National Concept Note

Knowledge Economy
Azerbaijan

Innovation Roadmap

UNDP
This document has been prepared by the United Nations Development Programme (UNDP) in Azerbaijan

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### Mapping the Superstructure of National Innovation Systems

Mapping the Superstructure of National Innovation Systems

### The Innovation Superstructure in Azerbaijan

The Innovation Superstructure in Azerbaijan

### SWOT Analysis – Building a Knowledge Economy in Azerbaijan

SWOT Analysis – Building a Knowledge Economy in Azerbaijan

#### Internal Strengths

- Strong Executive Branch of Government
- Strong Organisational Capabilities for National Scale Infrastructure Projects
- Ample Capital for Investment in Infrastructure

#### Internal Weaknesses

- Competition and Duplication Between Ministries
- Intellectual Property Creation and Protection
- Available Economies of Scale
- Capital Formation in Private Sector
- Language
- Entrenched Educational Establishment and Development of Human Resources

#### External Opportunities

- Emergence of Global Industrial Networks
- XaaS Infrastructure and Supercomputing Platform
- Artificial Intelligence
- MOOCs

#### External Threats

- Instability in Price of Oil and Gas
- Depletion of Reserves
- Brain Drain
- Powerful Neighbors; Unstable Neighbors

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Executive Summary

Making the transition to a knowledge-based economy in Azerbaijan means increasing the value added produced by the non-oil sectors of the economy. To this involves development of both computing infrastructure and human resources (skills and training).

In doing this, Azerbaijan must strive to remain mindful of the larger currents of evolution of ICT and factor in the endowments it can mobilise to make this transition.

In the evolution of ICT, we have reached the stage where the design, engineering, manufacturing and distribution of hardware systems has been concentrated to only a few places in the world, and as a consequence, Azerbaijan might give thought to scaling back its efforts in this area. Instead, it is useful to focus on the emerging technologies where it is possible to get a payoff from investments.

Artificial intelligence, cloud computing, and social media are three areas that will continue to see substantial innovation going forward. These also are areas in which Azerbaijan leverage its assets to better integrate into the world's economic system.

Azerbaijan should give careful consideration to building a national supercomputer centre that will roll out a platform based on the cloud model. This system will provide the perfect facility for creation of apps and the Internet-of-Things.

In order to orchestrate the type of innovation that is needed across all of its economy, Azerbaijan's numerous ministries and state enterprises can use ICT to erect virtual organisations that have a legal standing and can integrate strategy for innovation across multiple domains. Finally, there are many new innovations that Azerbaijan can take advantage of, including the proliferation of Massive Open Online Course (MOOC) approaches.

In sum, Azerbaijan can build a knowledge society by building up the formula that has worked so well in the past: State initiated and controlled innovation, with the government providing the infrastructure, and allowing enough flexibility so that the natural creativity of Azerbaijan's people can be leveraged. By using Azerbaijan's natural advantage of a strong executive, is can quickly take steps to build a knowledge society.
The Knowledge Based Economy

A knowledge-based economy is one in which the highest proportion of value-added is derived from analytical work. This concept goes back to Daniel Bell’s work on post-industrial social, published in the late 20th century (Bell, 1974) that anticipated that the “service sector” would generate more wealth than the “manufacturing sector” of an economy. A few years later, Marc Uri Porat published his study on the information economy (Porat, 1977). See Figure 10 Clark’s Sector model for industry sectors in the US economy from 1850 to 2009 on Page 64 for an example of this vein of research.

Earlier, Peter Drucker had stated that “the most valuable asset of a 21st-century institution, whether business or non-business, will be its knowledge workers and their productivity” (Drucker, 1959). He was writing at the very beginning of the commercial computer age. Previous computing had been developed by codebreakers working during the Second World War (Welchman, 2017). The first “computers” were electro-mechanical devices with no ability to store programmed instructions (Hodges, 2014). This was the first time machines had been dedicated to breaking codes (Kahn, 1996).

As Drucker defined the information worker, IBM was launching the first general purpose mainframe computers into the market (Pugh, Johnson, & Palmer, 1991). These first machines were capable only of batch processing.

From the early 1960s until now, computing has gone through several major phases, each one having a larger impact on society. See Table 1.

Table 1 Characteristics of ICT and Effects on Society

<table>
<thead>
<tr>
<th>Characteristics of ICT</th>
<th>Effect on Society</th>
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</thead>
<tbody>
<tr>
<td><strong>Mainframe</strong></td>
<td></td>
</tr>
<tr>
<td>Centralised computing architecture. Batch processing, then online transactions processing.</td>
<td>Increase efficiency of repeating business transactions. Larger economies of scale for organisations.</td>
</tr>
<tr>
<td><strong>Minicomputer</strong></td>
<td></td>
</tr>
<tr>
<td>Characteristics of ICT</td>
<td>Effect on Society</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Personal Computer</strong></td>
<td>First autonomous, then connected to network and mainframe systems. Terminal</td>
</tr>
<tr>
<td></td>
<td>emulation then file exchanges.</td>
</tr>
<tr>
<td><strong>Internet Age</strong></td>
<td>Distributed computing. Increased use of remote processing. First development of</td>
</tr>
<tr>
<td></td>
<td>large-scale software applications.</td>
</tr>
<tr>
<td><strong>Tipping Point</strong></td>
<td>Hardware advances continue to follow Moore’s law, but centre of innovation shifts to</td>
</tr>
<tr>
<td></td>
<td>software and large-scale distributed applications.</td>
</tr>
<tr>
<td><strong>Current Innovation Vectors</strong></td>
<td>In telecommunications, wireless Internet has penetrated everywhere. Mobile platform</td>
</tr>
<tr>
<td></td>
<td>now most common development platform. Social media, cloud computing, and other</td>
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<tr>
<td></td>
<td>virtual services exist on complex and redundant infrastructure. Machine translation</td>
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<td></td>
<td>and artificial intelligence are making possible complex coordination not seen</td>
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<tr>
<td></td>
<td>before. Applications have reached truly global scale, without regard to national</td>
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<tr>
<td></td>
<td>boundaries. Globalisation and pervasive penetration of ICT also has created</td>
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<tr>
<td></td>
<td>potentially devastating vulnerabilities for the world’s economy and governance.</td>
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<tr>
<td></td>
<td>Government are developing offensive and defence cyber weapons. All national</td>
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<tr>
<td></td>
<td>economies are heavily influenced by outside constraints and opportunities.</td>
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<tr>
<td></td>
<td>Manufacturing of ICT hardware has been concentrated in a very few places, but at</td>
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<td></td>
<td>scales capable of servicing the entire planet.</td>
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</tbody>
</table>

ICT is one of the most challenging and exciting areas of the world’s economy, but like all industries, it has stabilised into a geographical pattern that is unlikely to change. Hardware manufacturing has been relegated to only a few major companies and a few geographical areas. This has happened because of control over intellectual property, and the natural economies of scale that comes from being able to serve global markets.

The world’s computer industry is coordinated through Silicon Valley and Armonk, New York, but operates through a global industrial network tying together sub-component manufacturers and assemblers located around the world. The underlying design and architecture of computers for the most part is created in the United States. Major sources of crucial components are found also in Germany, Japan, Korea and to a lesser extent in China. Most assembly takes place in China, but this is rapidly changing as robotics makes increasingly irrelevant the ability to offer
lower labour costs. It is likely the newly adopted manufacturing and tax policies in the United States will result in the abandonment of much outsourcing of assembly and manufacturing. The consequence of these trends is that as a part of national strategy for a nation such as Azerbaijan, any effort to attract manufacturing or assembly of ICT should be abandoned.

Figure 1 Azerbaijan Should Focus on Machine Intelligence Which Now is at the Core of Global Innovation

If we define “knowledge” as being the behavioural and intellectual capabilities of a nation’s human resources, then the very concept of the “knowledge-based economy” is obsolete. For a while it has been known that the greatest share of economic transactions now is initiated not by human-to-human action, but instead by machine-to-machine action.

This means in practical terms that most of the economy takes place inside cyberspace, outside of the direct control of humans. After all, it was decades ago when computerisation made possible high-speed trading of equities and high-volume transactions systems such as airline reservations. Humans have been out of the picture for a long time. Computers are machines that have enabled societies to handle information volumes impossible if using only manual procedures.
So, in the first stages of this transformation computerisation led to an extension of human capabilities. There were even a number of science fiction scenarios in which humans were “supplemented” by implantation of microchips or in other ways had their intellectual capabilities extended by information technology.

The “smart phone”, and new technologies such as augmented reality all continued to extend the myth that the role of information technology was to extend the intellectual power of the individual. Some critics expressed the fear that over-reliance on smart phones would decrease the memory skills of the user, making them even more dependent. But these criticisms were muted out by the stampede to the mobile phone stores.

![Diagram showing the transition from Computing Age to Age of AI](image)

*Figure 2 The Computing Age is Being Replaced by the Age of Artificial Intelligence*

It is difficult for many to conceptualise that the computing age is no longer the leading-edge of ICT innovation. Instead, the shift of focus has shifted to complex and large-scale network systems that have large spans of control and proliferating points of contact with objects (Internet-of-Things) and humans.
The rise of social media and cloud computing represents a transitional state between the Computing Age and the Age of Artificial Intelligence. Cloud computing represents the movement of applications processing into giant virtual ICT infrastructures.

**Cloud Computing Provides a Secure and Reliable Infrastructure for Innovation**

Cloud computing has a number of advantages that were predicted long ago when the concept of the “network computer” was discussed.

The “network computer” originally was envisaged as the use of the web browser and the java programming language to embed application logic in downloadable java code, and to have data storage and backup located on a shared server, which could be the mainframe platform. The ICT world would return to the “golden age” of the 3270 terminal and the predictability and efficiency of the centralised computing model, but this time with “smart” terminals, able to do a significant amount of calculation and processing within the web browser. For example, it was possible to do word processing within the browser using java applets. A number of applications were developed. The advocates of network computing were eager to point out that the browser and java would run on any operating system, on any platform, and they were correct.

At the same time, this movement was seen as a threat to the traditionally entrenched client-server software providers, led by Microsoft. But Microsoft was not alone. Over time, in large part because of its wise efforts to release a number of development tools making it easy to create applications on the Windows platform, Microsoft had surrounded itself with an army of specialised application software providers, and they too had a strong interest in continuing this model. So, for the time being, the network computer was dead, but the fundamental truth of its underlying economics was not.

At the time (mid-1980s) there was much criticism of the client-server model of computing that had come to dominate ICT budgets. Indeed, never had a more expensive model of computing ever been rolled out to users. Compared to the mainframe with its “dumb” terminals, the client-server solution was dozens of times more expensive. Instead of a single software instance, each machine had its own operating system; instead of data being kept in a single secure location, it was distributed to hundreds of thousands of insecure and unreliable hard disk drives with a MTBF of only 2-3 years. It was much more expensive to have reasonably priced back-up systems, because each single instance of the “client” had to be duplicated.
It is ironic that at this time a narrative started concerning information economics and the productivity effects of ICT. The debate never was settled completely, but we can be sure that for at least a decade, the effect of ICT was to lower productivity in offices around the world. The client-server model was the most complex, expensive and difficult to manage technology solution in world history, and it still is with us in the form of continual upgrades, lack of cybersecurity, very high expense, and the use of incredibly complex operating systems that are necessitated by the requirement to address so many different types of technologies. An additional problem is that in any single organisation, there always are different generations of computing platforms and operating systems that must co-exist, leading to even more complexity.

As the world barrelled down the road of exponentially expanding complexity, cloud computing emerged as an alternative method to address the deficiencies in the client-server model. It all had started more than a decade earlier with the “network computer”, but not even Microsoft had developed the idea of providing a more robust role for its server family of ICT. For the client-server world, the “network computer” concept now was fine, as long as the back-end was compatible with Windows, and the traditional Windows suite of applications continued to dominate the desktop platforms.

Cloud computing emerged as a result of competition. When Google introduced its free Gmail system, this was only the beginning. It followed suite with a compete documents system and the ability to use Google servers as a virtual disk. Users liked that these applications were free of charge and were willing to hand over information about themselves in order to receive these free services. Google also introduced a number of collaborative features, including the ability to publish documents on the web, even without a website. At the same time, Apple, as usual, was even more innovative. It moved all of its software distribution completely to a web model. There were no more CDs for software distribution. It moved to automated updates, and a standard way for distributing all software, making it even easier to a giant community of application providers to find an easy way of advertising and distributing their software. Apple then moved its storage to the web and created automated syncing systems allowing users to maintain a number of devices (iPhones, iPads, laptops, and desktops) all with exactly the same set of applications and data. No other company has achieved this remarkable accomplishment.

The manufacturers of mainframe computers and other large-scale system also responded to these developments. IBM continued to boost the capabilities of its mainframe systems by switching to the open source Linux platform, and releasing giant multiple virtual machine
architecture solutions that allows an ICT department to create entire new “stand alone” servers at the push of a button. What appeared to be a stand-alone and dedicated machine actually was a synthetic instance encapsulated in a giant mainframe platform. These machines also followed the Apple model and moved storage and reliability back to the server, away from the client.

The client computer was shrinking as more functions were moved into the cloud. First the email, then the back-end storage, then the use of virtual disks. Apple, and then Microsoft created web-based versions of their applications, allowing editing through a web browser, as had been envisaged twenty years earlier. The original client-server software remains as a relic of the past, but gradually the web-based applications are being increased in sophistication so that they can mimic all of the features of the client-based software.¹

An IBM specialist was asked about security on their mainframe systems. The reply “We don’t worry because once they get in, they have to deal with VM (Virtual Machine)”.

So, what is called “cloud” computing is a return to the fundamental economics of the mainframe era, but with a significant amount of flexibility for the end-users because the applications that may be used still retain much of the robustness of the original client-server vision. In the cloud architecture, all basic data is stored in the cloud. There are a very large number of advantages to this architecture.

Scalability is a Major Advantage of the Cloud

Since cloud computing is based on the notion of creating multiple virtual partitions for each user or server system, there is no practical upper limit to its size. We have reached the point where all of humanity can have an online account, with a full set of office features. At the same time, every organisation, large and small, can be accommodated by these systems. There is no

¹ This progress in code-writing continues, but there may be a commercial reluctance to completely migrate all functions from the client to the cloud, because if this were completed 100%, then there would be no reason to purchase the client software, and this would destroy the business model of companies such as Microsoft. Apple has abandoned this model long ago and started simply giving away its suite of office applications for free.
need for the end-user to “worry” about the shared infrastructure supporting the back-end of the system. Technically, it would be possible for the entire nation of Azerbaijan to outsource all of its computing infrastructure to the cloud.

Reliability of Cloud Architecture is Much Better than the Outdated Client Server Model

Compared to the obsolete client-server model, the cloud solution is many times more reliable. Mainframe infrastructure is designed to operate flawlessly 24x7 for years without an interruption. The current standard for IBM mainframe computers is to have “down time” of only a few seconds *per year*. The formulation of routines for secure backup and disaster recovery have been worked out since the 1970s. There is nothing more reliable in the ICT world.

Cyber Security is Easier to Manage in a Cloud Architecture

The security of the cloud system also is many times greater. There are a number of reasons for this. The operators of cloud services are able to deploy the most advanced cyber security solutions that prevent viruses or other malware from infecting their systems. Another factor is that in the multiple virtual machine environment, there is a logical partitioning system that prevents malware infecting one system from spilling over into another, even though it is housed in the same machine. The track record shows that almost all breaches of cyber security occur at the client level. It is at the client level, not the server or cloud, where the cyber-criminal is able to find the zero-day exploits.

The Cost of Cloud Architecture Makes It the Most Effective Solution

The cloud solution is hundreds if not thousands of time less expensive than the traditional client-server model. There is less need for personnel. There is a greatly reduced chance of failure that leads to the need for the extraordinary expense of disaster recovery and restoration of the previously operational system. Storage is shared. Security is shared. Processing is shared. Applications development is shared. The costs of these essential elements of an information system are spread out over millions of users, and the practical result of this is that the cost is driven down to the lowest possible level, at least for the company providing the cloud service.

Standardisation of Application Interfaces is an Additional Benefit of the Cloud

The cloud also allows standardisation of the platform. This has important benefits, the most important of which is lowering of training cost. Standardisation eliminates the plague of the
client-server world, which is the proliferation of numerous platforms each having slightly different versions of software, drivers and operating systems. There is a shared lingua franca of the computing environment, not a Tower of Babel.

System Development is Simplified, and Investments are More Productive

Systems development is greatly simplified because a large amount of what normally be required has been outsourced to the cloud services provider. This leaves the end-user organisation with the flexibility to deploy all of its internal resources against the target of developing applications customised to its specific needs. More than one-half of the problem already is solved, so there is no need to allocate resources to it. This leads to more focus on building mission-critical applications, and less focus on designing the back-end utility and systems maintenance system that are needed for the underlying operation of the infrastructure. Indeed, cloud computing may be thought of as outsourcing the underlying infrastructure of the information system, but retaining control over those parts that are needed to tailor the system to one’s specific needs.

There is no record of a major system failure or breach of a cloud-based information system.

All of these trends lead to the inevitable conclusion that cloud computing – the provisioning giant shared infrastructures – is here to stay and will continue to grow.

Social Media has Emerged as the World’s Leading Computing Platform

At the same time, Social Media has become a world-wide phenomenon. Social media accounts for more email than all of the remaining email in the world. In practical terms, this means that social media is the largest application for ICT and is more important as a platform than any other information system. To the extent that systems development and applications creation are not using the social media model, then they are writing outside the principal platform for ICT.
Through social media, each person sees the world and reality as a reflection of themselves.

In the first decade of the 21st Century, social media had profound effects on political stability in some areas of the world. An example is the Arab Spring. In addition, the proliferation of this globalised media broke through cultural and national barriers, enabling the emergence of a global dialogue and generation of a new type of international social media language, a lingua franca used universally.

Some governments were worried about the potential destabilizing effects of social media, and took steps to censor or other control it. Other governments learned to use it effectively in promoting their public policy priorities. Social media has had such a large effect because it presents an infrastructure that grows not by central direction, but instead according to the actions of its members.

Social Media Optimises the Advantages of Self-Organisation

Social media platforms are a different model from classical ICT system which are designed for a specific purpose from the ground up. Instead, they change according to the actions of their members. This is a powerful form of organisation because in practice it means that there is little frustration because the social network adjusts to one’s use and preferences.

The task of the infrastructure provider operating the social media company is to respond to member needs based on their predicted behaviour.

Personal (Mass Customisation) Can Be Provided so that Each Individual Receives a Unique Experience

Social media also is designed to provide a unique experience to each individual. By using machine intelligence to understand the preferences and behaviour of its members, social media can provide an information environment that is agreeable. For example, we know that over time social media will provide news stories to an individual that are of interest – if they are
conservative, they start to see more and more conservative news items. If they are in the transportation industry, they start to see more news about transportation.

Eventually, social media learns to provide conservative persons with conservative news and liberal persons with liberal news. With social media, each person sees the world as a reflection of themselves, that is, each person sees the world in a way that is agreeable with their pre-existing ideas. For a specialist, the saves valuable time in keeping abreast of their field. It may also lead to the emergence of a divided society as differences are intensified.

The Free Cost Model Partly Explains its Rapid Expansion

Social media has spread so quickly because its cost model (business model) allows the consumer to use it for free. Behind the scenes, the social media enterprise is able to sell demographic and psychographic information regarding its members. This allows for highly targeted advertising that never before was possible. For advertising, using social media is superior to using mass media, which is more undifferentiated.

The providing of important communications functions such as email, messaging, and video all for no cost has been a major factor in social media proliferation, but also in eliminating many types of competition. For example, once Google started to provide free email, then all businesses that provided email for a monthly subscription cost became obsolete.

Social Media Providers Engage in Intensive Upgrading to Stay Ahead of Competitors

The growth of social media also has been characterised by aggressive upgrading of features. The product and context of social media is constantly expanding and changing. This further helps to retain members because the advantage of novelty remains at the forefront of the user experience.

At the heart of social media is a self-organising system that introduces change to itself depending on the actions and preferences of its members. In other words, its evolution is dictated by the actions and preference of its members. Evolution and improvement of the information system is an “outward-in” process.

Artificial Intelligence is a Major Challenge for Humanity

In contrast, Artificial Intelligence works in the opposite direction. It is an “inward-out” process, and it represents an entirely new director for ICT and for society. The interactions handled by
the AI-informed information system originate within the AI, then radiate outwards where it generates effects. AI is used to make decisions and exercise control over more complex operations and at a larger scale than would be possible should humans be responsible for the direction.

In the Age of AI, a number of applications are predicted to show the most potential. Below we will review a few of the emerging trends in utilisation of artificial intelligence. There is a very broad range of activity, and it is difficult to predict precisely the technology and applications trajectory for the medium-term. What is peculiar about the currently envisaged applications is that the processing to be done using AI is very specific, and “hidden” inside the information infrastructure of many organisations. Even today, millions of persons on a daily bass are touched by AI, but they are not aware of it because it stays hidden at the very core of the ICT infrastructure, which also is receding into the cloud, out of sight.

Object Detection Allows AI to “Sense” its Environment

Object detection is the ability of the information system to “sense” the environment and pick out objects that may be of interest. For example, in the next generation of vehicles, AI will be the driver. As part of its cognition, the AI will be made aware of other vehicles near to it, and also be aware of its environment.

This is complicated, because there is no method of programming every possible instance to be encountered into the AI software. Instead, a number of cognitive rules must be defined so that the AI can mimic thinking and awareness of its environment. This type of capability also will have important implications for military robotic applications.

Image Recognition Means that AI can “Read”

Image recognition is a large and complex field. The ability to “read” documents and to “recognise” the content in photographs is an important feature of this part of AI. Face recognition already is revolutionizing the surveillance world. Image recognition also will make it possible for AI system to go through documents and understand how to file them correctly after they are scanned. For photographs, image recognition capabilities can be used to attach tags to the image so that it may be retrieved later inside the information system.
There are obvious security and surveillance implications, but also other applications, such as perhaps the automated screening of millions of X-Rays to look for patterns that may help health researchers.

Analysis of Patient Data is Emerging as a Major Al Application

Processing of patient medical data is being aided by Al. The assignment of diagnostic tests, and their automatic analysis leading to diagnosis will enable remote medicine, and the provisioning of health services to populations that otherwise would remain unserved. Work on automated diagnosis has been going on for years, and it is aided tremendously by the existence of a large number of standard medical protocols that can be reduced to a series of decision trees, each with specific levels of probability.

This same type of “thinking” has been extended to several Al platforms, and the evidence shows that they gradually are learning to handle completely unstructured inquiries, and define themselves what type of information to retrieve from the World Wide Web.

Transactions Processing and Equities Trading are Dominated by Al

Artificial Intelligence also has a long history of development in transactions processing, particularly in the financial area. Automated buying and selling of stocks and other financial instruments long have been conducted using “computer algorithms”. The major brokerage firms have engaged in a type of arms race to develop trading algorithms that can outthink their competitors and outperform the market.

This has been remarkably successful, although it is not possible to completely master the financial markets, nevertheless the sophistication of these algorithms and the use of high frequency trading has pushed the individual trader out of the picture for the vast majority of these financial transactions. Apart from automated learning theory, these programs employ what is known of game theory, simulation, and many other fundamental analytical techniques.

Mapping and Logistics Managed by Al Already is Commonplace

In logistics, automated mapping, tracking, and optimised routing of vehicles is being used to introduce giant efficiencies into the world’s transportation systems. The most visible example of this is found in the use of Al to automatically dispatch taxis, and to optimise their routes. But this same technology is used in other more complex logistics systems, and this application will continue to grow in importance.
When the potential of mapping intelligence is added to a future of driverless cars, we can expect a world without traffic jams, even this sounds improbable at the moment. The idea of “going out for a drive” will become obsolete, but it will be possible to ask the AI dispatcher to program a nice scenic route for your trip.

**Predictive Maintenance of Complex Systems is being done by AI**

Artificial Intelligence is being used to monitor machinery and other complex operations such as factories and anticipate faults and problems in advance. This capability allows the assignment of maintenance prior to any slowdown in the system. Simple versions of this type of computation long have been found in automobiles, as expressed through the dashboard warning light system. When this type of AI is applied to a fleet of thousands of vehicles, such as a large delivery company, the potential savings can be enormous. It also has many practical applications in the military sphere.

**AI Can Provide Cyber Security Against Zero-Day Exploits**

Given the rapidly changing landscape of cyber threats, we have reached the point where only an automated system is able to keep up with the rapidly changing attack vectors of malware. The use of artificial intelligence has the most promise in helping to close “zero-day” exploits as soon as possible. In cyber security, seconds even milliseconds count.

The constant monitoring of threat and the ability to respond in a timely way long have escaped from the span of control of a human. There is too much change, too fast, and security personnel no longer can do the work. The next phase in this problem will be when the criminals also begin to exploit artificial intelligence, but we have not reached this level of threat.

**Digitisation using AI will Help Store the World’s Records**

AI also is being developed to increase the pace of digitisation — the process of scanning paper documents and storing them in digital form in information systems. This allows their shared use and permanent retention. Although the technologies of scanning and digitisation have been around since the beginning of the facsimile machine, and even before, the problem lies in what to do with the resulting file after the scanning is complete.

AI is used to *read* the document, understand its content, and develop macro-data to attach to the document so that it can be retrieved later. For example, if the document is a lengthy report, the AI must be able to determine what the subject matter is and assign the
correct key words for retrieval later. Otherwise, the document will be forever lost in cyberspace.

It is not only a question of determining the key words and subject matter of the overall document, but it also is necessary to locate important references or cross references within the document, again for the purpose of indexing and information retrieval. For example, if looking up an author on the web, it should be possible to find all instances where that same author is mentioned, even if in a passing footnote of a report that has been scanned and stored. The amount of macro-data associated automatically with a document may be a substantial fraction of the content of the document itself.

HR Systems are Using AI to Hire Personnel

One of the most controversial but popular use of AI is in selection of personnel. Thousands of resumes flood into an information system of the organisation advertising a job. These resumes (CVs) are never read by humans, but instead are read by machines. Then based on an AI algorithm, the leading candidates are selected, and also graded in rank order. Finally, a recommendation is made to the hiring managers who then review the finalists and decide on whether or not to extend an interview.

The use of artificial intelligence is particularly sensitive in countries that have practices in place that favour one group over another. But in societies that have a generally homogeneous population, the use of AI will be useful in helping millions of people find jobs, and hundreds of thousands of employers find workers. It is difficult to anticipate how far AI will go in the human resources area, but certainly it can be extended into making recommendations for training, and even in drawing up the first drafts of annual evaluations.

AI Analysis of Medical Imaging is Revolutionizing Research

In the medical field, AI is being used for reading medical images and developing macro-data for its electronic filing. This will be of immediate benefit to the operation of medical information systems. In the long run, however, it may aid in research because it will make it possible to “read” hundreds of thousands of images to determine whether or not certain conditions exist. For example, we can envisage AI being able to match the outcome of a genetic screening test to the problems found in patients, as revealed by medical imaging.
If the AI becomes accurate enough, then it will be possible to obtain automated diagnosis prior to review by a specialist. Of more interesting concern is the ability to go back over decades of images and look for patterns in certain classes of patients. This would never be possible using humans because it would take too long and cost too much. The ability to “see” inside a patient also may eventually aid robots in performing simple surgeries, or eventually perform surgeries, such as micro surgery, that is beyond the reach of human beings, even if they are doctors.

One emerging area of interest is the legal implications of artificial intelligence. The problem of how to deal with liability issues when is the AI that makes a mistake is a telling one. The litigation then will turn on the internal rules practiced by the AI, a very unfamiliar area of litigation.\(^2\)

Other Trends in ICT

Apart from cloud computing, social media, and artificial intelligence, there are several other important trends in ICT. These trends will continue to dominate the landscape for the next 5–7 years at a minimum.

**Digital Transformation by Firms is Leading to New Structures**

Digital transformation is a consulting-type term used to describe how ICT is changing the organisational structure and operational practices of organisations. ICT is changing the way that firms can organise themselves and also opening up new possibilities for interaction with stakeholders, such as customers, suppliers, government regulators, and public relations.

1. **New Organisational Forms.** The flexibility being fostered with ICT is leading to the emergence of organisations that have a flexible form and adapts to changing circumstances. In some organisations, employees do what they think is timely and that they are interested in. Organisations may be “flat” in their structure. The may add and divest the organisation of important functional elements as the possibilities arise. Parts of the organisation may come and go, and even move around.

2. **New Types of Interactions with Stakeholders.** The use of ICT to bring stakeholders closer to an organisation can have vivid consequences. For companies, the ability to tie suppliers even closer into the business transaction with a customer may engender a set

\(^{2}\) The legal consequences for artificial intelligence are a fascinating area of work, but is beyond the scope of this document.
of shared objectives and goals for performance. Both organisations can use ICT to work as an integrated corporation, even though technically they are autonomous. See Figure 3 Enterprise ICT Enabled Relationships with Stakeholders.

The way in which ICT is changing organisational structure in organisations should not be underestimated. It already has been shown that the classical Weberian\(^3\) hierarchical bureaucracy is no longer the only efficient form of organisations, or even the most preferable.

Even though the Weberian form still remains the dominant form for governments, it no longer is considered to be the most efficient or preferable form of organisation for many purposes. In particular, in situations where there is a need for rapid adjustment to changing situations, other “hybrid” forms of organisation are preferable.

The study of these new forms is a new science in itself and beyond the scope of this document. It should be noted, however, that these organisations all are dependent upon utilisation of new forms of ICT for their “electronic nervous system” that ties together the people and outside stakeholders that form the large virtual organisation encompassing the cluster of economic transactions within its scope.

In Figure 3 Enterprise ICT Enabled Relationships with Stakeholders we can see how ICT links together enterprises with several stakeholders.

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\(^3\) Max Weber is thought of as the founder of sociology and he made extensive studies of bureaucracy. See (Weber, 1978). Weber described the bureaucracy that still remains the dominant form of government organisation today. “First, it is based on the general principle of precisely defined and organised across-the-board competencies of the various offices. These competencies are underpinned by rules, laws, or administrative regulations.” He defines several characteristics of bureaucracy: (1) A rigid division of labour is established that clearly identifies regular tasks and duties of the particular bureaucratic system; (2) Regulations describes firmly established chains of command and the duties and capacity to coerce others to comply; (3) Hiring people with particular, certified qualifications supports regular and continuous execution of the assigned duties; (4) Recruitment based on merit (e.g., tested through open competition); (5) Uniform principles of placement, promotion, and transfer in an administrative system; (6) Careerism with systematic salary structure; (7) Hierarchy, responsibility and accountability; (8) Subjection of official conduct to strict rules of discipline and control; (9) Supremacy of abstract rules; (10) Impersonal authority (e.g., office bearer does not bring the office with him); and (11) Political neutrality.
Relationships with Suppliers Have Been Constantly Transformed

Linkages with suppliers originally started with Electronic Data Interchange (EDI) which was the batch transmission of an ASCII file arranged into a strict format. It has replaced the sending of letters and then faxes for placement of orders. Embedded codes were defined with the various data point necessary to effect economic transactions. These usually were orders or financial statements that were sent back and forth.

EDI remained a standard for years, but eventually was replaced by the introduction of leased line fixed communications between the information system of one organisation and another. These leased line connections were proprietary in operation, and were economical only when relationships between companies were long-standing and had a relatively high transaction volume, such as in the automobile manufacturing industry.

As the Internet arrived, it no longer became necessary to rely on fixed leased lines to link together enterprises. This happened in the late 1980s. But much research was needed on transactions security and encryption before using “Internet Commerce” (later re-named ‘e-commerce’) became practical.

The primary driver that made Internet Commerce practical was the development of exchanging cryptographic keys over a public non-secure channel such as the Internet. See (Diffie & Hellman, 1976). The problem of exchange of encryption keys had long been known as one of the key challenges in implementation of large-scale encryption systems. For example, during the Second World War, the first few letters of any encrypted message contained the enigma key settings and then their encoding. This offered a method of breaking this “unbreakable” code.

Once the technique of exchanging keys was perfected, it was built into the Internet browser, and is the foundation of today’s Internet security. It made possible the use of the Internet for linking together companies with their suppliers. The practical effect was the eliminate the need
to invest in building dedicated leased line private networks that linked one organisation with another.

Once this barrier was removed, the "switching costs" from one supplier to another were eliminated, or greatly reduced, leading to intensified competition, and the removal of geographical barriers to trade. Once the exchange of ordering and passing back and forth between the firm and its suppliers was made routine, then ICT made it possible to set up even more complex interactions including collaboration in real time in areas such as design and problem-solving. As this collaboration intensified, organisations and their suppliers gradually developed business processes that were trans-organisationally integrated.

Today we are in the next stage where these trans-organisational processes are being optimised, and some "virtual" organisations are being created from ground up based on this type of organisational architecture. None of this would be possible without ICT.

*Relationships with Customers Now Are Dependent on ICT Initiated Trust*

ICT also has enabled new types of relationships with customers. It was the Internet that opened up organisations to an unlimited number of customers. Firms now have the entire world as their customer base, although in practical terms, most economic transactions operate on a national or regional basis.

The current trend is towards greater access to customers regardless of where they are located, and for the customer, the trend is a blistering growth in the amount of choice available. It is obvious that the continued development of completely globalised markets is going to transform retail structures everywhere. Providing international payment systems are implemented in a way that has a low and economic transaction cost, and providing there is in place efficient and low-cost logistics that generally is quick and reliable, and providing we see a set of norms develop in which consumer rights are protected, then we can predict that large segments of the retail markets around the world will become obsolete.

This type of integrated international logistics-payment-guarantee system already is in place and is growing rapidly. One problem is that legal rights are not negotiated on an international basis.
So, if the supplier cheats or under-performs in providing goods and services to consumers, there is no legal recourse. And today there remain many scams and crooked suppliers, and no practical way for consumers to have their rights protected.

Nevertheless, even though there may be no legal recourse, the reputational effects of poor performance act as a very powerful disincentive against crooked behaviour. Social media allows a poor reputation to get around very quickly, and companies that have a poor reputation are driven out of business. In today’s ICT-driven market, the answer to the question “Who are your customers” is “Everyone”.

**Relationships with Social Media are Crucial in Maintaining Reputation**

Although social media has gathered much attention because of the Arab Spring and the what is perceived to be its ability to transmit social messages, leading to dissent against standing governments, there are other important functions as well, and they involve commerce. It is common today for all organisations to employ social media to get out their message to consumers or other stakeholders. Social media has emerged as one of the primary advertising channels for many organisations.

This has created a new industry as organisations have been forced to hire experts who are capable of operating a social media presence. But there are two directions for social media intermediated information: broadcasting and intelligence. For broadcasting, the organisation uses social media to put out a good image of itself. It is similar to advertising. Using social media linkages, consumers and others are enticed to visit special websites that convey a positive image of the organisation, such as socially responsible actions. In many cases, this information is little more than contrived organisational propaganda, but nevertheless it is effective, and now is an essential component in the information operations of every organisation. But the other direction of information flow is the intelligence function of social media. Here, the task of social media is to serve as a giant platform for automated collection and analysis of information on stakeholder behaviour and preferences.

The use of large-scale database mining and “big data” collection and processing efforts allows an organisation to understand its reputation. It can see its own reflection in the comments and other online actions of consumers and stakeholders. This type of information is an important product of social media companies, and one of the principal ways in which they generate income. In fact, the use of big data techniques and attention to social media may be the first time organisations have been able to get a clear and real time view of their reputation. And
having such information is crucial in the formulation of response. Public relations, advertising, and other information operations now can respond quickly even in “emergency mode” as soon as negative social commentary is detected.4

Social media platforms also have been an important element in the globalisation of e-Commerce. One important driver of this phenomenon is the element of trust. When a company is presented through social media as a potential partner or receiver of trust or funds as is required for consumers to buy, then the social media company and platform itself acts as a type of “stamp of approval” that legitimises the organisation.

It also should be noted that social media companies also have rolled out the ability to process and handle vast amounts of economic transactions, including international trade in both goods and services. In this way, social media has grown to serve an essential role in global e-Commerce and its influence will only continue to grow.

*Relationships with Government have been Vastly Improved*

ICT also has completely changed the relationship between stakeholders and governments. Much UNDP research has focused on e-Government and e-Participation, so there is no need to discuss these concepts in great detail here. E-Government in its most fundamental sense is the use of ICT in providing government services, of which there are many.

The scale and scope of government services (large market, ability to standardise transactions, the need for recordkeeping, large numbers of citizens) make ICT the optimal solution because otherwise there is no other way to handle such a large number of interactions. The advantages of e-Government are great including (1) economies of scale in data processing; (2) lowering of transactions costs for citizens; (3) better and more up to date information regarding citizen

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4 Content analysis and artificial intelligence is able to “read” social media information and identify negative information that can be brought to the attention of the organisation for immediate action.
problems and preferences; and (4) the ability to deploy standardised record keeping and retention of information. E-Government is compelling and irreversible process.

In the same way, e-Participation is the “listening” function of the government. It represents “market intelligence” for government services. By using ICT, including social media, it is possible for a government always to maintain a careful view of its society. Some applications are practical, such as the use of ICT to allow citizens to report holes in a road that should be fixed. Other applications are of a more serious nature, such as the ability to use ICT to detect criminal activity such as human trafficking or terrorism using technologies such as deep packet inspection.5

In this way, ICT has greatly magnified the intelligence and security capabilities of governments. Another aspect of ICT is the dramatic increase in the efficiency of informational relationships between governments and stakeholders. For example, in the pharmaceutical sector, ICT has made it possible for organisations to report massive details of their R&D in electronic form. The amount of information filed is astounding. Most will never be read unless years later that is a problem.

If paper-based methods still were used for filing this information, then it would be extremely expensive, because (1) the cost of paper and printing is many thousands of time more expensive than electronic methods of communication; (2) there was be a substantial cost of secure storage of the paper in massive warehouses; (3) there is a substantial cost in indexing all of the paper-based information so that in the future it is possible efficiently to retrieve information; and (4) analysis of the paper-based information is many time slower and less efficient because it is impossible to use automated tools for analysis.

This same story has been repeated in virtually every sector where it is vital that the government receives records of large numbers of transactions. These efficiencies also are found when the

5 Deep packet inspection (DPI) is a form of computer network packet filtering that examines the data part of a packet as it passes an inspection point, searching for protocol non-compliance, viruses, spam, intrusions, or defined criteria to decide whether the packet may pass or if it needs to be routed to a different destination, or, for the purpose of collecting statistical information that functions at the Application layer of the OSI (Open Systems Interconnection model). Deep Packet Inspection (and filtering) enables advanced network management, user service, and security functions as well as internet data mining, eavesdropping, and internet censorship.
government itself publishes important information but uses electronic form instead of paper. The practical result is that over the past decade, the amount of ICT based information flowing between organisations and their government has increased at a minimum by several orders of magnitude.

*Relationships with Employees have been Deepened through ICT*

ICT also has revolutionised the relationship between organisations and their employees. This has happened because for the majority of workers, most of their work consists of interactions with an information system. Organisations are able to keep track of employee communications, which remain the property of the organisation where they work.

Online training and education have been built into the human resources and performance review system. In addition, ICT provides an important cyber security function. Apart from maintaining complex access control systems that give to each employee the ability to see only the applications and information needed for their work, ICT also can keep track of every single interaction in the employee’s work.

When there is downloading of unauthorised information, or printing of information that either is not from the organisation or should not be accessed, then ICT will set off alarms that will alert security. ICT also enables the distribution of work geographically, and for many employees on the road, the complete ability to interact with their employer organisation at any time. Some critics have argued that ICT has created an “always connected” employee who is always at work, and who in practice puts in many more hours of work that normally would be the case, but these criticisms have fallen on deaf ears.

For nations such as Azerbaijan, there are few instances of this new form of ICT enabled organisation in light of the continuing persistence of classical hierarchical structures. This is unlikely to change. Nevertheless, even with a persistence of organisational form, ICT gives Azerbaijan the option to greatly revise and deepen its electronic relationship with a number of stakeholders.
Cyber Security and Cyber Espionage Have Emerged as Major Challenges

Cyber security is another important trend in ICT. The threat has magnified and continues to grow worse. For national security, almost every country’s government appears to have been penetrated, and many secrets stolen. Cyber-attacks have become commonplace, and some argue have become an element of state power. The cyber security doctrines published by many member nations all discuss the development of methods of responding to the threat. Much scholarship has focused on whether or not cyber-attacks that are attributable to one nation can be considered as a kinetic attack that would trigger the right to self-defence in the classical sense.

Cyber espionage in the past decade has emerged as one of the most important if not the most important part of national intelligence power. What originally was code-breaking and interception of point-to-point specific messages gradually evolved into massive collection of flows of information transiting the world’s public telecommunications infrastructure. As social media grew in importance, this also came under analysis by major nation states. Almost all of
these activities were designed to identify and prevent terrorism or other actions that were against the public order.

The other side of cyber espionage involved the use of hacking tools to reach into sensitive military and technology areas of target countries. Observers in one major industrial nation stated that cyber espionage was the “greatest transfer of intellectual property in the history of humankind”. Cyber espionage is difficult to prevent, and the “attribution problem” remains as a major barrier to enforcement of legal norms.

Figure 4 Pathway to International Law for the Control of Cyber Weapons (Blue present; Orange Future)

International Law for Control of Cyber Security Remains Under-Developed

In contrast to many other areas of international relations, in the cyber world, there is little international law that can be applied. Laws regarding war are difficult to enforce in the absence of “kinetic” (physical) damage. There has been some discussion regarding global cyber arms control under the auspices of the United Nations Commission on Disarmament. Although there was initial drafting of an international convention, the effort was suspended because of disagreements on the interjection of peripheral issues into the treaty. An additional problem is
that it is not clear that the major powers consider it in their interest now to agree on an international regime. So, an international treaty will be delayed possibly by a decade or more.

In Figure 4 we visualise the steps to building a set of international laws to control the spread of cyber weapons. Moving from left to right, the international community at this time is in the third phase – emergency of unwritten norms of behaviour between states. Examples of norms of behaviour include rules such as the pursuit of international criminal syndicates and other forms of law enforcement.

It is the nature of the international community that it responds best to a crisis. There is now a realisation that some deeper international communication is needed, but no political will to get it done. If there is a crisis, then it likely will stimulate work on an international solution. In the case of the international convention on chemical and biological weapons, it was events involving the use of nerve gas on civilian populations in Iraq that stimulated rapid completion of negotiations. Likewise, if there were a major cyber event that was global in nature, with a devastating effect on the world’s economy or political situation, then this also would be a powerful stimulus to negotiate an international agreement. This is for the future.

In the intermediate time frame, nations such as Azerbaijan will continue to need increased vigilance regarding the cyber threat. In practical terms, this will mean the requirement to invest a significant amount of resources in this form of national security.

Everything as a Service (XaaS) is the Current State of the Art for Infrastructure

Computing has evolved so that there is increasing abstraction of the computing layers available for use and systems development.
Over time, the architecture of large-scale systems has evolved through different layers of abstraction. The Infrastructure as a Service (IaaS) model relies upon virtual machines, servers, massive storage, and a systems architecture that ties them together through a network so that the intensive transactions load is optimised. The important aspect of IaaS is that the logic of the system has become separated from the specific qualities of the underlying infrastructure.

The Platform as a Service (PaaS) layer provides a suite of software and systems development tools that run on top of the multiple virtual machines in the IaaS layer. Database system, the web server, application development tools, and execution runtime capabilities are handled at the platform layer.

The Software as a Service (SaaS) layer provides applications such as email, a virtual desktop (such as all of the Microsoft Office Suite being provided through a browser), communications, games and Customer Relationship Management (CRM) capabilities. The end-user sees these applications, but is not concerned with the IaaS and PaaS layers that are operating underneath in a support mode. In reality, this type of architecture is designed specifically to *isolate* the end-user and their applications from the layers that are beneath this service, thus providing an important security capability.
The cloud clients layer includes technologies such thin client servers, terminal emulation, mobile applications, and support of web browsers. These are the only applications that the end-user is concerned with. There is no awareness of the layers that exist below in support mode.

**Implication of XaaS for Azerbaijan**

- The Government of Azerbaijan might form a study committee to consider taking over all of the lower layers of this model.
- If the Government of Azerbaijan could build a national supercomputer system to provide universal Software as a Service, it would greatly accelerate the proliferation of ICT into its society and economy.
- By moving to XaaS as an organising architecture, Azerbaijan should be able to radically decrease the number of resources and efforts put into the hyper-expensive client server model of computing.

**Mobile Apps and Internet-of-Things Set the New Programming Standards**

Mobile apps (applications) now represent the largest distribution channel for information and services, including government services. This is because they are distributed principally through mobile “smart” phones.
As seen in Figure 6, end user mobile devices are at the farther-most edge of the enterprise information system. Systems development has followed a historical path that started with the mainframe, now known as the enterprise system. As the distributed minicomputer network and client-server architectures emerged, a middleware layer was created because it was not economic to modify the coding of the enterprise system.

When the Internet and the World Wide Web came into the picture, a web server was added, but the back end of its interface into the middleware layer made web-based inquiries appear the same as other client server devices. Again, information economics played an important part because it was not economic to modify the middleware code. Later, as the Internet browser spread, a web server was put in place to translate incoming browser commands into the middleware languages.

When browsers were placed on small mobile devices such as initially on smart phones, the same system calls were made to the web server, again because of information economics. The apps on mobile devices represent a further development, but they also use the same query and
interactive language as browsers. As the Internet-of-Things (IoT) is put in place, it the query languages will follow the same pattern as the layers that exist underneath it.

The only principal change is that as the end-user interface migrated outwards to the mobile device and its app, the complexity of applications has become simplified. The complexity of interaction with the end-user has been simplified. The relationship between the human and the information system has been reduced to the minimum.

*Implication of mobile apps and Internet-of-Things for Azerbaijan*

- Use the design of mobile apps as the template for systems development. This will enable inherent simplification from the beginning.
- Begin testing with Internet-of-Things by experimentation using environmental sensors to boost agriculture.
- Develop *all* applications financed by the government and government supported institution in the mobile app format.
- Invest more in educating programmers to work on IoT and programming of mobile apps.
- Either abandon or simplify ongoing systems development efforts that are aimed at client-server devices.
- Consider a medium-term plan to eliminate the client-server architecture from most desktops.

*Virtualisation of Organisations is Enabled by ICT*

The concept of virtualisation involves the use of ICT to change organisational forms and more important to enable the creation of new “virtual” organisations that exist on top of the infrastructure of numerous fixed organisations.
In these organisations, an almost synthetic entity is created by harvesting or integrating workflows and the resources to make them work from multiple supporting organisations. Virtualisation depends on the willingness of each of the organisations to participate in a workflow network – a linking together of autonomous workflows into a single integrated workflow of a third-party organisation.

The important value of virtual organisations is that they can exist without disturbing the normal working of the supporting organisations. For example, in Azerbaijan’s ministerial system, a “virtual organisation” might be created that spans ministerial boundaries. In many ways, such a virtual organisation might be similar to merely an inter-ministerial committee.

But there is a large difference. In committees that are set up to operate with cooperation of participants from different ministries, each member of the committee retains their affiliation and allegiance with their “home” ministry. A virtual organisation is different. It operates as a separate defined and legally sanctioned organisation. For example, it is possible to have employees that work only for the virtual organisation, and for the virtual organisation to issue binding contracts.
Virtual organisations also offer a way potentially for Azerbaijan to build a super-structure on top of its ministerial system that is more innovative, and organised in a completely different way.

**Implications of Virtual Organisations for Azerbaijan**

- Experiment with setting up purpose-specific virtual organisations that span different ministries but are designed for working on a single important issue.
- Conduct a feasibility assessment of creating entirely new “purpose built” ministries that ride on top of the current ministerial infrastructure and operate virtually.
- Use virtual organisations to solve specific high priority challenges between the government, the private sector and individuals.
- Review administrative law and statutory law to make it possible for virtual organisations to have a recognisable legal identity.

**Artificial intelligence is Crucial to the Future of Governments**

Artificial intelligence (AI) already has been extensively discussed in this document, beginning on Page 17. It is assessed that this is the next logical area for Azerbaijan to place many of its ICT innovation efforts. This is because the manufacturing and assembly of hardware already has been focused in other parts of the world, and this is not likely to change. Nevertheless, the barriers to entry for utilisation of AI are low.

**Implications of Artificial Intelligence for Azerbaijan**

- Invest in education to build a dedicated core of AI researchers.
- Assemble study team to monitor practical emerging uses of AI world-wide with a view to identifying any application that can be used in Azerbaijan.
- Begin trials of AI in e-Government systems in areas where there is relatively simple logic and a high number of customers (citizens) and transactions.
- Build AI into all computer education curricula as soon as possible.
- Pick the top ICT educators in Azerbaijan and fund their travel to scientific conferences concerned with AI.
- Form inter-ministerial study group to study feasibility if incorporation of AI into the information processing and workflow infrastructure of the government.
Gigahertz Speed Wireless Networks are Changing the Economics of Telecommunications

The next generation of wireless devices (5G) will use very high-speed networks – 20 Ghz and higher, up to 70 Ghz. This will provide bandwidth for mobile devices much greater than is now possible with 4G LTE technologies. The amount of new spectrum capacity that will be coming online is greater than the entire remainder of the spectrum at slower speeds.

These technologies will allow new types of applications such as robotics, and intelligent devices including vehicles because the latency (delay) of the signal is only 1 millisecond or less, compared to 4G standards which have latency of 45 milliseconds or worse.

The infrastructure economics of these high-speed wireless networks is going to change the way infrastructure is built out. Rather than having to allocate the expense and time required to build terrestrial networks, wireless networks will be built much faster, and a much lower cost. The result is that the delays and complexities of laying underground fibre optic cable and wiring individual premises will be replaced by a much faster and less expensive solution. It will be possible to have universal broadband connectivity sooner.

Implications of Gigahertz Speed Wireless Networks for Azerbaijan

- Begin immediate experimentation with Gigahertz wireless networking across all new developments in Azerbaijan.
- Ensure that Azerbaijan allocates its spectrum (frequencies) in a way that matches the available Gigahertz technologies that are coming the market.
- Run trials of Gigahertz “mesh” network solutions so as to build redundancy into the network and keep speeds high.
- Possibly invest in overseas companies that are building Gigahertz equipment.
- Ensure that scientists and engineers in Azerbaijan participate in international scientific events covering 5G and Gigahertz wireless applications.

Gaming, Synthetic Worlds and Augmented Reality Offer New Options for Users

Gaming has emerged as one of the highest contact-hour applications. Many persons spend a large portion of their spare time involved in online games. Gaming no longer is a “stand alone” activity. Instead, gaming platforms allow groups of persons to form into teams and play together, and since games are accessed through the Internet, there is no practical limitation on
who can play, and how persons of different nationalities can participate in the same gaming
team.

Although gaming has been criticised as being negative psychologically for young persons, this
collection is not completely clear. There are a number of benefits for gaming, and little
evidence that significant immersion in gaming has a negative influence on the long-term growth
of a student.

At the same time, there is a larger issue of synthetic worlds and their use in simulations. For
example, virtual worlds have been used extensively for customer service training, and for
training of military personnel prior to deployment. Synthetic worlds also are being used to help
soldiers adjust to loss of limbs or other injuries sustained on the battlefield. In maintenance and
operations, particularly for complex operations that require extensive training because of
danger in the work environment, synthetic worlds are being used also for training.

Augmented reality is being used to supplement the knowledge of a semi-skilled worker who
does not know the repair or other procedure. Augmented reality is being developed in a
number of fields including navigation, and in advertising and many other geo-tagged
environments.

Finally, large-scale 3D virtual reality simulations are being used to train surgeons, and to help
scientists explore the interior or complex molecules such as proteins and even inside atomic
strictures and nanotechnology structures.

The ability for ICT to treat virtual reality as an “output”, such as a printer, means that we will
soon be able to enjoy complex 3-D dynamic representations of complex data sets. This will
create an entirely new type of dashboard or management control interface for complex
information display.

Implications of gaming, synthetic worlds and augmented reality for Azerbaijan

- Invest to ensure that Azerbaijan’s science establishment can take advantage of virtual
  reality technology.
- Investigate the use of virtual worlds for training of the military, and of customer-facing
  employees of the government.
- Place an augmented reality geo-tagged information grid across the City of Baku.
- Experiment with synthetic worlds as a new channel of education and training.
Massive Open Online Course (MOOC) Allow Countries to Update their Education System

Massive Open Online Courses have emerged as a major element in education. They now are being used for corporate training, competency-based education, and new types of services models for providing educational content.

In a MOOC, there may be thousands of students from every location in the world linked together into a single learning experience. Since the underlying philosophy behind the MOOC is that educational information should be open source, MOOCs are free, apart from minor administrative charges that may be levied.

The open source movement in many ways started with the Linux operating system, which is completely free, and is one of the most stable and secure operating systems available. Linux also has very high performance. The open source movement also inspired collaborative efforts such as Wikipedia. The information provided there is considered to be “open content”.

The first efforts at open free educational services was provided by the Massachusetts Institute of Technology (MIT) approximately 10 years ago. Shortly thereafter, the Open University started its “OpenLearn” project. What became clear very quickly was that there is a very great demand world-wide for education. The number of registrations exceeded even the wildest projections.

In the beginning of this decade (2010-2020), MIT’s efforts were supplemented by the Stanford MOOC, and organisations such as Udacity and Coursera. This enabled the consolidation of large number of courses into a single platform. For example, Coursera has a large number of courses covering the entire spectrum of learning for dozens of major universities, including virtually all of the leading universities in the world.

Implication of MOOCs for Azerbaijan

- Study MOOCs as a way to supplement education in Azerbaijan.
- Adopt the same models for the use by educators in Azerbaijan, offering courses in the languages of Azerbaijan.
- Create certification program for selected MOOC materials that allow students in Azerbaijan to obtain credit and degrees based on completely free education.
- Explore models where MOOCs are supplemented by classroom activities and instructors from Azerbaijan to serve as mentors and resource persons for Azeri students.
Mapping the Superstructure of National Innovation Systems

A national innovation system is not a single system, but a number of inter-related systems working together. There is rarely any central direction because there is too much information to make planning accurate and completely rational.

Everyone government employs a number of experts and advisory groups to engage in national level strategy and planning. The utility of the outcome of these exercises can be extremely useful or short-sighted. Some advisory groups are dominated by selfish interests that have as their object the bending of national policy in a way that will bring them wealth or power. Others produce outstanding and visionary results. We can only conclude that selection of members of strategy and planning is one of the more important functions of the executive.

Another actor is the state of human resources available in society. How many trained persons might be recruited into an important national effort? What incentives can be given to get their...
cooperation? Is the type training being given suited for the future? Are people being trained in the technologies and methods of the future or the past?

The role of science. Since the Second World War, the leader in science has been the United States. A giant organisational structure, the Office of Scientific Research and Development (OSRD) run by Vannevar Bush organised the gigantic science projects that developed technologies such as the atomic bomb (The Manhattan Project). These “big science” projects were truly massive in their scale and scope, larger than ever seen before in history. The increase in spending for science in the United States was dramatic:

“[O]verall federal R&D expenditures (in 1930 dollars) soared from $83.2 million in 1940 to a peak of $1,313.6 million in 1945.” (Mowery & Rosenberg, 2000, p. 819)

The pattern developed in the United States wherein the U.S. government funded basic research through universities and the private sector; but applied research was left primarily to the private sector, which was backed up by government purchasing. By 1970, the R&D expenditures being made in the United States still was more than twice the size of all of the R&D being conducted in West Germany, France, the United Kingdom and Japan combined.

The wave of inventions included the space observatory, credit card, transistor, cable television, video games, the compiler, Hamming code, barcode, MASER, crossed-field amplifier, acoustic suspension loudspeaker, nuclear submarine, hard disk drive, industrial robot, operating system for batch processing, Fortran, videotape, Laser, cable tie, Lisp programming language, integrated circuit, weather satellite, magnetic stripe card, global navigation satellite system, electronic spreadsheet, wearable computer, communications satellite, Light-emitting diode, computer mouse, BASIC, geosynchronous satellite, plasma display, Hypertext, minicomputer, cordless telephone, compact disc, dynamic random access memory, calculator, virtual reality, laser printer, charged coupled device, mark-up language, wireless local area network, personal computer, microprocessor, floppy disk, Email, C programming language, Global Positioning System (GPS), mobile phone, voice mail, Universal Product Code, Digital camera, Ethernet, Bulletin board system, Control-Alt-Delete, Graphic User Interface, Internet, Perl language, Firewall, the ZIP file format and artificial intelligence.

Industry plays another crucial part in innovation. Industry for the most part is concerned with applied research, that is, the taking of the results of basic research and turning into useable products. In the early post-war period in the United States, many of the products originally
developed under the auspices of the Department of Defence were adapted for commercial use, so-called “spin-offs”. One of the important roles of government is to use its purchasing power to stimulate demand for a commercial product. With the help of large government purchasing contracts, a commercial enterprise could help to obtain manufacturing economies of scale in order to drive down the unit cost of the product.

Another great science superpower was the Soviet Union. In the post-war period it made tremendous efforts to keep up with the United States. But the system of science operated in a completely different way. There was no role for the private sector because there was no private sector at all. All science was done within various national research organisations managed by the military and coordinated with the Academy of Sciences, which regularly conducted research in almost every field of science. It may have been the lack of an available private sector to turn basic research into applied research that led to under-development of consumer goods in the Soviet Union. There are also indications that in the more advanced areas of science involving military technology, the Soviet Union fell further and further behind. By the end of the Cold War, but bulk of R&D money was being spent on collection of scientific information and technology from the West. Very little was being spent on research, even though the ghost of giant R&D establishments continued to operate.

The finance sector is another important part of the innovation machinery in a nation. Apart from government funded R&D, financial institutions free up capital for investments in businesses, almost always focused on applied research. For the early post-war period, private finance did not play such a great role. However, particularly in Silicon Valley, venture capital and other forms of private finance started to play a major role in creating start-ups. This pattern is maintained today. Governments finance basic R&D, the private sector takes care of the practical aspects of innovation.

In some nations, government investment in large infrastructure programs have also played an important part in innovation. In the United States, the Global Positioning System may be an excellent example of how the government built an important infrastructure that is used by everyone and it a major source of innovation and new applications. But the Internet and the large telecommunications networks in the United States were built completely by private enterprise.
The Innovation Superstructure in Azerbaijan

Azerbaijan has never played a crucial role in the global innovation system. It has a large scientific establishment modelled on the Academy of Science pattern of the Soviet Union, and in spite of more than 25 years of independence, that part of the system has not substantially changed.

Azerbaijan has launched some experiments in fostering startups, and in stimulating innovation. For example, in the area of ICT it has created an ICT Fund, an ICT University, and an ICT Park that acts as a type of incubator for startups. These all have been important efforts, but as measured by the output of Intellectual Property, the results have been less than dramatic. In essence, these were efforts to engineer a situation in which a type of “Silicon Valley” experience would emerge.

It is assessed that in order to play on its strengths, Azerbaijan should use a government-centric approach, but with a different and more flexible coordination mechanism that was present in the past. Success should come from two paths: First, building a national ICT infrastructure that will lower to zero the barriers to entry for any person wishing to think about a new idea in ICT. Second, the government should continue to put in place new coordination mechanisms that are able to work across ministries to identify and solve problems that are unique to Azerbaijan. The government has the power to compel creation of these new ICT innovation-oriented mechanisms. It already has a strong record of success by using this technique in the roll-out of e-Government, and this pattern can be repeated across the entire range of technologies and applications of the knowledge economy.

This is discussed in greater detail below.

SWOT Analysis – Building a Knowledge Economy in Azerbaijan

A SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis is an organisational framework designed to help strategy makers brainstorm how to proceed in solving a specific problem. Here, the issue is what can be done to accelerate the transition of Azerbaijan towards being a knowledge economy.

The concept of the “knowledge economy” is not entirely agreed upon, but for purposes herein, we can say that it refers to the desire to create more value-added in Azerbaijan’s economy...
through information mediated goods and services so that as a result the share of GDP accounted for by oil and gas exploration and exportation decreases.

**Internal Strengths**

Azerbaijan has several internal strengths that can be leveraged to accelerate the transition to a knowledge economy.

**Strong Executive Branch of Government**

The nature of the Government of Azerbaijan is a high degree of centralisation around a powerful executive branch. This is a common and well-understood form of government. This represents a strength because once decisions are made at the top, there is little if any resistance throughout society in carrying out whatever policy is chosen. This has been shown numerous times in Azerbaijan and has its most visible expression today in the construction sector.

If there were a concerted effort on the part of the Executive to push forward several initiatives to create an information society, then Azerbaijan would make very fast progress.

**Strong Organisational Capabilities for National Scale Infrastructure Projects**

Another strength of Azerbaijan is its track record of being able to organise and successfully carry out large infrastructure projects on a national scale. This is shown clearly in the telecommunications sector, in provisioning of e-Government services, in the roads and other parts of the transportation network, and in the remarkably fast rebuilding of the skyline of Baku.

Any government and country that is capable of carrying out large infrastructure projects is perfectly placed to build a national supercomputer centre or national cloud service that can be rolled out through the entire economy. It is only a question of defining what the design will be.

**Ample Capital for Investment in Infrastructure**

The large infrastructure projects that have continued in Azerbaijan in spite of the temporary shock to the economy caused by the recent fall in the price of oil are a testimony to the availability of capital. Azerbaijan is not a nation seriously in debt. A large part of this concentration of capital comes from the way that oil and gas revenues are intercepted by the
government, then used for beneficial infrastructure projects for Azerbaijan’s citizens, who greatly appreciate it, if judged by the voting record concerning the current government, which is very strong. A very large amount of the capital that is accumulated by the Government of Azerbaijan is released into Azeri society in the form of government services and infrastructure. This has not gone unnoticed by Azerbaijan’s population.

If a decision were made to make a massive upgrade to Azerbaijan’s ICT infrastructure, we are sure it could be financed from readily available capital.

Internal Weaknesses

At the same time, Azerbaijan has several weaknesses that might inhibit its transformation. Many of these weaknesses involve the hang-over in organisational structure from the Soviet Union, still an important influence in the organisation of Azerbaijan. Others are related to basic factor endowments.

Competition and Duplication Between Ministries

The ministerial system in Azerbaijan is inherited from the Soviet Union and as such has been optimised for a non-capitalist type of society. It is assessed that there is much duplication between ministries. For example, there is little indication that they cooperate much with each other on national innovation projects, although there are a few programs to be found here and there. There is no national program for procurement of ICT, and no set of standards that everyone is forced to adopt. At the same time, the ministry structure is strong and resistant to change.

In order to improve the situation, Azerbaijan might work harder at inter-ministerial projects, and develop coordination mechanisms that eliminate duplicate spending.

Intellectual Property Creation and Protection

It is assessed that the state of intellectual property creation and protection in Azerbaijan is not as strong as it could be. Compared to another small country such as Israel, Azerbaijan produces almost no intellectual property. This is a serious problem that inhibits Azerbaijan’s attempts at innovation.

This problem further emphasises the importance of Azerbaijan integrating itself more deeply into the world’s economy.
Available Economies of Scale

Azerbaijan is a small country with a population smaller than The Netherlands. The practical effect of this size is that many classical government techniques of industrial policy, such as using the market reservation system or import substitution will not work. If a company in Azerbaijan is going to engage in manufacturing, then it can never reach the economies of scale of similar companies located in other countries.

In addition, there is little possibility of squeezing concessions out of foreign corporations in exchange for getting access to Azerbaijan’s market. This type of argument has been used by China and is effective, but China’s market is thousands of times greater than that of Azerbaijan.

The only strategy for Azerbaijan and its economy is to integrate as quickly as possible into the world’s economy.

Capital Formation in Private Sector

In Azerbaijan, because of the heavy dependence on oil and gas production and exportation as the primary earner for the country, capital and income from these resources is concentrated in the Government of Azerbaijan. These funds are then distributed through the ministerial system and find their way into the economy in the form of salaries and investments in infrastructure. Much also is spent on education.

A number of studies have indicated that capital formation in the private sector in Azerbaijan is relatively poor. This is because most of the capital in the country is tied up within the government and its system of ministries.

Although there are many strengths to the centralised nature of the Azerbaijan government, the persistent weakness of the private sector may do much to inhibit that innovation needed in order to make the ICT driven transition to a knowledge economy.

Language

Azerbaijan was part of Russia and the Soviet Union for many years. Part of that legacy is the Russian language. Although Russian is one of the official languages of the United Nations, and is a superpower, nevertheless, English is the international language of science, business and diplomacy, and this is not going to change for the foreseeable future.
In Azerbaijan, the older generation that will retire within the next decade is primarily oriented towards Russian as the second language.

Without any hint of criticism, we can only point out that the next generation of Azerbaijan’s citizens have been more strongly educated in English. To the extent they become fluent in English, it will be much easier for them to obtain knowledge and participate in the world’s economy. The effects of this change over to English as the dominant second language in Azerbaijan will be felt in the next decade, but for the time being, language is a weakness for Azerbaijan.

Entrenched Educational Establishment and Development of Human Resources

Based on a review of the educational offerings in Azerbaijan, combined with interviews, it is assessed that the educational establishment may not be optimally optimised. For such a small population, there are many universities, many having over-lapping missions between each other. It is not clear how the Academy of Sciences contributes to development of human resources. Some critics argue that it serves primarily as a talking shop, but has little else to show for its large budget.

It is assessed that the level of integration across Azerbaijan’s educational establishment is low, and the proliferation in number of universities has led to a thinning out and over-distribution of ICT related talent. It is urgent that a national commission be put in place for the purpose of benchmarking Azerbaijan’s educational establishment against world class standards.
External Opportunities

There are a number of exciting developments that have opened up a number of opportunities for Azerbaijan, its state enterprises, individuals, and the private sector.

Emergence of Global Industrial Networks

The waves of globalisation in the world’s economy has led to the emergence of large industrial networks operating around the world, and able to perform as if they are a single company, when actually they represent an ICT intermediated virtual organisation form. It is not clear exactly where opportunities may be fore Azerbaijan, but wish a systematic program to screen and locate such opportunities, the promise is that the economy of Azerbaijan can be integrated into one or more of these networks.

The underlying message is that ICT has loosened up what in the past were strongly integrated and unitarily-owned enterprises. There is a place for Azerbaijan and many of its companies
someone in this web of value-added chains. This phenomenon has generated a wave of opportunities never present in previous decades.

XaaS Infrastructure and Supercomputing Platform

The emergency of the XaaS approach to providing ICT may present a substantial opportunity to Azerbaijan if it is able to develop a plan for creation of a national cloud infrastructure to be based on a supercomputing centre (very large mainframe service centre).

The economies of scale that will be available, as well as the substantial economic advantage that comes from having a standardised infrastructure for provisioning of applications make this an excellent place for Azerbaijan to express their natural proclivity towards innovation. By providing a coherent and standardised infrastructure, even perhaps free of charge, Azerbaijan will unleash a powerful wave of innovation. With only practical problems to solve through using ICT, and without burdensome government licensing or control, investors, innovators, and others will rush to create income-generating software.

It is assessed that the building of this type of infrastructure will be a much more productive use of capital than investment in individual projects, many of which will fail to produce the expected results.

Artificial Intelligence

AI presents a unique opportunity because Azerbaijan is of a size small enough to deploy a coherent and integrated national computing infrastructure. Azerbaijan also has a strong tradition of bureaucratic centralisation. As a result, it likely would be possible easily to codify the decision mechanisms into AI algorithms.

A corollary to the opportunity presented by AI is the realisation that Azerbaijan faces little opportunity in manufacturing or even assembling ICT.

MOOCs

Massive Open Online Courses represent a significant opportunity for the country because using them presents a relatively low-cost and rapid way to upgrade many aspects of Azerbaijan’s educational system. Even though the bulk of these materials are presented in English, which is the international language of science and diplomacy, their open source nature presents opportunities for translation.
There is a possibility for Azerbaijan to form a national commission and completely re-engineer the curricula that it is providing in its educational establishment. Adoption of international certification standards for degrees will be a major start. But the adaptation of these materials to the Azeri language will even further stimulate learning.

One of the big advantages of the MOOC approach to education is that the courses usually involve the creation of a self-organising social network to allow the students (from around the world) to form groups, work together on projects, and communicate with one another. Many times, we see the emergence of long-lasting friendships between students who have worked together in the “virtual” classroom.

This type of collaboration is an important skill for the next generation of Azeris to learn. That is the type of skill that is going to be most useful in the future.

External Threats

Azerbaijan faces several geopolitical and geostrategic threats that it is unable to control.

Instability in Price of Oil and Gas

The continued dependence on revenues from oil and gas makes it more difficult for Azerbaijan to plan long-term for its economy. The fall in the price of oil leading to the recent devaluation in Azerbaijan’s currency complicated the planning and interrupted the steady flow of funding from the government to its many ministries.

To the extent that this type of instability could happen again, it continues to pose a threat to development of a knowledge economy.

Depletion of Reserves

There are projections that the reserves of oil and gas upon which Azerbaijan depends for more than 80% of its GDP are diminishing. At current rates of depletion, there may be less than a quarter of a century to cause a major economic crisis for Azerbaijan’s economy. It is not clear whether or not these projections take into account the rapid developments in oil and gas extraction technologies. It may be that the reserves will last much longer than projected.
Brain Drain

The lack of opportunities in much of the Azerbaijan private sector has stimulated a brain drain of young talent. This is seen particularly in the ICT sector and to a certain degree in science across the board. Part of the problem comes from the small size of Azerbaijan’s economy, and what some perceive to be a diminished set of opportunities for young talent. If a person decides not to work for the government, then their opportunities may be more limited in the private sector.

Powerful Neighbours; Unstable Neighbours

Azerbaijan is situated between powerful neighbours and the overall political situation in the area is unstable. The conflict with Armenia continues to add uncertainty into the larger political equation, and the separation of part of Azerbaijan’s territory needs to be solved. A nearby country, Turkey, is significantly involved in military conflicts in Syria and Iraq, and with the demands for autonomy from its Kurdish population. The neighbour to the South, Iran, faces several geostrategic challenges and is involved in a number of conflicts throughout the Arab world. Its continued work on the development of thermonuclear weapons may pose a medium-term threat to international peace and security. The state of Georgia also has had military conflicts in the past decade.

The Government of Azerbaijan appears to be well-aware of these issues, but nevertheless there is always the risk that conflicts can spill over and destabilise the region.
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Appendix – Use of UN Experts

The United Nations system offers a wide range of expert services that may be used for improving the use of ICT throughout the nation of Azerbaijan.

*Table 2 Use of UN Experts for Informatisation of Azerbaijan*

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Functionality and Utility for Azerbaijan</th>
</tr>
</thead>
<tbody>
<tr>
<td>World Intellectual Property Organisation</td>
<td>Mechanisms for monitoring emerging technologies for ICT and related fields where ICT is applied</td>
</tr>
<tr>
<td></td>
<td>Training in analytical techniques for assessment of intellectual property developments including patents that are of interest to long-range planning</td>
</tr>
<tr>
<td>United Nations Department of Public Administration</td>
<td>Selection methodology for identification of the most effective ICT based administrative systems for use in government</td>
</tr>
<tr>
<td></td>
<td>Work on integration of government services</td>
</tr>
<tr>
<td></td>
<td>Capacity building for inter-ministerial coordination in the realm of national ICT planning</td>
</tr>
<tr>
<td>United Nations Development Programme</td>
<td>Design engineering of national cloud computing platform to provide universal access to applications</td>
</tr>
<tr>
<td></td>
<td>Methodology for selection of technology and vendors</td>
</tr>
<tr>
<td></td>
<td>Best practices for contract negotiation for procurement of large-scale computing projects</td>
</tr>
<tr>
<td></td>
<td>Long-range forecasting of ICT trends in government</td>
</tr>
</tbody>
</table>
Appendix – Indicators to Evaluate Progress

There already are a great number of indicators to indicate progress in ICT innovation. For example, the ITU publishes a large amount of statistical information. In addition, UNDP publishes a bi-annual survey of e-Government which measures the effectiveness of governments as they roll out ICT for providing public services. The e-Government survey uses as its input information from the ITU, but also from other sources.

These statistics are based on self-reporting from nations, but generally are considered to be representative. In addition, these publications meet the UN criteria of being universal in nature, that is, every nation is represented, no matter how advanced, or poor in its use of ICT.

In contrast, there are a number of reports from specialised organisations, such as the European Union, that contain detailed information regarding selected countries. This information has a much larger number of indicators that the information provided by the UN’s, as it does not face the necessity of using measures that are applicable to every nation, regardless of its level of development.

For the purposes of this document, we will discuss indicators that are suited to Azerbaijan, taking into consideration its strategic challenges, national priorities for development, and level of ICT utilisation. In addition, we can select indicators that fit the general theory of development that has been expressed in this document.
### Table 3 Measurement of National Infrastructure – Mainframe Computing

<table>
<thead>
<tr>
<th>Classification</th>
<th>Total CPU Capacity</th>
<th>Storage capacity</th>
<th>Transactions per second peak and annual</th>
<th>Number of registered end-user devices</th>
<th>Number of registered users</th>
<th>Penetration of artificial intelligence in large-scale applications</th>
</tr>
</thead>
</table>

### Table 4 Measurement of National Infrastructure – National Cloud Services

<table>
<thead>
<tr>
<th>Classification</th>
<th>Number of virtual machines hosted</th>
<th>Number of registered companies using cloud-based e-Commerce functionality</th>
<th>Transactions per second at peak capacity</th>
<th>Number of transactions per year</th>
<th>Amount of data stored by end users</th>
<th>Percentage of use of Azerbaijan-produced cloud services being used compared to externally sourced cloud services</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Cloud Application Service</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
### Table 5 Measurement of National Infrastructure – Mobility Development and Accessibility

<table>
<thead>
<tr>
<th>Classification</th>
<th>Number of registered mobile devices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transactions per second at peak for all mobile devices</td>
</tr>
<tr>
<td></td>
<td>Percentage of services accessed within Azerbaijan compared to outside Azerbaijan as measured by: (a) transactions per second at peak rate; (b) transactions total per year; (c) amount of data storage</td>
</tr>
<tr>
<td></td>
<td>Percentage of applications developed first for mobile platforms before being developed for other platforms.</td>
</tr>
<tr>
<td></td>
<td>Number of applications that are accessed from mobile devices.</td>
</tr>
<tr>
<td></td>
<td>Growth Rate CAGR of mobility applications</td>
</tr>
<tr>
<td>Mobile Wireless Communications</td>
<td>2018–2020</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Global data volume reaches 140 Exabytes/Month</td>
<td>Begin deployment of mobile sensing infrastructure.</td>
</tr>
<tr>
<td>5G Network with 30-70Ghz Internet-of-Things</td>
<td>Internet penetration reaches more than 95% of humanity.</td>
</tr>
<tr>
<td>Internet-of-Things (IoT)</td>
<td>Begin introduction of wearable permanent Internet enabled devices.</td>
</tr>
<tr>
<td>Development of environmental sensors Initial introductions in consumer appliances Autonomous vehicles</td>
<td>Accelerated adoption of home-automation technologies.</td>
</tr>
<tr>
<td>Switching Fabric</td>
<td>Emergence of different business models for provisioning of telecommunications network services, including breakdown of vertical integration in providers.</td>
</tr>
<tr>
<td>Software Defined Networks (SDN) Network logic is separated from infrastructure</td>
<td></td>
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</table>
Table 7 Roadmap of Scenarios for Cyber Conflicts

<table>
<thead>
<tr>
<th></th>
<th>Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2018–2020</td>
</tr>
<tr>
<td><strong>Weaponisation of Cyberspace</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nations continue to build both offensive and defensive cyber weapons capabilities</td>
</tr>
<tr>
<td><strong>Legal Regime</strong></td>
<td>Continued work on definition of cyber war and interpretation of Article 52 of UN Charter allowing self-defence.</td>
</tr>
<tr>
<td><strong>Commercialisation of Cyber Security</strong></td>
<td>Continued development of cyber security software and systems; but no change in overall threat level.</td>
</tr>
<tr>
<td><strong>Overall Threat from Cyber Disaster</strong></td>
<td>Moderate threat, as security technology continues to be deployed and security training is improved.</td>
</tr>
</tbody>
</table>
### Role of Non-State Actors in Cyber Security

- Continued use of encryption and other cloaking technologies (“Dark Web”) by international criminal syndicates and terrorists.
- Higher chance of coordinated attacks against national infrastructures.
- Continued problems with financial fraud and other scams.
- More than 90% probability of major coordinated attack against national and international institutions leading to significant disruption.

<table>
<thead>
<tr>
<th>Global Information Security Market Total Revenue</th>
<th>2018 – $96.3</th>
<th>2021 – $111.6</th>
<th>2026 – $140.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019 – $100.0</td>
<td>2022 – $117.1</td>
<td>2025 – $134.2</td>
<td></td>
</tr>
<tr>
<td>2020 – $105.9</td>
<td>2023 – $122.9</td>
<td>2030 – $170.5</td>
<td></td>
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</tbody>
</table>

US $ Billions unadjusted for inflation
### Roadmap for National Planning

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Ministries</td>
<td>Work on developing trans-ministerial coordination and planning systems.</td>
<td>Convert coordination and planning system into stand-alone virtual organisations.</td>
<td>Refine process of searching and evaluating opportunities outside of Azerbaijan.</td>
</tr>
<tr>
<td>ICT Ministry</td>
<td>Increase focus on planning for development of national ICT infrastructure on the cloud and XaaS model. Consider dropping or cutting back investments in assembly or manufacturing of hardware.</td>
<td>Begin procurement of national supercomputer centre to provide cloud services for entire economy. Define architecture in which government controls the back end, leaving end-users to work with mobile and other thin clients.</td>
<td>Optimise operation of national cloud service. Continue to lower barriers to entry for innovators at the cloud client level. Continue to rationalise and streamline all government purchasing of ICT.</td>
</tr>
<tr>
<td>Executive</td>
<td>Begin formation of study group to put in place national coordination of ICT innovation. Encourage creation of collaboration systems working across ministries.</td>
<td>Allocate resources for development of national computing infrastructure. Manage compliance of ministries with national standardisation and procurement policies.</td>
<td>Continue to rationalise national procurement and centralisation of ICT infrastructure resources. Improve national strategy and planning efforts to match economic needs, particularly in non-oil sector.</td>
</tr>
</tbody>
</table>
Figure 10 Clark’s Sector model for industry sectors in the US economy from 1850 to 2009
Figure 11 Artificial Intelligence Applications – Cumulative Revenue 2016–2025 (US$ Million)
Figure 12 5G Mobile Subscriptions Worldwide by Region (Millions)
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