



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Insurance: Non Technology Recommendations

INS4: Facilitate policies and programs that support the key education and digital skills development across community colleges and four year universities for the current and future insurance workforce, including:

Technology and computer skills, Digital skills (analytics, cybersecurity, IT, networking, etc.), Data analytics, AI and Machine Learning, Privacy engineering

- Digital innovation is transforming the insurance industry.
- A shortage of digital skills and talent, however, is hindering the ability of the insurance companies to innovate and deliver new products and experiences, execute and operate new business models and to re-engineer existing processes and digitize operations.

Source: Strategy of Things

Draft Recommendations: Insurance

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Insurance: Technology and Infrastructure Recommendations

INS5: Facilitate cybersecurity in IoT in insurance

- Expand cybersecurity trust mark program to include IoT devices and modules used for insurance applications (e.g. telematics, facilities monitoring, etc.)
- Facilitate workforce development programs to increase pool of IoT cybersecurity trained resources in insurance

- IoT devices represent new attack surfaces and introduce additional vulnerabilities into the connected networks.
- IoT devices connected to home and business networks introduce entry points that allow hackers and cyber criminals to move laterally into the main network.
- Telematics devices can be breached to allow hackers to send commands through the connected car's internal network.
- Other impacts of an IoT breach include failure of the device to perform its intended functions and result in financial losses, loss of personal or critical business data, human injury or death and loss of products.

Source: Strategy of Things

Draft Recommendations: Retail

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Retail: Technology and Infrastructure Recommendations

RT1: Support research for the development of low cost sensor technologies.

- Low retail industry profitability margins limit the cost of adoption of IoT solutions. New lower cost sensing technologies at lower price points are needed. Costs need to be on the order of RFID chips.

RT2: Facilitate the use and development of privacy enhancing technologies

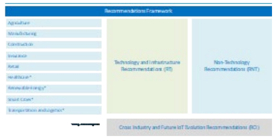
- Support research in privacy enhancing technologies
- Facilitate industry integration and use of PETs
- Consider the usage of PETs on IoT technologies and retail systems used in retail outlets on federal properties (including BXs on military bases, federally own and managed facilities)

[Some linkage with Debbie recommendation on PETs]

- Consumers want personalized experiences and are likely to become repeat buyers.
- IoT helps retailers understand and offer personalized experiences, which helps revenues and profitability.
- The use of IoT technologies and the data it collects enable retailers to understand their customers better.
- Privacy issues hinder the use of IoT technologies in retail and other consumer facing environments.

Source: Strategy of Things

Draft Recommendations: Retail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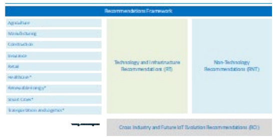
Retail: Non Technology Recommendations

RT3: Facilitate the adoption of AI in IoT in retail through:

- Support research in the development of trustworthy AI algorithms and tools, including AI explainability
- Support workforce development efforts to increase the pool of workers trained in data analytics and AI

- IoT is one of many sources that will provide a “tsunami of data” for retailers. Artificial intelligence (AI) technologies are poised to transform the industry by helping retailers make sense of data, create insights and act on those insights, with some in real time and autonomously. There is strong interest in AI by retailers. However, trustworthiness of the data, and explainability of the outcomes are major concerns.

Source: Strategy of Things



Draft Recommendations: Retail

Retail: Non Technology Recommendations

RT4: Facilitate policies and programs that support the key education and digital skills development across community colleges and four year universities for the current and future retail workforce, including:

- Software development and engineering
- IT (Networking, systems integration, cybersecurity)
- IoT (architecture and design, sensor and device integration, etc.)
- Cloud management and operations
- Data integration and analytics
- Artificial intelligence and machine learning
- Privacy engineering

- The retail industry is undergoing a long running technology transformation towards omni-channel retail.
- This is necessary for retailers to be relevant, operationally efficient, profitable and resilient.
- A lack of the relevant digital skills and workforce is hindering this transformation.

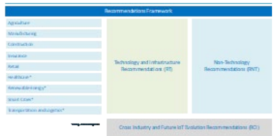
RT5: Facilitate small retailer adoption of IoT:

- Subsidies and tax credits for purchase of IoT technologies
- Increase awareness and education of smart retail technologies through SBA programs, publications, and other means.

- 98.5% of retail businesses in US < 50 people. Retail businesses operate with 4% margins, and small retailers have limited to no ability to invest in IoT technology.

Source: Strategy of Things

Draft Recommendations: Retail



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Retail: Technology and Infrastructure Recommendations

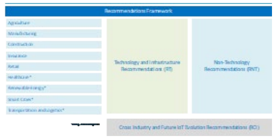
RT6: Facilitate cybersecurity in IoT applications for smart retail

- Expand cybersecurity trust mark program to include IoT devices and modules used for smart retail
- Facilitate workforce development programs to increase pool of IoT cybersecurity trained resources to support the digital transformation of retail

- The evolution of retail requires heavy use of digital technologies, from back office systems to IoT.
- The incorporation of IoT in the retail environment creates vulnerabilities and new attack surfaces that must be mitigated.
- Retailers lack the critical cybersecurity and digital skills to address these risks.

Source: Strategy of Things

Draft Recommendations: Healthcare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Healthcare: Technology and Infrastructure Recommendations

HC1: Support and promote industry and SDO efforts to address interoperability of medical and healthcare devices and systems.

- Diverse communication protocols
- Disparate data formats and structures. Diverse coding systems, data models, and terminology standards are prevalent across healthcare organizations, making it challenging to ensure consistency in data interpretation and exchange.
- Legacy systems that may not be inherently compatible with IoT and IoMT technologies.
- Inability to integrate and interoperate with electronic health record systems

Source: Strategy of Things

Draft Recommendations: Healthcare

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Healthcare: Technology and Infrastructure Recommendations

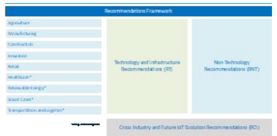
HC2: Facilitate cybersecurity in IoT in smart medical devices and equipment, including wearables, in-home devices, community IoMT systems, and in-clinic systems

- Expand cybersecurity trust mark program to include IoT devices and modules used in a variety of healthcare systems and applications
- Facilitate workforce development programs to increase pool of IoT cybersecurity trained resources for healthcare industry on both the solution provider side and care provider (buyer) side
- Consider development of programs, resources and incentives to help healthcare providers migrate away from those vulnerable legacy equipment and devices that cannot be patched, or upgradeable, or were not subject to compliance with section 524B of the Federal Food, Drug, and Cosmetic Act (FD&C Act)
- Develop a plan to audit, inspect and update healthcare and medical IoT devices, and the networks they operate in used in federally owned or funded health facilities (e.g. VA medical facilities, military medical facilities, etc.). Replace those legacy devices and equipment that cannot be patched or upgradeable or not subject to compliance with section 524B of the Federal Food, Drug, and Cosmetic Act (FD&C Act). Verify devices and systems, and practices meet IoT cybersecurity guidance and best practices.

- Vast attack surface due to the interconnected nature of IoT and IoMT devices.
- Data generated by IoT and IoMT devices in healthcare include sensitive patient information.
- Unauthorized access to healthcare data can have severe consequences, ranging from identity theft to compromised patient care.
- Patching millions of IoT and IoMT devices is logistically and operationally challenging. These devices often have a longer life cycle than traditional IT devices, and some lack the capability for regular software updates, while some legacy systems and devices cannot be patched or updated.
- Compliance with regulatory frameworks (e.g. HIPAA) can be challenging due to the dynamic and evolving nature of IoT and IoMT technologies.
- Securing endpoints (devices) and gateways against unauthorized access and breaches is critical as they act as crucial points in the data transmission process for IoT and IoMT devices.

Source: Strategy of Things

Draft Recommendations: Healthcare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Healthcare: Non Technology Recommendations

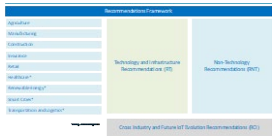
HC3: Facilitate U.S. government adoption and use of medical and healthcare IoT technologies, including:

- By federal healthcare providers in federally owned or funded health facilities (e.g. VA medical facilities, military medical facilities, Indian Health Service, federal prisons medical centers, etc.)
- Consider programs by healthcare payers (HMOs, PPOs, etc.) that support federal employees to adopt these technologies in the treatment of their patients
- Consider programs by federal healthcare programs (Medicare, Medicaid, the Children’s Health Insurance Program, Affordable Care Act) that support qualifying providers to adopt these technologies in the treatment of their patients
- Developing guidance that supports and integrates the use of IoT devices in existing medical services, procedures and supplies codes in Medicare (HCPCS, ICD-10-CM)

- A number of major healthcare insurance companies (payers) support its 2.951 million federal civilian employees (October 2023).
- Approximately 1.3 million active duty military in 2022 receive government sponsored healthcare insurance (Tricare).
- Nearly 45%, or 143.3 million persons are enrolled in, or heavily subsidized by, the big federal health programs: Medicare, Medicaid, the Children’s Health Insurance Program (CHIP), and the Affordable Care Act health insurance exchange plans.
- Because of the number of people it supports, the government can use its significant influence and scale to use innovation to help improve delivery of services, quality of services, and health outcomes in a way no private insurer can.

Source: Strategy of Things

Draft Recommendations: Healthcare



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Non-Technology Recommendations (RNT)
Cross Industry and Future IoT Evolution Recommendations (RCI)

Healthcare: Non Technology Recommendations

HC4: Facilitate the resolution of privacy concerns in healthcare and medical IoT

- Support research in privacy enhancing technologies specific to the needs of the healthcare industry
- Consider the incorporation of PETs on IoT technologies used in the treatment of patients in federal government owned medical facilities, and federal supported healthcare programs (Medicare, etc.)
- Incorporate considerations for healthcare in the development of a national privacy framework and regulations

- Securing data from unauthorized access, including data from clinical medical devices, as well as consumer wearable devices.
- Ownership and consent to use of patient data. The interconnected nature of healthcare IoT devices raises questions about data ownership and the extent to which patients have control over their health information. Obtaining informed consent from patients for the collection, use, and sharing of their data (outside of patient treatment) is a complex process
- Ethical use of data. Ensuring that data is used responsibly, without enabling discrimination or exploitation, requires robust ethical frameworks and regulations.

Source: Strategy of Things

Draft Recommendations: Healthcare

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Cross Industry and Future IoT Evolution Recommendations (RCI)

Healthcare: Non Technology Recommendations

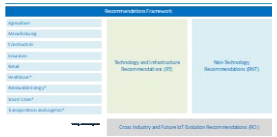
HC5: Facilitate and support the use and adoption of healthcare IoT in rural communities.

- Facilitate grants to drive healthcare IoT adoption among healthcare providers in those communities that have received broadband grants to build on new connectivity infrastructure
- Coordination with federal agencies to drive physician and patient awareness of IoT in healthcare for treatment

- Many rural areas are considered medical deserts with limited number of healthcare providers and facilities. In addition, residents in rural areas tend to be sicker than their urban counterparts, as well as older and more likely to suffer from chronic conditions. As a result, healthcare access inequities exist.
- Cost of connectivity services (rural residents may have affordability issues)
- Limited connectivity (wireless and fixed broadband service)

Source: Strategy of Things

Draft Recommendations: Healthcare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Healthcare: Non Technology Recommendations

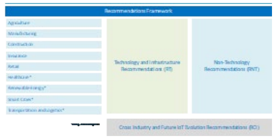
HC6: Facilitate adoption of IoT among small physician practices (< 50 physicians)

- Consider programs by healthcare payers (HMOs, PPOs, etc.) that support federal employees to adopt these technologies in the treatment of their non-federal employee patients
- Consider programs by federal healthcare programs (Medicare, Medicaid, the Children’s Health Insurance Program, Affordable Care Act) that support qualifying patients to adopt these technologies in the treatment of their patients
- Coordination with federal agencies to drive physician and patient awareness of IoT in healthcare for treatment

- Small physician practices make up the majority of physician practices in the United States. However, these practices tend to be less likely to use electronic information than those physician offices with 50 people or more.

Source: Strategy of Things

Draft Recommendations: Healthcare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Healthcare: Non Technology Recommendations

HC7: Facilitate policies and programs that support the key education and digital skills development for the current and future healthcare workforce, including:

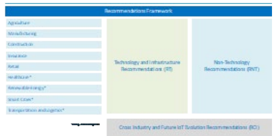
- Data analytics and management
- Artificial intelligence
- IoT technologies
- Networking and systems integration
- Cybersecurity
- Installation, maintenance and servicing of IoT systems

- Integrate the needs for the development of digital skills and workforce in the National Cyber Workforce and Education Strategy

- The integration of IoT and digital technologies in healthcare will provide more effective treatment, reduce the impact of a shortage of healthcare labor, and reduce healthcare expenditures.
- However, a lack of the relevant digital skills and workforce is hindering this transformation of healthcare across all levels, from device development and use, integration into hospital and healthcare systems, to analysis of patient data and development of AI algorithms for treatment and diagnosis.

Source: Strategy of Things

Draft Recommendations: Healthcare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Healthcare: Non Technology Recommendations

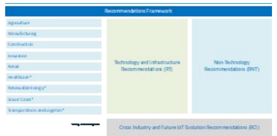
HC8: Facilitate the adoption of AI in IoT in healthcare through:

- Support research in the development of trustworthy AI algorithms and tools, including AI explainability
- Facilitate the development of IoT data usage and privacy policies that support the development of AI algorithms [linkage with Debbie recommendation]
- Support workforce development efforts to increase the pool of workers trained in data analytics and AI

- Diagnosing people and identifying treatments for people is complex as each person has a different reaction to treatments.
- AI generated recommendations may lead to negative or unintended outcomes due to use of data that may be outdated, contains bias, or incomplete. The source of the data may be unknown for privacy reasons.
- While the AI algorithms have been trained on this data, the reasons it led to a specific recommendation may not be explainable and transparent. This leads to a loss of confidence in the AI's ability to analyze the data accurately and reliably.
- Data privacy regulations and policies limit what data can be collected, and how it is used
- Lack of workforce trained to develop, test and refine data and AI algorithms

Source: Strategy of Things

Draft Recommendations: Smart Cities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Smart Cities: Non Technology Recommendations

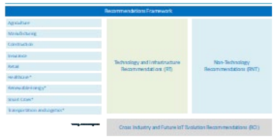
SC1: Facilitate opportunities for adoption and equity of benefits of IoT and smart city technologies for local governments (cities, counties), regional entities (water districts, sanitation districts, air quality districts, etc.) and utility companies. This may include:

- Funding regional or state programs that support municipalities and local governments in strategy and roadmap development and integration of smart city technologies into city vision, infrastructure and operations.
- Project grants for smart city and related innovations pilot projects and deployment projects
- Consideration and specification of IoT applications into the design, construction and operation of federally funded infrastructure projects (e.g. highway projects, street improvements, etc.)
- Facilitate smart city grants for communities that have received broadband grants to build on new connectivity infrastructure

- While cities, regional entities, and utilities may want to do smart city projects, a number of factors is hindering this, including the lack of funding for pilots and projects, a lack of leadership awareness, vision and planning for these innovations, and a lack of project owner specification for IoT.

Source: Strategy of Things

Draft Recommendations: Smart Cities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Smart Cities: Non Technology Recommendations

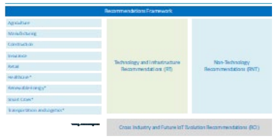
SC2: Facilitate smart community opportunities and adoption of IoT for those rural communities that have broadband infrastructure, have received broadband infrastructure funding or have completed broadband infrastructure build outs. Examples of smart community IoT opportunities include home healthcare monitoring, agriculture, natural resources and environmental monitoring, home energy monitoring, etc. Examples of approaches include:

- Coordination with federal agencies to drive community awareness of IoT opportunities, and support programs that encourage industry participation
- Project grants for community related IoT projects and deployment projects (e.g. environmental monitoring, etc.)
- Consideration and specification of IoT applications into the design, construction and operation of federally funded rural infrastructure projects (e.g. highway projects, street improvements, energy transmission lines, etc.)

- Rural communities lack many of the same resources, services and amenities that residents in urban areas benefit from.
- The lack of infrastructure, low population densities, private sector investment and other factors contribute to the urban/rural divide.
- Many rural areas are considered medical deserts with limited number of healthcare providers and facilities.

Source: Strategy of Things

Draft Recommendations: Smart Cities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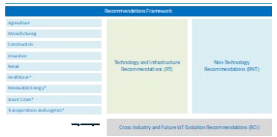
Smart Cities: Non Technology Recommendations

SC3: Facilitate U.S. government adoption of IoT and smart city technologies within its facilities, including government buildings, military bases, campuses and other facilities

- The federal government is the largest landlord and owner of properties across the United States. These facilities do not incorporate IoT technologies which could provide a variety of benefits, including energy savings, safety, resilience, etc.

Source: Strategy of Things

Draft Recommendations: Smart Cities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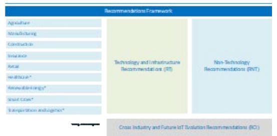
Smart Cities: Technology and Infrastructure Recommendations

SC4: Support and promote industry and SDO efforts to address interoperability of smart cities (including smart buildings, energy and utilities, traffic, etc.)

- Interoperability challenges are a major barrier to maximizing the value of IoT and smart city technologies.
- Disparate IoT devices and smart city systems have limited to no ability to communicate with each other and other city systems. This limits the ability of the city to monitor conditions, automate operations, respond quickly, effectively and efficiently.

Source: Strategy of Things

Draft Recommendations: Smart Cities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Smart Cities: Non Technology Recommendations

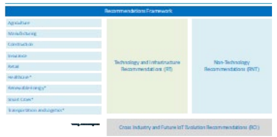
SC5: Facilitate small to medium city adoption of smart city technologies

- Develop smart city grants targeted for smaller communities and rural communities *[linkage to existing recommendation]*
- Develop smart city grants for communities that receive broadband infrastructure funding (BIL, USDA, etc.), to encourage them to build on their infrastructure investments
- Consider program grants that allow these communities to sustain the operation and maintenance of smart city technologies beyond the initial project funding (for initial acquisition, installation and operation). *[linkage to existing recommendation in smart cities/sustainable infrastructure]*
- Consider creating smart city innovation extension partnerships (modeled after MEP and agriculture extension offices) to provide the smaller cities with the technical and innovation expertise, resources and capabilities to design, operate and innovate with smart city technologies *[linkage to existing recommendation in smart cities]*
- Facilitate workforce development to support innovation, IoT and digital technologies in smaller cities (including municipalities, regional entities, and utilities)

- There are 1300 cities that have less than 250,000 people.
- These cities lack the funding, expertise and resources to implement, operate and maintain smart city technologies.
- These smaller cities also have needs that are different from their larger city counterparts, and may require grants that are more aligned to their needs.

Source: Strategy of Things

Draft Recommendations: Smart Cities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Smart Cities: Non Technology Recommendations

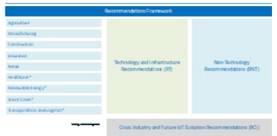
SC6: Facilitate policies and programs that support the key education and digital skills development across community colleges and four year universities for the current and future city and utility workforce, including

- Technology and computer skills
- Digital skills (analytics, cybersecurity, IT, networking, etc.)
- Cloud and other architectures
- Working with tools and technology
- Critical thinking

- Manufacturing jobs are no longer low skilled jobs, but require new skills.
- Automation will require people to work alongside robots and machines.
- A labor shortage and skills shortage will leave 2.4 million unfilled jobs between 2018-2028.
- This leads to a loss of $454 B of manufacturing value by 2028 and makes the US less competitive in manufacturing.

Source: Strategy of Things

Draft Recommendations: Smart Cities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Smart Cities: Technology and Infrastructure Recommendations

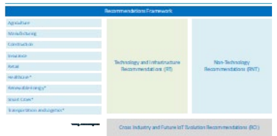
SC7: Facilitate cybersecurity in IoT in smart cities

- Expand cybersecurity trust mark program to include IoT devices and modules used in a variety of smart city and utility applications (including public safety, public health, energy and sustainability, facilities, economic development, traffic, mobility, water/wastewater, public infrastructure, and others)
- Facilitate workforce development programs to increase pool of IoT cybersecurity trained resources for smart city and utility on both the solution provider side and city/utility (buyer) side

- City and utility infrastructure are attractive targets for cyberattacks and the number of ransomware attacks on cities has been steadily growing.
- The introduction of IoT into utility OT infrastructure creates new attack surfaces and vulnerabilities to formerly air gapped systems.
- Cities and utilities lack the resources and capabilities to defend and mitigate.

Source: Strategy of Things

Draft Recommendations: Smart Cities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Smart Cities: Technology and Infrastructure Recommendations

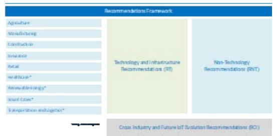
SC8: Facilitate the smart city privacy concerns

- Support research in privacy enhancing technologies
- Consider the usage of PETs on IoT technologies used in small city applications on federal government facilities and properties
- Consider the usage of PETs on IoT technologies and retail systems used in retail outlets on federal properties (including BXs on military bases, federally own and managed facilities)
- Increase industry awareness of privacy by design in developing smart city solutions and services
- Incorporate considerations for “smart cities” in the development of a national privacy framework and regulations *[Some linkage with Debbie recommendation on PETs]*

- Privacy concerns are hindering the adoption and use of IoT technologies.
- Concerns about the information collected and how it is used, as well as the accuracy of the data collected and the ability of the technology to create the correct outcomes.

Source: Strategy of Things

Draft Recommendations: Smart Cities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Smart Cities: Non Technology Recommendations

SC9: Continue and expand GCTC efforts to foster collaboration between municipalities and the broader smart city ecosystem (utilities, regional agencies), industry and academia.

- Build clusters and superclusters around select topic and collaboration areas

- Limited opportunities for cities to collaborate, exchange knowledge, and learn from each other. GCTC has moved away from clusters and superclusters.

Source: Strategy of Things

Draft Recommendations: Smart Cities

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Smart Cities: Non Technology Recommendations

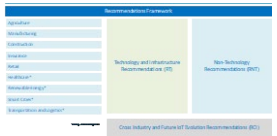
SC10: Facilitate equity in realization of smart city benefits. This may include:

- Smart city project grants for underserved and rural communities, including those applications where underserved communities are disproportionately impacted (e.g. environmental monitoring, healthcare, public safety, etc.)
- Increase access to broadband services and affordability
- Workforce development opportunities for residents of underserved and rural communities for the new IoT and digital jobs to be created

- Benefits of IoT and smart city technologies are not available to all members of a community.
- Socioeconomically challenged and rural communities may not have the broadband infrastructure, or have limited resources to implement and operate smart city technologies.
- The new jobs created by IoT, smart cities and digital transformation require skills and education that members of underserved communities may not be able to develop.
- Some services enabled by these technologies require smart phones and Internet service to access, which some community members may not have, while others are offered in ways that cannot be accessed by residents due to language barriers, digital literacy skills, etc.

Source: Strategy of Things

Draft Recommendations: Smart Cities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Smart Cities: Non Technology Recommendations

SC11: Develop a national smart city strategy.

- The strategy should take into account the broader ecosystem of stakeholders involved in the design, building and operation of smarter cities (local government, regional agencies and authorities, states, utilities, industry, communities), the vision, opportunities, federal/state/local coordination, equity of benefits, funding, etc..
- The strategy should take into account the various desired areas of outcomes, including resilience, economic vibrancy, public safety, mobility, quality of life, sustainability, health and wellness, and government/community responsiveness.

- Limited collaboration between cities, states and federal agencies
- Limited coordination and collaboration between federal agencies, who each own parts of "smart city and sustainable infrastructure" programs and initiatives

Source: Strategy of Things

Draft Recommendations: Research to support IoT evolution

Research Cross Industry: Technology and Infrastructure Recommendations

RCI1: Increase capabilities of IoT devices

- Device processing capabilities
- Decreasing microprocessor power consumption
- Energy harvesting technologies
- Low cost sensors

- As more IoT applications shift to the edge, the complexity and intensity of the workloads processed is expected to increase.
- Smarter IoT devices incorporate more capable microprocessors and microcontrollers. However, more capable processors consume more power.
- Battery powered IoT devices have a limited lifetime. With billions of IoT devices to be deployed, replacing those batteries is not realistic nor practical. Disposal of billions of batteries is a looming environmental waste issue.

RCI2: Interoperability and standards to support hyperconnected networks

- Future systems are expected to work across multiple industries and ecosystems to support autonomous and connected operations. The ability to communicate and exchange data is critical.

Source: Strategy of Things

Draft Recommendations: Research to support IoT evolution

Research Cross Industry: Technology and Infrastructure Recommendations

RCI3: Enabling robust infrastructure to support increasingly large number of IoT devices and systems

- Management of distributed IoT networks (at scale)
- Optimization and maintenance of performance and Quality of Service under continuously varying conditions
- Improving system fault tolerance and resilience
- Improving middleware to support scaling

- With billions of devices, routers and servers of all types soon operating in a multi-layer architectural environment, the ability to monitor, manage, operate and support this infrastructure over its life cycle is a complex undertaking.
- The ability to detect workload demand and allocate appropriate resources to collect, process and store the data, whether on a scheduled or dynamic basis, is crucial to IoT performance. This is made more complex by the addition of new devices of varying capabilities to the environment which consumes existing resources, devices that drop in and out of the network (e.g., mobile devices, etc.), devices with varying resource demands and availability of resources.
- IoT applications and its enabling systems may sometimes fail to work properly. These failures affect the operations that the IoT application is managing and could potentially spread to other processes through a chain of cascading failures. Even if detected immediately, it is not always possible to repair the fault or to do so in a timely manner.
- As more IoT devices are added to the network in the future, the ability of these devices to be integrated into the network and interoperate with existing and older devices and systems is critical to scaling. Middleware, the software that sits between increasingly diverse and heterogeneous devices and applications and allows them to communicate with each other, is essential to integration and scaling of IoT networks. However, middleware must also evolve to support future IoT infrastructure needs.

Source: Strategy of Things

Draft Recommendations: Research to support IoT evolution

Research Cross Industry: Technology and Infrastructure Recommendations

RCI4: Usable AI for IoT

- Ethical AI development
- Explainable AI tools and operations
- Collective intelligence IoT
- Human-AI collaboration

- The use of AI in IoT raises questions of fairness, privacy, ethics, maleficence, accountability and transparency
- For AI controlled operations to be trusted and adopted at scale, its users must be able to understand and assess the AI algorithm's decision-making processes, its alignment and precision to target outcomes under a variety of planned and unplanned conditions and its consistency in creating and acting on the outcomes.
- As IoT adoption scales and the number of devices grow, IoT will transition from devices working individually to create individual outcomes to a collection of IoT devices working together to create an overall greater outcome. Collective intelligence is relatively new and the technology is still immature.
- Human-AI collaboration requires both to "work together as partners to achieve a common goal, sharing a mutual understanding of the abilities and respective roles of each other". Successful collaboration requires the development of new techniques, methods and components to enable a tightly coupled perception-action integration.

Source: Strategy of Things

Draft Recommendations: Research to support IoT evolution

Research Cross Industry: Technology and Infrastructure Recommendations

RCI5: Hyperconnected communications networks

- Spectrum sharing and management
- Network infrastructure to support AI and complex IoT applications
- Fault tolerant and resilient network infrastructure
- Self-defending adaptive network security

- There is a finite amount of wireless spectrum available for IoT applications. In dense urban environments, this can become problematic as the number of IoT devices scale up and data traffic volumes grow, leading to network congestion and radio frequency interference.
- AI and autonomous IoT applications impose high performance requirements for communications networks. Further research and innovation are necessary to develop the network to meet these needs.
- As additional IoT devices with varying levels of quality and performance levels are integrated into the network, they introduce faults that could disrupt operations. During operation, some devices may be capable of tolerating errors, while others propagate errors. Some devices are operating with the latest firmware updates, while others are running outdated versions or cannot be patched. Finally, the IoT devices may be operating in networks that may be outdated, misconfigured or incompatible.
- IoT devices introduce new attack surfaces that can be exploited to breach the network. To be successful, self-defending and adaptive networks must “be effective in an unstructured, unstable, rapidly changing, chaotic, adversarial environments; able to learn in real-time and under extreme time constraints, using only a few observations that are potentially erroneous, of uncertain accuracy and meaning, or even intentionally misleading and deceptive.”

Source: Strategy of Things

Draft Recommendations: Research to support IoT evolution

Research Cross Industry: Technology and Infrastructure Recommendations

RCI6: Human centric ambient IoT

- Design for human-AI interaction
- Trust in human-AI interactions
- Accessibility and inclusion

- For replicable and successful collaboration with humans and AI systems, continued research is necessary to understand how humans can most effectively augment AI systems, how AI systems can enhance what humans do best and how to redesign operations and algorithms to support the collaboration.
- Human-AI collaboration breaks down or becomes less productive if one or both sides do not execute as expected. Humans may not trust the outputs of AI or its ability to execute.
- To be inclusive and accessible to as many people as possible, a connected society must develop interaction models and user interfaces that are intuitive, easy to use and program and consistent with the way people expect to interact with human-AI and IoT systems.

Source: Strategy of Things

Capability: Model to assess IoT technology impact on economy

Data Analysis Steps	Data Source	Refresh Frequency
Industry Trends and Challenges	Desk Research Industry/Vendor Interviews Industry/Vendor Surveys	12 – 24 Months
Industry Specific IoT Use Cases		12 Months
IoT Technical Challenges		12 Months
IoT Non-Technical Challenges		12 Months
Economic Analysis	SoT Economic Model	12 Months
Policy and R&D Opportunities		12 – 24 Months

- Work from this research has led to the development of an approach and economic model quantifying impact of specific IoT technology areas and industries
- Model and analyses can be used to support IoT technology investment and policy planning and development
- Gaps and analyses are “point in time” and should be updated to assess new gaps and track progress of IoT integration into the national economy

Source: Strategy of Things

Draft Recommendations: (RCI7)

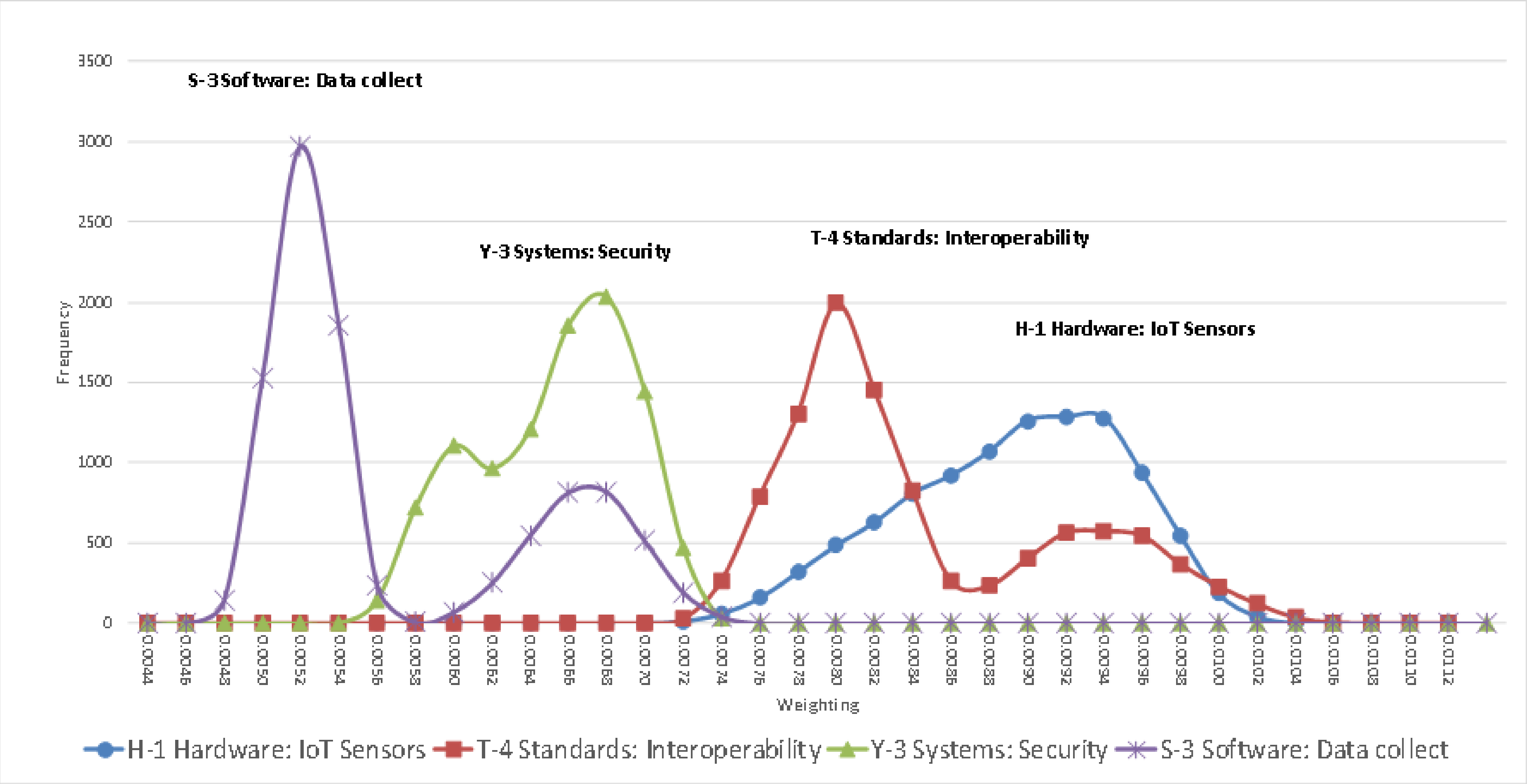
- Consider refreshing and building on the existing model and method to support policy and technology research and development priorities in support of the national IoT strategy:
  - Refresh the economic impact and assess progress toward the implementation of the national IoT strategy over the next five to ten years
  - Facilitate IoT adoption in other industries (not covered by current research) by identifying key IoT technology research gaps
  - Assess the economic impact of addressing emerging technology gaps as IoT continues to evolve to keep the United States competitive and ahead of its international economic rivals

- Justification
  - Analyses are "point in time" and outdated upon publication. IoT and industry continue to evolve
  - Quantification of economic impact over time to support policy goals and priorities in the development of the national IoT strategy

Source: Strategy of Things

Appendix

All industries: Monte Carlo main assumptions to see overlap



Source: Strategy of Things

Thank you!

STRATEGY OF THINGS

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