PROJECT REPORT: AIRS TECHNOLOGY FORESIGHTING

University of Toronto
APS1049H: Management Consulting for Engineers
By: Akshat Mathur,
Chung Hong Ng, Rishabh Nanda, Amine Mikati, and
Yosua Husodo

TABLE OF CONTENTS

Acknowledgments

On behalf of our team, we would also like to thank Deloitte LLP as our client throughout this project. A very special thank you to Ish Habib and Jeff Booth for the guidance, support, and professional insights throughout this project. Your experience as Management Consultants made this project such a remarkable learning experience for us, and we cannot thank you enough for that.

We would also like to recognize Professor Stephen Armstrong for guidance throughout this project. The tools provided equipped us with fundamental concepts that applies to the case presented by our client.

Executive Summary

This report presents a framework for Deloitte to identify the maturity of an emerging technology developed based on four preceding technologies. The AIRS Technology Foresighting Framework presents itself under four pillars: applicability, impact, risks, and sustainability. Each component is defined below:

Applicability: The relevance to business challenges
Impact: The value created to the client's business
Risks: The exposure to uncertainties on the client
Sustainability: The ability to adapt to market changes

Each pillar consists of five assessment questions, all of which are mutually exclusive to the problem statement. The AIRS Technology Foresighting Framework was tested by individuals who have not previously used the assessment on several recent technologies to ensure the validity and minimize biases.

We concluded that this framework is a valid assessment in determining the maturity of emerging technologies. This does not mean that an "immature" technology is not adoptable but may be associated with more challenges than those that are "mature." This assessment should be an initial test for emerging technology for Deloitte. A more stringent evaluation should be performed to identify the adoptability of the given technology.

Introduction

In a world so dependent on technology, companies are looking for new cutting-edge technologies to leverage the operations of the organization. The variety of technologies creates multiple levels of competitive advantage, such as data science, increased operational efficiency and productivity, and cost-efficiency.

The rapid growth of emerging technologies makes it difficult for organizations to adopt and stay current with market trends. Being a globally acknowledged consulting firm, Deloitte wants to take a more aggressive approach and to recommend emerging technologies that will support the clients' needs. Thus, Deloitte needs to identify and analyze the trends and patterns of emerging technologies.

Client Profile

Deloitte is a globally acknowledged firm that provides audit & assurance, consulting, financial advisory, risk advisory, and tax-related services to both public and private clients globally. Deloitte services four out of five Fortune Global 500® companies through a network of firms in more than 150 countries. This brings in world-class capabilities, insights, and services to address complex business challenges that their clients face.

Deloitte LLP is the Canadian firm of Deloitte Touche Tohmatsu Limited, which is a network of firms that are legally independent entities. Under the Deloitte LLP is OMNIA AI, Deloitte's collaborative team of Artificial Intelligence (AI) experts who seek to recommend cutting-edge technologies to facilitate successful technological transformation. With the ability to develop AI-enabled solutions to address the client's journey, the OMNIA AI team aims to emphasize the business outcome of their client as well.

Goals and Objectives

The purpose of this project is to develop a framework to determine the maturity and applicability of emerging technology. Currently, Deloitte identifies themselves as a "fast-mover" in recommending new technologies to their clients. With goals to be an industry leader, Deloitte wants to take calculated risks and recommend cutting-edge technology to its clients before the technology becomes a market trend.

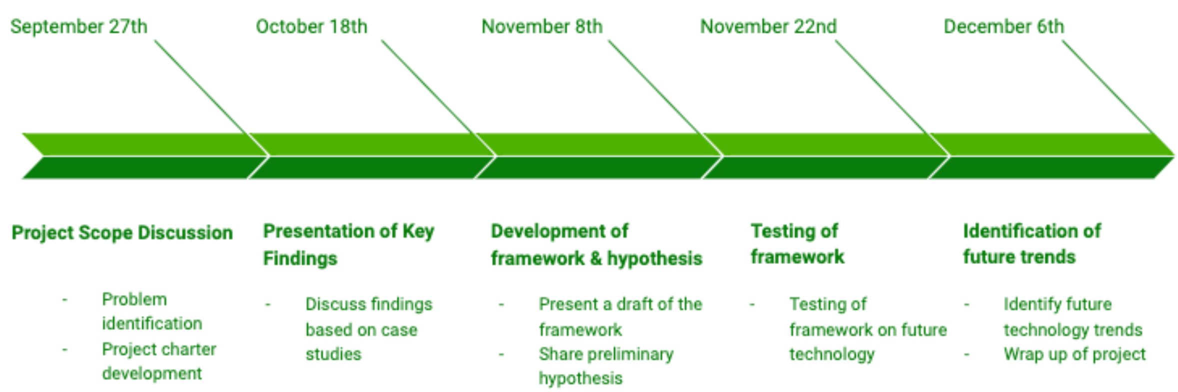
Problem Statement

How can Deloitte identify future technology trends and determine the maturity and applicability to their clients?

Project Scope

The AIRS Technology Foresighting framework is an assessment tool that seeks to present where technology sits on the maturity curve. The assessment criteria presented under each pillar are meant to be subjective as a "first pass" for the technology. The adoptability of a given technology is not within the scope of this project.

Project Timeline



The Approach & Methodologies

The following section presents an in-depth analysis of the four case studies. The outline is as follows: background information, the sectors it applies to, the pros and cons, and how the technology come to maturity.

Case study 1: Cloud Computing

Background:

Many believe Joseph Carl Robnett Licklider invented cloud computing in the 1960s with his work on ARPANET to connect people and data from anywhere at any time. However, its commercialization boosted by Amazon through its Amazon Web Services (AWS) in the early 2000s. A model based on cloud computing enables convenient, on-demand network access to a shared pool of configurable computing resources (i.e., networks, services, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction (Mell & Grance, 2011, p. 2). The main idea behind a cloud-based system model involves organizations migrating their IS/IT from an in-house server to a cloud server. As a result, companies could outsource their information technology needs to cloud-based providers (Geczy et al., 2012, p. 58) such as Amazon or IBM.

For a cloud computing system to be functional, total outsourcing costs should be lower than their information technology investments; hence, such technology creates savings for the organizations. Cloud computing providers supply services to multiple organizations and exert the economy of scale. Thus, they can offer attractive pricing to the customers and yet maintain reasonable margins.

There are three broad categories under which cloud computing can fall depending on the stage of technological advancement. These categories are

1. Software-as-a-Service (SaaS): It delivers a single application through the browser to customers using a multitenant architecture. From a customer's perspective, no upfront investment in servers or software licensing is necessary. Contrary to that, providers only need to maintain one application, which is far more cost-efficient.
2. Platform-as-a-Service (PaaS): It delivers development environments as a service. Customers build their applications that run on the provider's infrastructure to be delivered to users via the internet.
3. Infrastructure-as-a-Service (IaaS): In this case, an organization outsources the hardware used to support operations, including storage, hardware, servers, and networking components. The service provider owns the equipment and is responsible for housing, operating and maintaining it. The client typically pays on a per-use basis.

Some significant applications of cloud computing are Storing File Online, Video Making and Editing Software, File Converters, Anti-Virus Applications, E-commerce Application, Business Process, Big Data Analysis, and Backup and Recovery. These applications can be performed in multiple industries causing the cost to be much more affordable than in previous years.

Advantages of Cloud Computing:

Cost-Effectiveness– The primary reason behind the shift to the cloud is the cost-efficiency of the technology in comparison to on-site storage. This stems from the fact as it does not need any physical infrastructure investments or any expert management.

*Unlimited Storage– T*he most significant advantage of cloud computing is the endless storage capacity which can be expanded on a nominal monthly fee.

Reliable and Secure– Data safety and security is the key to cloud computing. Unlike traditional storage infrastructure, the cloud offers a more secure ecosystem, which significantly lowers the chances of hacking, malware, and virus threats.

Scalability– Cloud computing allows for increased integration between different areas of business operations which improves efficiency and performance. Cloud helps integrate various tools like Basecamp, Salesforce, Hive, etc.

Flexibility– Cloud allows accessing of data or files from any location. This is very handy for new work cultures, where many employees are working remotely and having access to work-related documents is essential.

Disadvantages of Cloud Computing

Network Dependent– Cloud computing is entirely dependent on the network. A reliable, consistent and fast internet service is required.

Downtime– Any technical glitch due to any reason like a power outage, low internet speed or connectivity, maintenance of data centers can result in downtime, which can be taxing for the business.

Vendor Lock-In– Shifting between clouds can be challenging due to the inherent differences in the vendor platform requirements. Migration can also lead to issues related to support, complexities of configuration and other additional costs. Such transfers often also make the data vulnerable to different security concerns due to compromises and changes made to facilitate the migration.

Limited Control– As your data is on remote servers managed by service providers, your control over it becomes limited, especially for businesses that seek enhanced control over their back-end infrastructure.

Case study 2: Artificial Intelligence (AI)
Background:
AI is one of the most popular and robust technology, with a tremendous impact on people's lives. Despite constant developments and improvements, AI has reached a point where corporations are comfortable implementing this technology for various purposes.

The term artificial intelligence emerged in 1956, but AI has become more popular today due to increased data volumes, advanced algorithms, and improvements in computing power and storage. (SJ Russell, P Norvig - 2016) Artificial intelligence (AI) makes it possible for machines to learn from experience, adjust to new inputs and perform human-like tasks.

Artificial intelligence can be broken down into 3 main categories: artificial narrow intelligence, artificial general intelligence, and artificial super intelligence.

1. Artificial Narrow Intelligence: Narrow AI is the only category that has been achieved today developed to perform tasks such as facial recognition, suggestion systems, and sales forecasting. Computer vision and natural language processing are still considered narrow AI as it requires data input for learning and cannot perform any action unsupervised.
2. Artificial General Intelligence: General AI is known as a human-level AI with the ability to understand and reason the world as well as any human and perform a wide range of tasks. General AI is capable of performing any task a human could and likely many that a human could not. General AI has the potential to combine human-like thinking and reasoning with advanced computational performance.
3. Artificial Super Intelligence: Nick Bostrom (2014) describes Super AI to have intelligence beyond the capacity of a human brain in every category, such as innovation, wisdom, and social skills.

Advantages of AI:
Impact on multiple fields– AI has a significant impact on many of the fields. It includes Natural Language processing, vision system, speech recognition, medical industry, robotics, and self-driving vehicles. Integrating AI system makes the systems listed more effective compared to traditional automation.

Increased efficiency– AI impacts different industries as it automates repetitive learning and discovery through data, which significantly increases productivity. Instead of automating manual tasks, AI performs regular, high-volume, computerized duties reliably and without fatigue.

Easy integration with existing products– AI can be integrated with current technologies to improve its performance and make it 'smarter.' AI will unlikely be sold as a separate product, instead, integrated into an existing product to enhance its capabilities and performance. One example is Apple's Siri; an AI virtual assistant uses a natural language user interface to respond to the user's voice queries, which is added to Apple's product line as a critical feature.

High level of accuracy– AI helps reduce human error in achieving error-free decision making. AI decisions taken by machines are based on previous data inputs as well as algorithms for actions. Assuming the programming of AI is errorless, solving complex problems that require complicated calculations can be done without any scope of error.

Disadvantages of AI:
Unemployment– Since AI can automate repetitive human jobs, the job market for less-skilled workers will decline. Robots have already taken assembly line jobs. As AI gets better at performing complex tasks, more and more of these jobs that do not require special skills will diminish, causing unemployment.

Wealth inequality– The economic system is based on compensation for contribution to the economy, often assessed using an hourly wage. The majority of companies still depend on hourly work when it comes to products and services. By using artificial intelligence, a company can drastically cut down on relying on the human workforce, which means that revenues will go to fewer people. Consequently, individuals who have ownership of AI-driven companies will make all the money.

Ethical issues– Since AI can be integrated with existing technology to improve its functionality and automates the process; it will bring up ethical issues as a drawback. Take the self-driving car as an example; AI is integrated into the system to make decisions and drive the car; if the autonomous vehicle is involved in an accident, the liability will be unclear.

Case study 3: Drone Technology

Background:
Drones have reached a tipping point. The ability to inspect remote locations, respond to emergencies, and deliver products have taken accessibility to a different stage. Tech companies are reaching a point where drones are safe enough to operate alongside other aerial transportation. Drones are dropping off food, vaccines and blood samples from skies in some parts of the world. These things went from toys to tools that we might be able to use on a commercial scale.

Drone or UAV (Unmanned Aerial Vehicle) is an aircraft with no onboard or passengers. It can be automated or remotely piloted. They can fly for extended periods at a controlled speed and level of height, and a role in many aspects of aviation.

The earliest unmanned aerial vehicle in the history of drones was seen in 1839 when Austrian soldiers attacked the city of Venice with unmanned balloons filled with explosives. The Wright

Brothers' famous Kitty Hawk flight was in the autumn of 1900, and only 16 years later, Great Britain developed the first pilotless winged aircraft: the Ruston Proctor Aerial Target. The Aerial Target was based on designs by Nikola Tesla and was controlled with radio control, much like the drones of today (though the technology was much more rudimentary.)

However, recreational drone use took off very recently but has multiplied. Convincing the Federal Aviation Administration that commercial drones were safe led to the development of commercial drones. Recently, companies such as Amazon have explored the use of unmanned aerial vehicles for commercial purposes. Amazon Prime Air has promised a 30-minute delivery service for packages up to 5 lbs. Google, in altruistic contrast to Amazon, has developed aerial drones for environmental conservation and delivery of medicine to remote locations.

Applications of drones:
Agriculture– Farmers and agriculturalists are always looking for cheap and effective methods to monitor their crops regularly. The infrared sensors in drones can be tuned to detect crop health, enabling farmers to react and improve crop conditions locally, with inputs of fertilizer or insecticides.
Delivery– Major companies like Amazon, UPS, and DHL are in favour of drone delivery. Drones could save a lot of manpower and shift unnecessary road traffic to the sky. Besides, they can be used over smaller distances to deliver small packages, food, letters, medicines, beverages and the like.

Law enforcement– Drones are also used for maintaining the law. They help with the surveillance of large crowds and ensure public safety. They assist in monitoring criminal and illegal activities. Border patrol monitors fire investigations, migrant smugglers, and illegal transportation of drugs via coastlines with the help of drones.

Emergency services– The presence of thermal sensors gives drones night vision and makes them a powerful tool for surveillance. Drones can discover the location of lost persons and unfortunate victims, especially in harsh conditions or challenging terrains. Besides locating victims, a drone can drop supplies to unreachable areas in war-torn or disaster-stricken countries.

Environmental monitoring and conservation– Available to amateurs and professionals, drones can acquire very high-resolution data and download imagery in difficult-to-reach locations like coastlines, mountaintops, and islands. They are also used to create 3D maps and contribute to crowdsourced mapping applications.

Media– Drones are now being used to capture footage that would otherwise require expensive helicopters and cranes. Fast-paced action and sci-fi scenes are filmed by aerial drones, thus making cinematography easier. These autonomous flying devices are also used in real estate and sports photography.

Advantages of drones:
Quality aerial imaging– Drones can take high-quality aerial photographs and video and collect vast amounts of imaging data. These high-resolution data can be used to create 3-D maps and interactive models, which have many beneficial uses. This includes mapping of disaster areas that can enable rescue teams to assess the site before entering hazardous situations.

*Precisio*n– Since unmanned aerial vehicles are equipped with GPS, they can be programmed and maneuvered accurately to precise locations. This is helpful for agriculture purposes where UAVs are used to fertilizer and insecticide, identifying weed infestations and monitoring crop health, all of which save time and cost.

Easily deployable– The rapid technological advancement allows drones users to operate drones with minimal experience. Combined with the relatively low cost, drones are much more accessible to a wide range of operators. UAVs also have a greater range of movement than manned aircraft, being able to fly lower and in more directions, which allows them to navigate hard-to-access areas easily.

Disadvantages of drones:
*Uncertainty in legislatio*n– Since the widespread use of unmanned aerial vehicles is relatively new, law is still catching up. The Federal Aviation Administration has established specific rules for small, unmanned aircraft that apply to commercial and recreational use, but there are still ambiguities. Questions include how best to determine airspace property rights and protect landowners from aerial trespassing.

Safety– Safety is a primary concern when dealing with unmanned aerial vehicles. UAVs need to be programmed with "sense and avoid" capabilities to avoid mid-air collisions. In the event of system failures, the ground impact is another danger, primarily when drones are used near large crowds.

Privacy– Drones can collect data and images without drawing attention, leading many rights of privacy may be in jeopardy if government entities were to use drones to monitor the public.

Risk of atrocities– The accessibility and convenience of drones attracted not only tech geeks and hobbyists, but also people with illegal motives. Terrorists and criminals have found ways to use drones for their malicious interests.

Case study 4: Blockchain

Background:
Blockchain is a reliable, difficult-to-hack record of transactions based on distributed ledger technology, which securely records information across a peer-to-peer network. Although it was created to trade Bitcoin, blockchain's potential reached far beyond cryptocurrency. Blockchain ledgers can include land titles, loans, identities, logistics manifest, and almost anything of value. The technology is still new, but it has a tremendous amount of potential to impact various business sectors. This may include automotive, financial, government, healthcare, insurance, media & entertainment, retail, travel and transportation.

A distributed ledger is a database of transactions that is shared and synchronized across multiple computers and locations without centralized control. Each party owns an identical copy of the record, which is automatically updated as soon as any additions are made — a blockchain records data across a peer-to-peer network. Every participant can see the data and verify or reject it using consensus algorithms. Approved data is entered into the ledger as a collection of "blocks" and stored in a chronological "chain" that cannot be altered.

Companies using blockchain:

Naturipe– is implementing blockchain to digitally track crops from their point of harvest along the supply chain. Thanks to this technology, Naturipe will be able to deliver fresh fruit faster and provide consumers with proof of the grower's sustainability practices.

Boehringer Ingelheim– a global pharmaceutical company and SAP co-innovation customer, is using a blockchain-based system to verify the authenticity of pharmaceutical products and combat counterfeits.

Sudtirol– The Italian region of South Tyrol is pioneering the use of blockchain to replace inefficient legacy systems, break free from excessive government bureaucracy, and comply with European data-sharing regulations.

The potential uses of blockchain are:

Supply Chain– Blockchain technology has the potential to improve transparency and accountability across the supply chain. Applications are already being used to track and trace materials back to the source, prove authenticity and origin, get ahead of recalls, and accelerate the flow of goods.

Public Sector– The public sector is looking at the potential of blockchain to serve as the official registry for government and citizen-owned assets like buildings, houses, vehicles, and patents. Blockchains could also facilitate voting, reduce fraud, and improve back-office functions like purchasing.

Utilities– Blockchain software solutions are being tested for a wide range of applications in the utility industry: peer-to-peer solar energy sales between neighbours, energy trading among utility conglomerates, automated billing for autonomous electric vehicle charging stations, and more.

Advantages of using blockchain:

Fewer Intermediaries– Blockchain is an actual peer-to-peer network that will reduce reliance on some types of third-party intermediaries such as bankers, lawyers, and brokers.

Faster Processes– Blockchain can speed up process execution in multi-party scenarios and allow faster transactions that are not limited by office hours.

Transparency– Information in blockchains is viewable by all participants and cannot be altered. This will reduce risk and fraud and create trust.

ROI– Distributed ledgers will provide quick ROI by helping businesses create leaner, more efficient, and more profitable processes.

Security– The distributed and encrypted nature of blockchain mean it will be difficult to hack. This shows promise for business and IoT security.

Automation– Blockchain is programmable – which will make it possible to automatically trigger actions, events, and payments once conditions are met.

Disadvantages of blockchain are:

Data modification– Once data has been added to the blockchain, it is complicated to modify it. While stability is one of blockchain's advantages, it is not always right. Changing blockchain data or code is usually very demanding and often requires a hard fork, where one chain is abandoned, and a new one is taken up.

Private keys– Blockchain uses public-key (or asymmetric) cryptography to give users ownership over their cryptocurrency units (or any other blockchain data). Each blockchain address has a corresponding private key. While the address can be shared, the private key should be kept secret. Users need their private keys to access their data. If a user loses their private key, the data is effectively lost, and there is nothing they can do about it.

Storage - Blockchain ledgers can grow very large over time. The Bitcoin blockchain currently requires around 200 GB of storage. The current growth in blockchain size appears to be outstripping the growth in hard drives, and the network risks losing nodes if the ledger becomes too large for individuals to download and store.

Framework

Based on the case studies, we developed a framework to identify technology maturity and applicability based on the technologies analyzed. This step is essential to provide an understanding of the indicators to determine whether a technology is mature, maturing or still immature. These indicators act as pillars of the decision-making criteria and are developed to be mutually exclusive and collectively exhaustive (MECE). The aim of considering the MECE approach was to reduce the complexity by avoiding overlaps among sub-criteria while ensuring a comprehensive collection of all possible options without leaving alternatives.

To make sure that the framework is framed with a holistic approach, rigorous analyses of various types of framework models were conducted, including process maps and a pyramid-hierarchy, among others. However, as this framework is the first-level analysis of a technology, we determine that an equally weighted process map would be most suitable. All the pillars of the framework are equally important (as shown in appendix A) so that the framework as a whole gives the Deloitte an understanding if additional resources are required to be put into further research into the technology maturity and applicability. Each pillar consists of five assessment questions, and the components are listed below:

1. Applicability: Seek to assess the relevance of the technology to the business challenge(s) of the company or the industry. Criteria to assess this pillar can be found in appendix C.
2. Risk: Covers the uncertainties that the technology might bring in the industry or on the client's business. Criteria to assess this pillar can be found in appendix D.

3. Impact: Assess the value created by the technology in the client's business once matured and applicable enough to be considered. Criteria to assess this pillar can be found in appendix E.
4. Sustainability: The ability of a technology to adapt to the market change defines this pillar of the framework. Criteria to assess this pillar can be found in appendix F.

Assessment

The questions cover the common themes identified from the cases provided above to determine the maturity level of the technology. A broad set of questions was developed to ensure validity regardless of the type of technology. All the items are mutually exclusive, and they can be found in appendix B.

This framework does not use a quantitative assessment methodology. The technology analyzed in this framework is expected to be in its early stages, so the scarcity of information is a challenge for a numeric evaluation. Because the questions are expected to cover a wide range of technology, a qualitative assessment is more appropriate.

Each assessment matrix used for each question will be translated into a heat map as shown in appendix G. At the question-level, the heat map is broken down into three segments, while at the pillar level, the spectrum of the heat map consists of five divisions: red, yellow and green. However, since the pillar-level matrix has five portions, we added two additional segments are red-yellow and yellow-green, further clarify the maturity level of the technology as shown in appendix H.

The heat map is translated to a numeric system to calculate the pillar-level and overall state of the technology. Therefore, red corresponds to one, yellow to two and green as three. The average of all values of a pillar is taken to determine the maturity level. Moreover, since the framework is mutually exclusive, the questions are weighted equally. Lastly, an average calculation of the pillar-level values is computed to obtain the overall maturity of the technology.

Hypothesis

Based on the above assessment, if the overall evaluation of the technology falls in the yellow spectrum or above, it is mature enough for the next assessment process. However, if it falls in the red spectrum, the technology is immature. If the assessment of technology falls in the yellow spectrum, the technology is on a path to maturity. Any technology that falls in the green spectrum is a mature technology that can be adopted, but more than likely already commercialized, thus, not providing any competitive advantage to Deloitte's clients.

Testing the Framework

Quantum Computing

It is an emerging technology with the ability to solve many problems that cannot be done by a supercomputer. It takes advantage of subatomic particles to exist in more than one state at a given time. Because of the particle's behaviour, operations can be done more efficiently with less energy usage than classical computers.

The applicability of quantum computing falls in the yellow-green spectrum. Some sectors and/or processes that it is capable of including Monte Carlo Simulation, financial modelling, weather forecasting, particle physics, and drug discovery. On the other hand, quantum computing can be integrated with existing systems with additional effort as it requires specific firmware and drivers. The customizability of quantum computing can change its core function according to the software that it is running. However, the market acceptance of quantum computing is low due to the small number of companies investing in technology primarily because of its high cost. Further, only a tiny section of the market requires the computational advancement of quantum computers.

Risks fall in the yellow spectrum for this technology. Currently, quantum computers are not able to untangle the complexity of molecular interactions or factor large prime numbers. However, in the future, quantum computing may be able to do just that. And because a sufficiently powerful quantum computer could run Shor's algorithm and factor complex prime numbers, encryption would be of limited utility. Due to the enormous computational power of quantum computing, it will cause privacy issues and hence bring negative social stigma to the technology as many may think that if hackers are using a quantum computer, internet security will be a great concert. To address this possible privacy issue, regulations with regards to the use of quantum computing will be in place.
On the other hand, because quantum computing is so powerful, it is unlikely to be subjected to cyber-attacks. Although quantum computing is a very advanced technology with a very complicated working principle, it would not require a lot of additional training to operate it. Since quantum computing will most likely come in the form of a cloud service, and it will not have a significant difference with a current computer other than computational power.

Quantum computing falls in the yellow-green spectrum in terms of impact. Due to the behaviour of subatomic particles, quantum computing can perform tasks much faster than a current supercomputer, thus, significantly optimizing the existing computing systems. According to Google, quantum computers performed the targeted computation in 200 seconds and from measurements in their experiment, they determine that it would take the world's fastest supercomputer 10,000 years to produce similar output. With the astonishing computational power, it will bring a significant impact on the industry as it allows many tasks that cannot be performed in the past due to computational power to be completed. For example, solving the NP-Hard problem used to be impossible, but with quantum computing, it can be solved in quantum polynomial time. Quantum computing will also bring financial benefits and added value to the client's value chain. Quantum computers offer a more powerful way of computing, thanks to quantum mechanics. Compared to a traditional or digital network, quantum computers can solve certain types of problems more efficiently. However, qubits, the primary processing unit in a quantum computer, are fragile. Any imperfection or source of noise in the system can cause errors that lead to incorrect solutions under a quantum computation. A more massive quantum computer may be able to perform increasingly complex tasks, like machine learning or simulating complex systems to discover new pharmaceutical drugs. Engineering a more massive quantum computer is challenging; the spectrum of error pathways becomes more complicated as qubits are added and the quantum system scales.

Finally, in terms of sustainability, quantum computing is in the yellow spectrum at the current stage, which implies that quantum computing will have a substantial possibility to adapt to market changes. Moreover, quantum computing is developed and invested by many large technology companies, such as Google and IBM. This support through capital investments and research shows the potential of this particular technology. Quantum computing is projected to be staying in the market for a long time as it is a very advanced technology, and it is developed to replace supercomputer, which has been in the market for a very long time.

CRISPR

Since its discovery back in 2012, the genome editing system, known as "clustered regularly interspaced short palindromic repeats," has been used by scientists to make precise alterations in the DNA sequences of living cells. It offers the prospect of treating and even eradicating genetic conditions, improving fertility treatments, fighting cancer, and allowing safe transplantation of tissues and organs between species.

The applicability pillar fell under the yellow spectrum, which means that CRISPR is still in its development stage. CRISPR only applies to human gene editing and in the food industry. As this is the only gene-editing technology, further such systems and processes will be developed based on CRISPR. This technology can be used to fight cancer, extract HIV, self-destruct diseases, and eliminate malaria. Due to its potential, many organizations continue to invest in research and development.

The risk pillar fell under the red-yellow spectrum, which implies that it has a lot of risk due to the risk of atrocities. Humans manipulating the genetic code, and those manipulations get passed on from generation to generation. Furthermore, the implications, in the long run, are still a mystery to us, which can infringe on human rights as well as receive negative social stigma. Only a few have the knowledge and experience to carry out such a delicate and complicated process. As it is a process and only chemical lab equipment is required to carry out the process, there are no cyber-threats to this technology.

The impact on a given organization was rated yellow-green, which implies that it has a pretty strong effect on the market. The use of this technology will benefit us with a healthier lifestyle and better quality of products, which will be a market disruptor. Further, this tech will require frequent maintenance to keep up with the various new types of genes they come across.

The sustainability pillar of CRISPR is quite promising, implying the ability to adapt to market changes. This technology requires frequent updates as it comes through various applications from fighting cancer to creating biofuel. Pharma companies are either currently working on it or have invested in research labs that are developing this technology. As gene editing process, no previous technologies are present, but it will form a base for future gene-editing operations and techniques to advance on. Current trending technologies that should associate with CRISPR are already compatible and have been integrated with it like machine learning, AI, etc.

5G Technology

5G is the 5th generation mobile network. It will take a much more significant role than previous generations. 5G will elevate the cellular network not only to connect people but also interconnect and control machines, objects, and devices. It will deliver new levels of performance and efficiency that will empower new user experiences and connect new industries. 5G will provide multi-Gbps peak rates, ultra-low latency, massive capacity, and a more consistent user experience.

The applicability of 5G falls in the yellow-green spectrum, which means that it has great potential for different clients to implement. 5G technology can be applied to multiple industries, for example, self-driving vehicles in the automotive sector, remote surgery for healthcare, and improve supply chain processes in the logistics industry, which can bring a massive impact on them. 5G is compatible with existing systems with slight changes in the hardware and is compatible with existing 4G networks.

In terms of Risk, 5G technology fell in the yellow spectrum, which implies that it has a moderate risk at the current stage. Since 5G is the next generation of the existing 4G system, the potential of having regulations against 5G will be minimal. Similarly, 5G also has a low potential to infringe human rights and a small chance of having negative social stigma since the general public already accepted the existence of a fast-mobile network. However, 5G, like the majority of other technologies, will have the potential of being subjected to cyber-attacks.

In terms of impact, 5G technology falls in the yellow-green spectrum, which means that it has a high possibility to bring a significant effect on the market. 5G as the next generation of the mobile network compared to the current system, it has a much higher bandwidth, lower latency and much more top speed with up to 100 gigabits per second, which is as much as 1000 times faster than 4G. With this technical advancement, it is a true industry disruptor. 5G will also bring benefits to a company's value chain and increase financial performance. Take the retail industry as an example, according to a US consumer report, more than 100 million Americans purchased their smartphone in 2018, the report noted, and the move to mobile shopping is primarily due to the rise of 4G/LTE. The faster speeds 5G will enable new retail experiences like virtual reality (VR) dressing rooms. Another example will be in the manufacturing industry, which 5G is poised to help manufacturing production operations become more flexible and efficient, while also improving safety and lowering maintenance costs.

Finally, in terms of sustainability, 5G fell in the yellow-green spectrum, which means that it has excellent potential to be staying in the market for an extended period and adapting to market changes. 4G and LTE technology have already been in the market since its first launch in 2009. Similarly, 5G is supported by many leaders in the mobile network field such as Cisco Systems, Huawei, Qualcomm, and Samsung, which creates an opportunity for the technology to stay in the market for over ten years. Another essential factor that will make 5G sustain is that it is easy to integrate with trending technologies, it can be integrated with technologies that require high data-rate instantaneous communications, low latency, and massive connectivity for new applications for mobile, eHealth, autonomous vehicles, smart cities, smart homes, and the IoT.

AR/VR

Augmented reality (AR) refers to technology with the capability of overlaying information and virtual objects on real-world scenes in real-time (Marr, 2018). While Virtual Reality (VR) is defined as a technology by which computer-aided stimuli create the immersive illusion of being somewhere else (Rubin, 2018). Based on its assessment through this framework, AR/VR is mature.

AR/VR was rated in the yellow-green spectrum for the applicability pillar. Since this technology can be applied to many sectors such as healthcare, shopping, gaming, and many others, it was rated in the green region. Also, because this technology can be used in many industries and sectors, it is accepted by many companies. VR has been researched extensively as its first application; stereoscopes date back to the 19th century (Rubin, 2018). However, the only issue with this technology is its customizability. Since this is a sophisticated technology, it is challenging for users to make changes.

The technology scored in the green for risk, which means it has little chance. The only concern with this technology is the negative social stigma as many users do not accept to have a screen located inches away from their face. Despite this concern, AR/VR has been developed for various uses. Apart from its social stigma, since this technology would not request any personal information for its use, the likelihood of cyberattacks is low. For most of its applications, this technology has the plug and play feature, so little to no training is required to use it.

This technology's impact is significant; thus, it fell in the green spectrum. According to Deloitte's research, this technology is expected to disrupt the healthcare industry (Allen, 2018). Also, since this technology will be enhancing its user's experience in the respective use, it will be positively affecting the value chain. Furthermore, since this technology is most commonly used through a headset or a mobile application, it is rare to face any downtime in usage.

Lastly, this technology fell in the green spectrum for the sustainability pillar. Given its versatile use, this technology is expected to remain in use for a long time, and its market size is expected to grow to $18.8 billion by 2020 (Liu, 2019). This technology has attracted tech giants who made serious commitments towards its development (Markarov, 2019).

The detailed testing of the framework can be found in the appendix I.

Conclusion

The AIRS Technology Foresighting Framework is a valid initial assessment to determine the maturity of emerging technologies. After testing this assessment on 5G, AR/VR CRISPR, and Quantum Computing, we identified where the technology sits on the maturity curve. Understanding the lifespan of a given technology is critical in trying to make recommendations for Deloitte's clients. It is essential to realize that a more detailed assessment focusing on adoptability should be performed as a next step after the completion of this assessment. This assessment should look into more detail specific to the client that Deloitte is working with.

Appendices

Appendix A: Pillars of the framework

	Technology 1	Technology 2
Applicability		
How many sector does this technology apply to?		
Is this technology compatible with the existing systems and processes?		
How customizable is this technology?		
How accepted is the technology in the market?		
How much research has been done on this technology?		
Risk		
Are there any regulations in the foreseeable future in place against this technology?		
Does this technology have the potential to infringe on human rights?		
Are there any negative social stigma from the society in the foreseeable future?		
How much additional training is required to adopt this technology?		

How prone is this technology to cyber-attacks?		
Impact		
How much does this technology optimize the existing technical system?		
How much will this technology impact the industry?		
How often does this technology require maintenance?		
How much financial benefits will this technology provide to the client's business?		
How beneficial is this technology to the client's value chain?		
Sustainability		
How often does this technology requires updating to stay current with the market trends?		
What is the projected life-expectancy of this technology?		
How has tech-leaders supported this technology?		
Is this technology based on any existing technology?		
How easy is it to integrate this technology with trending technologies?		
Overall Score		
Band of Score		

Appendix B: Set of questions to ensure validity regardless of the type of technology

Applicability			
How many sectors does this technology apply to?	1-6	7-13	13+
Is this technology compatible with the existing systems and processes?*	Very difficult to integrate with existing infrastructure	Can be integrated with additional effort.	Easily integrated with existing infrastructure.
How customizable is this technology?**	Very difficult to customize	It is possible to customize this technology with some repercussions	Easy to customize

How accepted is the technology in the market?	Small number of companies	Moderate amount of companies	Large number of companies
How much research has been done on this technology?	No published articles	Some published articles	Many published articles

**Existing system refers to the current infrastructure on which this technology will be integrated*
***Customizable refers to the ability to add or modify the functionality of the technology*

Appendix C: Applicability-pillar assessment criteria

Risk			
Are there any regulations in the foreseeable future in place against this technology?	Likely	Potentially	Unlikely
Does this technology have the potential to infringe on human rights?	Likely	Potentially	Unlikely
Are there any negative social stigma from the society in the foreseeable future?	Likely	Potentially	Unlikely
How much additional training is required to adopt this technology?	Significant amount	Some amount	Little to no amount
How prone is this technology to cyber-attacks?	Very prone	Prone	Not prone

Appendix D: Risk-pillar assessment criteria

Impact			
How much does this technology optimize the existing technical system?*	Insignificant	Moderate	Significant
How much will this technology impact the industry?	Little to no impact	Moderate impact	Industry disruptor
How often does this technology require maintenance?**	Constant	Frequent	Infrequent
How much financial benefits will this technology provide to the client's business?	Little to no financial benefit	Moderate financial benefit	Significant financial benefit

How beneficial is this technology to the client's value chain?	Low	Medium	High

**Technical system refers to current technology/processes in place*
***Maintenance refers to potential downtime*

Appendix E: Impact-pillar assessment criteria

Sustainability			
How often does this technology requires updating to stay current with the market trends?	Constant	Frequent	Infrequent
What is the projected life-expectancy of this technology?	4 years or less	5 - 7 years	8 years or more
How has tech-leaders supported this technology?	No current support	Support through public statement	Support through investments
Is this technology based on any existing technology?	No	Partially	Yes
How easy is it to integrate this technology with trending technologies?	Very complex	Modification required	Very easy

Appendix F: Sustainability assessment criteria

Appendix G: Heatmap at the question-level

Appendix H: Heatmap at the pillar-level

	VR/AR Score	Quantum Computing	CRISPR-Cas9	5G	Red	<= 1.4
Applicability	2.6	2	2.2	2.2	Red-yellow	>1.4 and <=1.8
How many sector does this technology apply to?	3	3	2	3	Yellow	>1.8 and <=2.2
Is this technology compatible with the existing systems and processes?	3	1	3	1	Yellow-Green	>2.2 and <=2.6
How customizable is this technology?	1	1	2	1	Green	>2.6
How accepted is the technology in the market?	3	2	2	3		
How much research has been done on this technology?	3	3	2	3		
Risk	2.8	2	1.6	2.6		
Are there any regulations in the foreseeable future in place against this technology?	3	2	1	2		
Does this technology have the potential to infringe on human rights?	3	1	2	3		
Are there any negative social stigma from the society in the foreseeable future?	2	2	1	2		
How much additional training is required to adopt this technology?	3	2	1	3		
How prone is this technology to cyber-attacks?	3	3	3	3		
Impact	2.8	2.6	2.6	2.6		
How much does this technology optimize the existing technical system?	3	3	3	3		
How much will this technology impact the industry?	3	3	3	3		
How often does this technology require maintenance?	2	1	2	1		
How much financial benefits will this technology provide to the client's business?	3	3	3	3		
How beneficial is this technology to the client's value chain?	3	3	2	3		
Sustainability	3	2.2	2.2	2.8		
How often does this technology requires updating to stay current with the market trends?	3	3	2	2		
What is the projected life-expectancy of this technology?	3	3	3	3		
How has tech-leaders supported this technology?	3	3	2	3		
Is this technology based on any existing technology?	3	1	1	3		
How easy is it to integrate this technology with trending technologies?	3	1	3	3		
Overall Score	2.8	2.2	2.15	2.55		
Band of Score	Green	Yellow	Yellow	Yellow-Green		

Appendix I: Testing of the framework for AR/VR, Quantum Computing, CRISPR-Cas9, and 5G technology

References

Allen, S. (2019). 2019 Global Health Care Outlook. Retrieved from https://www2.deloitte.com/global/en/pages/life-sciences-and-healthcare/articles/global-health-ca re-sector-outlook.html

Chief, E. in. (n.d.). 14 Vital Pros and Cons of Drones. Retrieved from https://vittana.org/14-vital-pros-and-cons-of-drones

Drones at work - Quartz Daily Obsession. (n.d.). Retrieved from https://qz.com/emails/quartz-obsession/1592647/.

Geczy, P., Izumi, N., Hasida, K. (2008). Cloudsourcing: Managing cloud adoption. Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1945858

Liu, S. (2019). Forecast augmented (AR) and virtual reality market size worldwide from 2016 to 2023. Retrieved from https://www.statista.com/statistics/591181/global-augmented-virtual-reality-market-size/

Markov, A. (2019). 9 Augmented Reality Trends to watch in 2019-2020. Retrieved from https://mobidev.biz/blog/augmented-reality-future-trends-2018-2020

Marr, B. (2018). 9 Powerful Real-World Applications of Augmented Reality (AR) Today. Retrieved from https://www.forbes.com/sites/bernardmarr/2018/07/30/9-powerful-real-world-applications-of-augmented-reality-ar-today/#7b3cf6102fe9

Mell, P., Grance, T. (2011). The NIST definition of cloud computing. Gaithersburg, MD: National Institution of Standards and Technology (NIST).

Rubin, P. (2018). The WIRED Guide to Virtual Reality. Retrieved from https://www.wired.com/story/wired-guide-to-virtual-reality/

What is Blockchain? (n.d.). Retrieved from https://www.sap.com/canada/products/leonardo/blockchain/what-is-blockchain.html.