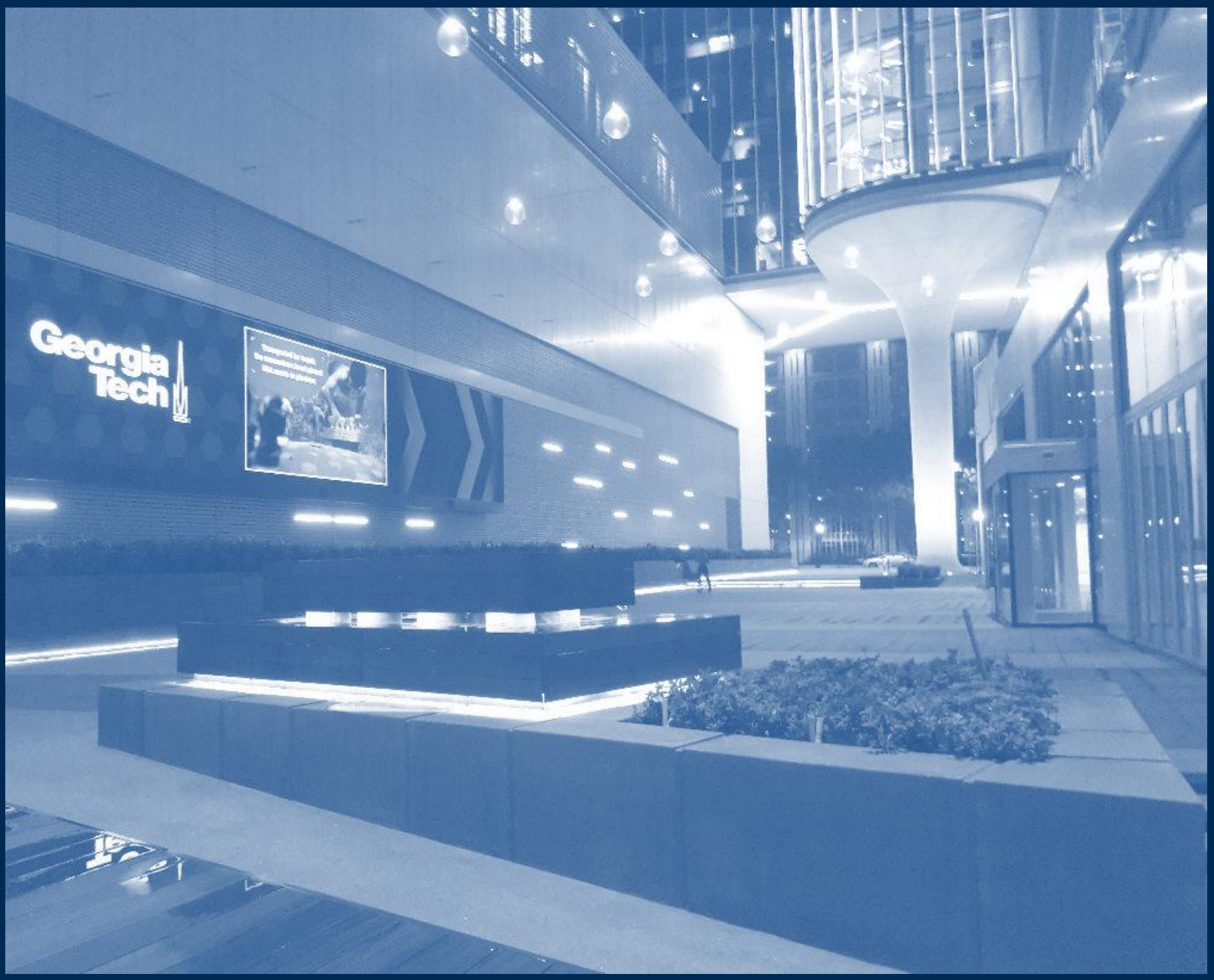
Georgia Tech Center for the Development and Application of Internet of Things Technologies



Digital Transformation and the Internet of Things

Georgia Institute of Technology (Georgia Tech)
Center for the Development and Application of Internet of Things Technologies (CDAIT)
IoT Thought Leadership Working Group

Atlanta, Georgia, USA

November 2019

PREFACE

The topic for this white paper, Digital Transformation and the Internet of Things, was presented by the Center for the Development and Application of Internet of Things Technologies (CDAIT) IoT Thought Leadership Working Group[1], headed by Karen I. Matthews, Ph.D. and Technology and Market Development Manager, Science and Technology at Corning Incorporated, and was approved for creation October 2018 by the CDAIT Executive Advisory Board.

The CDAIT IoT Thought Leadership Working Group, along with other CDAIT collaborators, subsequently authored this paper for publication. The key contributors, listed at the end of the paper, come from different walks of industry and academia and are directly involved in Digital Business Transformation and the building of IoT. Special thanks goes to Michelle Mindala-Freeman, former Vice President in the Telecommunications, Media and Technology Practice at Capgemini; Pramod Kalyanasundaram, Ph.D., former Vice President and CTO at Verizon Connect; and Sébastien Lafon former Global Head of Digital and Marketing Services at Boehringer Ingelheim, all Georgia Tech Visiting Scholars at CDAIT, who animated and guided the team's effort.

Following the same approach as for other CDAIT publications, contributors have shared their personal ideas, observations and opinions grounded in research and real-life experience.

As a result, the views expressed in this white paper are solely the authors' collective own and do not necessarily represent those of Georgia Tech, the CDAIT company members, the individual members of the IoT Thought Leadership Working Group, the University System of Georgia or the State of Georgia.

[1] Information about CDAIT and the CDAIT IoT Thought Leadership Working Group can be found at the end of this paper.

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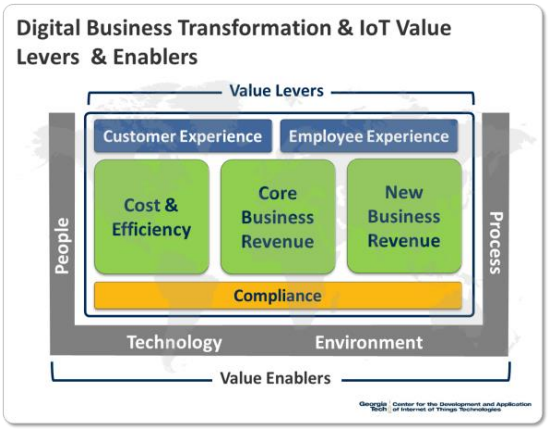
EXECUTIVE SUMMARY

There has been much said about the Internet of Things (IoT) and what it can bring to business and society - creating a more deeply connected world, informed by data sourced from connected things, made better by smarter, more meaningful actions and interactions. These views often focus on how IoT technical solutions can deliver this new future, emphasizing the technology "DNA" of IoT – devices, networks and applications. We have found, however, both through research and experience, that while technology is, in fact, the core of IoT's DNA; it is just a piece of the puzzle needed to deliver on IoT's promise. With 60% of IoT projects still struggling to move out of proof-of-concept and scale successfully[2], there is more to IoT success than technology alone. What is needed and how can business leaders plan better for IoT success?

We believe the answer rests in both IoT program owners and business leaders taking a more holistic view – both of IoT itself and of IoT in the context of Digital Business Transformation. Our full report attempts to flesh out these views, providing guidance on how to think about Digital Business Transformation and the full IoT value chain; a view into the benefits, risks and mitigations of IoT-driven Digital Business Transformation; and, finally, concrete recommendations on the capabilities that must be in place for both IoT and Digital Business Transformation success.

While readers will find many insights, data points and useful references throughout, there are essentially three key takeaways for those who are thinking about IoT for business improvement or transformation or those who have been working on IoT but are struggling to take their programs to scale within the enterprise:

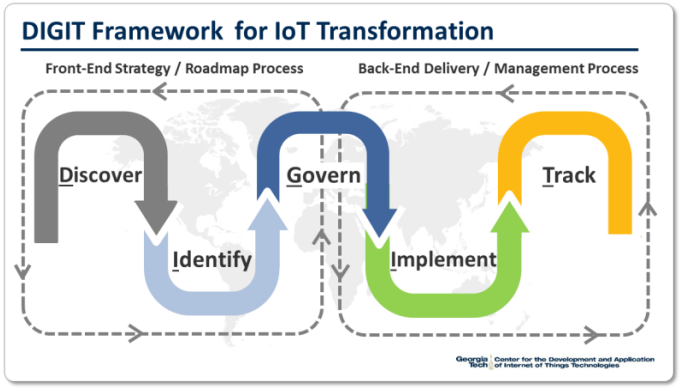
1. ***IoT projects are, in essence, Digital Business Transformation projects and must be treated as such to achieve the expected business benefits of IoT at scale and over time*.**

   We characterize Digital Business Transformation as the (beneficial) changes brought about by the advent of digital technology, the implementation of digital operations (people, process) and the successful creation of a pervasive digital culture. These changes create enterprise value along several vectors - cost reduction, revenue growth and experience improvements. IoT programs involve similar levels and types of digital change and provide business value across the same vectors. In short, IoT is, as we see it, both a microcosm and enabler of Digital Business Transformation. Therefore, for IoT

[2] Cisco "The Journey to IoT Value", May 2017; https://www.slideshare.net/CiscoBusinessInsights/journey-to-iot-value-76163389

projects to succeed, they must be put in context with the enterprise digital strategy and related business transformation programs. There are several critical elements of such programs that are “must do’s”, which, unless addressed, will put IoT projects at risk of failure.



Our DIGIT framework abstracts what is an inherently unique, and can often be a complex and messy transformation process into a simpler form, allowing us to reveal those actions and activities we believe are mission-critical for Digital Business Transformation, and therefore IoT program, success. Our detailed recommendations can be distilled into three essentials:

- Create Momentum through Enterprise-Level Alignment: The top issues inhibiting IoT project success tend to be budget, lack of interdisciplinary collaboration (e.g., between IT teams and operational technology (OT) teams), more complexity than expected and a missing or weak connection between technology solution and business problem.[3] We believe root causes of these issues often rest in a weak IoT program foundation, especially vis a vis the enterprise transformation agenda. Project support and funding for enterprise IoT initiatives must be considered in the broader context of enterprise digital transformation. The best remedy for this is to create the right business context - from creating leadership alignment to establishing and tracking business-driven measures of success - showing how IoT projects contribute to the overall digital transformation agenda, how projects can deliver top or bottom line benefits, and how (if applicable) projects might enable other transformation programs through delivery of saving suitable for reinvestment or as foundational projects themselves. This will allow IoT projects to be considered in the main line of enterprise-level digital transformation projects and priorities, rather than simply as proof of concepts (PoCs) or experiments, and receive the proper focus and business commitment.
- (Over) Index on Culture and Change: Many experts on Digital Business Transformation point to leadership alignment, digital culture and employee engagement as keys to transformation success[4]; yet these tend to be the most overlooked and underperforming areas for such programs, with issues seen from the top down. For example, according to a recent Intel study, 56% of the

[3]See: https://www.verypossible.com/blog/most-iot-products-fail-heres-how-to-make-yours-a-success; https://www.slideshare.net/CiscoBusinessInsights/journey-to-iot-value-76163389; https://iiot-world.com/connected-industry/five-main-reasons-why-iiot-projects-fail-at-the-proof-of-concept-stage/

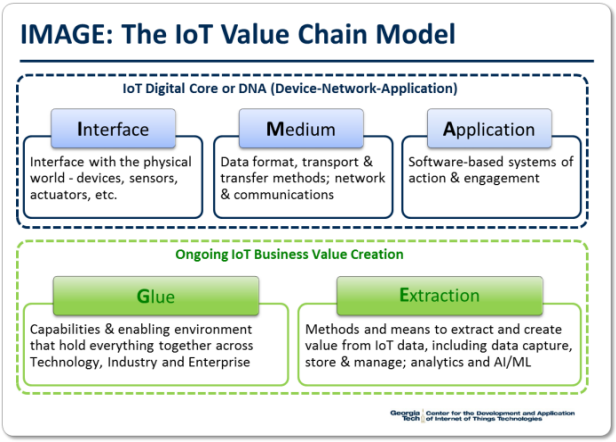
[4] See: https://www.mckinsey.com/business-functions/organization/our-insights/unlocking-success-in-digital-transformations; https://www.capgemini.com/2019/04/successful-digital-transformation/; https://www.bcg.com/en-us/publications/2018/not-digital-transformation-without-digital-culture.aspx

respondents attributed the majority of obstacles to transformation to culture and leadership.[5] Another survey highlights disconnects between leadership and employees, where, when surveyed, 40% of leaders believe there is a clear digital culture; while only 27% of employees agree.[6] Finally, with digital programs exploding there are still serious issues with change management and employee engagement. Recent studies prove digital business transformation is more successful when employees are a part of the process - understanding role changes, contributing to the design of digital change and seeing personal benefit through improved employee experience. Companies that engage in such activities - aligning on a clear strategy and change story, active leadership engagement, encouraging employee contributions and collaboration - are between 1.4 and 1.8 times more likely to see digital transformation success.[7] Addressing these people and culture gaps must include specific and continual emphasis on leadership alignment, transparency, communications, change management and talent management activities.

- Establish a Model Designed for Change: The adage "the only thing that is constant is change" is as true today as it ever was, and even more true for IoT and Digital Business Transformation. Program and business leaders must plan for and establish a leadership-driven operating model that builds in agility to address unique business unit needs, ongoing technology change, business disruption and the resulting need for ongoing transformation management – this work is never "done"; rather, it is a journey. In early stages, when focus and accountability is most critical, consider a dedicated organization under the leadership of a Chief Digital Officer (CDO) to establish and align on new "digital operating model" foundations, including governance and policy (especially for critical areas like security, data management and interoperability), process and operations, change and performance management, aligning to new digitally-driven and business-aligned key performance indicators (KPIs). Long term, while the CDO role itself may diminish in importance, it is still critical to maintain an organization or leadership construct to manage or oversee ongoing innovation and continuous digital change efforts. Data proves that companies focused equally on creating these new digital business capabilities as well as technology capabilities, are more likely to perform well in this rapidly changing market.[8]

[5] Irene Petrick, Faith McCreary, "Industry 4 .0 Demands the Co-Evolution of Workers and Manufacturing Operations," April 2018; https://newsroom.intel.com/wp-content/uploads/sites/11/2018/04/abstract-intel-manufacturing-research.pdf
[6] Capgemini "Digital Transformation Review Twelfth Edition", February 2019; page 72; https://www.capgemini.com/be-en/news/digital-transformation-review-12th-edition/
[7] McKinsey Survey, "Unlocking Success in Digital Transformation". October 2018; https://www.mckinsey.com/business-functions/organization/our-insights/unlocking-success-in-digital-transformations
[8] G. Westerman, D. Bonnet, A. McAfee, et al "The Digital Advantage: How digital leaders outperform their peers in every industry"; MIT Sloan School/Capgemini Consulting, July 2017; https://www.capgemini.com/wp-content/uploads/2017/07/The_Digital_Advantage__How_Digital_Leaders_Outperform_their_Peers_in_Every_Industry.pdf

2. ***IoT programs are often looked at too narrowly as technology solutions; but successful, scalable IoT solutions are actually far more complex and should be defined and executed to address the end-to-end value chain.***



Our IMAGE framework allows those considering IoT transformation programs to take that end-to-end view, considering not only the typical elements – interface (devices), medium (network) and applications – but also the elements that enable long-term success and business value – such as the "glue" (which including critical areas like change management, third party relationships, legacy ecosystems, regulations and security) and value extraction (the collection, management and use of data). The importance of these last two elements cannot be underestimated as contributors to at-scale IoT success and, in our experience, are the areas where, if minimized, introduce greatest risk. We recommend business and program leaders address these risks by:

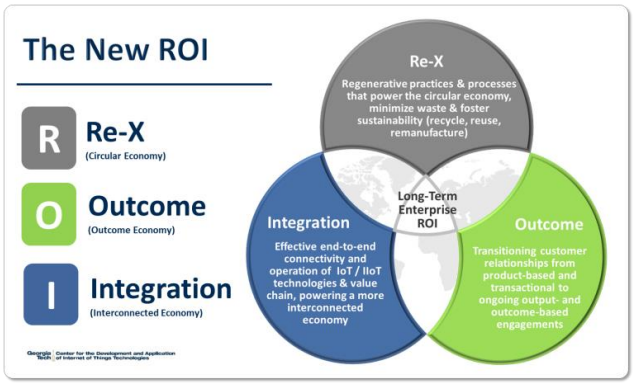
- Clearly frame the IoT IMAGE at the outset, with a specific emphasis on external environments, operational and people impacts and the related change management needs.
- Consider the use of an IoT platform, which can mitigate risks related to interoperability, standards and interfaces and can also bring foundational IoT device management capabilities – allowing the business to focus on value creation. Whether considering private or cloud-based platforms, beware of vendor lock-in – interoperability and open systems are key.
- Avoid tunnel vision - look across your industry and enterprise to identify program elements that might otherwise be overlooked - regulatory compliance, key partnerships, performance simulations, business model, talent management - this "glue" is necessary for any program to stick together and scale.
- Ensure data extraction is tightly coupled to value creation and have a robust data strategy, aligned with enterprise data strategy. Failure to consider performance, scaling, privacy and security for IoT data foundations can be a costly error.

3. ***Looking forward, it is important to keep a much bigger picture in perspective – that of Digital Societal Transformation and the role of IoT therein.***

IoT will be a lynchpin enabler to a new future – that of Digital Societal Transformation – where, as we describe in our paper, societal fabric is re-woven into

a tightly knit network of digital relationships and engagements - powered by the regenerative, integrated and outcome-driven ecosystem of connected people and things. This will be enabled and accelerated, in no small part, through investment in IoT and Digital Business Transformation[9], bringing scaled rollouts, cost reductions, technology advances and innovation. We believe leaders should expand their view of measurable benefits to include new value vectors that contribute to these longer-term business and societal benefits. We define these vectors as the "New ROI":

- **Re-X**: The regenerative nature of a more impact-aware and circular economy, emphasizing concepts like re-use, re-cycling and re-manufacturing.
- **Outcome**: The transition from a single product/service-based transaction to ongoing customer relationships focused on and building a more outcome-based model and economy.
- **Integration:** A more interconnected economy that is enabled by effective integration of the end-to-end value chain for IoT.



Broader, longer-term and social measures of enterprise value, like the New ROI, are growing in importance across businesses and industries, aligned with a shift from Shareholder to Stakeholder Capitalism.[10] In our estimation, then, there will be continued pressure to consider actions as part of Digital Business Transformation strategy and operations that deliver broader (societal) stakeholder benefit, not just shareholder benefit. Business leaders and those driving digital strategy will be well-served to start to include these factors in both their broader digital business transformation plans, as part of IoT program value creation and in their measures of program success.

With IoT as a key enabler of Digital Business and Societal Transformation, we have outlined meaningful parallels between IoT and Digital Business Transformation approach, opportunities, risks and mitigations. By using our frameworks to guide program design and our recommendations to drive mission-critical actions in alignment with enterprise digital business transformation efforts, we believe business leaders will increase the likelihood of positive business outcome and IoT program success.

[9] See: R. Aria et al., The effect of the Internet of Things on sustainability, https://www.weforum.org/agenda/2018/01/effect-technology-sustainability-sdgs-internet-things-iot/; S. Chandler, "How The Internet of Things Will Help Fight Climate Change", https://www.forbes.com/sites/simonchandler/2019/11/05/how-the-internet-of-things-will-help-fight-climate-change/#26068e7558a3

[10] Steve Klemash, Jamie C. Smith, and Rani Doyle, "Stakeholder Capitalism for Long-Term Value Creation", EY Center for Board Matters, June, 2019; https://corpgov.law.harvard.edu/2019/06/13/stakeholder-capitalism-for-long-term-value-creation/

1 INTRODUCTION

1.1 OBJECTIVES

As technology constantly evolves, companies must continually evaluate and reinvent themselves to remain competitive and take advantage of new capabilities. With each new technology revolution comes new challenges and opportunities. The Internet of Things (IoT) is one such revolution, with technical advances promising improved efficiencies, revenues and customer experiences with successful implementation.

Many approach IoT implementation as a technology project. We believe that IoT implementation goes beyond technology and, for successful implementation, must be considered in a broader context – that of Digital Business Transformation – which brings profound change to the "who", "what" and "how" of business. As companies look to leverage IoT and embark on creating a connected business, it is important they stay grounded in this context - understanding their unique "why" for transformation and, with that, taking a more holistic view of and approach to their IoT journey.

Our paper endeavors to set the stage in a business context for those who are looking to digitally transform (using IoT) or who have started IoT efforts and are seeking additional perspective on how to proceed and deliver improved results. This paper will cover:

- Baseline definitions, putting context and clarity around Digital Transformation and the Internet of Things;
- Overview of and perspectives on the IoT ecosystem (using our IMAGE model) ;
- Some approaches for and common themes of Digital Business Transformation;
- IoT opportunities and risks as part of Digital Business Transformation; and
- DIGIT, our framework outlining the stages of and identifying mission-critical activities for a successful IoT digital transformation plan or program.

This paper does not intend to provide a step-by-step guide for IoT-driven digital business transformation, nor is it a rehash of the many technologies and tools available; rather we intend, through our experience as business people and researchers to provide a guide for those chartered with leading and driving IoT initiatives and business leaders on how one might think about IoT and Digital Business Transformation more holistically and approach these initiatives together in joint context and what steps and actions one might take to improve chances for success and positive business results.

1.2 DEFINITIONS

There are enumerable publications on both IoT and Digital Transformation. Often digital transformation has been viewed as a facet of change management, which is a domain thoroughly researched, with some estimates suggesting there are over 80,000 publications on the topic of 'change management.[11] Similarly, IoT is viewed through

[11] Source: Andy Noronha, Director of Strategy & Thought Leadership at Cisco, quoted in Quora Contributor, "How Is Digital Transformation Different from Change Management?" Forbes, March 4, 2019, https://www.forbes.com/sites/quora/2019/03/04/how-

multiple lenses - for example, as Industry 4.0, connected devices, smart cities- with an equally vast array of publications and points of view: nearly 30,000 when looking at available books and academic papers alone.[12]

It's no wonder there is confusion about these topics and that the deep connection between IoT and Digital Business Transformation is often overlooked. We look to remedy this oversight and will start with aligning on definitions, terms and concepts.

1.2.1 Digital Transformation[13]

Digital Transformation is a broad term used to describe changes brought about by the advent of digital technology. While change management principles, processes and general guidance are undeniably useful, Digital Transformation comprises specific concerns and features that require more holistic approaches to implementation. It contains multiple components and perspectives that vary in impact and complexity, which explains in part the lack of a definitional consensus:

> *"There is considerable disagreement regarding what the characteristics of an organization's DT [Digital Transformation] are. This is reflected in inconsistencies, overlapping and contradictory definitions, and different and heterogeneous schools of thought.*[14]

Without any claim to completeness, we believe Digital Transformation incorporates elements which, though defined discretely here, in reality are often realized in organic and non-linear ways.

1.2.1.1 Digitization

Digitization is the conversion of analog material to a digital format or the creation of data and material in digital format.

Examples of conversion include scanning photographs into a digital format, or entering physical records into a digital database (either manually or using something like optical character recognition (OCI)). Other examples of digitized data is that which is created or captured from electronic transactions, created and stored digitally in devices (like digital photos). Capturing and leveraging digitized information / material is a foundational element of digital transformation.

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is-digital-transformation-different-from-change-management/#655746ae38d5 ; See also groups targeting change management such as Association for change management professionals (ACMP), https://www.acmpglobal.org/; Change Management Institute, https://www.change-management-institute.com/; and Organization Change Alliance, https://organizationchange.org/.

[12] CDAIT online research on Amazon.com and academia.edu

[13] Definitional work in line with, without being identical to, what is proposed here can be found in: R. Anand, M. K. Andrews, M. Bunzel, S. DiMatteo, B. Fraser, R. Wenzel, and T. O'Hanlon, "A New Digitalization Strategy Framework to Advance Reliability and Asset Management," Uptime Magazine, April –May 2019, Reliabilityweb.com, https://reliabilityweb.com/articles/entry/a-new-digitalization-strategy-framework-to-advance-reliability-and-asset-ma; and G. Unruh and D. Kiron, "Digital Transformation on Purpose", MIT Sloan Management Review, November 6, 2017, https://sloanreview.mit.edu/article/digital-transformation-on-purpose/

[14] Riasanow, Soto-Setzke, Böhm, Krcmar "Clarifying the Notion of Digital Transformation: A Transdisciplinary Review of Literature," Journal of Competences, Strategy & Management, 2019, vol. 10, https://ideas.repec.org/a/rai/jcsman/jcsman-2019-02.html

1.2.1.2 Digitalization

Leaning on digitization, digitalization is moving existing business processes from analog to digital.

Digitalization does not, de facto, alter how a company does business; however it can make existing processes more widely used and even more efficient by joining multiple contextual elements to otherwise single dimension measuring techniques. Technology is necessary to mesh these multiple information threads into meaningful information. Once digital processes and the resultant data are in place, they become another tool in the management strategy toolkit.

As a case in point, when credit card transactions at retail points of sale shifted from sending a carbon copy off for further handling to real-time processing at the terminal, retailers' business models remained the same; they still sold goods and services while continuing to accept credit cards as a form of payment. However, the insertion of new technology fostered substantial productivity gains at the retailer - it sped the checkout and transaction process, reduced paperwork and manual efforts and even reduced revenue leakage and fraud. Given faster and better experiences for consumers, retailers and card providers, the digitalization of credit card processing helped herald the dramatic growth in credit cards use compared to other forms of payment.

1.2.1.3 Digital Business Transformation

Digital Business Transformation refers to a company reinventing itself through pervasive digital change (across people, process, technology & environment), which can include reducing costs, growing revenues, introducing new business models and improving customer and employee experiences

This means change with not just how a company does things; but also with who or what performs business functions, adding automated, intelligent processes and new digital experiences. With it also comes the need for new skills and new digital ways of working.

Often, it also means changing what a company does altogether. While this implies a complete overhaul of the company's business model, this does not necessarily mean that the company abandons its core business. We see two facets to new business models: evolution or enhancement of core business models and/or entry into entirely new areas of business (complementary; but perhaps with some impact to the core) - both powered by pervasive digital change.

Building on our prior example, new revenue streams and business models opened up between credit card companies, retailers and brands post-digitalization with data availability and analytics of purchasers and their behavior. Creating these new "data offers" didn't detract from, but rather was accretive to, their core business.

One final aspect of Digital Business Transformation is the constancy and consistency of change. As technology continues to evolve, new capabilities are enabled and

stakeholder expectations change, Digital Business Transformation and its related people, process and technology change will become the operative norm.[15]

1.2.1.4 Digital Societal Transformation

Digital Societal Transformation is about the metamorphosis of the entire analog societal fabric into a tightly knit network of links and relationships through digital engagement and dissemination.

The set of participants for Digital Societal Transformation is all-encompassing and includes individuals as well as the whole gamut of for-profit and non-profit entities in the private and public sectors.

As a result, in addition to organizations fully engaged in Digital Business Transformation and accelerating the creation of new, at-scale digitally connected ecosystems as described above, Digital Societal Transformation also comprises government bodies or agencies, and other entities founded by citizens performing a broad variety of service and humanitarian functions (including NGOs) incorporating technology to better serve their constituents at any level (e.g., local[16], state[17] or national[18]).

In this space, the immediate driver is not financial profit (although cost savings through efficiency or new revenues can certainly be part of the equation) but rather, social profit. This term refers to "the good done in, for and to the community (including protecting the environment and other elements related to the quality of life), and may or may not lead to an immediate monetary gain…but eventually serve[s] the whole community." [19]

Examples include a wide range of possible IoT-enabled solutions, such as voting systems, public safety, event management, environmental accident monitoring, traffic flow management, energy cost / environmental footprint reduction, procurement processes, citizen experiences with government agencies, and assistance to underserved-population (e.g. ergonomic work assistance for persons with limited mobility, or the deaf and hard-of-hearing). The early stages of this transformation are manifesting today in smart city initiatives around the world using various IoT / sensor technologies, communication networks and applications to address mobility, security, health care and other economic development needs.[20]

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[15] See as example: https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/perpetual-evolution-the-management-approach-required-for-digital-transformation; https://www.enterprise-cio.com/news/2018/jun/21/digital-transformation-preparing-business-perpetual-change/; https://enterprisersproject.com/what-is-digital-transformation ,

[16] Ben Sebree, "How Society's Digital Transformation is Impacting Local Government," CivicPlus website n.d., https://www.civicplus.com/blog/ce/how-digital-transformation-is-impacting-local-government

[17] W. D. Eggers and S. Hurst, "Delivering the digital state - The State Policy Road Map: Solutions for the Journey Ahead," Deloitte Insights, February 2018, https://www2.deloitte.com/insights/us/en/industry/public-sector/state-leadership/government-reform-digital-state.html

[18] Ashok Nare, "Top Six Digital Transformation Trends in Federal Government for 2018," Medium, April 2018, https://medium.com/@ashok.nare/top-six-digital-transformation-trends-in-federal-government-for-2018-dbb503dd1b07

[19] Alain Louchez and Jay Sexton, "Deploying IoT Technologies Is Not Only About Technology," Fierce Electronics, July 2018, https://www.fierceelectronics.com/iot-wireless/deploying-iot-technologies-not-only-about-technology

[20] J. Bughin, J. Manyika, J. Woetze, et al. "Smart Cities: Digital Solutions for a More Livable Future", McKinsey, June 2018; https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/smart-cities-digital-solutions-for-a-more-livable-future

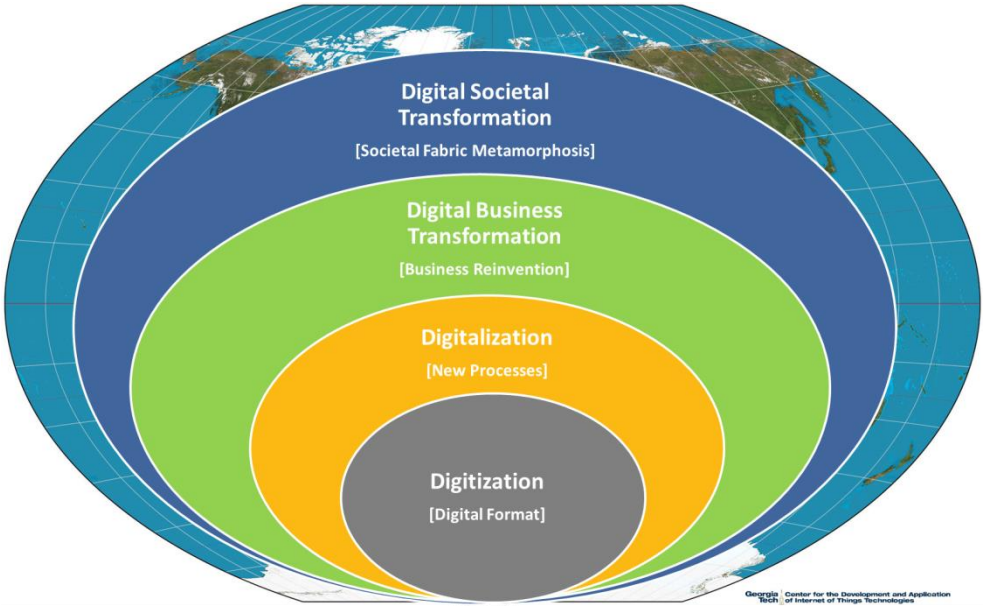

Figure 1 - From Analog to Digital: Digital Transformation

The figure above encapsulates our view of Digital Transformation – from the basic digitization of content to the expansive benefits of Digital Societal Transformation. Without loss of generality regarding the possible use of these observations in a broader context, the rest of this paper will focus in on Digital Business Transformation and the role it plays in delivering on the promised benefits of IoT.

1.2.2 The Internet of Things[21]

Since there is not an “internet” exclusively dedicated to “things”, the expression “Internet of Things” (IoT) is best understood as a metaphor that encapsulates the immersion of almost anything and everything into the communications and connectivity space thanks to the timely convergence of scientific, technological and societal advances and trends. The use of electronics, software, actuators, sensors and network connectivity allows “things” to collect and exchange data (communicate) and, when programmed properly and designed in an accessible manner, allows users or systems to use this data to make decisions or take actions that can be enabled via a human (e.g.: on smart phone or PC) or a digital/automated (e.g.: in a vehicle, machine or home) interface. In short, the "Internet of Things" is about the interconnection of intelligent things. While interconnection (and its related concepts such as interoperability and interdependence) is axiomatic to IoT and a non-trivial building block, the intelligence of things (as a matter

[21] Section leverages Georgia Tech CDAIT paper: “Driving New Modes of IoT-Facilitated Citizen/User Engagement,”, July 2018; https://cdait.gatech.edu/sites/default/files/georgia_tech_cdait_thought_leadership_working_group_white_paper_july_9_2018_final.pdf

of course) is what makes the IoT paradigm "game-changing". [22,23] As the European Research Cluster on the Internet of Things (IERC) puts it, IoT is:

> *"A dynamic global network infrastructure with self-configuring capabilities based on standards and interoperable communication protocols where physical and virtual things have identities, physical attributes and virtual personalities; use intelligent interfaces; and are seamlessly integrated into the information network."*[24]

Therefore, it is safe to say that IoT is a complex, multilayered value chain composed of many moving parts - not just technology, but also the enabling environments, data created and the platforms and processes needed to extract value from connected things. We capture this value chain in our IMAGE model (see figure), describing the "end to end" framework and key components.

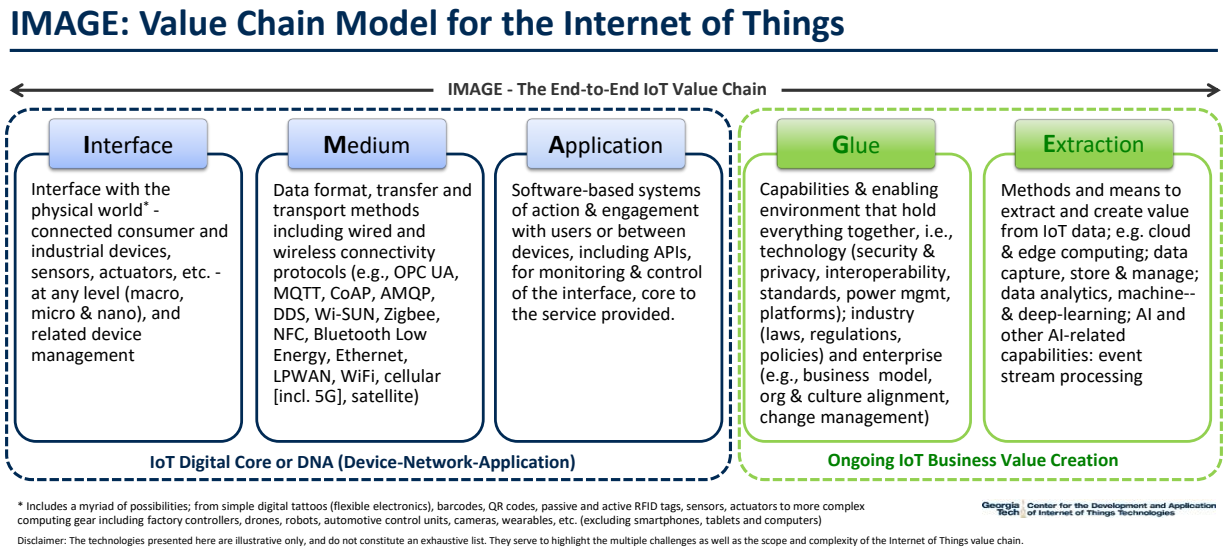

Figure 2 - IMAGE model of the IoT Value Chain

Using this model, it is not difficult to see that, beyond technology, IoT solutions will require a kaleidoscope of new skills and capabilities - new partners, systems, processes, tools and ways of working. Further, as part of Digital Business Transformation, IoT will cause enterprises' relationships with customers to profoundly change.[25] Successful implementation of IoT requires the "digital core" (or DNA) -

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[22] Georgia Institute of Technology CDAIT Website (n.d.). *About - The Internet of Things*; https://cdait.gatech.edu/internet-things-infrastructure. An overview of Georgia Tech IoT research and perspectives can be found in "Connected New World," Georgia Tech Research Horizons, March, 2018 http://www.rh.gatech.edu/features/connected-new-world.

[23] A very insightful and useful collection of perspectives on IoT can be found in: Datta, S. (2017) *Haphazard Reality - IoT is a Metaphor: Principles and Practice of Connectivity and Convergence.* MIT Library https://dspace.mit.edu/handle/1721.1/111021

[24] European Research Cluster on the Internet of Things (IERC) website: http://www.internet-of-things-research.eu/about_iot.htm

[25] S. Ferguson, "Stanley Black & Decker CIO Drills Down Into Industrial IoT," Light Reading, January 2018 https://www.lightreading.com/enterprise-cloud/iot-and-edge/stanley-black-and-decker-cio-drills-down-into-industrial-iot/a/d-id/739658; M. Cushin, "Georgia-Pacific IoT Ecosystem Leader Breaks Down Intrapreneurship", Enterprise Innovation, http://www.enterpriseinnovation.com/articles/georgia-pacifics-iot-leader-breaks-down-intrapreneurship/ ; H. Volberda, F. A.J. Van Den Bosch, K. Heij, "Reinventing Business Models: How Firms Cope with Disruption," (Oxford, UK,: Oxford University Press, 2017), p. 240; P. Bernier, "New IoT Champion: Dell Commits to the Internet of Things," IoT Evolution, February 2018,

devices, network and application; but true, long-lasting value cannot be achieved without an equally strong focus on enabling capabilities and tools for value extraction.

2 IMAGE: THE IOT VALUE CHAIN

As posited, IoT requires a holistic approach, with strategies and tactics for each part of the value chain. Using the IMAGE model as our guide, we will dig into each facet and its key considerations in the sections that follow.

The model brings explicit, end-to-end visibility to the complex IoT ecosystem, providing an easier way to see any project gaps (and therefore risks). As a practical matter, however, IMAGE pillars are not linearly mapped to IoT solution architecture. The following shows a more logical view of the common components of IoT solution architecture and how IMAGE functions are distributed across that architecture.

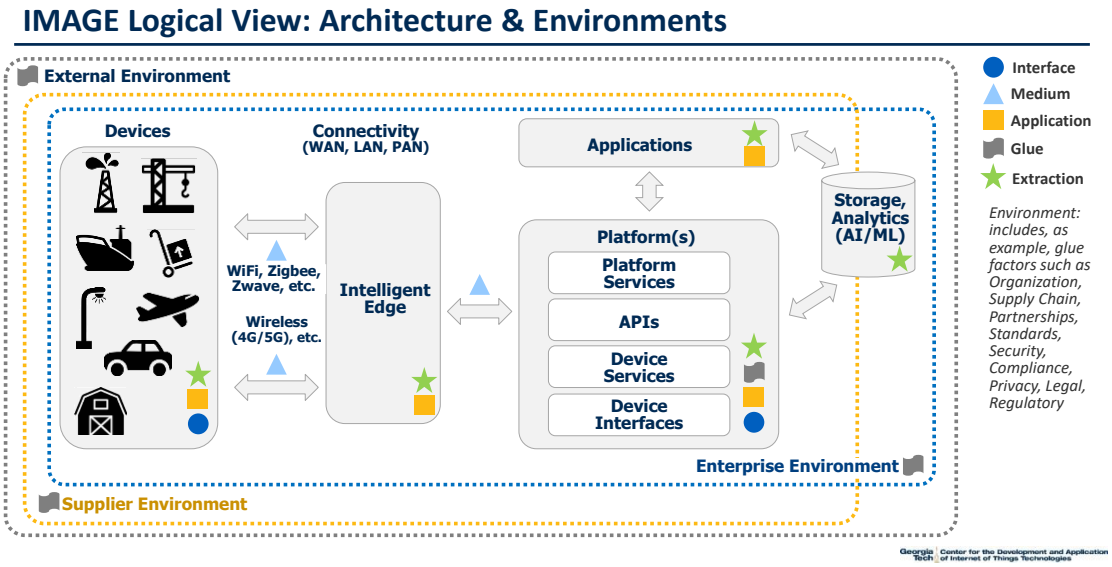

Figure 3 - IMAGE as a Logical Architecture

Devices (Interface) are fundamental to IoT, coming in all sizes, shapes and capabilities – including some with applications and response capabilities (Application and Extraction) built-in. As next generation wireless technologies emerge, decisions and actions can be distributed to other intelligent edge/ cloud-based components (again, Application and Extraction), enabling more complex ecosystems (like public-private or multi-tenant solutions, often called multi-access edge computing (MEC)). These eventually connect to backend platform(s) providing device management and operational features, data collection and APIs (Application Program Interface) to enable

http://www.iotevolutionworld.com/iot/articles/436793-new-iot-champion-dell-commits-the-internet-things.htm; J. Moye, "Connected Coolers: How IoT is Powering Coke's Fleet of Cold Drink Equipment," March 2018 https://www.coca-colacompany.com/stories/connected-coolers-how-the-internet-of-things-is-powering-coke-s-fleet-of-cold-drink-equipment ; Corning website: https://www.corning.com/worldwide/en/innovation/the-glass-age/the-glass-age-today/ces-2016/jeff-evenson-takes-the-stage-at-ces.html.

developers and connect to the enterprise or host application environment (again, crossing the IMAGE pillars). The logical solution architecture is also supported by other technical elements – like security (Glue), data models and master data systems (Extraction) – and operational elements – like governance, change management and regulatory/standards (again, all Glue). Depending on enterprise structure and strategy, these can be distributed across enterprise, partner and external environments.

So, even though capabilities include both common foundations and unique attributes and will logically be widely distributed, IMAGE provides a way to keep the full system in mind while developing a business case, making technology choices and defining the people, process and operational needs for an IoT project.

2.1 INTERFACE: DEVICE CONSIDERATIONS

The most obvious and plentiful participants in the value chain are IoT Device Companies. These companies make the physical devices ("things") that provide actuator, sensor and physical system data, giving businesses visibility and insights necessary for their IoT use cases. The number of companies grows daily, which makes for a continuously changing and somewhat fragmented landscape.

Figure 4 - IoT Device Companies[26]

The basic sub components of a device include hardware functionality (chips, sensors, memory and, as applicable, power), physical network connectivity and software functionality (including, but not limited to security, interface or communication protocol and application layer or device client), with key aspects for device selection being performance (including power), modularity, interoperability, standardization and manageability, especially for internet-connected devices which, once connected become vulnerable to cyber-attack similar to any other device on the IT network.

The network connectivity interface is standardized and is limited to key chipset vendors and service providers; but devices themselves must be modular and standardized to accept these interfaces. There are some standards emerging for both inside physical spaces as well as extra-net communications. This is key to enabling rapid adoption of the devices on multiple networks globally, creating scale and volume. Similarly,

[26] Extracted from "Leading Industry 4.0 Vendors 2019," source: IoT Analytics, "The Leading Industry 4.0 Companies 2019," IoT Analytics website, January 23, 2019, https://iot-analytics.com/the-leading-industry-4-0-companies-2019/

interoperability between devices and versions is another key consideration as, over time, multiple versions of devices and devices from multiple vendors will need to be supported by platforms and applications. Oftentimes, open source solution components are included as well. Key to successful integration of these disparate parts is a tuning exercise (see Section 2.4.1) to assure all components are working smoothly together.

Finally, with hardware product lifecycles typically shorter than, say, network technology, sustainability at the device client and protocol levels will play a key role in ensuring hardware versions can evolve and still connect to the network rapidly, keeping the level of integration complexity and risk manageable. In short, while hardware options will continue to evolve and change, any hardware selected must support appropriate modularity and upgradeability for network and software aspects (protocols, interfaces and application layer) so in-market assets and investments are not stranded long-term.

2.2 MEDIUM: NETWORK AND CONNECTIVITY OPTIONS

Connectivity is the key element of the Medium pillar enabling IoT. While complex due to the plethora of options available, this pillar can be broken down into 1) physical connectivity 2) protocols and 3) end-to-end solution connectivity - the essential elements to create a connected network and make “things” come alive.

Building the Connected Network: For physical layer connectivity, depending upon the application, the options are PAN (Personal Area Network), LAN (Local Area Network), and WAN (Wide Area Network). Of the PAN protocols, RFID-based protocols are used in situations where there is no battery (e.g. for assets like warehouses pallets or packages), while NFC (Near Field Communications) is used for personal applications (e.g. payments, hospitality, local information exchange) and in environments involving data transfer over very short distances, roughly 2-4 feet. Other low power PAN protocols like BLE (Bluetooth Low Energy), Zigbee and Z-Wave are commonly used in both commercial and industrial IoT to connect various devices to a gateway or edge device used to backhaul data to the cloud. For LAN connectivity, the de facto protocol is Wi-Fi. Currently, for WAN (mobility and long-range connectivity), cellular (2G/3G/4G/5G) or satellite are typically used.

For protocol, while there are several that are used at the physical and logical data link layer; at the network level, Internet Protocol variants (IP, IPv6) are protocols of choice.

End-to-end solution connectivity includes not only the physical layer and how the connected devices/apps communicate in the edge environment; but also wider connectivity needs, where network choices will need to be made to connect and transport data to the cloud, a central hub or IoT services provider. There are choices regarding the type (wireline, wireless or satellite) and technology based on the solution workflow, provider and/or geographic regions. It is a safe bet, however, that most end-to-end use cases will include multiple means of connectivity. For instance, an IoT-enabled refrigerated shipping logistics workflow might involve tracking assets starting at a warehouse (using RFID), followed by the journey of the truck to a port (over 4G

cellular) and tracking the goods' health in route overseas via globally accessible satellite technology. In the case of IoT-enabled smart energy business or consumer use case, connectivity might use Zigbee for devices on-site or in-home with a cellular WAN connection back to the service provider or head office.

When choosing a wireless connectivity option for IoT solutions, the considerations are range, power, data transfer profiles, scalability, application environment and cost. Starting with distance - for long range and higher data rates, the choice is clearly cellular or satellite depending upon application requirements for latency and data transfer rates. For low power and lower data rates, BLE, Zigbee or Z-Wave are possible choices. LTE-M (LTE for machines), NB-IOT (narrow band IoT), LoRa and LoRaWAN (both low range spread spectrum modulation technologies) are suitable for applications that require longer range with lower power. The figure below provides a summary of key performance attributes for some common connectivity protocols. Exploring each of these options in depth should be a key technical consideration for IoT solution design[27].

	RFID	Zigbee	Wi-Fi 5 (802.11ac)	Cellular (5G)
Range	2-100 meters	10-20 meters	50 meters	900 meters
Power	Low	Low	High	High
Data Speeds	Low (typical: 40 Kbps, spec: up to 640 Kbps)	Low (250 Kbps)	High (1300 Mbps)	High (10 Gbps)
Application Environment	PAN	PAN	LAN	WAN
Endpoint Scalability	100-1000s per reader (Depends upon application)	232 devices per node (Can scale to 250 nodes)	50-100 clients	1 million devices/sq. km.
Spectrum	100 KHz (LF) - 100 MHz (HF)	2.4 Ghz	5 GHz	Millimeter (24- 100 Ghz)
Cost	Low	Low	High	High

Figure 5 - Comparison of Select IoT Connectivity Technologies

The Role of 5G: Given the current focus on and long-term movement towards 5G, we felt it worthwhile to give specific attention to the topic of 5G and IoT.

Many IoT use cases are becoming increasingly sophisticated - spanning logistics, medicine, national security and other mission-critical scenarios - and will need to be more real-time, responsive and data intensive. For instance, remote robotic surgery requires reliable connection and failsafe methods for sending and receiving data in close to "real time". For traffic management, low latency and more efficient use of network in making traffic related decisions at the edge is critical – such as dynamic decisioning regarding highway on-ramp traffic flows based on traffic data. For all use cases that transport sensitive data, privacy and security has to be airtight. For interactive video applications, bandwidth and speed of delivery will make a huge difference in user experience. Increasingly, algorithms powered by artificial intelligence

[27] Note: given that connectivity is a key component for IoT solutions and standards bodies continue in their efforts to progress capabilities, it is our expectation that each of the standards in the table will continue to evolve in future. As example, WiFi has five pending standards releases and one recently issued update for 802.11ax (WiFi6). See https://asmed.com/wifi/

(AI) are running at the edge to perform in-line sifting of streaming data. In all these cases, connectivity technology choices can make or break the project.

While there is a lot of hype around 5G and its benefits, the capabilities that will help IoT use cases are density of devices per cell, reduced latency versus 4G, network slicing, and download/upload speeds. Let's walk through each benefit as it relates to IoT.

IoT is expected to reach tens of billions of devices over the next few years[28] - this means there will be massive device density in any given area. 5G allows for far more connections per cell (vs 4G or prior generations), which may reduce or slow the need for added cell-sites, therefore reducing network costs and stabilizing or lowering user service costs. With application needs ranging from low data volume and high connection rates, to high data volumes and low connection rates (and everything in between), the network also needs to support a variety of traffic profiles. While 4G allowed for some localized Quality of Service management, this was limited and had customer experience tradeoffs. Not only will 5G deliver orders of magnitude faster speeds for high bandwidth applications, the network slicing capability of 5G allows the network operator to support different speed, latency and service requirements simultaneously for different clients and uses on the same infrastructure. These 5G functions will enable what is known as Massive IoT (connectivity to extremely high volumes of low complexity IoT devices based on NB-IoT and CAT-M technologies - for use cases like wearable IoT or remote asset monitoring) and Critical IoT (extreme low latency and ultra-high reliability connectivity –for remote surgery or similar use cases).[29] Finally, 5G will bring a network architecture that is more accessible, open and software driven to deliver on the new functional expectations like edge computing (key to local data collection, analysis and decision making) and multi-tenancy for public-private network partnerships (supporting creation of smart communities).

Should those looking at launching IoT solutions wait for 5G? Frankly, it depends on the use case. For some of the use cases mentioned above, 5G is a necessity. However, it is important to recognize in the near term, there are challenges – regulatory, financial and technical - with wide-scale global. Additionally, many high-value enterprise use cases can be very effectively enabled through the use of current technologies. As 5G will bring greater capability, capacity, accessibility and cost benefits long-term, it is important to maintain technology flexibility to future proof the investments.

In the end, IoT isn't a reality without the medium provided by physical connectivity, protocols and end-to-end network technology. While physical connectivity and the protocol to transport data can be designed at the device level, network connectivity will be impacted mostly by geography and service provider. Keep a focus on

[28] Carrie MacGillivray, David Reinsel, "Worldwide Global DataSphere IoT Device and Data Forecast, 2019–2023"; IDC, May 2019; https://www.idc.com/getdoc.jsp?containerId=US45066919

[29] While there are many references on these topics, Ericsson provides good foundational background: https://www.ericsson.com/en/internet-of-things/iot-connectivity; https://www.ericsson.com/en/ericsson-technology-review/archive/2019/key-technology-choices-for-optimal-massive-iot-devices

interoperability, flexibility, reliability and the ability to scale and be sure to select the connectivity technologies that fit your digital strategy and IoT use case.

2.3 APPLICATION: SOFTWARE CONSIDERATIONS

The Application pillar enables the customer experience and operational aspects of the IoT use case via different types of applications. As an IoT project or program leader, it is important to understand the impacts of IoT on the application environment, aligning your approach to fit with your enterprise IT model and addressing other factors surrounding applications – such as testing, security, automation and deployment.

IoT and Application Impacts: Where do we see the biggest IoT-driven application impacts? In system of record applications that are enhanced or improved by IoT data; in systems of engagement or new applications that enable specific IoT use cases; and in decisioning and automation software, which bring together IoT, systems and operational data to drive decisions and action in these apps or in the systems of engagement.[30]

One recent evolution is that systems of record - ERP (enterprise resource planning), EAM (enterprise asset management) and other OT (operations technology) systems for manufacturing, warehouse, labor management or other specialized functions - are becoming smarter. They are taking advantage of IoT technologies and data to gain visibility within business subsystems[31] , analyzing areas like asset utilization, equipment health, product supply chain, employee safety and productivity – with the goal of improving internal effectiveness, efficiency and experiences. These IoT use cases are often considered part of Industrial IoT (IIoT) or Industry 4.0.

New applications, of course, can be developed specifically for IoT – these applications can be user facing applications (e.g.: an application that alerts a store or warehouse manager of low inventory as items are removed from the shelf) or can be embedded applications that are designed to perform functions at the edge of the network or in the IoT device, like raise alerts or launch actions in other systems (e.g.: an automatic trouble ticket is created when a remote device's performance threshold is reached).

Related to this, recent additions to many enterprise IT estates are decisioning and automation software applications. These new tools are particularly valuable in an IoT environment. They are able - with analytics, rules engines and automation - to use data from IoT devices and other relevant sources to guide action and response. These software tools can prioritize, schedule, drive workflows, make recommendations and even auto-resolve IoT notifications and alerts, engaging with enterprise users or driving action and response without any user intervention. In many cases, technology is closing gaps in human perception, such as the case where AI assisted quality

[30] See Gartner's reference model in "Pace-Layered Application Strategy and IT Organizational Design: How to Structure the Application Team for Success". April 2016; https://www.gartner.com/binaries/content/assets/events/keywords/applications/apn30/pace-layered-applications-research-report.pdf

[31] See: https://www.industryweek.com/technology/how-internet-things-can-boost-erp; https://internetofthingsagenda.techtarget.com/blog/IoT-Agenda/Integrating-IoT-and-ERP-data-to-achieve-performance-excellence

inspections are improving defect detection rates. In other cases, self-learning programs are used to train co-bots to assist with tasks injurious to people.

In the end, IoT presents an opportunity to re-think applications and determine how, with the integration of IoT devices and related IoT data, applications and experiences can become smarter and deliver more positive business impact.

Aligning to an Enterprise Software Approach: With software being a key component of any business, it is important to align IoT Application pillar choices at a technology, architecture and business level with the broader enterprise IT model. Architectural considerations for application software should include simplicity, security, maintainability, extensibility, serviceability and scalability to ensure that the solution or service is built for the long-term. Technology and business decisions may include open source vs. licensed software (trading off cost against supportability), in-house vs. outsourced support (trading off cost and scale against institutional knowledge), build vs. buy and/or on premise vs SaaS choices (trading off internal control and custom functions against market-based best of breed functions). While not the purpose of this paper to deeply review or recommend any of these options, it is essential that IoT program or project leaders engage IT and architecture teams early to understand the target future state, principles and guardrails, so smart decisions regarding software can be made in alignment with digital business transformation and technology goals.

Other Application Considerations: One of the key benefits of IoT is that it provides ample opportunities to automate data collection, reporting, end to end workflows, device management, systems monitoring and subsequent actions based on insights generated.

With automation possible at so many different layers, it is important to consider the right languages, user experience, test and related management systems – for application, workflow and operations management - so the business can have visibility to make decisions and improve business outcomes. Automation of device onboarding, data collection, test and monitoring and reporting of metrics are a few of the areas worth considering. Key to adoption / acceptance by users is the level of built-in domain knowledge, which can make the solution and insights provided easier to use and more meaningful to the intended audience. In fact, in a number of cases where there are purpose-built solutions successfully running processes, the IoT enhanced solution simply puts a more friendly experience / interface in front of the user, leaving the existing systems to continue performing their unique function.

Given the number of components, and within each component the number of vendors and touch points, there will be many dependencies and integrations needed to make the solution work end to end. From a project perspective, if these areas are not carefully defined and managed, it can create complexity, slipped deadlines, and quality issues.

Finally, to enable application development and service extension (internally, via third parties or by customers), it is important to have a robust IT Governance and API strategy and environment that is secure and easy to use, extend, and maintain.

Future proofing investments in IoT requires component based thinking and API based approach for extensibility in applications. Leaders must make major decisions on software and architecture, partnerships, integrations and automation, and must be in alignment with the broader digital transformation and enterprise technical strategy.

2.4 GLUE: HOLDING THE VALUE CHAIN TOGETHER

The Glue pillar within the IMAGE model is key to ensuring that all the functions and components are connected and stick together to create and sustain value. Hence, the Glue pillar includes elements across technology, industry and enterprise that aren't otherwise neatly categorized elsewhere in the value chain. We encourage IoT leaders to spend meaningful time planning in this area. As "glue" functions will vary by business and industry; and as such, we'll cover the broadest elements to consider here.

2.4.1 Technology Glue

The additional technology needs that must be considered when implementing an IoT project include interoperability and integration, security, standards and other areas, like platforms and power management. Given the variety of standards, the reader is encouraged to refer to their relevant standards organizations and publications for a thorough treatment thereof; however, typically such standards will cover device, network, protocol and interoperability standards.

Integration: In any IoT solution architecture, there is a need to ensure that the various software components integrate well to deliver the end-to-end use case. For this to be successful, an API based approach ensures easier integration and flexibility for multiple software products and both IT and OT systems of record. In addition to APIs themselves, enabling other integration functions - clear contracts across the interfaces supporting various protocols, accurate protocol "translation" (especially for the wide variety of embedded / specialized OT systems), visibility to software errors, troubleshooting, acceptance testing and automation – will help speed up the time to integrate and get to market. Integration is one of the primary causes for delays in projects due to misunderstood interfaces, lack of tools to localize the problem, and manual testing. Clear solution architecture and strong project management helps define performance and integration expectations up front, capture dependencies and proactively manage risk to avoid unnecessary delays.

Modeling & Simulation (M&S)[32]: It is fair to say that any IoT solution ecosystem (which includes the core solution and the additional complexity that grows over time – e.g.: hardware and software versions, varied suppliers, different data models, solution scale, connectivity technologies, interfaces) is, or will be over time, orders of magnitude more

[32] Substantially sourced from prior work by Dr. Margaret L. Loper and Alain Louchez , Georgia Institute of Technology, "The Internet of Things and the Importance of Modeling and Simulation", August, 2015; https://www.automationworld.com/article/industry-type/all/internet-things-and-importance-modeling-and-simulation and Gabor Kecskemeti, Devki Nandan Jha et al "Modelling and Simulation Challenges in Internet of Things", Jan 2017; https://www.researchgate.net/publication/315305311_Modelling_and_Simulation_Challenges_in_Internet_of_Things

complex than the typical enterprise IT environment. Adding to this complexity expectations regarding performance, security, privacy and even health and safety (for wearable IoT), it is folly to leave testing for quality and performance to chance.

While initial instantiations of enterprise IoT solutions will not be infinitely complex, it is advised that IoT leaders make creating models, executing simulations and performing experimental runs a prerequisite for launch and to include staged versions of M&S in their (agile / iterative) development and release process. This will help with risk reduction and provide the opportunity to course correct or pivot earlier in the development cycle should M&S outcomes not meet expectations.

M&S factors that need to be considered as IoT matures and expands are scalability of simulation fabric, elastically modeling sensor populations, modeling device heterogeneity, modeling heterogeneous data models & extraction methods along with, of course, specific regulatory and safety tests (i.e.: FCC testing), holistic performance evaluation and security vulnerability testing.

While it makes technological sense to walk before running, i.e., to model and simulate before deploying, it must also make financial sense. Akin to insurance, M&S looks expensive before adversity strikes. But, IoT-focused businesses must understand that embracing M&S in project development and management is good practice and will help avoid unnecessary costs to address issues later in development or in the market.

A best practice has emerged recently where the CDO office establishes a 'swat team' approach to facilitate M&S strategy in a lab environment before releasing for full deployment. The 'swat team' is typically comprised of subject matter specialists in the IoT/digital domain, the impacted business systems (such as MES (manufacturing execution system) or ERP systems), data analyst or scientist, data model/cleansing , user experience or design and security. This core team helps establish M&S foundations for enterprise benefit and oftentimes becomes the M&S execution team, providing benefits from concentrating skill sets and creating core team continuity.

M&S is a broad discipline with a wide range of technologies and methodologies. Academic and business resources in the field typically focus on a specific aspect with a different purpose (e.g., discrete event simulation in industrial systems vs. continuous simulation in electrical and computer engineering). There is a need for an all-encompassing approach, especially in the IoT arena.

Security & Privacy[33]: Security has become a key topic for C-level executives, since lapses can be both costly and catastrophic to the brand and enterprise trust and breaches, ransomware incidences and their consequences are becoming more regular and public. While security refers to protecting data/information from being improperly accessed and/or affected, privacy refers to the right of an individual (or entity) to determine use of data/information, consistent with their preferences.

[33] See perspectives on security and privacy in Georgia Institute of Technology CDAIT paper: "Driving New Modes of IoT-Facilitated Citizen/User Engagement.", July 2018

Both aspects should be addressed "by design"[34] as we move toward data-rich, connected environments with porous or poorly defined boundaries. Due to the nature of many IoT devices (ubiquitous "always on" deployment, limited computing capabilities, limited memory, and extreme power limitations), security can be especially difficult to manage. These limitations complicate on-device security; therefore, security must be holistic, systemic and systematic to ensure data integrity. During development, the solution must be architected, designed and tested for security. Having strong partners who can scan software for vulnerabilities and a delivery methodology that includes scans and end-to-end penetration testing are key to ensure that customers can deploy the solution with confidence. It is also important to establish both proactive (e.g.: logging / monitoring) and reactive (e.g. firewall rules to shut services down immediately) procedures to both detect and then contain any issue which might arise.

Similarly, privacy must be addressed both at the level of the individual user as well as at the system level, with policies and procedures playing a fundamental role in addition to technology[35]. There must be proper controls and processes in place to comply with both enterprise-level and legal/regulatory data privacy rules, such as GDPR (General Data Protection Regulation). Privacy efforts need to include awareness training, keeping privacy guidelines part of design thinking, implementation that conforms to regulations and compliance verification processes.

The enterprise must make security and privacy mission critical. This will ensure the right investment, processes, partnerships, training, audit and organizational capability to support implementation and ongoing maintenance of end-to-end security and privacy.

Power Management: An addition area gaining importance and attention as the number of IoT enabled devices increases is that of power management[36]. Initial steps in power management can be addressed during solution design. Decisions regarding connectivity technology, protocol and / or the frequency and payload of communications are important factors in managing power and battery life. However, this will not be enough. With massive device connectivity in the future, it will be impractical and inconvenient to connect all devices to perpetual power sources or too expensive to regularly re-charge or replace power sources over time – think of the cost to dispatch a truck to change sensor batteries on a pipeline; or the inconvenience of a power cable plugged into an outlet for your connected doorbell.

[34] "Security by Design" is one of four foundational pillars, with "Device Intent", Autonomous, Scalable, Secure Device Onboarding (SDO), and Device Lifecycle Management, of "IoTopia" – See Anasia D'Mello, "GlobalPlatform launches IoTopia to give device makers and service providers a blueprint for IoT security," IoT Now, October 23, 2019 https://www.iot-now.com/2019/10/23/99492-globalplatform-launches-iotopia-give-device-makers-service-providers-blueprint-iot-security-implementation/

[35] Privacy concerns surrounding IoT, especially in the consumer arena, have been addressed by Dr. Shoshana Zuboff, in *The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power;* January, 2019 – See related interview here: Joanna Kavenna, "Shoshana Zuboff: 'Surveillance capitalism is an assault on human autonomy', The Guardian (UK), October 2019 https://www.theguardian.com/books/2019/oct/04/shoshana-zuboff-surveillance-capitalism-assault-human-automomy-digital-privacy

[36] See: Dr. Manos M. Tentzeris & Alain Louchez, "Independent power to boost the Internet of Things' lift off"; IoT Now (UK), August 2015; https://www.iot-now.com/2015/08/27/36235-independent-power-to-boost-the-internet-of-things-lift-off/ ; and "Energy Harvesting – The Internet of Things Accelerator?"; M2M Magazine, Sept-Oct 2015 https://issuu.com/vanillaplus/docs/m2m-now-magazine-sep-oct-2015

Therefore, power management will also need to include exploration and use of new sources of power, especially in the area of energy harvesting or scavenging. Energy harvesting refers to the process whereby power-generating elements are incorporated into electronic systems. These might include solar cells, piezoelectric elements or thermoelectric elements, for example, to turn sunlight, vibration (kinetic), ambient RF and/or heat energy, into power.[37]

Investments in emerging harvesting technologies are projected to grow over 10% compounded annually, to reach a market size of nearly $700M by 2023.[38]

> *"The ease of availability of [energy harvesting] (EH) solutions and ultra-low-power microcontroller units] is propelling their rate of adoption across the wide range of applications aggressively… building and home automation application(s) [are] likely to grow at a significant rate over the forecast period, due to the increasing adoption of EH devices in building and home automation equipment. [Further], recent advances in EH technologies permits wireless sensor network (WSNs) to extend their lifetime, by utilizing energy that is readily available through natural resources."*[39]

Beyond harvesting, there is ongoing research and development in other power management areas, such as supercapacitors, wake up receivers, on-chip batteries and nano-generators, [40] all of which can help improve power access, storage and efficient power use. Suffice it to say, this area is and will continue to be a critical design area and important for successful, widespread IoT operations at scale.

Role of Platforms[41]: Finally, a discussion of "technology glue" would not be complete without a drill down on a unique element of IoT solution architecture -- the IoT Platform.

IoT Platforms and platform companies support the deployment and management of IoT devices across multiple assets and sites. These companies usually, but not always, have cloud backend execution platforms, software services and applications to support multiple industry applications and markets for IoT.

Their solutions typically include low-level IoT device management, such as operating and configuring devices (e.g. firmware updates and cybersecurity protections), message management, including queuing and events , orchestration of software services, like logging, user authentication and other operational services and a front-end user interface to support mobile and web applications.

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[37] Jessica Twentyman, "IoT drives progress towards low-power technology"; Financial Times, January, 2018; https://www.ft.com/content/f2b4de5a-d8ee-11e7-9504-59efdb70e12f ; and "Internet of things sparks race to replace the battery," Financial Times, October, 2019; https://www.ft.com/content/3ba7fc12-8205-11e9-a7f0-77d3101896ec

[38] ResearchAndMarkets report "Global Energy Harvesting Systems Market - Growth, Trends and Forecasts (2018 - 2023)"; Dec 18, 2018; https://www.researchandmarkets.com/research/thlppn/global_energy?w=12

[39] Ibid.

[40] Dave Evans, Cisco, "The Internet of Things -- How the Next Evolution of the Internet Is Changing Everything", citing nanogenerator breakthrough of Zhong Lin Wang Lead Scientist, Georgia Institute of Technology ; April 2011; http://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf; see also Jessica Twentyman/FT reference.

[41] See also Georgia Tech CDAIT, "Driving New Modes of IoT-Facilitated Citizen/User Engagement,", July 2018, https://cdait.gatech.edu/sites/default/files/georgia_tech_cdait_thought_leadership_working_group_white_paper_july_9_2018_final.pdf

The explosion in the number of IoT devices has led to a proliferation of platforms. One 2019 list showed 400 companies with IoT platform capabilities.[42] The IoT research firm, IoT Analytics, distinguishes five different platform types: cloud platforms, application enablement platforms, device management platforms, connectivity platforms and advanced analytics platforms. Each of these may be deployed in different ways (from on premise to cloud) with different licensing & usage models.[43]

The role of platforms in the IoT value chain is to provide the environment where devices can connect, data can be stored and retrieved, applications can leverage platform services and integration and extensibility can be easy provided to the various IoT solution components, business processes and workflows. The platform is a key choice to make early on, since changing platforms when the business is scaling is a really hard problem. Tradeoffs to be considered while making choices include cost, the software stack, applicability to the business problem being solved, support and skillset.

A platform choice is like a Swiss army knife – a multipurpose tool that has to support requirements including fit for purpose, scale, security, reliability, serviceability and extensibility. If the platform chosen is not flexible and extensible, the solution is tied to it and can potentially impact the long-term outcome for all IoT projects. However, a right platform choice will help expedite time to market and will scale with the business while reducing the complexity and integration requirements.

2.4.2 Industry Glue

In addition to the hard elements of the IoT value chain, like hardware, software and networks, there are also soft elements involving people and process and the external environment, without which the value chain would fall apart.

Partnerships: Partners are a critical part of the value chain, with partnerships coming in many different forms. First, there are technology partners that help with developing the solution. These are device vendors, software providers, integrators, security companies and even those that perform 3rd party testing. For the project to be successful, partner stakeholders must have a clear understanding of the vision, strategy, delivery plan and measures of success. It is the job of leadership to ensure there is clear communication to all partners and incentives are aligned so everyone understands their role and impact to the success of the project. There are also public-private partnerships that can provide a different path to value creation. A typical example is the partnership created to service a smart city/community IoT use case. This requires the enterprise, along with some form of local or state government partner to define, design and implement solutions together. These partnerships, when target outcome and success criteria are designed

[42] See Press Release, April 24, 2019, "Global Internet of Things (IoT) Platforms Market Radar, 2019 - Evaluates Over 1,000 Platforms Globally; 400 Companies Determined to Have True Platform Capabilities," https://www.globenewswire.com/news-release/2019/04/24/1808763/0/en/Global-Internet-of-Things-IoT-Platforms-Market-Radar-2019-Evaluates-Over-1-000-Platforms-Globally-400-Companies-Determined-to-Have-True-Platform-Capabilities.html

[43] See: IoT Analytics Press Release, "Microsoft and PTC named leading IoT Platform vendors for Cloud and AEP, respectively, as growth in the IoT Platforms Market accelerates to 39%," June 26, 2018, https://www.iot-analytics.co/report-us22-billion-iot-platforms-market-by-2023/index.html

properly, can not only benefit the city/community but can also be accretive to enterprise value. Further they can be the foundation for other programs that increase citizen engagement with technology and the community, delivering broader "societal benefit". A good smart community implementation provides information flow and value to citizens while providing the town with information that can enable more friendly, efficient and effective local public services.

Policies, Laws & Regulations: The external environment is the source of additional "glue" - that of laws, regulations and related compliance processes. In addition to any existing regulations that must be considered in industry-specific IoT solutions (e.g.: patient data privacy rules in the healthcare industry), there is also a growing movement to enact specific laws and regulations specifically for IoT.

As one example, the U.S. House of Representatives has proposed the SMART IoT Act, tasking the Department of Commerce with studying the U.S. IoT industry, including who develops IoT technology, what federal agencies have oversight for the industry and what regulations have already been developed.[44]

Additionally, the U.S. Congress also proposed legislation seeking new security standards for IoT devices; with a call for similar security laws in the UK to protect consumers.[45] Addressing security through regulation will prompt businesses to make IoT security a forethought, rather than afterthought, leading to a reduction in exposure and damage due to exploited IoT vulnerabilities.

In advance of regulation, entities like the U.S.'s NIST (National Institute of Standards & Technology) are looking to help the IoT industry by preemptively creating security and privacy design recommendations.[46]

It would be in IoT leaders' best interest to be aware of these initiatives, work now to integrate available design recommendations and work with other industry players to develop means for testing and validation. This will not only help avoid future in-market issues; but may preemptively address future regulatory requirements.

2.4.3 Enterprise Glue

Another set of soft factors holding the value chain together are internal to the enterprise itself - this includes having a clear, agreed to business case and model, clear organizational alignment across stakeholders, plans for training and talent management and effective change management.

This is especially important as IoT-driven digital transformation allows the enterprise to pursue dramatically new business models, such as XaaS (X-as-a-Service, where X can

[44] Mark Rockwell, "Survey: Execs worldwide back IoT security rules", FCW, January 2019; https://fcw.com/articles/2019/01/18/iot-security-survey-rockwell.aspxThis bill was proposed in 2018 and again in May 2019.
[45] Elizabeth Montalbano, "New IoT Security Regulations on Tap in U.S., U.K.". The Security Ledger, May 2019; https://securityledger.com/2019/05/new-iot-security-regulations-on-tap-in-u-s-u-k/
[46] See: https://www.nist.gov/topics/internet-things-iot for links to NIST content and https://csrc.nist.gov/publications/detail/nistir/8259/draft for draft release of IoT security feature recommendations

be anything sold via subscription or consumption model), which has pervasive enterprise impact across virtually all enterprise functions and processes. With XaaS, for example finance will need to adjust processes for revenue recognition, operations may be reduced in size as certain functions are automated and customer care and support may change to manage to new outcome-driven service level agreements.

These topics are covered more deeply in the risks and recommendation sections of this paper. In short, however, there is a much lower likelihood of program success without rigorous and sustained leadership attention on people, culture and operational impacts.

The Glue holds everything together: The Glue pillar might seem like a "catch all"; but in truth its elements are extremely critical to IoT project success, scaling and longevity. Much like the characteristics of actual glue, when addressed, they help bond otherwise disparate areas into a cohesive solution, allow for a more "elastic" and flexible solution over time, and help manage the solution risks and "stresses" as conditions change.

2.5 Extraction: Analytics and Insights

This pillar includes two aspects: 1) value extraction, which includes data lifecycle, analytics and computing models enabled by the intelligent edge and cloud technologies and 2) value creation, which is the use of data to enable enterprise use cases and monetization through visualization, prediction, prescriptive action and service delivery.

Every device introduced into a connected system generates data which must be transported, normalized, stored and accessed in a scalable, cost effective way. This data needs to be governed via verifiable policies and processes for security and privacy. And, to deliver value, a well-defined data architecture needs to be in place with initial methods and technologies for analytics and visualization, integrated with the right tools to act on insights generated and operationalized with the right business construct, team and talent. The figure below highlights key capabilities that must be in place.

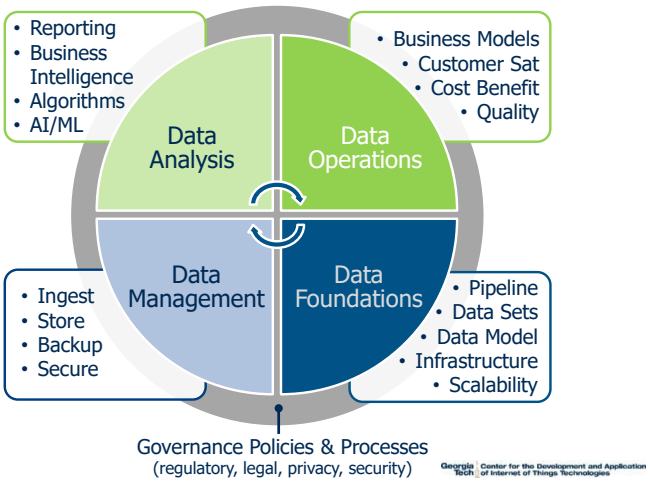

Figure 6 - Insights and Data Capability Ecosystem

While data collection and transmission is foundational to IoT, the real value comes from solving business problems. To illustrate, collecting and storing raw data via sensors on soil moisture levels over time (Data Management) by itself isn't valuable to an enterprise or, their customer, the farmer. What the farmer wants to know is what actions to take to increase yields, given moisture levels, at the best possible cost. More useful, then, is to use data regarding crop yields across climatic conditions coupled with actual field sensor data to determine on a continual / real time basis the optimal amount of water delivery needed (Data Analytics) and provide that to the farmer via insights- or actions-as-a service (Data Operations). Scaling this to collect and integrate the data sets across farmers and integrating larger 3rd party data sets (Data Foundations) will allow the enterprise to create additional models and actionable insights, which they can deliver as new services to their farmer customers – creating a virtuous cycle of value creation from data extraction through data operations.

When we look at the data pipeline, i.e., the data coming in from various inputs to support the solution, we need to consider collection mechanisms, routing, storage and protection of data in transit and at rest. The ingress mechanism must be able to scale horizontally to handle a rapid increase in device footprint should the service or solution become successful quickly. Further, analytics software must be able run on large data sets and provide visualization and insights to support the business. Finally, data collected must be stored safely, securely and with proper privacy controls. Any software that is chosen for this function also must be reliable, accurate and high performing.

Failure to consider performance, scaling and security for Data Management and Data Foundation aspects early can be a critical error, impacting costs, program ROI and business case projections.

The following figure provides an overview of some of the companies involved in data management and value creation tools. BI (business intelligence) Tools provide the reporting and visualization of IoT data; Analytics Tools provide the software needed to provide AI (artificial intelligence) and ML (machine learning) capabilities; and IoT platforms support data collection and management (although many are also providing analytics and AI services, frameworks, and/or visualization services and technologies).

Figure 7 - Vendor companies supporting the Extraction Pillar

Why this much focus on the data ecosystem? According to a recent IDC white paper sponsored by Seagate (*Data Age 2025)*, "Data is at the heart of digital transformation," and the "global datasphere" will grow from 33 zettabytes in 2018 to 175 zettabytes in 2025 – with IoT will contributing substantially to this massive data set.

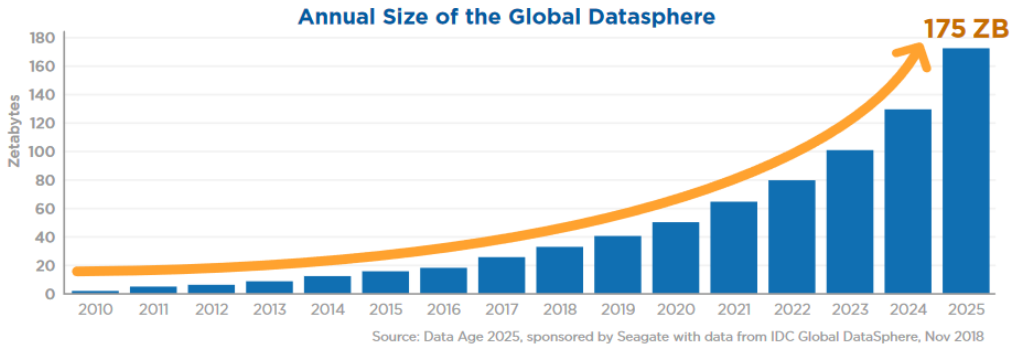

Figure 8 - Annual Size of the Global Datasphere

> *"Today, more than 5 billion consumers interact with data every day – by 2025, that number will be 6 billion, or 75% of the world's population. In 2025, each connected person will have at least one data interaction every 18 seconds. Many of these interactions are because of the billions of IoT devices connected across the globe, which are expected to create over 90ZB [zettabytes] of data in 2025."*[47]

Value creation through data creation and extraction is the fundamental purpose of connecting people and things - and must be approached with a complete view to what is required to create this value. It is much more than mining data and creating charts - it includes data management foundations, governance and the enterprise operational construct to deliver the promised value.

In Closing - Framing up IMAGE: With so many facets to the IoT ecosystem to consider and so many technology and partner choices, it can be easy to get distracted. As one final recommendation, we suggest IoT partner selection and solution design decision criteria include:

- Partner business model and alignment, including flexibility to address enterprise (buyer) needs;
- Partner cultural alignment: ways of working, strategic vs tactical support;
- Technology landscape alignment: architecture, design principles and integration;
- Technology fit assessment to key IoT use case performance attributes (capacity, latency, interoperability);
- Ability to meet key security and privacy requirements; and
- Ability to scale with rapid and potentially massive business growth.

[47] David Reinsel, John Gantz, and John Rydning, "The Digitization of the World From Edge to Core," An IDC White Paper – #US44413318, Sponsored by Seagate, November 2018, https://www.seagate.com/files/www-content/our-story/trends/files/idc-seagate-dataage-whitepaper.pdf

3 TRANSFORMATION FRAMEWORKS AND COMMON THEMES

Despite the critical importance of managing digital transformation, few organizations are using a formal and structured process. Even fewer companies are managing it strategically and holistically under the direct supervision of the CEO.[48] Our own CDAIT members validate this, with only 7.7% of respondents in a 2018 survey identifying the CEO as the person in charge of digital transformation.[49]

This "digital iceberg" depiction from *CXO Transform* provides a good illustration of the underlying complexities in executing digital transformation - notably, the ability to actively manage the less visible part of the iceberg is key to successful transformation.

Figure 9 - The hidden challenges of digital business transformation[50]

A structured approach remains the best avenue to avoid un-prioritized, siloed projects that lack alignment between transformation strategy and execution. Many influential organizations have created frameworks and approaches for formally managing and monitoring their efforts toward digital business transformation. We'll provide an overview of a few and extract a few key themes and lessons.

3.1 IMD

IMD (the International Institute for Management Development), a leading management institute in Lausanne, Switzerland, uses the analogy of a "digital orchestra" to help describe a company's digital transformation efforts:

[48] Thomas M.Siebel, "Why digital transformation is now on the CEO's shoulders," McKinsey Quarterly, December 2017, https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/why-digital-transformation-is-now-on-the-ceos-shoulders
[49] Georgia Institute of Technology CDAIT member Digital Transformation Survey Report, October 2018
[50] CXO Transform Website, "Digital Business Transformation Icebergs," n.d., https://cxo-transform.com/digital-business-transformation-icebergs/

"The music your orchestra will play is meant to execute your strategies (harvest/retreat/disrupt/occupy) to drive value (cost value/experience value/platform value)…[with] the sections of players set to play in concert for successful digital business transformation."[51]

Just as a real orchestra is composed of four instrument sections (strings, brass, woodwinds and percussion), the orchestra framework outlines four "sections" of operating model elements: Go to Market, Engagement, Operations and Organizations. Together - playing in harmony - they can execute a company's digital business transformation. The figure below shows how IMD believes component parts of each section must work together to achieve the right balance for success.

The power of this model is that it gives equal weight to each element, which reflects the difficulty of successfully orchestrating a digital business transformation. By not securing the right level of engagement with stakeholders, or by not focusing on an organization's ability to execute, transformation initiatives will be like a melody without rhythm or harmony – poorly composed and in jeopardy of failing.

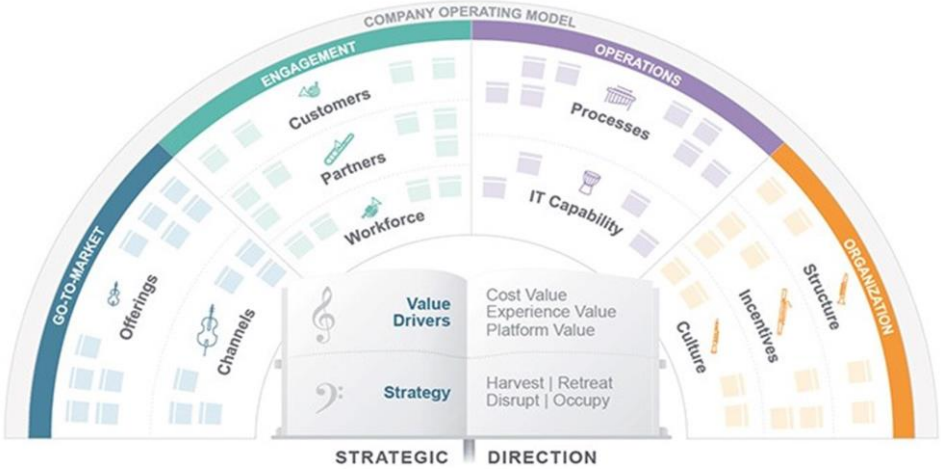

Figure 10 - IMD's Digital Orchestra[52]

3.2 McKinsey & Company

In the March 2017 article "A roadmap for a digital transformation",[53] McKinsey, a leading worldwide management consulting firm, offers 10 guiding principles for digital transformation. The article reveals how intense and difficult transformation can be.

"It is not for the fainthearted, but CEOs are heading in the right direction if they grasp the fundamental importance of heavyweight management commitment, are willing to make significant investments and set clear, ambitious targets."

[51] Michael R. Wade, "Crescendo: Build your Digital Orchestra," IMD Research & Knowledge, November 2017, https://www.imd.org/research-knowledge/articles/crescendo-build-your-digital-orchestra/
[52] IMD Global Center for Digital Business Transformation, 2015-2017
[53] Tanguy Catlin, Johannes-Tobias Lorenz, Bob Sternfels, and Paul Willmott, "A roadmap for a digital transformation," McKinsey website, March 2017, https://www.mckinsey.com/industries/financial-services/our-insights/a-roadmap-for-a-digital-transformation

They also give a realistic size of investment and emphasize the need to manage the duality of improving the core business while investing for future business models. McKinsey's insights ring true across industries in their assessment of transformation in insurance: "Digital transformation is likely to require significant investment. European insurer Axa, for example, invested €950 million over just two years. Our experience suggests that in IT alone, companies with outdated systems might need to double their current spending over a five-year period. That investment is likely to result in lower profits for a while; but without it, there is a serious risk to profits in the longer term. Importantly, companies will need to allocate investment both to improve the current business and to build new businesses as the insurance model evolves." The figure below shows the ten principles related to the transformation process.

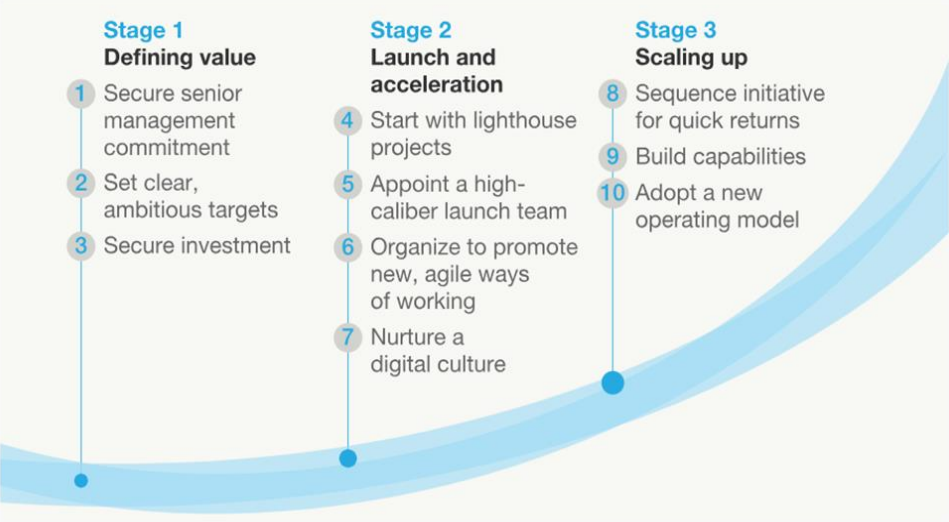

Figure 11 - McKinsey's ten guiding principles of Digital Transformation

3.3 CAPGEMINI

Since 2010 Capgemini, in conjunction with MIT, has been researching the topic of digital transformation and what constitutes successful transformation and digital mastery. Their extensive research shows companies considered "Digital Masters", irrespective of industry, outperform their peers in the market. Further, while each has taken their own transformation journey, there are two common dimensions on which these masters focus that have led to their success:

> *"Digital Masters excel in two critical dimensions: the "what" of technology (digital capabilities) and the "how" of leading change (leadership capabilities)…What you invest in matters, to a point. How you use those investments to transform your company is a key to success. Neither dimension is enough on its own. Each is associated with different types of financial performance, and each provides only*

partial advantage. Taken together, they combine to give Digital Masters a clear advantage over their competitors."[54]

Capgemini further identifies those specific aspects that are seen across successful transformation journeys, outlined in their Digital Transformation Compass.

Figure 12 - Capgemini's Digital Transformation Compass

Capgemini believes that the compass is an apt metaphor, as each enterprise is at a different state of digital readiness, has their own starting point and will need to chart their own course to digital business change.

Nearly a decade later, Capgemini continues their research, refining the set of required digital and leadership capabilities; while still using the Digital Transformation Compass as a tool for business to navigate their transformation journey.[55]

3.4 Common Themes and Lessons

These three examples are just a sample of the numerous models that exist; others, without limitation, include the SAP Business Transformation Management Methodology (BTM2) or the THRIVE methodology from CXO Transformation. What becomes clear in examining various models and looking at our CDAIT member experiences is that successful digital transformation must:

[54] George Westerman, Didier Bonnet, Andrew McAfee, *Leading Digital – Turning Technology into Business Transformation*, Boston, MA: Harvard Business School Publishing 2014, pages 4, 12-14, 173-174
[55] Capgemini Research Institute "Understanding Digital Mastery Today", January 2019, https://www.capgemini.com/wp-content/uploads/2018/07/Digital-Mastery_08Jan2019_with_latestlogo.pdf

- Establish enterprise strategic context - define the why, what and how at leadership level to focus initiatives and efforts - communicate this fully and regularly. Continually reinforce the strategic "north star";
- Take a holistic view of the transformation – across people, process, environment and technology – to identify what is in place and what is needed now and in the future for digital success;
- Stay focused on both digital and leadership capabilities. Don't fall into the trap of overemphasis on technology change - equally important are aspects of culture, change management and adoption;
- Allow for flexibility and change – measure progress, make adjustments and accept transformation is often an evolution, rather than revolution; and
- Build the organizational infrastructure to support sustained transformation and change, as Digital Business Transformation is not a "one and done" activity.

Given the tight coupling of IoT and Digital Business Transformation, it follows these tenants are equally important for the IoT and connected enterprise journey.

4 IoT Opportunities and Risks

A review of Thomas M. Siebel's recently published book "*Digital Transformation: Survive and Thrive in an Era of Mass Extinction*," succinctly captures IoT's central role in digital transformation, stating it is possibly the most important defining feature of the 21st century economy:

> *"We will have 50 billion small computers connected to a network. Fifty billion squared is equivalent to the number of stars in our universe. Siebel states: The Internet of Things may be the single most important defining feature of the 21st century economy. A powerful global network becomes a new computing platform. And much of the computing will take place within the sensors at the periphery of the network rather than at the core of the network."*[56]

With that it is incumbent on those looking to leverage IoT to have a clear view of the potential value and possible hurdles they'll face as part of this transformative change.

4.1 Industries and Use Cases – the Big Picture

An increasing number companies are leveraging IoT-driven digital business transformation to create new business opportunities, improve efficiency, provide better customer experience, and collect more data about their products, operations, and customers to better manage and run their business.

[56] Larry Stybel and Maryanne Peabody, "Board Members: Ask This One Question Every Year – 'Change comes gradually' is an assumption," [Review of Thomas M. Siebel's book, " Digital Transformation: Survive and Thrive in an Era of Mass Extinction," Hardcover, 256 pages, Published July 9th 2019 by RosettaBooks], Psychology Today, August 1, 2019 https://www.psychologytoday.com/us/blog/platform-success/201908/board-members-ask-one-question-every-year?amp

These companies are ‘consuming’ (purchasing or leasing) IoT solutions (services, platforms and devices) and integrating them into their business practices. The following are examples of industries where companies are embracing IoT:

- Aerospace: Aircraft controls systems, engine monitoring, aircraft maintenance
- Retail: Autonomous point of sale systems, inventory management, store traffic monitoring
- Home and Business: Smart homes and buildings, building automation, energy management, access control
- Transportation: Fleet management, routing planning, autonomous vehicles
- Healthcare: Home health, medical devices, telemedicine, aging in place
- Agriculture: Smart irrigation, farming/seeding systems, livestock monitoring
- Education: Remote education and digital education tools
- Entertainment / Hospitality: Venue management, safety and security, staff scheduling and routing, room automation and access control
- Manufacturing: Equipment monitoring and maintenance, product visibility
- Utilities: Smart grids and smart meters, grid performance, demand planning
- Construction and Mining: Asset tracking and worker safety monitoring

While just a snapshot and hardly all inclusive, there are clear opportunities for radical business transformation and value creation across most industry verticals.

4.2 Transformation and Value Opportunities

IoT, like many other enabling capabilities, can transform and add value to a company in four key ways, as illustrated below: reducing costs, increasing revenues, enhancing experiences and more effectively supporting compliance. This is driven through core enabling capabilities across people, process, technology and environment.

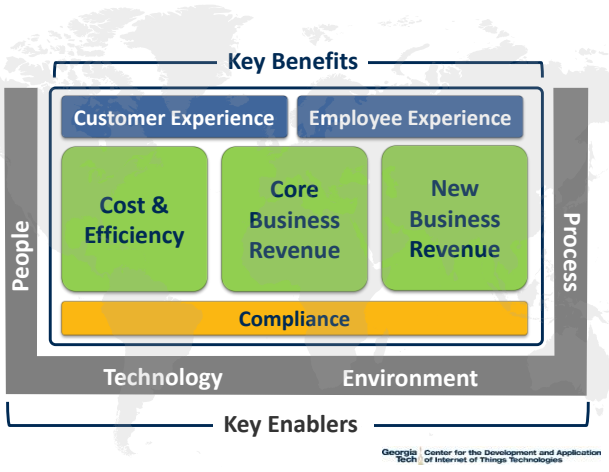

Figure 13 - View of Benefits & Enablers

4.2.1 Cost Reduction

Cost savings, as delivered through operational efficiencies, is still one the main adoption driver of IoT, as confirmed in a 2019 market survey provided by Million Insights:

> *"IIoT [Industrial Internet of Things] uses IoT technology to connect machines and devices in industries such as manufacturing, healthcare, transportation, and more. By connecting machines in these industries, time-consuming manual processes are eliminated and overall business operations are conducted more efficiently. Factors responsible for IIoT growth include cost-effectiveness and ease of availability for devices like processors, sensors, and connected systems. The IIoT market is predicted to reach a CAGR of 27.8% in the next six years."*[57]

IDC's 7th Annual Global IoT Decision Maker Survey released in August 2019, which reveals IoT as a Leading Digital Transformation Initiative, also highlights cost reduction as one its key findings:

> *"Improved productivity, reduced costs and achieving better product quality became the focus for investment in 2019 marking a notable shift from improving security being the key driver in previous editions of the study."*[58]

In the era of Industry 4.0, many companies are connecting physical objects to networks in order to create massive trails of data used to improve decision making, provide live feedback for immediate corrective actions such as maintenance, perform tasks and optimize processes – all in all, creating material productivity gains. As example, Stanley Black & Decker turned to Cisco and AeroScout to leverage IoT to improve visibility and accelerate productivity gains in one of their plants. Their pain points focused on production schedule lack of transparency, under optimization of production lines and high labor cost compared to standard cost. The IOT solution included outfitting a large part of production with Wi-Fi RFID tags, collecting data and providing real-time visibility and information to plant employees and management. The solution as implemented was a major success, delivering material impact to the bottom line - 24% increase in equipment utilization, 10% increase in throughput, 10% inventory reduction, improved analytical capabilities and increased employee empowerment on the plant floor.[59]

4.2.2 Revenue Increase

Generating new revenue streams is where the future of IoT lies. A 2019 CompTIA report provides optimism that creating new revenue streams through IoT is increasingly becoming a priority. Of companies surveyed, 31% believe the financial benefits of IoT

57 Macy Bayern, "Industrial IoT market will hit $922B by 2025, driven by cost savings and availability," [article is about an Insights report on IIoT], Tech Republic, March 11, 2019, https://www.techrepublic.com/article/industrial-iot-market-will-hit-922b-by-2025-driven-by-cost-savings-and-availability/
58 IDC, "IDC's 7th Annual Global IoT Decision Maker Survey Reveals IoT as a Leading Digital Transformation Initiative, but Organizations Struggle with Skills Gaps and Infrastructure Readiness," IDC Website (press release), August 12, 2019, https://www.idc.com/getdoc.jsp?containerId=prUS45426819
59 Cisco study: Leading Tools Manufacturer Transforms Operations with IoT, April 2019 https://www.cisco.com/c/dam/en_us/solutions/industries/docs/manufacturing/c36-732293-00-stanley-cs.pdf

will be primarily due to revenue generation, with an additional 35% believing it will be a combination of revenue and cost savings.

These same companies believe revenue growth will come from three main areas: core business growth (either by increasing production and therefore sales of products or by attracting new customers), offering product-as-a-service and monetizing data.[60]

Thanks to IoT, more companies are able to move to this "IoT-enabled servitization" model - either by selling their product as a service or selling incremental services for their products[61], giving rise to the "subscription economy".[62] This change not only leads to new revenues; but also transforms customer interactions from transactional to recurring (and ideally more engaging or sticky) relationships.

> "*Examples of companies that have made the leap [to as-a-service] with IoT technology seem to be popping up everywhere. For instance, there's the air-pump company Kaeser Compressors, which is moving toward selling compressed air-as-a-service rather than pumps and compressors. And then there are jet engines, trains, elevators, turbines — all of which are available to rent rather than own."*[63]

With sensors and actuators capturing multiple bits of information across customers, products, external environments and the enterprise, it may take time; but businesses will find new ways to monetize IoT data:

> *"The concept of turning IoT data into a product to sell to others is an upward trend that companies have been looking at to add an additional revenue stream. Of course, the concept of selling data is nothing new...[but]…the only difference now is that with thousands of smart devices connected and continuously gathering data, there is an untapped market opportunity that many have not taken advantage of with this IoT data."*[64]

One example is Michelin's purchase of NexTraq, a telematics company that uses connected devices and GPS geo-location asset tracking for fleets. This was part of a strategy to expand Michelin from a products company (tires) to a "technology and services" company for fleet management, broadening their offerings and potential customer and revenue base.[65] With NexTraq Michelin, in addition to expand their

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[60] CompTIA "2019 Trends in Internet of Things", Feb 2019; https://www.comptia.org/resources/2019-trends-in-internet-of-things
[61] Marco Arnold, "Servitization, an emerging business model for the Internet of Things," Digital Republic, April 2019, https://digitalswitzerland.com/2019/04/29/servitization-an-emerging-business-model-for-the-internet-of-things/ ; and C. Suppatvech, J. Godsell, and S. Day, "The roles of internet of things technology in enabling servitized business models: A systematic literature review," Industrial Marketing Management, February 2019, https://www.sciencedirect.com/science/article/pii/S0019850118305364
[62] See: Zuora, The Subscription Economy Index, September 2018, http://info.zuora.com/rs/602-QGZ-447/images/Zuora_SEI_Q2_Report_2018.pdf. In this study, Zuora defines companies who are taking advantage of sensors and connectivity in order to diversify their revenue mix with digital services.
[63] Source: Brian Buntz, "8 Strategies to Transition to a Product-as-a-Service Business Model," IoT World Today, June 14, 2017, https://www.iotworldtoday.com/2017/06/14/8-strategies-transition-product-service-business-model/
[64] Miguel Gudino, "IoT data monetization: Turn your IoT data into additional revenue," IoTTimes, April 25, 2019, https://iot.eetimes.com/iot-data-monetization-turn-your-iot-data-into-additional-revenue/
[65] See: Michelin Press Release, "Michelin to Acquire NexTraq, a Telematics Provider, from FLEETCOR," June 14, 2017, https://www.prnewswire.com/news-releases/michelin-to-acquire-nextraq-a-telematics-provider-from-fleetcor-300473574.html

offerings, is gaining insights on how their core products are used and enable them to create new "service solutions".

Airbus is also expanding their business opportunities through digital transformation and the collection and use of data. Their Skywise platform is a collection point for disparate airline and aircraft data sources, where platform data can be used by customers for new operational use cases. Airbus has launched Skywise Digital Services to their customers – launching a new business model and revenue stream – in areas like predictive maintenance and fleet performance services.[66]

4.2.3 Improving Compliance

While IoT is becoming a domain shaped by stringent regulation (directly or indirectly),[67] its role in complying with legal and regulatory mandates continues to be an important adoption catalyst.[68]

IoT technologies improve knowledge and reporting capabilities. The real-time monitoring and adjustment made possible by intelligent systems open up degrees of freedom for companies.

> *"An IIoT enabled factory provides live monitoring of regulatory reporting, potentially reducing the validation efforts many manufacturers face with a risk-based approach."*[69]

For example, past regulatory compliance models required a company to study a topic (e.g. emissions) and create rules to keep within the required limits. Data would be analyzed periodically, and rules adjusted accordingly until the next review cycle; adding latency and rigidity to the process.

> *"IoT-powered sensors can also allow oil and gas operators to adequately monitor environmental conditions and ensure compliance with regulations on emissions and waste."*[70]

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[66] Airbus: https://services.airbus.com/en/aircraft-availability/digital-solutions-for-aircraft-availability/skywise-fleet-performance.html and https://www.airbus.com/aircraft/support-services/skywise.html

[67] See: Syed Ismail Shah, "Policies and Regulations Pertaining to IoT," ITU Academy, 2016; https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/Documents/Events/2018/IoT-BDG/IoT_Policy_Sept26%20Ismail%20Shah.pdf ;J.C.Boggs, "Regulating the Internet of Things," RFID Journal, November 2018; https://www.rfidjournal.com/articles/view?18038; Body of European Regulators For Electronic Communications (BEREC), "Internet of Things Indicators," March 2019; https://berec.europa.eu/eng/document_register/subject_matter/berec/download/0/8464-berec-report-on-internet-of-things-indic_0.pdf; Hogan Lovells, "A comparison of IoT regulatory uncertainty in the EU, China, and the United States," March 2019, https://www.hoganlovells.com/~/media/hogan-lovells/pdf/2019/a_comparison_of_iot_regulatory_uncertainty.pdf?la=en; i-SCOOP "IoT regulation: IoT, GDPR, ePrivacy Regulation and more regulations, "; https://www.i-scoop.eu/internet-of-things-guide/iot-regulation/; and Javier Ruiz, "An overview of EU Regulations affecting Internet of Things,", December 2018; https://www.openrightsgroup.org/policy/virt-eu/an-overview-of-eu-regulations-affecting-internet-of-things

[68] Verizon, "State of the Market: Internet of Things 2017 - Making way for the enterprise,", Verizon Report, 2017, https://www.verizon.com/about/sites/default/files/Verizon-2017-State-of-the-Market-IoT-Report.pdf

[69] Martyn Williams, " Smarter Steps to Compliance: The Future of Regulatory Compliance in the Pharmaceutical Industry," IoT ONNE, May 14, 2017, https://www.iotone.com/guide/smarter-steps-to-compliance-the-future-of-regulatory-compliance-in-the-pharmaceutical-industry/g690

[70] Jeffrey Lee, "How the Internet of Things is Powering the Oil And Gas Industry," Particle Website, November 15, 2018 https://blog.particle.io/2018/11/15/oil-and-gas/

Now, IoT-supported systems allow continuous real-time monitoring, and rules can be changed on the fly to ensure monitored parameters stay within the desired levels. As a result, companies can be bolder in their approaches to solving problems, knowing their systems will not allow them to run afoul of regulators. Examples where IoT can help meet legal and regulatory requirements are plentiful.[71]

4.2.4 Enhanced Customer and Employee Experience

In an era of "ATAWADAC"[72] (Any Time, Any Where, Any Device, Any Content), expectations for both customer and employee experience is at an all-time high. Companies need to be crystal clear on the added value they are bringing to users (internal and external) for their transformation programs in light of these expectations. As such, enhanced, data-driven, experiences must be at the core of any digital business transformation. The purpose of this paper is not to be exhaustive on all aspects of designing strong customer (CX), end user (UX) or employee experiences (eX); but rather to provide additional clarity in these areas and highlight their importance.

We do want to emphasize that the internal workforce is a key enabler of transformation – be it through embracing the new digital norm, being agents and advocates for change or in delivering new digital services and experiences to customers. Consequently, the "internal" user experience is vitally important and must be taken into consideration in any transformation program.

To summarize, customer experience is the sum of all interactions customers have with the organization that need to be connected and supported by digital systems, tools, processes and employees which, together, enable the creation of enterprise value. As a mnemonic, the "formula" $CX = \Sigma$(UX + eX) captures this value equation essence.

4.2.4.1 Customer and User Experience (CX / UX)

In a digital world, there are vastly more customer touchpoints and experiences to consider that impact CX - websites, mobile applications, automated interactions or chat bots - all of which are additive to non-digital experiences they may have (in-store, on the phone or elsewhere) and product related experiences, both digital and non-digital. A leading software company, Salesforce.com, defines Customer Experience[73] as:

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[71] A few cases: GSMA, "Air Quality Monitoring Using IoT and Big Data A Value Generation Guide for Mobile Operators," February 2018; https://www.gsma.com/iot/wp-content/uploads/2018/02/iot_clean_air_02_18.pdf; Jeffrey Newman, "How Technology Helps You Comply With FSMA [Food Safety Modernization Act], CalAmp, December 2018; https://www.calamp.com/blog/2018/12/how-technology-helps-you-comply-with-fsma/; Jim Sabogal, "Preview: How the Internet of Things (IoT) meets the needs of the US Drug Supply Chain," LinkedIn, June 2019; https://www.linkedin.com/pulse/preview-how-internet-things-iot-meets-needs-us-drug-supply-sabogal; Rymedi,Temptime/Zebra, Indiana University Health, WakeMed Health & Hospitals, Good Shepherd Pharmacy, the Center for Supply Chain Studies, the Global Health Policy Institute, "FDA Approves Pilot Using Next-Generation Blockchain and IoT to Track Healthcare System Medicine Transfers," April 2019; https://www.marketwatch.com/press-release/fda-approves-pilot-using-next-generation-blockchain-and-iot-to-track-healthcare-system-medicine-transfers-2019-04-25 and "ERTICO and Gemalto leverage the IoT to enable eCall across Europe," Gemalto website, October 2018 https://www.gemalto.com/m2m/customer-cases/ecall

[72] The expression is from Xavier Dalloz consulting - See New Corner, "ATAWADAC: Foundation for a Digital Future?" New Corner website, October 17, 2019, http://www.new-corner.com/atawadac-foundation-for-a-digital-future/

[73] How to Ensure the Very Best Customer Experience Each and Every Time, https://www.salesforce.com/products/service-cloud/best-practices/customer-experience/#

> *"The sum of all the interactions people have with your brand. This includes offline considerations as well as online. For example, your customer experience management team ensures a visitor to a retail store has a positive, helpful, professional experience when [they] interact with your team face-to-face."*

While the user experience is defined as:

> "*The interaction users have with your product. According to DigitalGov, it 'deals with people interacting with your product and the experience they receive from that interaction.'"*

A great example of improving consumer experience is the launch of Alexa by Amazon. Amazon key objective was to reduce the pain points around purchasing products online. They wanted to create a frictionless purchasing experience without sign in, search and order validation.. Alexa focused on the user experience and as a consequence generated revenue from the sales of the device (with 100 million sold to date)[74] and enabled future acceleration for online purchases through the Amazon marketplace.

According to recent market research from Salesforce.com[75]

- *70% of customers say connected processes — such as seamless handoffs or contextualized engagement based on earlier interactions — are very important to winning their business.*
- *84% of customers say being treated like a person, not a number, is very important to winning their business*
- *66% of customers say it takes more for a company to impress them with new products and services than ever before*

Salesforce also reported that 76% of customers believe switching costs are low and they find it easier than ever to switch to a brand that will meet their experience and performance expectations.

A paradox is that while digital technology breakthroughs - like cloud, mobile and social - provide the ability to deliver personalized, high value, and immediate experiences to customers; these same technologies also lower the barrier to competitive entry and lower switching costs for customers who have ever-growing CX expectations.

Here is where IoT coupled with digital technologies – like analytics, AI, ML and automation – can help overcome this paradox, using IoT connected devices and resulting data to understand the customer and/or product environment, identify and assess signals and determine the next best action better and faster than competition.

Consider the improvement in customer experience and value delivery with this example: as a provider of equipment management services to an important manufacturing

[74] Lucas Matney, Tech Crunch, Jan 2019; https://techcrunch.com/2019/01/04/more-than-100-million-alexa-devices-have-been-sold/
[75] Salesforce Research "*State of the Connected Customer*" 2019; https://www.salesforce.com/research/customer-expectations/#

customer, a product is operating slightly out spec, discovered via a sensor alert. Rather than waiting for a failure, this initiates an automated replacement order and kicks off a workflow dispatching a field technician to the site as the part arrives – all without getting an irate call from the client and before performance SLAs were in jeopardy. This is the new CX enabled by IoT.

4.2.4.2 Employee Experience (eX):

Looking back at our equation, the other key factor in delivering exceptional CX is eX – employee experience. A recent article from Forbes[76] suggests that "employees are the new customers" - as customers have elevated expectations, so also do employees. Creating an exceptional eX includes providing an improved digital workplace and implementing digital processes and tools that ease employee pain points. In short, to attract and retain the best talent and positively impact CX, companies must equip their people with the right tools, skills and capabilities for new digital ways of working.

Prospective and current employees are expecting this from their employers

According to a recent survey from Randstad[77] feeling equipped with the latest digital and technology skills was among the top factors cited for job satisfaction. Sadly, it was also discovered that less than half of respondents (45%) say their employers encourage skill development, and only one-third agree their employers offer them ample opportunities to acquire digital skills with training or on-the-job learning.

Overlooking eX and proper employee enablement is a risk to digital transformation success and value creation; but can also be an untapped asset to accelerate it. A recent Intel study looking at Industry 4.0 and the co-evolution of workers and manufacturing operations clearly shows employees recognize they are key players in this change:

> *"When transitioning to the intelligent factory, leaders are often seen as decision-makers and workers seen as being along for the ride. But in this research, it was not just the manufacturing leaders or managers who proclaim influence. It was also operations and logistics coordinators, quality specialists, maintenance technicians, and hands-on line workers…Fully 98% of the workers who participated believed that they had direct or indirect influence over* ***technology adoption*** *[emphasis added] and implementation decisions."*[78]

Bottom line, digital business transformation and IoT programs can provide not only a platform to dramatically improve eX; but also a vehicle to engage employees in the process. Engaging employees at an early stage and making them part of digital transformation and solution creation can lead to better solutions, greater employee

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[76] Brian Anderson," *Transforming the Digital Workplace through Employee Engagement*", Jan 2019; https://www.forbes.com/sites/forbescommunicationscouncil/2019/01/04/transforming-the-digital-workplace-through-employee-engagement/#34feab602d02

[77] HR Daily Advisor, "*The Digital DNA of Job Satisfaction*", July 2018; https://hrdailyadvisor.blr.com/2018/07/13/digital-dna-job-satisfaction/

[78] Irene Petrick and Faith McCreary, "Industry 4 .0 Demands the Co-Evolution of Workers and Manufacturing Operations," Intel, April, 2018; https://newsroom.intel.com/wp-content/uploads/sites/11/2018/04/abstract-intel-manufacturing-research.pdf

advocacy and support for digital change and can accelerate program success as you move from an analog company to a potential digital disruptor.

4.3 RISKS

"You have to [take risks] if you're going to innovate and revolutionize anything with an organization. In fact, your tolerance for risk is directly related to how successful you can be…and that tolerance is worth challenging." - Ginna Raahauge, CTO, SVP Strategy & Architecture, Catholic Health Initiatives[79]

While there are tremendous opportunities with IoT, we would be remiss if we didn't point out some of the biggest risks and potential stumbling blocks to successful and sustainable digital business transformation & value creation leveraging IoT.

4.3.1 Scope, Complexity and Scale

As referenced earlier, the expression "Internet of Things" is best understood as a metaphor that encapsulates the immersion of almost anything and everything into the communications space. The upshot of this is that the potential scope of IoT is unprecedented. Highlighted earlier in IMAGE, the interfaces (devices) will be massively varied and the choices for hardware types, vendors and versions will continue to grow. Even though, as Marc Andreessen famously said, "software is eating the world", it is important to remember in IoT that hardware is still hard. Said differently, as outlined in this section and in our DIGIT framework, we recommend taking the time to design hardware systems to address key factors and risks aligned to your use cases, such as performance, power, end-to-end connectivity, interoperability, futureproofing.

Similarly, the scale of IoT is novel as well. While estimates vary widely, there will be tens of billions of IoT devices deployed throughout the world. Managing that much data, much less managing the devices themselves, will require new business models, tools and experts. Seat-of-the-pants methods will have to give way to more rigorous approaches, and a result, modeling and simulation capabilities will become an indispensable element of the Internet of Things toolbox.[80] Inability to cost-effectively scale up is one of the reasons that explain the lack of success of some IoT companies.

We believe a company must be ready to deal with this new scale, scope and IoT's intrinsic complexity by staying focused. Specifically, focus on the right opportunities, use cases and data; and focus internal energies on the parts of the value chain that create the greatest differentiation and value. While IMAGE must be addressed holistically, this focus will help with delineating the areas you care about and speed decisions on platforms, partnering and outsourcing.

[79] Source: Carla Rudder, "Risk-taking quotes to inspire business leaders," The Enterprisers Project, October 18, 2016, https://enterprisersproject.com/article/2016/10/risk-taking-quotes-inspire-business-leaders

[80] See Margaret Loper and Alain Louchez, "The Internet of Things and the Importance of Modeling and Simulation - A look at why modeling and simulation capabilities are becoming an indispensable element of the Internet of Things," Automation World, August 3, 2015, https://www.automationworld.com/article/industry-type/all/internet-things-and-importance-modeling-and-simulation

4.3.2 Usability and Adoption

For any solution to achieve market success in either business or consumer markets users must: 1) see solution value (does it offer something they need and will they pay for it), 2) find the solution usable (is it easy to install and use, is it a good experience) and 3) be confident in the solution (is it well-supported, secure and usable over time).

Interestingly, the three biggest challenges in consumer adoption of IoT/connected products directly correlate and include: "clumsy integrations with the user's life, lacking data security and privacy protections and dubious value propositions".[81] Results from a recent survey by Clutch[82] reinforce this view:

- *Only 33% of respondents had no issues with their connected devices [meaning 68% did]. Top two issues with connected devices were connecting to network (19%) and maintenance (13%).*
- *Over half (53%) do not plan to invest in a connected device in the next 12 months, citing device compatibility issues and not seeing value in capabilities.*
- *Security / privacy is a concern and mystery for users, with nearly 30% not knowing if or how their data is shared.*

Potential catastrophic project or product failings can be avoided by putting as much attention to user experience design and testing as is given to technology selection. Particular attention needs to be given to device set up, connectivity, interoperability and feature usability. As simply stated by the team at ReadWrite, "companies that make adoption easiest tend to be the ones with the most adopted products".[83]

4.3.3 Security and Privacy

The amount of identifiable personal data that is detected, processed, communicated, stored and monetized is growing exponentially, nourishing at the same time the need for tighter privacy protection.[84]

The issues surrounding security and privacy have become a staple of today's IoT conversation. As referenced earlier, NIST has developed a trustworthiness model for IoT and cyber-physical systems, which addresses safety, security, privacy, resilience and reliability.[85] IoT programs (and possibly growth of IoT at large) could be negatively impacted without laser-focus on delivering security and privacy built-in by design.

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[81] Kevin Williams, "IoT Adoption Is Weaker Than It Should Be", readwrite, April 2018; https://readwrite.com/2018/04/04/iot-adoption-is-weaker-than-it-should-be/

[82] Clutch IT Services Survey "How People Use Connected Devices", October 2018; https://clutch.co/it-services/resources/how-people-use-connected-devices

[83] ibid footnote 73

[84] See the General Data Protection Regulation (GDPR) in the European Union and Dr. Shoshana Zuboff's book on "The Age of Surveillance Capitalism: The Fight for the Future at the New Frontier of Power," both mentioned in section 2.4.1 Technology Glue

[85] See Edward R. Griffor, Christopher Greer, David A. Wollman, Martin J. Burns, "Framework for Cyber-Physical Systems: Volume 2, Working Group Reports," June 26, 2017, https://www.nist.gov/publications/framework-cyber-physical-systems-volume-2-working-group-reports

We recommend security-by-design, including, as example, assessment of impacts and readiness for GDPR and other regional security and privacy requirements (like the California Consumer Privacy Act, CCPA); and having strong security oversight and governance with enterprise participants who can skillfully evaluate risk and compliance against security and privacy best practices.

4.3.4 People, Culture and Talent

Technology is nothing without the people behind it. It stands to reason technology-driven digital transformation requires significant enterprise investment in its people – enabling a culture of change, driving employee engagement and managing today's and tomorrow's talent. Without this investment, digital transformation and related IoT programs are bound to fail.

Culture and Change: One of the earliest and biggest challenges with successful digital business transformation is creating the right culture and employee engagement for the digital imperative and the coming digital change. Sadly, this can be one of the biggest blind spots for leaders. In a 2017 survey on digital culture by the Digital Transformation Institute, there was a massive gap between how leaders and employees perceived digital culture, where 40% of leaders believed there was a clear digital culture; while only 27% of employees agreed. The culture gap was even more prevalent when looking at middle management vs leadership views relative to the following statements about cultural enablers of digital transformation:[86]

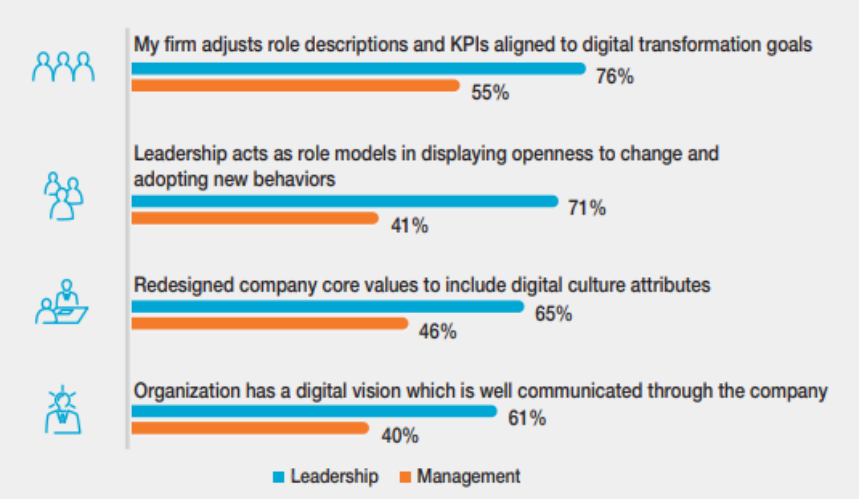

Figure 14 - Digital Culture Employee Perspectives[87]

Issues with digital business change acceptance continues once projects are underway, as project teams prioritize the design and development of the technology and overlook the need to design and develop new digital ways of working and engage in specific

[86] The Digital Transformation Institute, "The Digital Culture Challenge: Closing the Employee-Leadership Gap". March/April 2017; https://www.capgemini.com/consulting/wp-content/uploads/sites/30/2017/07/dti_digitalculture_report.pdf
[87] ibid

change management efforts to drive adoption. While measurements can be somewhat subjective, there is evidence that when people are truly invested in change it is 30% more likely to stick.[88]

The "employee experience" factor, as outlined earlier, is becoming more and more critical to digital business transformation success. As such people and culture strategies and tactics must be in place at an enterprise and project level.

Addressing the Talent Gap: An oft-quoted bottleneck to IoT program expansion (and digital business transformation projects generally) is the lack of available skills and expertise, which represents a substantial risk for the project and its long-term viability. The range of skills needed is far reaching and goes well beyond scientific and technical know-how and background:

> *"…Technical know-how is only part of the picture – communications and problem solving skills are important too… [People] certainly need to have the ability to comprehend the technologies being deployed, but far more important is their overall awareness of business and their attitude to working in a fast-paced and constantly changing environment…"*

Regarding new graduates, digital transformation changes the game in terms of the core skills for these new hires (and will impact the learning agenda for them on the job):

> "…*Companies are starting to cast the net farther afield, taking on graduates from a far wider range of disciplines. [Our firm] often looks for people with a background in the arts, because alongside their analytical skills they are creative and can play a key role in user experience, and [can] make sure a product is actually something people want to interact with."*[89]

From the perspective of the current workforce, participants in a recent study regarding the impact of digital workplace change felt automation could free them from onerous and injurious work:

> *"They relished the thought of be able to focus more on value-add tasks that were uniquely human and having freedom from today's constraints of manufacturing. They looked forward to more transparency in work and communication, where*

[88] Boris Ewenstein, Wesley Smith, Ashvin Sologar,"Changing Change Management", McKinsey Insights, Oct 2015, https://www.mckinsey.com/featured-insights/leadership/changing-change-management

[89] Mark Hillsdon, "The 'Internet of Things': What it is and why business is taking it seriously," The Guardian (UK), October 27, 2017, 2017 https://www.theguardian.com/break-into-tech/2017/oct/17/the-internet-of-things-what-it-is-and-why-business-is-taking-it-seriously; for a review of the importance of the liberal arts in digital transformation see: Scott Hartley (2017), The Fuzzie and the Techie – Why the Liberal Arts Will Rule the Digital World, Boston, MA: Houghton Mifflin Harcourt, https://www.amazon.com/Fuzzy-Techie-Liberal-Digital-World/dp/0544944771; George Anders (2017), "You Can Do Anything: The Surprising Power of a 'Useless' Liberal Arts Education," https://www.amazon.com/You-Can-Anything-Surprising-Education/dp/0316548804; Christian Madsbjerg (2017), "Sensemaking: The Power of the Humanities in the Age of the Algorithm," https://www.amazon.com/Sensemaking-Power-Humanities-Age-Algorithm/dp/031639324X

they could access information about anything from anywhere, leading to an organization that was more in-sync and data driven."[90]

Bottom line, any project must include a clear strategy for talent management. This is not only about attracting and retaining relevant new talent; but equally about looking at current talent and what is expected to change with IoT-based digital transformation. Roles and tasks will change or be eliminated, and individual resource capacity may fluctuate. Studies indicate there is a hunger for change, and that workers are enthusiastically embracing advanced IoT based technologies. Talent Management should include new skills acquisition with an eye towards diversity of person and experience but also must include plans for re-skilling and re-deploying employees, along with a long-term approach to keeping skills/knowledge current.

4.3.5 Rigidity of Legacy Systems

By many accounts, dealing with legacy systems is one of the most vexing challenges of IoT development:

"Manufacturers who want to [transition to IoT] already have a lot of legacy hardware, embedded software and firmly established production lines. These have been developed from years of experience and quality testing, and companies would rather stick to them when making design decisions and technical choices rather than spend huge amounts of money to move into new, uncharted territory. That's why many brands and enterprises remain wary about getting involved in IoT, despite acknowledging its potential impacts."[91]

In early 2018, Couchbase, a private software company in Santa Clara, California, surveyed 450 heads of digital innovation and found out that 84% of digital projects were being cancelled or hindered because of legacy database limitations.[92] Modern architectural models, such as legacy system abstraction and the use of containerization and microservices can help mitigate these issues; but requires strong alignment and planning between business and technology teams.

4.3.6 Futureproofing

For most IoT applications, the device life cycle is 10 to 20 years or more.[93] Since the rate of technological change is accelerating, it is vital that digital/IoT solutions be designed to seamlessly accommodate the transition to "new and improved". Swapping out devices is a costly proposition; hence solution design and Platform strategy should

[90] Irene Petrick and Faith McCreary, "Industry 4 .0 Demands the Co-Evolution of Workers and Manufacturing Operations," Intel, April, 2018; https://newsroom.intel.com/wp-content/uploads/sites/11/2018/04/abstract-intel-manufacturing-research.pdf
[91] Joe Britt, "Here's your first tech buzzword of 2017: 'Brownfield'," Recode, December 2016; https://www.recode.net/2016/12/14/13925096/iot-brownfield-development-internet-of-things-greenfield-afero
[92] CrouchBase, "Is the Data Dilemma Holding Back Digital Innovation," January 2018; https://www.cbronline.com/whitepapers/data-dilemma-holding-back-digital-innovation/
[93] Dr. Michael Vedomske "Achieving the Grand Vision of the Internet of Things without Device Longevity Will Never Be," Medium, January 2016; https://medium.com/achieving-the-grand-vision-of-the-internet-of/without-device-longevity-the-internet-of-things-will-never-be-58c904703abb

address the growing need for future proofing capabilities for power management, memory and software, where capabilities, such as FOTA (Firmware-Over-The-Air) can address changes needed for things like embedded applications, security updates, syntax, data link or transport protocols.

5 THE DIGIT FRAMEWORK AND GUIDE TO SUCCESSFUL TRANSFORMATION

Thus far, we have provided perspectives, insights and references regarding IoT and Digital Business Transformation - setting context, defining the ecosystem, identifying opportunities and risks and showcasing some of the commonalties across digital business transformation methodologies. But to what end? How can a business or IoT leader take these insights and turn them into actions? What should be prioritized? What are the must-do's and how can they increase the likelihood of success?

To answer these questions, CDAIT has a point of view regarding what attributes and activities are critical for successful digital business transformation and IoT-driven transformation programs. While we do not claim it to be revolutionary, we believe our views are resolutely simple, easy to understand and pragmatic - based on our own and our members' experiences.

Our guidance centers on the DIGIT framework - five straightforward stages to digital transformation programs which are perpetually and iteratively managed through a front-end strategy/planning process and a back-end delivery/management process – and includes our recommendations of critical actions or activities that will set the stage for IoT Digital Transformation success. By addressing these recommendations at each stage, the enterprise can stay grounded with the rigor, discipline, coordination and purpose needed for successful transformation, rather than falling into the traps of short-termism, lack of transparency and organizational misalignment.

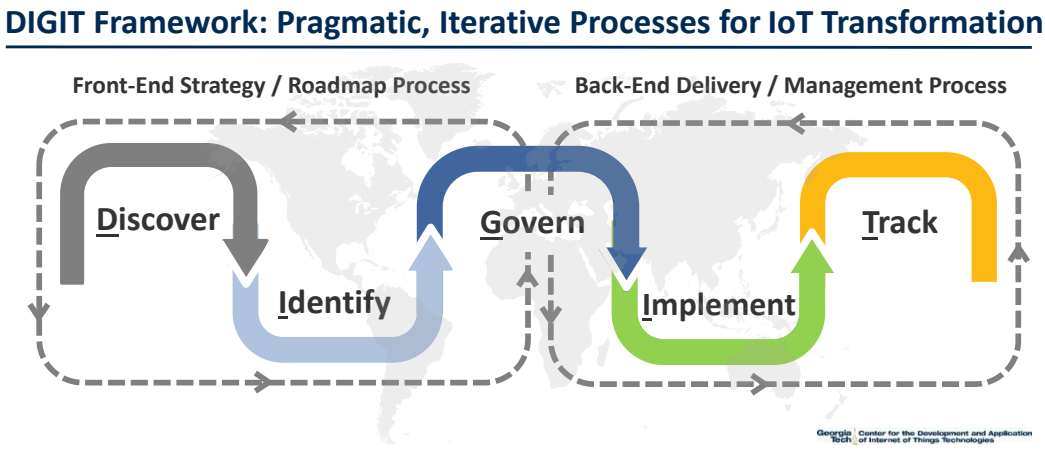

Figure 15 - The DIGIT Framework

- **Front End Strategy/Roadmap: Discover, Identify, Govern**
  This iterative process takes the enterprise from the wide, often messy start of the idea and opportunity funnel to and through the prioritization and funding steps that result in a clear digital transformation and IoT project roadmap. The front-end process starts with a common and established digital transformation vision and mission for the enterprise. With this, newly discovered problems, opportunities and ideas can be developed "just enough" into proposals or limited proof-of-concepts to be evaluated at an enterprise level (for example, via a front-end process managed by the Office of the CDO) for fit, function, cost/benefit and alignment to enterprise transformation goals and principles. Projects that meet criteria can move forward for additional funding, exploration and development and those that do not can be mined for lesson learned and discarded or sent back to the drawing board - leading to more effective use of resources and a more aligned organization. Effort is not expended on poor ROI, non-strategic projects and there is better alignment across the organization - with clarity on the "why" or "why not" for any new opportunity. The enterprise can avoid skunkworks projects or never-ending IoT PoCs that drain teams; and rather it can properly deploy resources on high value programs that forward the enterprise transformation agenda

- **Back-End Delivery/Management: Govern, Implement, Track**
  This process includes the ongoing iterative delivery and management of these projects. This is not a static effort; but active management via the governance process to track investments, development efforts, operational readiness, IoT project impact and performance to plan.

  The team, beyond those part of enterprise governance, leading this work is typically comprised of experts in controls and/or product engineering, enterprise architecture, security, relevant IT and OT systems, experience designers, HR and in some cases reliability, safety and / or other domain specific experts.

  In this, it is the responsibility of these leaders to evaluate the project, think forward and design an architecture which connects to the broader enterprise perspective - assessing performance, constructively challenging themselves and being ready to make any requisite adjustments - from supporting team needs to tweaking project scope, re-prioritizing or even killing projects that have no clear path to success.

In both the front-end and back-end processes, the emphasis is on organizational effectiveness, alignment and transparency. It is easy to establish this ideal; but hard to execute. We will endeavor to provide our recommendations in each of stage – Discover, Identify, Govern, Implement, Track - that, if addressed, will improve the likelihood of Digital Business Transformation and related IoT project success.

5.1 DISCOVER THE PROBLEM/OPPORTUNITY

This stage is about finding and contextualizing the problem(s) and/or opportunity(ies). Paramount to any digital transformation is the recognition that it is, at the core, a change driven by economic, financial and market considerations.[94]

Too often, companies "manage by headlines" (i.e., react to seemingly popular ideas) and rush into launching projects that have no overarching/strategic framework. More often than not, these initiatives, when all is said and done, aim to "keep up with the Joneses" and show off (poorly digested) latest technologies (if not fads).[95]

Perhaps this can explain why many IoT projects are stranded technology experiments. This can be corrected as part of the front-end Discover stage. Making the following three activities mandatory at the start of digital transformation as new team projects are brought forward will help set the stage for future project success (or will allow for quick redirection – discovering very early if a project concept is off- base)

5.1.1 Ask and Answer the Fundamental Questions

At the very start and at a leadership level, fundamental questions must be asked to help define and frame the transformation overall and the specific projects therein:

- What is (are) the short- and long-term problem(s) the company is trying to solve?
- What are the pain points (internally and externally)?
- How might addressing problems/pain points improve revenues, profits or brand?
- What could be done better?
- What is missing?
- What do our stakeholders and customers want?
- What are the scope and objectives (of the transformation)?

This stage requires a thorough grasp of the company's present and anticipated context. A key success factor for enterprise digital transformation is setting the stage, answering these questions and providing a specific and relentlessly focused set of objectives against which digital transformation projects and initiatives can be assessed.[96]

5.1.2 Establish the Strategic Context

A strategic and situation analyses is a prerequisite for any new IoT project, taking both an outside-in and inside-out view. An evaluation of strengths, weakness, opportunities and threats (SWOT) combined with a review of outside factors from political, economic,

[94] Economic considerations relate to the optimal allocation of scarce resources whereas financial ones deal with monetary constraints and outcomes.
[95] "The lack of well-identified use cases is causing "blockchain fatigue' to set in; caution urged for early adopters," Leo Jakobson, Gartner Survey: 90% of blockchain-based supply chain projects are in trouble, Modern Consensus, May 7, 2019, https://modernconsensus.com/uncategorized/gartner-survey-blockchain-supply-chain-trouble/
[96] Jonathan Deakin; Laura LaBerge; and Barbara O'Beirne, "Five moves to make during a digital transformation," McKinsey Survey, April 2019, https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/five-moves-to-make-during-a-digital-transformation

social, technological, legal and environmental dimensions (PESTLE) will provide strong context for market position. Coupling this with an assessment of how addressing this problem/opportunity fits with enterprise strategy and the digital transformation agenda will provide a fertile ground to justify and support the undertaking.

5.1.3 Define the Unfilled Need

Many years ago, Al Ries and Jack Trout, in their seminal groundbreaking book on "Positioning: The Battle for Your Mind",[97] suggested companies adopt a French marketing concept, "*cherchez le créneau"*, or "find the hole", meaning the position not yet filled in the target's mind that the brand can easily occupy.[98]

While Ries and Trout's marketing concept rests on perception, it can still guide the digital strategy without loss of impact and meaning. Since an opportunity always arises because of the existence of a gap, the unfilled need is the lodestar of the digital quest.

Any project proposal going through the Discover stage must outline the current unmet need and objectives to address it, which will establish the mind-space around which organizational consensus can emerge.

To reiterate, these activities are required both at an enterprise level - setting the foundations and guardrails for digital business transformation - and at a project level. It is the product/solution/project team's responsibility to define the solution, its market need and value, its fit with enterprise transformation objectives and how it fulfills unmet needs – satisfying both the team and the business that the opportunity is grounded and suitable for continued offer.

5.2 IDENTIFY THE SOLUTION

As opportunities are discovered, each will require a solution be identified and elaborated to pass muster as part of the front-end process; as the old aphorism goes, "A problem well stated is half solved".[99] We believe there are two mission-critical activities in this stage: framing the solution and defining the value.

5.2.1 Focus on the IMAGE

The difficulty of this step for IoT projects cannot be overstated, particularly due to the complex end-to-end value chain as defined in our IMAGE model (Interface, Medium, Application, Glue, Extraction), impacting both the technical and the business/operations.

Technical Framing: While we will not endeavor to outline fully the process of defining an IoT solution technical scope, we recommend that projects teams ensure they address the full suite of Interface, Medium, Application, Glue and Extraction capabilities

[97] Al Ries and Jack Trout, "Positioning, The battle for your mind," Warner Books – McGraw-Hill Inc., New York, 1981 - Chapter 6
[98] Al Ries, "A Few Words About Jack Trout and Positioning," Ad Age, June 9, 2017, https://adage.com/article/al-ries/a-words-jack-trout-positioning/309341
[99] Quote often attributed to John Dewey (1859 - 1952), American Philosopher; and Charles Franklin Kettering (1876 – 1958) American inventor, engineer, businessman (GM).

required; and answer some critical questions as part of solution architecture and design that often are overlooked:

- Will the technologies, which are constantly evolving, harmoniously blend into an efficient whole? Is the solution built on industry standards?
- How will the solution mesh and operate with legacy systems?
- How will it stand the test of time? In short, will it be backward compatible and "future proof"?
- Can technologies (open- or closed-source, standards-based or bespoke) handle updates to security, software, firmware, etc.? How is the process managed?
- How are security and privacy built-in and resilient?
- Is there a governance policy in place to manage business system requirements, data storage and security strategies?

Operational Framing: The operational impacts and the "human factors" are sometimes not examined until after IoT projects are undertaken. The success of the entire project will depend on operational execution and how well a wide variety of internal and external stakeholders absorb and leverage a broad range of new technologies and capabilities. A few key questions that are often overlooked, but critical are:

- Have business domain specialists been identified for the project?
- Are there any regulatory or compliance impacts to address?
- What are the skill and talent requirements and how might we address them?
- What ecosystem or partnerships should we consider to flesh out our solution?
- What is adoption and change management strategy?

A robust assessment of operational impacts – across people, process and internal/external environments is an absolute must. Understanding and addressing those impacts in any plan can make the difference between delivering benefits at scale or staying in "pilot purgatory".[100]

5.2.2 Define Value and Determine ROI(s)

The existential challenges posed by technology and operations notwithstanding, relevance and value over time is probably the most critical hurdle that the IoT industry, and any IoT project, has to overcome to grow and thrive. We believe long-term success requires the business address two distinct value equations.

[100] See Mike Sutcliff, Raghav Narsalayf, and Aarohi Sen, " The Two Big Reasons That Digital Transformations Fail," Harvard Business Review, October 18, 2019, https://hbr.org/2019/10/the-two-big-reasons-that-digital-transformations-fail ("Most of the leaders we surveyed (companies representing 17 countries and 13 industries) reported poor returns on their digital investments. The primary reason: unsuccessful efforts to scale digital innovations beyond early pilot work."); and Sunil Avhal, "IoT purgatory and how digital leaders can beat it," Capgemini website, March 12, 2019, https://www.capgemini.com/2019/03/iot-purgatory-and-how-digital-leaders-can-beat-it/

5.2.2.1 Traditional ROI and the Business Case

It is critical to understand that "going digital", as far as traditional return on investment (ROI) is concerned, is not any different from any other business project[101] - the value proposition must be crisply defined and the return carefully estimated.

However seductive and loud the voice of the digital solution, in all its protean forms (IoT, AI, machine learning, blockchain, Big Data, etc.), can be, one should recognize that it could also be a force of diversion and distraction. Submitting projects to the rigor and discipline of a business case and a review in context with broader digital transformation charter and initiatives can avoid financial disasters.

Sometimes, the value might not be there yet or dependencies on other systems' digital maturity may dictate postponing an investment. This can be uncovered through oversight of the front-end process to set the strategy and prioritized project roadmap.

5.2.2.2 Digital Transformation and the "New ROI"

In addition to the traditional measures of ROI and enterprise value, there is an ongoing evolution in the definition of enterprise value and to whom that value accrues. Specifically, with pervasive disruption and transformation in industry, society and governments, many are taking a broader view of value-creation factors - including less tangible assets related to culture, environmental, social or governance initiatives - and the recipients of that value, which extend beyond shareholders to customers, employees and potentially society at large. This phenomenon is considered, in brief, a shift from Shareholder Capitalism to Stakeholder Capitalism[102]. When such initiatives and factors are digitally powered, in our view, they constitute a step towards the long-term vision of Digital Societal Transformation (mentioned at the start of this paper).

Drilling deeper, we believe, companies face three major interconnected transformational forces, illustrated below, in addition to any idiosyncratic challenges tied to a particular industry or situation. When these forces, labeled the "New ROI", are well-considered and addressed as part of (IoT driven) Digital Business Transformation strategy, these can be forces of acceleration for both enterprise and societal good:

- **Re-X**: No longer just nice-to-have, sustainability and sustainable operations are becoming mission critical. This emphasis on the circular economy, dubbed "Re-X" (e.g.: recycle, reuse, re-manufacture), is becoming a priority as "sustainability bolsters the bottom-line, boardrooms and corporate reputations".[103]

[101] Only this aspect of digital project management is invariant; the others are substantially different since "digital transformations are even more difficult than traditional change efforts to pull off," see: Hortense de la Boutetière; Alberto Montagner; and Angelika Reich, "Unlocking success in digital transformations," McKinsey Survey, October 2018, https://www.mckinsey.com/business-functions/organization/our-insights/unlocking-success-in-digital-transformations

[102] Steve Klemash, Jamie C. Smith, and Rani Doyle, "Stakeholder Capitalism for Long-Term Value Creation", EY Center for Board Matters, June, 2019; https://corpgov.law.harvard.edu/2019/06/13/stakeholder-capitalism-for-long-term-value-creation/

[103] Terri Toyota, "Sustainability is now mission critical for businesses. Here's why", WEF, September 2018; https://www.weforum.org/agenda/2018/09/sustainability-is-now-mission-critical-for-businesses-heres-why/

- **Outcome**: As the movement to SaaS software shows, today owning a product is not as vital as having access to it and securing desired results. Customers' attention is drifting away from the tangible asset to the service, output or result. Innovative companies are reshaping strategy and hinging new business models on services and outcomes rather than products (product- or outcome-as-a-service) and moving away from one-and-done payment to recurring revenues ("subscription economy"). This servitization model[104] will demand a complete overhaul of the business.
- **Integration**: Industry 4.0, which is gaining global traction, fosters seamless and real-time vertical (internal/functional) and horizontal integration (throughout the supply chain up to and including the customers) into a vast cyber-physical system.[105] Firms that want to remain competitive are embracing this trend.

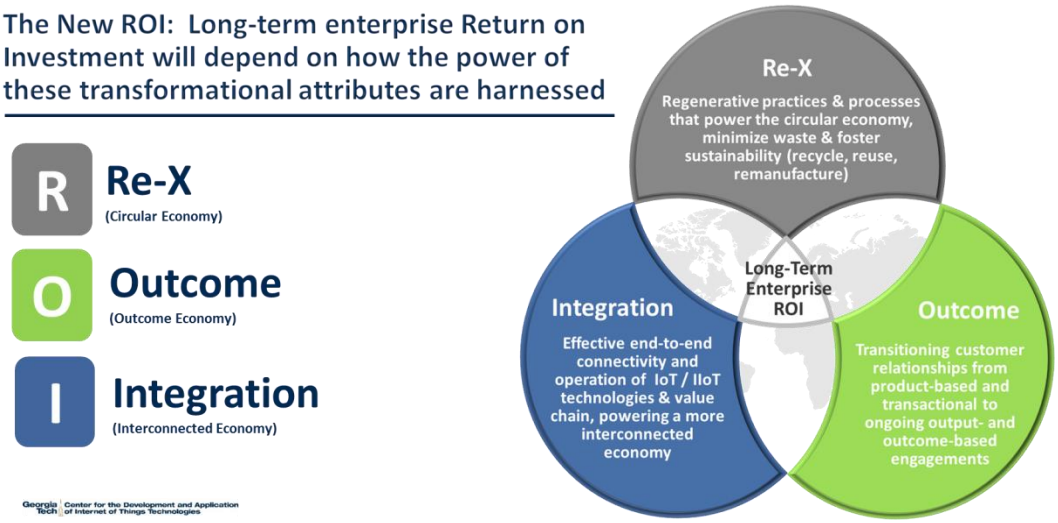

Figure 9 ROI of Digital Business Transformation[106]

Companies' long-term return on investment (ROI), especially in the world of Stakeholder Capitalism, will be determined in great part by how they harness this New ROI (Re-X, Outcome and Integration). IoT technologies, and therefore IoT digital transformation projects, can play a meaningful role in this rapid evolution[107]. Depending on the level of preparation and readiness, these three forces, which are inexorably and rapidly materializing, will be headwinds or tailwinds.

To maximize tailwinds and push ahead of competition, we recommend that the enterprise define express objectives regarding these three forces as part of the

[104] For a review of the impact of IoT technologies on servitization see: Chutikarn Suppatvech, Janet Godsell, and Steven Day, "The roles of internet of things technology in enabling servitized business models: A systematic literature review," Industrial Marketing Management, February 2019, https://doi.org/10.1016/j.indmarman.2019.02.016

[105] See: Dr. Helen Gill, "From Vision to Reality: Cyber-Physical Systems," https://www2.ee.washington.edu/research/nsl/aar-cps/Gill_HCSS_Transportation_Cyber-Physical_Systems_2008.pdf

[106] See Alain Louchez, "Internet of Things, Industry 4.0 and Digitalization at a Crossroads," Presentation at event jointly organized by Konrad Adenauer Foundation, Hamburg and U.S. Consulate General Hamburg October 18, 2018, Amerikazentrum, Am Sandtorkai 48, 20457 Hamburg, Germany, https://cdait.gatech.edu/sites/default/files/konrad_adenauer_stiftung_october_18_2018_alain_louchez_gt_cdait_rev1.0_0.pdf

[107] World Economic Forum, "Internet of Things Guidelines for Sustainability" states: "The internet of things (IoT) is undoubtedly one of the largest enablers for responsible digital transformation" http://www3.weforum.org/docs/IoTGuidelinesforSustainability.pdf

enterprise digital transformation strategy; and that new project opportunities moving through the front-end process define long term project value and impact for both traditional financial metrics as well as metrics for the New ROI.

5.3 GOVERN THE PROCESS

Project governance and leadership are critical to sustained success since digital business transformation can modify a company's identity, not just its technology or processes. This is reinforced in a recent paper:

> "Digital transformation governance and steering are *a sine qua non* [an essential ingredient] of success".[108]

Following are what we believe are the absolute essential ingredients for front- and back-end process governance, without which the enterprise will compromise organizational effectiveness, alignment and transparency and will jeopardize the expected results and benefits of digital transformation efforts and related IoT projects.

5.3.1 Lead from the Top

Top-level leadership (C-suite) must be engaged from transformation and project inception. The impact of changing methods and business models can cause insecurity with stakeholders, from employees to investors to customers.

Showing a united front at a leadership level - including, but not limited to, those leaders responsible for technology, security, legal, finance and HR - will ease fears and instill confidence that the company is committed to successful transformation. However, it is imperative that one person be named overall lead for the digital transformation effort.

5.3.2 Bring the Right (Digital) Expertise

It is crucial to have key posts, both at the executive level and the task/function level, filled with technically proficient people. According to a McKinsey Global Survey, only one-third of companies undertaking a digital transformation effort engaged a Chief Digital Officer (CDO); however, those that did had a 60% higher chance of self-reported success.109 Further, in a report by Egon Zehnder, much of this talent may need to be secured externally, with 64% of CDO's surveyed hired form the outside.[110]

This prerequisite notwithstanding, the need for familiarity with digital technologies and the injection of true technical expertise in critical functions do not necessarily mean that the company's overall digital transformation must be led by a technical guru:

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[108] EY and EBG, "Pratiques observées pour la gouvernance de la transformation digitale [observed pratices for digital transformation governance]" EY website, January 2019; https://www.ey.com/Publication/vwLUAssets/ey-livre-blanc-la-transformation-digitale-des-entreprises/$FILE/ey-livre-blanc-la-transformation-digitale-des-entreprises.PDF. Quote translated from French.
[109] Boutetière, et al, p.6
[110] Egon Zehnder Survey, "CDO Decoded:The First Wave of Chief Digital Officers Speaks", June 2019; https://www.egonzehnder.com/cdn/serve/article-pdf/1560525503-8e343689ff3069fac551d81862fdade7.pdf

"Ultimately digital transformation is as much about organization change as it is about technology. Insiders who are willing to learn have an advantage because they understand how the business works, they have the relationships to get things done and, most important, they understand what they don't know. They also understand when they need help: Smart insiders hire digital expertise into their team and then lead them to success based on their understanding of how to use digital to serve the business."[111]

5.3.3 Keep an Eye on the Bigger Picture

The excitement associated with digital transformation and IoT projects is infectious from ideation through delivery; but there is a risk that teams can become myopic and neglect bigger picture impacts. As part of governance, leadership should keep a check on oft-overlooked areas and ensure they are addressed during planning and execution.

- **External Factors**: As outlined in IMAGE, there are any number of end-to-end elements that must be considered at the design stage of the IoT program. Some decisions that were made early on for expediency – for example a particular technology decision or partner selection – may need to be reviewed again in a broader context. Factors like technical debt or standards alignment (where technology choice or timing can strand an IoT investment) or supply chain operations (where partner choice can make or break scaling) need to be a part of regular program and progress reviews

- **Employee / People Impacts**: If programs are scoped properly at the outset, the people and operational impacts will have been assessed and addressed in design and planning stages. IoT transformation scale and success relies on finding, creating and motivating digital (technical and creative) talent. Further, while new jobs will be created, others will be gone. As part of governance, then, inspection that these people issues – be it readiness and ability to acquire new talent, addressing potential role changes or creating the right training and tools for today's team - are addressed sensitively, timely and with a strong unified plan, as it is critical to morale, employee engagement and achieving the desired business results.[112]

- **Regulatory Adherence**: Digital business transformation is a great opportunity to build an enterprise framework which is conducive to efficiently meeting a wide range of regulatory constraints dealing with privacy, security, pollution, chain of custody (for certain industries like pharmaceuticals) to name a few. This requirement must be factored in the governance process, as highlighted below:

[111] See: Nathan Furr, Jur Gaarlandt, and Andrew Shipilov, "Don't Put a Digital Expert in Charge of Your Digital Transformation," Harvard Business Review, August 5, 2019, Don't Put a Digital Expert in Charge of Your Digital Transformation

[112] See: Maciej Kranz, "Success with the Internet of Things Requires More Than Chasing the Cool Factor," Harvard Business Review, August 7, 2017, https://hbr.org/2017/08/success-with-the-internet-of-things-requires-more-than-chasing-the-cool-factor Justine Brown, "Why is IoT talent so hard to find?" CIO Dive, August 24, 2017, https://www.ciodive.com/news/why-is-iot-talent-so-hard-to-find/449576/; and Mark Hillsdon, "The 'internet of things': what it is and why business is taking it seriously, " The Guardian (UK), October 17, 2017, https://www.theguardian.com/break-into-tech/2017/oct/17/the-internet-of-things-what-it-is-and-why-business-is-taking-it-seriously

> "*A key initial focus for many CDOs is to get a handle on data governance and regulatory adherence so that the entire organization has a coherent and well-communicated strategy. CDOs can head up coordination between business users and IT to ensure that all personnel are aware of and follow regulations and organizational policies. Most privacy regulations call for greater transparency. The CDO should lead strategies for improving transparency, which often involves setting up better metadata and semantic data management and integration to make it easier to find and track data assets on premises and in the cloud."*[113]

Bottom line, it is the role of governance to bring perspective and oversight to transformation project teams. It is critical that there be proper functional leadership representation (adding, for example) HR, Legal and Regulatory along) as part of governance to keep teams mindful of and addressing these many exogenous factors.

5.3.4 Create the Right Environment

It is easy for an initiative as wide-ranging as digital transformation to get sidetracked and its related projects to go off the rails, especially if the right tone, environment and coordination efforts are not driven and supported by top-level management.

- **Visibility, Transparency and Clarity**: Opacity will destroy digital business transformation before it has even a chance to be felt. A key governance effort (aligned with leadership) is to promote a culture of enhanced visibility of the "why", "what" and "how" of change, which will go a long way towards getting buy-in, collaboration and support from both employees and customers.[114]

- **Rigor and Accountability**: No matter the division of labor, each leader – whether for a specific task, an entire function, or overall project success – must be held accountable for the outcome and the process along the way. Accountability must be clarified and tracked throughout the effort.

- **Failure as a License to Learn**: No one should set out to fail; but not every endeavor will achieve all intended results, especially so for new-to-the-business endeavors, like IoT projects. Without diminishing the rigor needed in up-front planning, project transparency and leadership accountability, the business must be open to and allow for "failures". In some cases, failures are the learning objective for certain kinds of projects. In any event, these should not be treated as a personal or team failings, rather as learnings to be shared and used to improve future projects and outcomes.

Holding leaders to account on a regular basis, with periodic check-ins and coordination, will increase the likelihood of transformation success. But more than closed door project

[113] David Stodder, "Eyes on the Data: The Growing Importance of the CDO," TDWI Website, August 13, 2019, https://tdwi.org/articles/2019/08/14/ppm-all-growing-importance-of-the-cdo.aspx - See also regarding the importance of compliance: Mary Wells," Unveiling ASG's 'Data Intelligence Priorities 2019: The Impact of Digital Transformation on the IT Organization and Data Professionals' Survey Report," ASG Technologies Website, July 23, 2019, https://www.asg.com/en/Resources/Blog/July-2019/Unveiling-ASG-s-Data-Intelligence-Priorities-2019.aspx

[114] See the related research work of Professor Ryan W. Buell at Harvard Business School on operational transparency, e.g., "Operational Transparency," Harvard Business Review, March-April 2019, https://hbr.org/2019/03/operational-transparency

reviews, leaders must ensure there is an ongoing communication plan with proper vehicles to convey vision and mission, plans and progress, successes, setbacks and lessons across the organization to build credibility, maintain momentum and improve likelihood and speed of success over the long haul.

5.4 IMPLEMENT THE SOLUTION

Digital business transformation project implementations, including IoT projects, require a specific (*sui generis*) approach. In the same way each business will have a unique strategy, objectives and roadmap of initiatives, each will also have its own methods for development, staging, release, rollout and scaling of implementations. Even with this, there are still some common factors during this stage that are important for success, especially given the inevitable highs and lows of implementation.

5.4.1 Create Advocates and Agents of Change

Digital business transformation touches a company's whole ecosystem with many "value points",[115] necessitating internal (employees) and external (customers/suppliers) buy-in and training. As underlined in an April 2018 research report on Industry 4.0 by Dr. Irene Petrick and Dr. Faith McCreary from CDAIT Member Company, Intel, effective communication relating to concrete operational concerns is critical:

> *"To successfully navigate the transition, you must be able to translate the grand vision into changes that workers care about, namely solving the problems they face today."*[116]

Rather than taking an "ivory tower" approach with an elite few working on digital initiatives as PoC's or ideas mature, it is important project teams build advocacy and encourage involvement from the start. Change agents – either those impacted by the digital change or future early adopters of new capabilities – must be engaged in the design, delivery and implementation of the program. These change agents will bring invaluable insights into the "as is" state users really face, should be active contributors to defining the "to be" state and be enlisted to assist with the training and rollout of the change. Not only will they be best positioned to educate others, they will become a built-in network of advocates to enroll peers in acceptance and adoption of the new capabilities. A residual benefit of this approach is the cultivation of the next set of digital leaders on the ground in the organization.

5.4.2 Align to an Enterprise Framework

Technologies on which digital business transformation depends are constantly changing.[117] Complicating matters, digital business transformation is more likely to be

[115] Samuel Greengard, "IoT Success Demands Engaged Stakeholders," IoT Playbook, October 29, 2018, https://www.iotplaybook.com/article/iot-success-demands-engaged-stakeholders

[116] Irene Petrick and Faith McCreary, "Industry 4 .0 Demands the Co-Evolution of Workers and Manufacturing Operations," Intel website, April, 2018; https://newsroom.intel.com/news/intel-study-discovers-why-many-factories-stuck-last-century/#gs.vaybv9 and https://newsroom.intel.com/wp-content/uploads/sites/11/2018/04/abstract-intel-manufacturing-research.pdf

confronted with both inertia (due to people reluctant to change (human factor))[118] and the difficulty of meshing new systems with legacy system (technology factor).[119] While it is the responsibility of the program team, with governance checks and balances, to prepare for these hurdles; it is the responsibility of the enterprise to establish the right framework to support them. Specifically, a clear set of digital technical architecture and design principles, grounded in the strategy and objectives of enterprise digital transformation, will be needed to help program teams assess technology change impacts and support / guide key solution design decisions (e.g.: the needed degree of legacy system interoperability or the amount of legacy data migration). These same principles will help address the negative effects of inertia, especially if they are they are consistently used and applied as evaluation criteria and guideposts both for new solutions and continued investments in the current technology estate.

5.4.3 Manage Expectations

In the broadest sense, digital business transformation is a high-stakes enterprise endeavor. As such, overall failure tolerance tends to be low because of the high visibility given to the transformation and its key projects.[120] However, as with any new effort, especially with IoT projects, which are breaking new ground technically, operationally and in business models, there is a risk of failure - delays, de-rails, missed business results. It is also often difficult to manage short-term demands for quick results vs. long-term nature of digital transformation.[121] Because of this, collaboration might be dampened if team members believe there are personally catastrophic consequences of failure (e.g.: demotion, transfer, termination). The following suggestion from Dr. Marie-Agnès Jouanjean, Trade Policy Analyst at OECD [Organization for Economic Cooperation and Development] is worth considering for any industry:

> *"There is a need to manage expectations about what the technology can deliver, to build understanding of and manage potential risks, in order to create the environment of trust that will allow the significant benefits of digitalization…to materialize*."[122]

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[117] Jeannette Chin, Vic Callaghan, and Somaya Ben Allouch, "The Internet-of-Things: Reflections on the past, present and future from a user-centered and smart environment perspective," Journal of Ambient Intelligence and Smart Environments, vol. 11, no. 1, 2019, https://content.iospress.com/articles/journal-of-ambient-intelligence-and-smart-environments/ais180506

[118] P. Brous, M. Janssen, P. Herder, "The dual effects of the Internet of Things: A systematic review of the benefits and risks of IoT adoption by organizations," International Journal of Information Management, May 2019; https://doi.org/10.1016/j.ijinfomgt.2019.05.008

[119] Madhup Mishra, "IoT and the legacy system apocalypse," IoT Agenda, December 2019; https://internetofthingsagenda.techtarget.com/blog/IoT-Agenda/IoT-and-the-legacy-system-apocalypse

[120] Dusty Weiss, "5 Reasons IoT Projects Fail," Association for Equipment Manufacturers, January 2018; https://www.aem.org/news/january-2018/5-reasons-iot-projects-fail/; David Linthicum, "5 IoT project failures that could get you fired," TechBeacon; https://techbeacon.com/app-dev-testing/5-iot-project-failures-could-get-you-fired

[121] Nick Ismail, "The Internet of Things hype versus reality for businesses," Information Age, April 2018, https://www.information-age.com/iot-hype-reality-business-123471438/; April Hamilton, " Managing IoT User Expectations - Developers must recognize and accept that consumer expectations are unrealistic," A Cloud Guru, February 2017, https://read.acloud.guru/managing-iot-user-expectations-7722ad1f4a23

[122] Marie-Agnès Jouanjean, "Digital technologies will profoundly impact the way we grow and distribute food: here's how," Journal of Consumer Protection and Food Safety, June 2019, Volume 14, Issue 2, pp 103–104, https://link.springer.com/article/10.1007/s00003-019-01224-6

At the outset, then, project leaders must set reasonable expectations for their programs - establishing a risk and outcome profile for the project, setting performance tolerances, securing early buy-in from leadership on the allowable upside/downside and having pre-defined triggers via the governance process to take (or not take) corrective actions. This will help avoid any hasty actions or reactions when the inevitable program fluctuations occur and will give projects and teams the runway they need to allow their programs to achieve the intended results.

5.5 TRACK EFFECTIVENESS

Success requires sustained effort over time. Similarly, a digital business transformation project does not end with the installation and activation of the new products, services and processes. Instead, after delivery, the transformation components must be closely tracked and quickly adjusted to ensure they continue to provide the desired effects.

Many project management practices recognize that cardinal attention must be given to the tracking step. The Plan-Do-Check-Act (PDCA) cycle[123]; the Supply Chain Operations Reference (SCOR) model[124]; the Design Thinking process[125]; the Hoshin Kanri planning process[126] and the Define Measure Analyze Improve Control/Verify (DMAIC/DMAIV) Processes [Six Sigma][127], presented here without any order of priority, are examples of inherently iterative and dynamic methodologies incorporating post-delivery support, reviews and adjustments.

Digital Transformation is no different, except that since digital transformation is always a work in progress (due to a wide array of factors such as continuous innovation induced by rapid technological evolution), it can never be closed.

5.5.1 Establish Specific Digital Measures of Success

What to measure to determine your digital business transformation success? Well, there is simply no cookie-cutter answer; but Gartner has provided useful guidance into how to think about KPIs differently.

They advise to look at KPIs in two categories. The first is around the company's progress in digitizing its current business model by measuring goals in sales, marketing, operations, supply chain, products/services and customer service. The second set of KPIs should assess growth, revenue, market share and margin related to new digital business models, differentiated from traditional models.[128]

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[123] See: American Society for Quality (ASQ) website, https://asq.org/quality-resources/pdca-cycle
[124] See: Association for Supply Chain Management (ASCM) website, https://www.apics.org/apics-for-business/frameworks/scor
[125] See: The Interaction Design Foundation (IDF) website, https://www.interaction-design.org/literature/topics/design-thinking
[126] See: Harry Witcher, "Hoshin Kanri through the eyes of English Language Texts," Perspectives on Performance - Volume 11, Issue 1, 2014, pp. 16-24, https://www.pmaconference.co.uk/assets/downloads/news-volume-11-issue-1.pdf
[127] See: ASQ website, https://asq.org/quality-resources/dmaic
[128] Clint Bolton "Digital KPIs: Your keys to measuring digital transformation success", CIO.com, Sept 2018; https://www.cio.com/article/3236446/digital-kpis-your-keys-to-measuring-digital-transformation-success.html?upd=1568838219047

With the human element – both that of customers and employees – being a critical component to digital business transformation and experiences, there is also value in formally measuring customer and employee engagement – through vehicles like customer and employee NPS (net promoter score).

Based on this, the enterprise should define KPIs upfront aligned to digital strategy and the related IoT/digital business transformation value drivers – be it cost, revenue and/or experience-driven value. As example: measures can include efficiency gains or cost reductions based on shifts from traditional to digital engagement, digitally driven revenue growth in the core business and/or for new IoT/digitally enabled business models, improved customer experience (NPS) or improved employee experience (eNPS), which can include growth in digital learning, reduction of non-value added tasks and increased digital collaboration.

Finally, don't measure too much - especially at an executive level, focus on the handful (five to eight) measures that really matter to your business. Measures should be developed based your specific industry, aligned to your strategic transformation objectives, your current state and aspirations and still be precise enough to point to and drive specific action should performance dictate corrections are needed. Ask a few of the following questions to improve the quality of your digital KPIs:

- *What is being measured? (e.g.: percent of digital interactions, eNPS)*
- *Where are we today?*
- *What is our target goal?*
- *What is our desired business outcome and benefit?*
- *What is our balance point? (i.e.: when do we see diminishing returns on further investment/change in this area)*[129]

5.5.2 Put Measures of Success in Business Context[130]

Most importantly, your new digital KPIs must be tied to business outcomes. To elaborate, old measures of technology performance - defects per lines of code, mean-time-between-failures, developer productivity - simply don't translate well into this new world driven by outcome and value delivery. While high code quality, low down time and effective use of talent are still important, to secure ongoing support for digital business transformation initiatives (and investments needed to continuously improve), it is important to contextualize measures in terms those holding the purse-strings and setting the priorities understand - that of business risk and value. An example provided by Gartner relates to how an IT department at a car manufacturer frames digital risk:

> *"In [the] manufacturing plant, a car rolls off the production line every 90 seconds. One hour of line stoppage due to IT issues means 40 "lost" cars. This…puts*

[129] Gartner insights, "How to Measure Digital Transformation Progress", October, 2018; https://www.gartner.com/smarterwithgartner/how-to-measure-digital-transformation-progress/
[130] ibid

digital risk in a business context, by reporting on inventory, revenue and other direct business impacts instead of downtime."

A final thought from Gartner than rings true is that "when a metric has business context, it is much more interesting to the intended audience - and more effective".

5.5.3 Adopt a Perpetual Beta / Continuous Innovation Mindset

As technology continues to evolve, customer expectations continue to elevate and digital disruption becomes the norm, it is important to recognize that there is no "done" in digital business transformation - it is a journey rather than a destination.

The data and insights that come from assessing KPI performance, surveying customers and employees and measuring business results are, in effect, inputs and guideposts for the journey. This input, along with market outlooks and other leading indicators will spur additional digital improvements, ideas and disruptions. Some will flourish, others will fail. What is important, though, is to adopt a "perpetual beta mindset".[131] Similar to the world of software development, where iteration and improvement is the norm, the organization overall needs to welcome continuous evolution and change. This means testing and trying new ideas, technology and partnerships, seeing what fits and works and allowing for not just success or failure, but continual iteration and innovation based on learnings.

This has cultural, organizational and process implications. Culturally, there needs to be the right mindset. This includes creating an environment of openness, trust and receptivity to and outreach for feedback - from employees, customers, users and prospects - as their inputs might be the nugget for the next iterative change, disruption or transformation. From an organization and process perspective, there needs to be a means to accept, assess and harness innovations and learnings and allow them to be nurtured. This could be fashioned as a continuation of an enterprise digital transformation team, or it might take the form of a new organization focused on digital business innovation. While we cannot suggest what might be right for every enterprise, we strongly believe that cultivating this mindset of perpetual learning, change and evolution (living in "perpetual beta") is critical to avoid complacency and continue the digital drive forward.

6 CONCLUSION

Digital business transformation is a broad-based, long-term, dynamic process, which includes many moving parts. Internet of Things technologies as a whole constitute one of these critical foundational parts. As such there is a tightly coupled relationship between the two - the success of IoT programs rests on the same foundation and

[131] See; Mike Willis, "Build a Perpetual Beta Mindset to Speed Organizational Change," Perficient website, July 22, 2018, https://blogs.perficient.com/2018/06/22/build-a-perpetual-beta-mindset-to-speed-organizational-change/ and Abhijit Bhaduri, "What does it mean to live in Perpetual Beta," Linkedin blog, March 2, 2017 https://www.linkedin.com/pulse/what-does-mean-live-perpetual-beta-abhijit-bhaduri

success factors as Digital Business Transformation and digital transformation success for many enterprises rests on delivering the transformative business value of IoT.

It therefore holds true that, regardless of the non-trivial technological dimensions of IoT - such as those in play today (like artificial intelligence, cloud/edge computing; communications protocols (from low power to 5G) or miniaturized sensing and actuating devices with increasing capabilities) or those farther out and less widely in play (like quantum computing, bio-transistors or advanced energy harvesting) - IoT programs as part of Digital Business Transformation are first and foremost undertakings firmly and deeply rooted in business.

Making it exclusively a technological endeavor not only misses the point, but is downright risky if not dangerous for the firm across multiple dimensions - not only technical; but also financial, operational, cultural, managerial - and even risks company brand and reputation - as evidenced by our elaboration of risks and mitigations.

Therefore, the tools provided here - the IMAGE model, the DIGIT framework and our recommendations, which are designed to augment traditional project, delivery and management practices - start and finish by looking at the whole and addressing both the "what" (i.e.: what is important, what must be addressed) and the "why" (i.e. why are we doing this, why should we continue).

However highly complicated the technical dimension of IoT is, which, if anything, will become even more so and whose effective and efficient handling allows no shortcuts or vague approximations, the human dimension, albeit fuzzy and somewhat volatile, is much more complex and in need of leadership and management attention.

Companies contemplating launching digital transformation initiatives and/or initiatives powered by IoT would be well served to integrate early on these two strategic keystones: business (the end-game) and people (the engine), in their thinking.

Success in digital transformation, and therefore IoT-driven digital programs, will come to those who take the time to:

- Thoroughly understand the reasons that justify and support this undertaking;
- Acknowledge that it can only be achieved by, through and for their various stakeholders;
- Establish the proper program framework, taking a holistic approach and setting reasonable objectives accordingly; and
- Recognize the broad enterprise impact and plan for ongoing digital evolution and change.

APPENDIX I - ADDITIONAL CDAIT MEMBER VIEWS

This Appendix I provides a sample of both past and present CDAIT members' views on Digital Transformation and IoT[132].

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ABOUT CDAIT

CDAIT Vision and Mission

The Center for the Development and Application of Internet of Things Technologies (CDAIT, pronounced “sedate”) is a global, nonprofit, partner-funded center located in Atlanta that fosters interdisciplinary research and education while driving general awareness about the Internet of Things (IoT).

CDAIT bridges sponsors with Georgia Institute of Technology (Georgia Tech) faculty and researchers, as well as industry members with similar interests. Central to its value proposition is the belief that only a holistic approach, i.e., mindful of the complexity of the entire IoT value chain and the intricate relationships between the various links, can generate superior results.

CDAIT’s broad overarching goal is to expand and promote IoT’s huge potential and transformational capabilities. CDAIT aims to efficiently identify, understand, and solve challenges and problems that may arise along the entire Internet of Things value chain through six Working Groups: IoT Education and Training; IoT Startup Ecosystem; IoT Thought Leadership; IoT Security and Privacy; IoT Standards and Management; and IoT Research.

For more information, including the current membership list, visit https://cdait.gatech.edu.

The CDAIT IoT Thought Leadership Working Group

While there are many technological challenges that are inherently tied to the development of the Internet of Things (IoT), there are also a number of non-technological, yet critical, issues that must be addressed for IoT to succeed at any level. The CDAIT IoT Thought Leadership Working Group is tasked with exploring these dimensions and hurdles, which are rooted in the radical business, economic and societal transformation the Internet of Things is bringing about. Business models; monetization; technology awareness, acceptability, and accessibility; and ethical, legal, policy and regulatory frameworks are only a few examples of such potential research areas. This is a multidisciplinary undertaking, which encompasses a host of perspectives, including especially those found in social sciences and humanities. By focusing on these crucial issues, the IoT Thought Leadership Working Group strives to ensure IoT is implemented in a seamless, sustainable and impactful way.

Additional IoT thought leadership perspectives can be found on the CDAIT website at:
https://cdait.gatech.edu/thought-leadership

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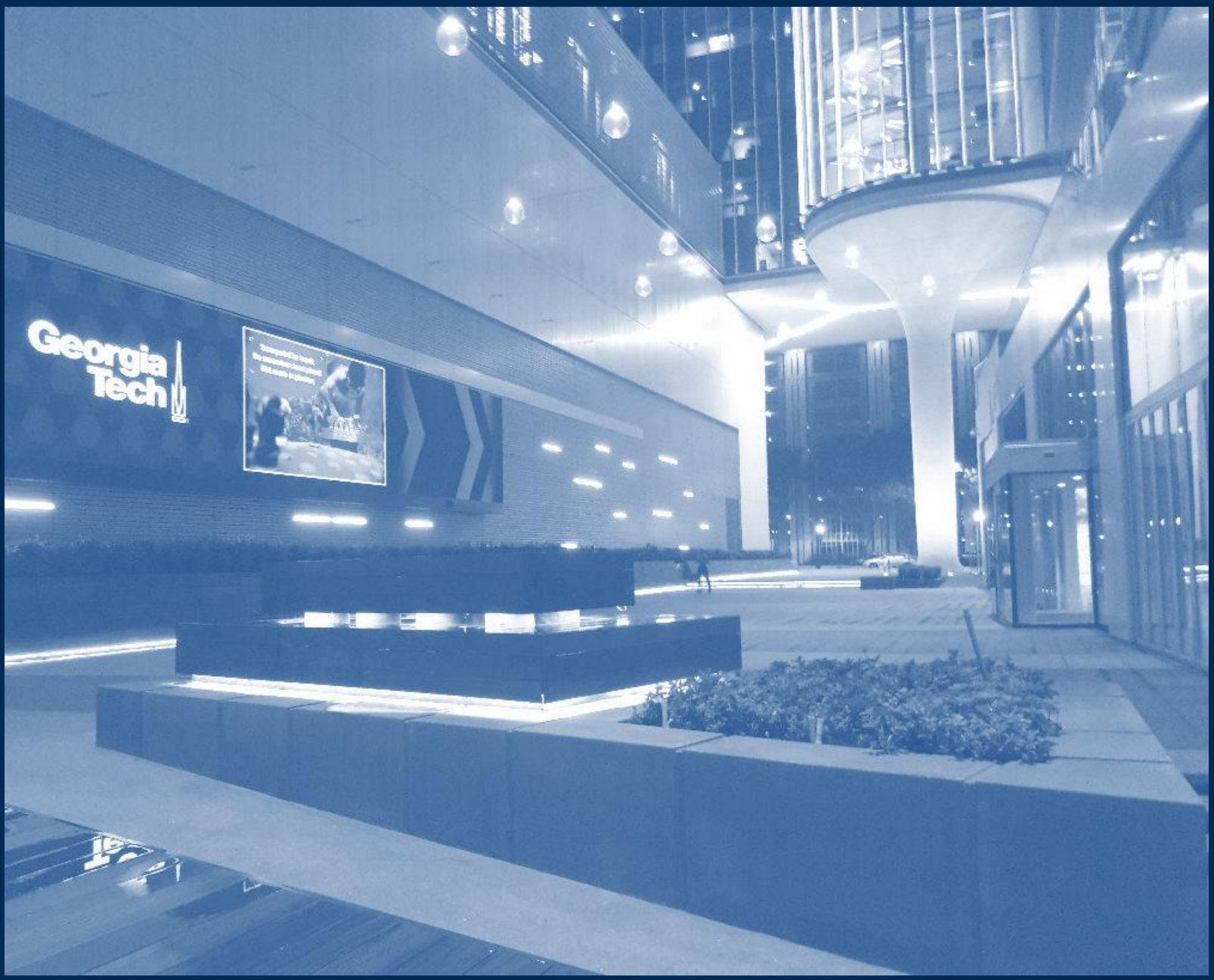

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