ECONOMIC REFORM AND GROWTH DYNAMICS DISCUSSION PAPER SERIES

In 2015 the United States Agency for International Development commissioned a set of discussion papers to review Myanmar's economic status, benchmark its performance relative to other countries, and identify priority policy reforms and institutional innovations to place the country on an inclusive growth path. This effort has been led by Nathan Associates under the Private Sector Development Activity and the ASEAN Connectivity through Trade and Investment Project.

Nathan Associates has a long history of providing economic analysis of the Myanmar economy. In 1953, Nathan Associates, along with Knappen Tippetts Abbett McCarthy Engineers and Pierce Management, delivered to the U Nu Government an 8-year economic and social development program. Unfortunately, what the report called a "golden opportunity" for rapid growth was lost. The present set of discussion papers is designed to revive the initiative begun more than 60 years ago, providing a careful analysis of conditions in Myanmar and recommendations for delivering growth and prosperity to all of the people of the country.

USAID
FROM THE AMERICAN PEOPLE

ICT DEVELOPMENT FOR INNOVATION AND GROWTH IN MYANMAR

FEBRUARY 2016; UPDATED JUNE 2016
This publication was produced by Nathan Associates Inc. for review by the United States Agency for International Development.

ACKNOWLEDGMENTS

This discussion paper was prepared by Solomon Moore and David Madden. The authors are grateful for comments and suggestions on earlier drafts from Lynn Salinger, Steve Parker, Bruce Bolnick, and other participants in the Economic Reform and Growth Dynamics Study workshop held at the Private Sector Development Activity office in Yangon, Myanmar on January 13–14, 2016.

PHOTO CREDITS

The team would like to thank the following for the photos provided.
- Jeffrey Barth, Paula Bronstein, Tom Cheatham, Nathan Associates Inc.
- Asian Development Bank, Ericsson, World Bank

ICT DEVELOPMENT FOR INNOVATION AND GROWTH IN MYANMAR

DISCLAIMER

This document is made possible by the support of the American people through the United States Agency for International Development (USAID). Its contents are the sole responsibility of the author or authors and do not necessarily reflect the views of USAID or the United States government.

ECONOMIC REFORM AND GROWTH DYNAMICS DISCUSSION PAPER SERIES

In 2015, as Myanmar prepared for new elections, the United States Agency for International Development (USAID) commissioned a set of discussion papers to review Myanmar's economic status, benchmark its performance relative to other countries, and identify priority policy reforms, investments, and institutional innovations to re-establish the country on a new, inclusive growth path. This effort has been led by Nathan Associates under the Private Sector Development Activity (PSDA) and the Association of Southeast Asian Nations (ASEAN) Connectivity through Trade and Investment project Economic Reform through ASEAN Integration program.

Nathan Associates has a long history of providing economic analysis of the Myanmar economy. Originally headed by the economist Robert R. Nathan, who helped develop the United States' first national accounts in the U.S. Department of Commerce, Nathan Associates was founded in 1946 to provide applied economic analysis services to clients in the United States and around the globe and started working in Burma in 1951 at the request of the U Nu government. The latter sought "advice with respect to various important aspects of the country's economy and engineering problems and assistance in solving practical operating difficulties." Nathan Associates worked in Burma until 1959 with two U.S. engineering firms to deliver this advice, initially with funding from the U.S. Technical Cooperation Administration (a predecessor to USAID) and later with direct support from the Burmese government.

In 1953, Nathan Associates, along with the firms of Knappen Tippetts Abbett McCarthy Engineers and Pierce Management, delivered to the U Nu government an 8-year economic and social development program. The comprehensive plan, "Economic and Engineering Development of Burma," laid out a strategy of economic and administrative policies to stimulate growth in agriculture and irrigation, transportation, telecommunications, power, and industry, along with an analysis of the country's macroeconomic conditions. Unfortunately, what the report called a "golden opportunity" for rapid growth was lost, as many of the recommendations were set aside due to political developments in the late 1950s and early 1960s.

The present set of discussion papers is designed to revive the initiative begun more than 60 years ago, providing a careful analysis of conditions in Myanmar and recommendations on how the country can accelerate its integration into the global economy and deliver growth and prosperity to all of the people of the country.

Lynn Salinger, Principal Associate at Nathan Associates, has led the design and implementation of the discussion paper series in collaboration with Steve Parker, Chief of Party of the Private Sector Development Activity, and Tim Buehrer, Chief of Party of the ASEAN Connectivity through Trade and Investment Project. Daniel Swift has supervised the effort from the U.S. Agency for International Development Mission to Burma.

LIST OF ACRONYMS

2G	(GSM) refers to network speeds of up to 9.6 Kbps voice calls, and SMS
3G	(UMTS) refers to speeds 384 Kbps & 2 Mbps, VOIP calls, music, video
4G	(LTE) refers to speeds between 3-100 Mbps, high-definition streaming
5G	High-frequency millimeter waves that are theoretically capable of transmitting gigabits of data per second
ADB	Asian Development Bank
ADSL	Asymmetrical digital subscriber line
API	Application program interface
ARPANET	Advanced Research Projects Advanced Network
ASEAN	Association of Southeast Asian Nations
ATM	Automated teller machine
BW	Bandwidth
CBM	Central Bank of Myanmar
CDMA	Code division multiple access
CDN	Content delivery network
CIO	Chief information officer
CSO	Civil society organization
EFT	Electronic funds transfer
EHR	Electronic health record
ESCOs	Energy service companies
ESMF	Environmental and Social Management Framework
FDI	Foreign direct investment
GAD	General Administration Department
Gbps	Gigabits per second
GDP	Gross domestic product
GHz	Gigahertz
GIS	Geographic information system
GPS	Global Positioning System
GSM	Global System for Mobile communications
GSMA	Groupe Speciale Mobile Association
HTTP	Hypertext transfer protocol
IAB	ICT advisory board
ICT	Information and communications technology
IEEE	Institute of Electrical and Electronics Engineers
IGT	Irrawaddy Green Towers
IMF	International Monetary Fund
IP	Intellectual property
IPMO	ICT project management office
IPOM	Intellectual Property Office of Myanmar
ISP	Internet service provider
ITCSD	Information Technology and Cyber Security Department
ITS	Intelligent transportation system
ITU	International Telecommunication Union

JICA	Japanese International Cooperation Agency
Kbps	Kilobits per second
kHz	Kilohertz
KSGM	KDDI Summit Global Myanmar
LTE	Long-term evolution
MAU	Monthly active users
Mbps	Megabits per second
MCF	Myanmar Computer Federation
MCIT	Ministry of Communications and Information Technology
MCRB	Myanmar Centre for Responsible Business
MCRC	Myanmar Communications Regulatory Commission
MHz	Megahertz
MMCERT	Myanmar Computer Emergency Response Team
MMSIS	Myanmar Statistical Information Service
MOH	Ministry of Health
MOTC	Ministry of Transportation and Communications
MPA	Mobile Product Authentication
MPT	Myanmar Posts and Telecommunications
MPU	Myanmar Payment Union
MW	Megawatt
MYTHIC	Myanmar-Malaysia-Thailand International Connection
NGO	Nongovernmental organization
OECD	Organization for Economic Cooperation and Development
PPIAF	Public-Private Infrastructure Advisory Facility
PTD	Post and Telecommunications Department
RFID	Radio frequency identification
RTGS	Real-time gross settlements
SEA-ME-WE-3	Southeast Asia-Middle East-Western Europe 3 cable
SIM	Subscriber identification (or identity) module
SME	Small and medium enterprise
SMS	Short message service
STEM	Science, technology, engineering, and math
TCP/IP	Transimission Control Protocol/Internet Protocol
TRIPS	Trade-Related Aspects of Intellectual Property Rights
TVET	Technical and vocational education and training
UHF	Ultra-high frequency
UN	United Nations
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
USAID	United States Agency for International Development
USN	Ubiquitous sensor network
USF	Universal service fund
USO	Universal service obligation
VHF	Variable High Frequency
WCDMA	Wideband Code Division Multiple Access
WiMax	Worldwide Interoperability for Microwave Access
WIPO	World Intellectual Property Organization
WS	White space
WTO	World Trade Organization
YPT	Yatanarpon Teleport

CONTENTS

ILLUSTRATIONS

Figures

Tables

THIS PAGE IS INTENTIONALLY LEFT BLANK

1. INTRODUCTION

Until the entry of foreign mobile operators in 2013, Myanmar was one of the world's last information and communications technology (ICT) greenfield—that is, completely undeveloped— markets. Myanmar was a nation where public pay phones were the standard, residential fixed-line telephones were an unattainable luxury for most citizens, and a 2G[1] mobile SIM card[2] could cost thousands of dollars with no guarantee of reception. Since Myanmar established democratic elections and economic liberalization policies in 2011, no sector has transformed as radically or as rapidly.

Now more than half of the nation peers into mobile phones on a daily basis and the majority of those devices are smartphones. Myanmar's mobile phone subscription market grew by 5 million subscriptions in the third quarter of 2015, making Myanmar the world's fourth fastest growing mobile market, surpassed only by China, India, and the United States.[3] As of September 2015, Myanmar had 29 million active mobile subscriptions in a country with an official population of 53 million, representing 300 percent subscriber growth in just one year. Voice and data usage grew by 90 percent and 200 percent respectively in the first half of 2015.[4]

Putting networked communications tools in the hands of millions of citizens has improved access to information, seeded new online constituencies, and transformed social relations, virtually overnight. The government's liberalization of information technologies is also being perceived as a dramatic move toward greater openness and accountability.

Telecommunications investment is the second largest component in approved foreign direct investment (FDI) projects over the period 2013–14 to 2015–16.

ICT: SECOND BIGGEST CONTRIBUTOR TO FDI IN MYANMAR

Telecommunications sector development is also having a significant positive economic effect in Myanmar. Telecommunications investment is the second largest component in approved foreign direct investment (FDI) projects over the period 2013–14 to 2015–16, ranking behind the energy sector.[5] Telecommunications licenses in 2015 accounted for 2 percent of Myanmar's gross domestic product (GDP) in 2015.[6] Myanmar's ongoing build-out of nascent telecommunications networks sets the stage for the establishment of Internet services and broadband

[1] The terms 2G, 3G, 4G, and 5G refer to progressively more powerful generations of mobile telecommunications; see Acronym list for definitions.

[2] A SIM card is an integrated circuit chip that securely stores subscriber and authentication information on mobile telecommunications devices.

[3] Ericsson (2015).

[4] Wayan Vota, "Wow, Myanmar is Going Straight to Smartphones," ICT Works, September, 16, 2014, http://www.ictworks.org/2015/09/30/wow-myanmar-is-going-straight-to-smartphones/, (accessed January 5, 2016).

[5] Over the three years, oil and gas projects accounted for 37 percent, transport and communications 22 percent, and manufacturing 20 percent of the value of approved projects. Myanmar Directorate of Investment and Company Administration, "Yearly Approved Amount of Foreign Investment (By Sector)."

[6] Tenzin Dolma Norbhu, "Leveraging ICT Sector Reforms for Growth and Transparency" (PowerPoint presentation, Yangon, December 10, 2015).

networks and indicates the potential for more growth.

Information and communications technologies (ICTs) increase the speed, fidelity, and range of communications; they generate, collect, and store information autonomously at scale; and they facilitate analysis with precision—again, with speed and scale. ICTs can also have broad multiplier effects throughout economies by improving access to basic services, enhancing connectivity, and creating employment opportunities, especially for marginalized communities. Most studies of the economic impacts of ICT growth show that investment in ICT infrastructure can have a significant positive impact on GDP and productivity.[7] A few show higher positive correlations between ICT and growth in developed countries than in poorer nations due to infrastructure scarcity, low-skilled labor, and other relative deficits. Other studies suggest that positive causal relationships between ICT and growth only emerge in relatively stable political settings or after digital services have reached a threshold of universal access or other such conditional contexts.

Even contrarian findings—such as the conclusion that ICT investment may not have a direct impact on growth, but instead contributes indirectly to economic growth through increased trade—suggest ICT investment has multiplier effects that make the sector a vital area for broad development.[8] For example, a survey of available literature on ICTs' impact on economic growth (focused mainly on the United States and Europe) found that a 10 percent increase in ICT investment leads to a 0.6 percent increase in GDP growth on average. Moreover, the impact of ICT has grown as the sector has advanced. Another study of 2008 data from 33 Organization for Economic Cooperation and Development (OECD) member countries concluded that doubling broadband speeds for an economy can add 0.3 percent to GDP growth.[9] And a 2010 survey of 22,000 respondents in eight nations, including Brazil, India, and China, found that introducing an average 0.5 Mbps (megabits per second) broadband connection increased household income by US$800 per year.[10]

Nearly all research on the economic effects of ICT supports the notion that it is a general-purpose enabler of whole economies and a vector of wide-scale social and institutional development. Studies consistently show that ICTs improve access to basic services, enhance connectivity, and create new employment opportunities. Research also suggests that ICTs are foundational technologies for innovation and knowledge production, which have deeper and more endogenous economic effects than the production of ordinary goods.[11]

POVERTY, POOR INFRASTRUCTURE, SANCTIONS: STILL ICT RISES

The full potential of ICTs in Myanmar has yet to be realized. So far, ICT development has progressed in an unplanned manner. Internet networks, cybersecurity policies, interoperability standards, adequate spectrum regulation, and other essential requirements for healthy sector growth are insufficient. Myanmar's ICT development must also contend with systemic obstacles, including the legacy of a military dictatorship that until 2011 regarded electronic media as a threat to its rule and a propagandistic weapon to subvert opponents. Authorities remain ambivalent about ICT and monitor Facebook pages of dissidents whose communications regularly result in prison sentences.

ICT investment has multiplier effects that make the sector a vital area for broad development.[8]

The full potential of ICTs in Myanmar has yet to be realized.

Myanmar ICT networks remain dependent on unreliable, low-bandwidth 3G networks, and suffer from too few international gateway connections to the global Internet.

Myanmar's ICT sector has attracted investment despite crippling United States sanctions and the lingering effects of former European and Australian embargos.[12] Myanmar continues to be one of Asia's poorest nations, where a recent government proposal to set a US$2.80 minimum daily wage was wildly controversial and scared off several of the few manufacturing firms remaining in Myanmar after decades of economic stagnation. More than 70 percent of the population is rural—a rate virtually unchanged since the 1930s—evincing a lack of investment in workforce development and structural transformation since that time. Myanmar suffers from scarce investment in science, technology, engineering, and math (STEM) education, high informality, minimal regulatory capacity, and a paucity of data to guide policymakers, investors, and researchers.

Infrastructure scarcity, including in telecommunications, also hinders Myanmar, which ranks 133 out of 155 in the World Bank's Logistics Performance Index.[13] When Myanmar issued its telecommunications request for proposals in 2013, the nation's communications infrastructure consisted mainly of copper trunk lines between Mandalay and Yangon and a more extensive 2G network under strict military control. Myanmar ICT networks remain dependent on unreliable, low-bandwidth 3G networks, and suffer from too few international gateway connections to the global Internet. Myanmar relies on a single submarine cable, a transoceanic link to the Southeast Asia-Middle East-Western Europe 3 (SEA-ME-WE-3) cable. At least one company plans to deploy a second undersea cable by 2017. Telecommunications networks in 2016 remain mostly limited to Myanmar's urban centers, with two-thirds of the population lacking coverage.

Private companies Telenor and Ooredoo[14] and Myanmar Posts and Telecommunications (MPT) are currently engaged in a breakneck race to install ducts, cables, masts, towers, transponders, routers, switches, dishes, servers, and other infrastructure in time to meet obligations under their commitments with the Ministry of Transportation and Communications (MOTC). The logistical obstacles faced by telecommunications providers and tower companies are formidable. No industry has deployed such infrastructure under such disparate conditions in Myanmar: traversing rainforests, mountains, and rivers in one of Asia's largest and most sparsely populated land masses. Tower companies must also contend with

[7] Kretschmer, Cardona, and Stobel (2013).

[8] Meijers (2012).

[9] Ericsson, Arthur D. Little, and Chalmers University of Technology (2013).

[10] Rohman and Bohlin (2012).

[11] "The *technological capabilities* of workers and managers refer to their abilities to use machines and technologies properly. These capabilities are partly based on formal education and training but can also depend on on-the-job learning-by-doing," in Khan (2013, 2).

[12] Australia lifted economic sanctions against Myanmar in 2012, and in 2013, the European Union lifted all sanctions against Myanmar, except for an enduring arms embargo.

[13] The Logistics Performance Index is based on a worldwide survey of operators on the ground (global freight forwarders and express carriers), providing feedback on the logistics "friendliness" of the countries in which they operate and those with which they trade. Although not a direct assessment of the level of infrastructure development in a country, it can be used as a proxy on the state of transport infrastructure and ease of getting around. Arvis et al. (2012).

[14] The Norwegian Telenor Group and the Qatar-based communications firm, Ooredoo, were awarded the first foreign-held licenses for mobile telecommunications service in Myanmar in mid-2013. They both signed 15-year licenses with Myanmar in January 2014.

power shortages in one of the world's least electrified nations.

MYANMAR'S ICT CHALLENGES ARE ORGANIZATIONAL, NOT JUST TECHNOLOGICAL

As daunting as these challenges are, the greatest tests for Myanmar's ICT development are less technological than they are organizational and political. The system requirements for rolling out ICT are fundamentally the same everywhere. Engineering standards, information architecture best practices, skills-base prerequisites, applications, and hardware for ICT systems are more or less globalized. The difficulty for Myanmar's government of ministerial fiefdoms and resource silos is less the acquisition of new technologies, and more about developing institutional capacity. As ICT is not a stand-alone sector, Myanmar's toughest challenge will be bypassing bureaucratic chokepoints, implementing regulatory and political reforms, and creating an enabling environment for investment by a broad array of service providers and operators. To succeed, Myanmar must employ a whole-of-government approach, a capability that until now has been the domain of Myanmar's military. Interministerial and interagency coordination will require new laws and regulations regarding ICT policy implementation. For example, government functions including data sharing, standardized web platforms, broadband spectrum maintenance, procurement, and other ICT activities should be made more efficient by the establishment of interoperable frameworks.

While Myanmar's ICT deficit is a hindrance to development, it also presents certain greenfield advantages specific to the distinctly fluid, modular nature of digital innovation. In more developed information societies, innovation is made more complicated and expensive by the many layers of legacy technologies that require expensive technological workarounds. If it executes its ICT strategy carefully, Myanmar has the opportunity to maximize efficiencies in scaled procurement and infrastructure construction.

To proceed, a strong, coordinated approach is needed. While such an approach may resemble industrial policy, considered controversial among some economists, strong government intervention is arguably the preferred strategy.[15, 16] The birth of the Internet in the United States was fostered by strong industrial policy elements, with public funding provided to leading technology centers across the country (Figure 1).

To proceed, a strong, coordinated approach is needed.

MYANMAR'S ICT SECTOR IS GROWING AS GLOBAL TECHNOLOGIES BOOM

Myanmar is coming online in the midst of a global expansion of ICT networks beyond industrialized nations and into developing world contexts with wide-ranging effects on agriculture, health, education, logistics, and other sectors.[17] Myanmar is already being swept up by one of the major global technology trends of our time: mobile computing. The proliferation of smartphones and other cheap sensors is creating networked systems that are massively expanding data collection and analysis capabilities. The most transformative network innovations are three interlocking conceptual and technological frameworks: cloud computing, big data, and the Internet of Things. These three cutting-edge digital resources are changing the way information is collected, managed, analyzed, and distributed.

As ICT is not a stand-alone sector, Myanmar's toughest challenge will be bypassing bureaucratic chokepoints, implementing regulatory and political reforms, and creating an enabling environment for investment by a broad array of service providers and operators.

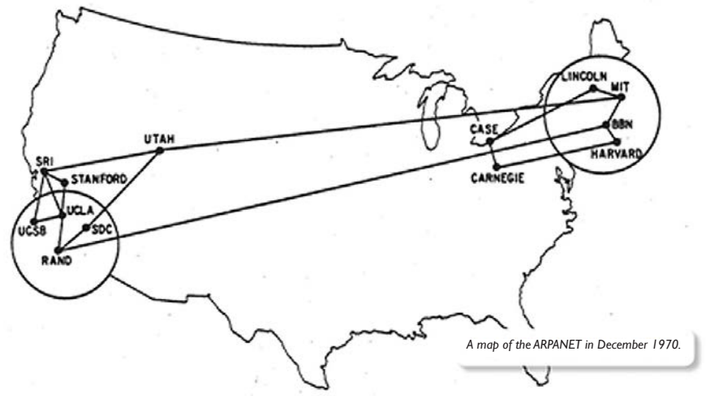
Myanmar is coming online in the midst of a global expansion of ICT networks beyond industrialized nations and into developing world contexts with wide-ranging effects on agriculture, health, education, logistics, and other sectors.[17]

[15] http://www.darpa.mil/attachments/(2O15)%20Global%20Nav%20-%20About%20Us%20-%20History%20-%20Resources%20-%2050th%20-%20Internet%20(Approved).pdf, (accessed on January 5, 2016).

[16] Pereira (2014).

[17] http://recode.net/2015/05/29/the-next-billion-a-new-digital-generation/, (accessed on January 5, 2016).

FIGURE 1: THE INTERNET WAS CREATED BY INDUSTRIAL POLICY



A map of the ARPANET in December 1970.

Note: This diagram of the Advanced Research Projects Advanced Network (ARPANET), the Internet's predecessor, from 1970 is widely available on the Internet today.

"Cloud computing" refers to pooled networked storage and processing resources that are accessible over the Internet to all users—governments, industries, civil society groups, and individuals—anywhere in the world. "The cloud" is democratizing computing power by providing on-demand service, broad network access, and shared computing resources. Features of the cloud include access to (1) software, allowing users to interact with applications running on cloud infrastructure; (2) platforms, allowing users to deploy applications using programming resources supported by the provider; and (3) infrastructure, which provides users with processing, storage, networks, and other fundamental computing resources to run software remotely. Clouds may be provided publicly, privately, or in hybrid fashion. Myanmar's workforce lacks adequate technical skills and its ICT network infrastructure is weak, but the government could mitigate these deficiencies while fostering private investment by procuring cloud computing services.

"Big data" refers to massive and networked databases, usually stored in the cloud, analyzed using software to reveal patterns often perceptible only at scale. Myanmar has embarked on a path of modernization and reform, but with relatively little analytic insight due to poor data collection and minimal analytic capability. Government can use big data frameworks to prioritize its data collection, organize essential research functions, enhance analysis, and spur evidenced-based policy formulation. Big data illuminate service delivery, social behavior, and sector trends, thereby both helping policymakers to target reforms and also lowering risks to potential market entrants.

The "Internet of Things" refers to connection of the Internet to the physical world via ubiquitous, intelligent sensors. Initially, the most important applications of this framework in Myanmar will be in the agricultural and logistics sectors, where market actors will be required to establish traceability and quality assurance regimes for produce and livestock, especially for export. Myanmar's energy sector can also benefit from the use of networked, machine-to-machine sensors to monitor and increase the efficiency of critical infrastructure like pipelines and power grids. Among

the three global ICT trends mentioned here, the Internet of Things is the least developed in Myanmar and likely has the most potential for disruptive impacts.[18, 19]

While such technological applications may seem remote in Myanmar, they are not. Myanmar has an opportunity to bypass legacy systems in order to take advantage of global paradigm shifts in information technologies during the last two decades. Eighty percent of Myanmar's mobile subscribers now use smartphones—networked computers with GPS (Global Positioning System), environmental, audiovisual, and other sensory capabilities. Smartphones connected to the Internet via data plans are among the fundamental building blocks for cloud computing, big data, and the Internet of Things. Many of the 3G networks now being deployed in Myanmar will eventually support 4G or 4G LTE, with significantly faster download speeds than 3G. In May 2016, Ooredoo announced the roll out of its 4G networks.[20]

Other technologies are also coming. For example, 4G LTE and 5G networks may soon be supported by aerial platforms. High-altitude balloons, low-altitude satellites, and solar-powered drones planned for global deployment as early as 2016 could provide access to the Internet from the skies. This would dramatically reduce the expense of fiber networks in remote areas and thereby accelerate ICT sector progress.[21]

GEOGRAPHY AS DESTINY: MYANMAR, THE ICT HUB

In addition to Myanmar's technological blank slate, it enjoys another, more concrete advantage for ICT development: its geographic location, which could enable it to become an ICT hub. Technology is often deployed to transcend geospatial obstacles; the cloud, for example, can be located and accessed anywhere there is a reliable link. But research suggests proximity continues to play an important role in innovation and technology transfer, which is good news for Myanmar.[22]

Myanmar's ICT sector is already, to a large extent, the beneficiary of regional developments in ICT. Myanmar's sole submarine link connects the nation's Internet to Malaysia. Other terrestrial links to Bangladesh, Thailand, India, and China also facilitate Myanmar's ambition to emerge from isolation and join the global marketplace of online goods and ideas.

Due to its size and geographical location, Myanmar could become an information hub if it makes smart investments in infrastructure, human resources, and policy reforms. Myanmar should also work closely with China, India, the Association of Southeast Asian Nations (ASEAN), and Western governments to pursue a regional ICT leadership role. Part of Myanmar's strategy will be to add generic infrastructure, for example, simply increasing fiber links, data centers, and other facilities. Myanmar also needs to consider carefully how to apply specific ICT innovations to its existing industries to increase overall growth and greater productivity.

Myanmar's ICT development will be influenced by the technological trajectories of its neighbors, particularly China and India, the world's most aggressive builders of new technological

Myanmar has an opportunity to bypass legacy systems in order to take advantage of global paradigm shifts in information technologies during the last two decades.

Due to its size and geographical location, Myanmar could become an information hub if it makes smart investments in infrastructure, human resources, and policy reforms.

[18] GSM Association (2014).

[19] Bradley, Barbier, and Handler (2013).

[20] http://www.mmbiztoday.com/articles/ooredoo-myanmar-launch-4g-services (accessed on June 13, 2016).

[21] Simonite (2015).

[22] Torre (2008).

infrastructure. China, the world's third most prolific smartphone producer, dominates the mobile phone market in Myanmar and is also helping to build Myanmar's fiber networks. China regards Myanmar as a component of several important regional network integration strategies. India, too, is at a critical point in its ICT industry development. Although India has yet to establish the same kind of presence in Myanmar as has China, the relative commercial importance of the Indian presence in Myanmar is likely to change as India's ICT sector, particularly its software industry, gains more capacity.

The region offers plentiful opportunities for rapid progress. Myanmar stands to benefit from greater involvement in the United Nations Economic and Social Commission for Asia-Pacific (UNESCAP)[23] and China's One Belt, One Road initiatives.[24] Deploying infrastructure that capitalizes on its long borders with China, India, Bangladesh, Laos, and Thailand, Myanmar can leverage strides each of those nations have made in ICT development. Also, as a member of ASEAN, Myanmar is also partnered with Viet Nam, Cambodia, Malaysia, Indonesia, and most importantly, Singapore, the world's most advanced ICT hub and a primary ICT skills market.

Myanmar's experience is singular. Seldom have so many offline people been connected to digital networks so quickly. It is also important to note that the rapid uptake of mobile telephony in Myanmar has been achieved with only the barest legal and regulatory frameworks and minimal institutional capacity, which suggests much faster and more pervasive growth will be achieved with a well thought-out approach. The most notable enabling decision the government has made to date has been simply to get out of the way, allowing foreign mobile network operators to enter the market. Starting from a virtual standstill, the explosive growth of ICT in Myanmar is proof of pent-up demand and an encouraging sign of what the future holds as ICT markets are formalized.

Myanmar's experience is singular. Seldom have so many offline people been connected to digital networks so quickly.

OVERVIEW OF PAPER

This discussion paper provides a snapshot of ICT development in Myanmar, offering a vision for implementation of ICT across government agencies and economic sectors and recommending and prioritizing policy reforms to accelerate ICT development. It is informed by desktop research and interviews undertaken in September and October of 2015 with ICT stakeholders in Myanmar and elsewhere in Southeast Asia, and was updated in mid-2016 to take account of the new government's restructuring of institutional responsibilities for the sector. The rest of this paper presents a brief historical overview of ICT development in Myanmar, rationales for investment in ICT as a general purpose sector, and a vision to harness ICT's potential to modernize Myanmar and link it to regional and global markets (Section 2). The paper suggests priorities for ICT development, including the need for physical ICT infrastructure (Section 3), and the legal and regulatory reforms and requirements to modernize state institutions and attract technology sector investment (Section 4). The paper also presents a snapshot of potential ICT applications in several of Myanmar's economic sectors (Section 5). The paper closes with a series of prioritized policy recommendations for consideration by the new Myanmar government and its development partners (Section 6 and Annex 1).

[23] United Nations Economic and Social Commission for Asia and the Pacific (2014).

[24] Dollar (2015).

2. HISTORICAL OVERVIEW AND VISION OF THE FUTURE

Myanmar's emerging digital information society is the result of globalization and technological trends intruding upon the nation's internal political conflicts.

ICT BREAKS THROUGH

Myanmar's emerging digital information society is the result of globalization and technological trends intruding upon the nation's internal political conflicts. Myanmar's political dissidents, along with the military and state-run Internet service providers, were among the earliest adopters of digital communications technologies. By the 1990s, exiled opposition groups and journalists were using video tapes, satellite broadcasts, news groups, mailing lists, and websites to coordinate protests and disseminate political information. Despite low Internet penetration rates (less than 1 percent of the population), cybercafes proliferated—particularly among students and young people—allowing cyber dissidents to circumvent censorship rules.

Government concerns about the destabilizing effects of information technologies were countered by the desire of elites to capitalize on ICT's economic benefits. By 2001, electronics—mainly Chinese calculating machines and Singaporean data processing equipment—comprised US$57 million in annual import revenue.[25]

As information technologies began to seep into the country and more information about Myanmar's political conflicts trickled out to international media outlets, the government updated its censorship regime to capture digital communications. It first adopted the 1996 *Computer Science Development Law*, which imposed 15-year prison sentences on unlicensed users of network-ready computers, modems, and fax machines.[26] The government also passed the 1996 *Television and Video Law*,[27] which set similar restrictions for television sets, video players, and satellite receivers. Following a traditional content regulation approach, the government also required cybercafes to log and take screen shots of user identities. The *Electronic Transactions Law* of 2004[28] outlawed communications "harming state security, community peace and tranquility or national solidarity."

[25] *Myanmar Internet and E-Commerce Investment and Business Guide* (2014).

[26] *Computer Science Development Law*, September 20, 1996, Chapter X, available at https://www.myanmarisp.com/ICTnews/law10–96, (accessed January 5, 2016).

[27] *Television and Video Law*, available at http://www.burmalibrary.org/docs6/Television_and_Video_Law.pdf, (accessed January 5, 2016).

[28] *Electronic Transactions Law*, available at http://www.ibiblio.org/obl/docs/Electronic-transactions.htm, (accessed January 5, 2016).

THE SAFFRON REVOLUTION: STREAMING DISSENT

In August 2007, sparked by political repression and sharp increases in fuel prices, the Saffron Revolution exploded into the streets with massive nationwide protests and brutal government crackdowns that killed hundreds of demonstrators. The street protests also reverberated online as journalists and demonstrators uploaded camera phone videos, blogs, and other accounts, which found their way to international news outlets including Al Jazeera, CNN, and the BBC. These revealed an unprecedented tableau of internal conflict inside a nation that had long avoided international scrutiny. The movement was the most dramatic example at that time of ICT's role in facilitating the real-time coordination of exiled and domestic dissidents in Myanmar. International support groups called for additional, costly sanctions.

The government responded by repressing street protests and, with the assistance of expert advisors from Russia, China, India, and Singapore, shutting down virtually all digital communications. This led to even more international pressure on the government to re-establish digital links. In fact, the government did re-establish Internet access, but this time with greater controls and surveillance. While some opposition supporters held that the Saffron Revolution proved that Myanmar's digital sphere had reached a critical saturation point, could no longer be eliminated, and Internet freedoms could only increase, the government displayed a new determination to dominate ICT with new legal restrictions on electronic communications, by expanding state-run ICT infrastructure to expand its control.[29]

STATE ATTEMPTS FAIL TO DOMINATE ICT SECTOR

The government also attempted to dominate the ICT sector by establishing state-owned Internet service providers including Myanmar Posts and Telecommunications (MPT), Bagan Cybertech, Information Technology Central Services, and other state- or quasi-state-owned start-ups and government-financed "cyber-cities" and ICT parks. Many of these projects were supported by the military, crony financiers, and Chinese technology firms.[30] The opposition satirized government domination of Myanmar's ICT sector, calling it the "Myanmar Wide Web."

In its efforts to funnel Myanmar's population into state-run (rather than international) online platforms, the government employed filtration and surveillance systems provided by foreign firms including China's Alcatel Shanghai Bell Company and two Silicon Valley companies, Fortinet[31] and Blue Coat.[32] Blocked content included YouTube, Skype, Blogspot, CNN, Reuters, Gmail, Yahoo Mail, and tens of thousands of other sites.

The government's suppression of content, its total control of all communications infrastructure, and sanctions by Europe, the United States, and Australia had the effect of stifling ICT sector innovation and discouraging network infrastructure investments beyond military requirements. By 2003, Myanmar's Internet bandwidth was the lowest in the region: nine megabits per second (Mbps) per user. By 2005, only 0.27 percent of households had Internet access. By 2010, only 1 percent of the population had cellular phone subscriptions and prices of SIM cards ranged from US$500 to US$5,000.

The government's suppression of content, its total control of all communications infrastructure, and sanctions by Europe, the United States, and Australia had the effect of stifling ICT sector innovation and discouraging network infrastructure investments beyond military requirements.

After the election of an avowedly pro-democracy government in 2011, then-newly elected President Thein Sein promised in his inaugural address sweeping reforms and reconciliation with political opposition groups. Later that year, the government lifted restrictions on 30,000 blocked Internet sites operated by the political opposition, the media, advocacy organizations, and others. The government also dismantled firewalls restricting Facebook, Twitter, Google, YouTube, international news organizations, and other foreign media.

The government also began a process of economic reform by opening markets to foreign investment. The government developed the 2011–2015 Follow-Up Plan to improve on two previous ICT master plans. It sought to build ICT infrastructure, human resources, and legal frameworks, and outlined action plans for use of ICT in e-education, e-commerce, e-government, data gathering, and e-society.[33] Elements of the master plan were set in motion with the 2013 *Telecommunications Law*,[34] which established a basic licensing framework, along with interconnection, competition, and dispute resolution rules. The 2013 law also established the role of the Ministry of Communications and Information Technology (MCIT), now part of the Ministry of Transportation and Communications, and proposed to convert the Post and Telecommunications Department (PTD) into an independent regulator, to be renamed the Myanmar Communications Regulatory Commission (MCRC).

Elements of the master plan were set in motion with the 2013 *Telecommunications Law*,[34] which established a basic licensing framework, along with interconnection, competition, and dispute resolution rules.

A new telecommunications law planned for 2016 aims to delineate the policy, regulatory, and operational functions of various government stakeholders in the sector. Other related laws to support the development of the ICT sector are also being pursued as part of the country's ASEAN Economic Community commitments. These laws, once passed, will make Myanmar the fourth ASEAN nation to have a full complement of ICT laws.[35] Table 1 presents a roster of applicable ICT-related legislation. These reforms coincided with the 2012 *Foreign Investment Law* that allowed foreign companies to own up to 100 percent of domestic firms and opened the way for foreign entrants into the telecommunications sector.

[29] Conrad (2011).

[30] Min Lwin, "Junta Approves Investment in Cyber City," Citizen Lab, July 29, 2008 https://citizenlab.org/2008/07/junta-approves-investment-in-cyber-city/, (accessed January 5, 2016).

[31] OpenNet Initiative (2015).

[32] CitizenLab (2011).

[33] Draft Telecommunications Master Plan available at http://www.mcit.gov.mm/content/draft-telecommunications-masterplan.html, (accessed on January 5, 2016).

[34] The 2013 *Telecommunications Law* is available at http://www.mcit.gov.mm/sites/default/files/Telecom%20Law%20English%20Version_0.pdf, (accessed on January 5, 2016).

[35] Nam, Cham, and Halili (2015).

TABLE 1: LEGISLATION GOVERNING ICT IN MYANMAR

Relevant Legislation
The *Computer Science Development Law* of 1996 provides measures for the development and dissemination of computer science and technology, including the supervision of imports and exports of computer software and information.
The *Wide Area Network Order* of 2002 allows for the establishment of a computer web using a wide area network; it also prohibits illegal acts relating to network usage.
The *Electronic Transactions Law* of 2004 supports the development e-commerce, e-government, and online banking. Moves are under way to replace this law because technologies appear to have made it partially redundant and provisions infringe on citizens' freedom of speech and access to information.
The *State-owned Economic Enterprises Law* of 1989 grants government the sole right to carry out a range of economic enterprises as state-owned economic enterprises, including a postal and telecommunications service. But in accordance with section 4 of the law, the state-owned enterprise acting in the country's interest is permitted to enter into joint ventures with any other person or economic entity, subject to conditions.
The *Myanmar Special Economic Zone Law* of 2011, which provides for the establishment of special economic zones, including information and telecommunication technology zones.
The *Foreign Investment Law* of 2012 allows for 100 percent foreign ownership of local businesses with approval from the Foreign Investment Commission in many areas of investments, including in the ICT sector.
The 2013 *Telecommunications Law* established a basic licensing framework, along with interconnection, competition, and dispute resolution rules.

OPENING MYANMAR'S TELECOMMUNICATIONS MARKET

In 2013 Myanmar issued its first-ever invitation to tender in pursuit of an estimated US$1.5 billion needed to fulfill coverage targets set by the nation's ICT master plan.[36] Myanmar received more than 90 expressions of interest. That list, populated by a mix of local interests and more experienced multinationals, was honed to a shortlist of 11 candidate firms, including Singapore's SingTel, India's Bharti Airtel, Japan's KDDI, Viet Nam's Viettel, France's Orange, and Caribbean provider Digicel.[37]

The winning bids to provide mobile telecommunications services were Norway's Telenor and Qatar's Ooredoo, both well-established operators in South and Southeast Asia.[38]

In its official filings with the government, Telenor committed to achieving nationwide coverage of 83 percent for voice and 78 percent for data after five years. Ooredoo committed to geographic coverage of 84 percent for both voice and data within the same time frame. Telenor promised 70,000 points-of-sale for SIM cards and over 95,000 top-up locations within five years. Ooredoo promised an even larger network, committing to 240,000 SIM points-of-sale and 720,000 points-of-sale for top-ups. The price for a SIM card was capped by both operators at US$1.50. Telenor announced in February 2016 that it has 14 million subscribers in Myanmar.[39] Ooredoo counted 4.8 million customers in its third-quarter results.[40] By comparison, MPT, which is 100 percent government-owned, has 16 million subscribers.[41]

Total mobile subscriber rates in Myanmar surpassed 50 percent in 2015 with 80 percent of those subscribers on smartphones.

To increase competition in the telecommunications sector, the government also approved in 2014 a 10-year, US$2 billion partnership between MPT and two well-established Japanese technology companies, KDDI and Sumitomo Group.[42] KDDI and Sumitomo have established a joint venture, KDDI Summit Global Myanmar (KSGM), which in turn has signed a joint operations agreement with MPT. This arrangement provides MPT with access to state-of-the-art network technologies and infrastructure project management resources, capital, and corporate strategy.[43] The partnership is also intended to help MPT strategize to implement the government's pledge to liberalize the telecommunications market and privatize MPT by the end of 2016.

Total mobile subscriber rates in Myanmar surpassed 50 percent[44] in 2015 with 80 percent of those subscribers on smartphones, which have a 60–75 percent national penetration rate. This is due, in part, to the availability of inexpensive Chinese electronics.[45] The fact that so many subscribers are on smartphones presents new opportunities for service delivery and innovation, not to mention e-commerce and FDI. More fundamentally, mobile usage is being driven by investments in telecommunications infrastructure. These investments are being made by multinational telecoms operators, their subcontractors, tower companies, local construction firms, and logistics contractors to expand the network of fiber optical wire in the country. That network today encompasses 20,000 kilometers, spanning 7,430 mobile towers (discussed in more detail in Section 3).

In March 2016, the incoming National League for Democracy government merged the Ministry of Transport and Rail Transportation and the Ministry of Communications

[36] This estimate now seems quaint in light of the much larger investment realized to date in Myanmar's telecommunications sector.

[37] The evaluation process consisted of eight major criteria: (1) the quality of the network development plan, including the infrastructure plan offered, and the coverage of the network; (2) the strength of the technical plan; (3) the quality of the marketing strategy, value-added services, and distribution commitment; (4) the foreseen tariff for all mobile services, including voice, data, and handsets; (5) the quality of the management of human resources, including its organization and plan to recruit and train local expertise; (6) customer services and billing quality; (7) the corporate social responsibility of the company; and (8) the robustness of the business plan and the financing plan. Republic of Union of Myanmar. *Invitation to Submit an Expression of Interest (EOI) for Partnership with Local Consortium Willing to Apply for Fourth Telecom Operator License*. December 7, 2015.

[38] Telenor operates in Thailand (dtac), Malaysia (DiGi), India (Uninor), Bangladesh (Grameenphone), and Pakistan (Telenor); Ooredoo is in Indonesia, Singapore, Laos, and the Philippines. Ablott (2013).

[39] Clare Hammond, "Telenor racks up 14 million users," *Myanmar Times*, February 11, 2016, http://www.mmtimes.com/index.php/business/technology/18928-telenor-racks-up-14-million-users.html, (accessed on February 12, 2016).

[40] Aung Kyaw Nyunt, "Myanmar Calls EOI for Fourth Telecoms Operator," *Myanmar Times*, December 15, 2015, http://www.mmtimes.com/index.php/business/18150-myanmar-calls-eoi-for-fourth-telecoms-operator.html, (accessed on January 6, 2016).

[41] Ibid.

[42] KDDI is Japan's largest broadband and mobile networks solutions company, with more than 50 million clients generating US$42 billion in yearly revenue and a market capitalization of US$64 billion as of May 2015. Sumitomo is one of the world's oldest corporations with roots that stretch back to Japan's first discovery of copper by the Sumitomo Clan of Kyoto in the 1590s. Sumitomo saw sales of US$34.19 billion in 2015 and had a market capitalization of US$13.5 billion. Revenues listed at http://www.forbes.com/companies/kddi/and http://www.forbes.com/companies/sumitomo-corp/, (accessed on January 5, 2016).

[43] Republic of the Union of Myanmar, *Terms of Reference for the Provision of Consulting Services for Technical Advisory and Management Support for Corporatization of MPT, Ref. No. C.1.4.1*, 2015, www.mcit.gov.mm/download/file/fid/1393/, (accessed on January 5, 2016).

[44] Nam, Cham, and Halili (2015).

[45] Tenzin Dolma Norbhu, *op. cit.*

and Information Technology. The new, merged entity is called the Ministry of Transportation and Communications (MOTC).

Several motivations drove the merger. First was a desire of the incoming government to reduce the number of ministries. The merger is also the result of a long debate within the government over rights of way. Since the Ministry of Transport and Rail Transportation already owned a large amount of dark fiber installed along roadways and rail lines, mainly lain by Chinese military contractors, merging the communications and transport ministries made functional sense. The Ministry of Transport and Rail Transportation and the former MCIT were often competitors vying for control of rights of way and fees for fiber installation and leases. It is telling that the new minister of the merged agency had a career in the railway sector. It is also likely that officials formerly affiliated with the larger, better funded Ministry of Transport and Rail Transportation will dominate the new body's ICT component.

Despite the fact that the merger may resolve issues around collocation and rights of way, the merger is detrimental from a policy standpoint because ICT will likely take a backseat to comparatively massive transportation infrastructure demands. Furthermore, relegating ICT to a directorship status within such a large and powerful agency will hamper realization of whole-of-government approaches to ICT.

MYANMAR'S VITAL ICT PARTNERSHIPS

International development partners are playing an important role in the rollout of Myanmar's ICT regulatory and policy framework:

- The World Bank allocated US$31.5 million in 2013 under its **Public-Private Infrastructure Advisory Facility** (PPIAF) to provide equipment, software, and technical assistance to the PTD. The PPIAF has funded a team of more than two dozen consultants to the PTD, back-office data systems, furniture, cars, and other essentials required by the MOTC. The World Bank's main task is to advise the ministry on the development of laws and regulations to define the work of the PTD, which is soon to become the Myanmar Communications Regulatory Commission (MCRC).[46] The World Bank also coordinates Myanmar's other international partners in ICT sector development.
- With funding from the Asian Development Bank, the Republic of Korea, and China, the Indian firm Infosys produced an **e-governance master plan**, which is among the most comprehensive policy studies on Myanmar's ICT rollout and addresses everything from e-government platforms to the reorganization of the MCIT.[47]
- The Korea International Cooperation Agency has also provided technical assistance to the Central Statistical Organization and the Ministry of National Planning and Economic Development (now part of the combined Ministry of Planning and Finance) to develop a national web portal aggregating trade, investment, demographic, and income data. The **Myanmar Statistical Information Service** (MMSIS) provides socioeconomic statistical data and metadata at national and subnational levels, across various periods.[48]
- The Myanmar Centre for Responsible Business conducted a human rights-focused study on Myanmar's ICT sector, the **Myanmar ICT Sector-Wide Impact Assessment**, which advocated due diligence standards for companies in Myanmar concerning freedom of speech, privacy, land rights, and other civil liberties issues.[49]
- These matters have also been addressed by the **U.S.-Myanmar ICT Council**, an initiative of Cisco, Google, HP, Microsoft, and Qualcomm that advises the United States and Myanmar governments on sector-enabling legislation and regulatory policies. The council also mentors the Myanmar Computer Federation, a local industry and professional association, and has advised government on laws and regulations addressing intellectual property, cybercrime, privacy, and ICT sector liberalization.

Civil society organizations in Myanmar use ICT tools to promote greater community awareness and participation, as well as new constituencies and governance structures, by amplifying the voices of marginalized communities.

CIVIL SOCIETY FOR ICT DEVELOPMENT

Civil society organizations (CSOs), tightly controlled under the previous regime, currently play a vital role in proliferating ideas about democratic and inclusive governance as well as delivering services the government is unable to provide. CSOs have used ICT tools to promote greater community awareness and participation. ICT-enabled CSOs are also promoting new constituencies and governance structures by amplifying the voices of marginalized communities, including women, youth and elderly, disabled people, and ethnic and religious minorities. Some examples of their work are presented below.

Phandeeyar, a community technology hub funded by the U.S. Agency for International Development and the Schmidt, Omidyar, and Soros Foundations, has since 2014 spearheaded efforts in Myanmar to grow ICT capabilities among civil society and entrepreneurial groups.[50] Phandeeyar has hosted a variety of seminars, workshops, and hackathons, including startup challenges and hardware design competitions. With financial support from Google, Phandeeyar organized a hackathon for creatives and, with support from The Asia Foundation and Telenor, held a two-week competition to develop voter education applications. It supported the development of an election-themed mobile application that was downloaded 200,000 times in five weeks. Phandeeyar has also been at the forefront of efforts to train Myanmar's news media to use various digital platforms, including data visualization and web design to enhance storytelling. In June 2016, Phandeeyar announced it had received US$2 million in additional investment and a variety of in-kind

[46] The MCRC is expected to regulate the telecommunications sector, including the issuance of operator licenses, spectrum management, and other policies intended to accelerate ICT uptake.

[47] Infosys Ltd. (2013).

[48] http://www.mmsis.gov.mm/.

[49] http://www.myanmar-responsiblebusiness.org/swia/ict.html.

[50] For more information, see www.phandeeyar.org.

services from the Omidyar Network to fund a technology start-up accelerator program, which will also support an open data program and a maker space for hardware innovation.

The **Myanmar Computer Federation** (MCF) is an official trade group and professional organization that advises the government on ICT policy.[51] The MCF has provided guidance on three consecutive ICT master plans for Myanmar, hardware distribution to teacher training colleges, ICT trainings and awards for ICT innovations, and business plans. The MCF has also proposed legislative reforms for various laws governing the ICT sector.

The **Myanmar Information Management Unit** is a service of the United Nations (UN) Country Team and Humanitarian Country Team, under the management of the UN Resident and Humanitarian Coordinator. Its purpose is to improve analytic and decision-making of UN agencies and other organizations by maintaining an open data repository focused on socioeconomic and humanitarian issues.

A4AI is a technology sector coalition seeking to implement the United Nations Broadband Commission target of entry-level broadband prices of affordable Internet, which it defines as less than 5 percent of per capita income.

ICT4D Working Group is a Yangon-based forum that seeks to create awareness of new tech initiatives that enable civil society to achieve development goals.

The **Myanmar ICT for Development Organization** provides services, ICT solutions, and training for CSOs and individuals in order to provide them with ICT tools to address development and poverty reduction goals.[52]

LIRNEAsia is a regional research think tank funded by the International Development Research Centre of Canada, the United Kingdom's Department for International Development, the World Bank, and the Ford Foundation. It focuses on ICT usage, regulation, and innovations to spur greater access in Myanmar.[53]

The **Myanmar Centre for Responsible Business** (MCRB) is a donor-funded partnership between the Institute for Human Rights and Business and the Danish Institute for Human Rights that promotes international standards for enterprises conducting business in Myanmar. MCRB's Sector-Wide Impact Assessment on Myanmar's ICT industry identified three main categories for potential risks to human rights under Myanmar's ICT legal framework: (1) criminalization of legitimate speech, censorship, and disruption of expression; (2) surveillance and interception; and (3) lack of access to information. Other areas of ICT governance inadequately addressed by Myanmar laws include data privacy and protection, cybercrime, lawful interception, and intellectual property.[54]

[51] For more information, see www.mcfmyanmar.org.

[52] http://myanmarido.org/.

[53] http://www.lirneasia.net/.

[54] http://www.myanmar-responsiblebusiness.org/swia/ict.html.

Myanmar's 53 million population sits amid the planet's largest and densest agglomeration of offline human beings—massively underserved regions of China, India, Bangladesh, and the rest of rural South and Southeast Asia. ICT investors in Myanmar are positioning themselves to compete for the last untapped broadband market outside of North Korea.

REGIONAL MOBILE TELECOMMUNICATIONS MARKET

Mobile telephony verges upon ubiquity across the planet. Ninety percent of the world's population is covered by at least a 2G signal that provides voice and text messaging services; 70 percent are covered by 3G, which provides access to the Internet. However, there remain approximately 2-2.8 billion people—most of them in Asia and sub-Saharan Africa—with no access to the Internet.[55]

Myanmar's scant networks cluster along the nation's main thoroughfares between Yangon, Bago, Nay Pyi Taw, and Mandalay. Currently, these are mainly old trunk lines: outdated, low-bandwidth, high-latency, copper wire installed by Chinese state-owned enterprises.

While Myanmar's greenfield ICT market is often cited as a motivator for investors, this underestimates the financial and geopolitical stakes. Myanmar's 53 million population sits amid the planet's largest and densest agglomeration of offline human beings—massively underserved regions of China, India, Bangladesh, and the rest of rural South and Southeast Asia. ICT investors in Myanmar are positioning themselves to compete for the last untapped broadband market outside of North Korea.

The potential profits are huge, as demonstrated by neighbors' recent experiences. At the end of 2014 China was the world's largest Internet market with 629 million users, a figure that represents a year-on-year increase of 31 million users. Thirty percent of China's Internet traffic in 2014 occurred on mobile phones.[56] India is seeing even faster growth, with 232 million Internet users at the end of 2014, a 37 percent increase, which made it the world's third largest national market. In 2015, 65 percent of India's Internet traffic took place on mobile phones. As of March 2015, India comprised the second largest Facebook market (after the United States) with 112 million monthly active users (MAUs), the second largest LinkedIn market with 24 million MAUs, and the largest WhatsApp market with 70 million MAUs. Approximately 7 percent of all YouTube users—70 million people—are in India.[57] Myanmar, by virtue of its geographical location, has a chance to link into these huge information and capital flows among India, China, and the rest of the world.

REGIONAL ICT INITIATIVES

Asia is among the most dynamic of the world's ICT markets, with several major regionalization projects with significant implications for Myanmar. UNESCAP is working with Asian nations and the International Telecommunication Union (ITU) to develop mechanisms such as treaties and cooperative trade and infrastructure projects to facilitate and promote a common agenda for ICT development. Member nations are developing a regional framework for common norms and principles of practice, including equal access to infrastructures and right of way (cross-jurisdiction between sovereign states) and technical specifications of backbone infrastructure.

[55] Hatt, Okeleke, and Meloan (2015).

[56] KPMG and Internet and Mobile Association of India (2015).

[57] Sources: MAU for Facebook (Facebook earnings call), WhatsApp (statement by Neeraj Arora of Whatsapp), LinkedIn (per company blog, press release, and earnings), YouTube data (Google).

Proposed agreements include: (1) common principles for pan-Asian network development; (2) a cohesive regional network through cooperation and collaboration; (3) public funding and regulatory support for broadband infrastructure projects; and (4) open access principles for cohesive regional network development.[58]

The Asia-Pacific Information Superhighway initiative[59] is at the center of this work and seeks to increase the availability and affordability of broadband Internet across Asia and the Pacific by strengthening the underlying Internet infrastructure in the region. The initiative, administered by UNESCAP, involves regional Internet maps and policy analysis to support countries working to develop a regional, seamless information and communication space. A set of online maps developed by UNESCAP and the ITU feature terrestrial Internet infrastructure, including optical fiber and wireless networks, as well as various segments of the Asian Highway and Trans-Asian Railway. This multisectoral mapping tool allows policymakers to identify weak points in terrestrial broadband infrastructure and opportunities for cross-sector infrastructure development.

Similarly, the ASEAN ICT 2015 Master Plan is working to harmonize ICT regulations, public-private partnership models, ICT education and certification standards, and security protocols.[60] The plan is also promoting the creation of an ASEAN broadband corridor, an ASEAN Internet exchange network, an ASEAN digital content exchange, before a registry of experts and standard operating environments governing software operating systems.

China will play a major role in Myanmar's ICT development. Its One Belt, One Road initiative is expected to contribute US$200 billion in three years and US$1 trillion in total government funds by the time it is complete.[61] Driving the project will be the recently established Asian Infrastructure Investment Bank, headquartered in Beijing; the China Development Bank will also play a driving role.[62] In addition, Chinese President Xi Jinping has announced plans to create a US$40 billion Silk Road Fund to invest in businesses along the way.[63] The One Belt, One Road initiative is envisioned as a network of road, rail routes, oil, and natural gas pipelines and ports stretching from Xi'an in central China, through Central Asia, and ultimately reaching as far as Moscow, Rotterdam, and Venice. The vital Bangladesh-China-India-Myanmar route is one of several major corridors in the plan. ICT connections will be strung along every mile of the project, connecting Myanmar not only to China, but also to China's entire trade network.

The Asia-Pacific Information Superhighway initiative[59] is at the center of this work and seeks to increase the availability and affordability of broadband Internet across Asia and the Pacific.

[58] United Nations Economic and Social Council Secretariat (2015).

[59] http://www.unescap.org/our-work/ict-disaster-risk-reduction/asia-pacific-information-superhighway.

[60] Association of Southeast Asian Nations (2011).

[61] Ernst & Young (2015).

[62] Bert Hoffman, "China's One Belt One Road Initiative: What We Know Thus Far, East Asia & Pacific on the Rise," *East Asia Pacific Blog,* December 04, 2015, http://blogs.worldbank.org/eastasiapacific/china-one-belt-one-road-initiative-what-we-know-thus-far.

[63] "China's Xi Pledges US$40 Billion for Silk Road Infrastructure Fund," *Bloomberg News,* November 8, 2014, http://www.bloomberg.com/news/articles/2014-11-08/china-s-xi-pledges-40-billion-for-silk-road-infrastructure-fund.

THIS PAGE IS INTENTIONALLY LEFT BLANK

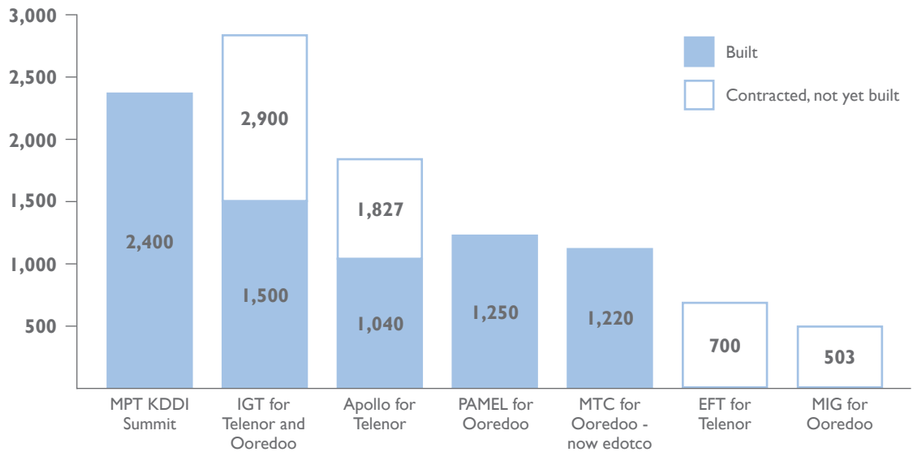
3. MYANMAR'S PHYSICAL ICT INFRASTRUCTURE

Because Myanmar's electrical grid is scarce, especially in rural areas, tower companies must secure their own energy resources—often diesel and occasionally green energy such as solar, hydropower, or wind. In other cases, tower companies subcontract with third-party energy providers.

The actions of Telenor, Ooredoo, and MPT have catalyzed the growth of a group of infrastructure firms (such as tower companies), backed by a few Myanmar-focused, internationally-listed, venture capital firms, development funders, and large family holdings. Tower companies also subcontract with construction and logistics firms. The tower companies are applying a variety of business models, including build-and-lease deals with mobile operators. Because Myanmar's electrical grid is scarce, especially in rural areas, tower companies must secure their own energy resources—often diesel and occasionally green energy such as solar, hydropower, or wind. In other cases, tower companies subcontract with third-party energy providers.

These companies are in the third phase of mobile infrastructure construction, having begun by increasing coverage in and around Yangon, Nay Pyi Taw, and Mandalay, and then intensifying coverage along the trunk-lines that connect these urban population centers. The next phase—providing coverage over the rest of Myanmar—will take considerably longer and require more capital. As of November 2015, 7,470 mobile towers had been built with a goal of 17,300 towers,[64] each with an average coverage range of five kilometers.

FIGURE 2: ESTIMATED STATE OF TOWER CONSTRUCTION IN MYANMAR



Note: The vertical axis indicates numbers of towers.

Source: TowerXchange (2015).

[64] GSM Association and International Finance Corporation (2014).

Summarized in Figure 2, tower players include:

- **KDDI Summit Global Myanmar:** KSGM, MPT's association with KDDI and Sumitomo, leads the field, having constructed 2,400 mobile towers for MPT with the help of Nokia of Finland and China's Huawei and the ZTE Corporation.[65]
- **Irrawaddy Green Towers:** Irrawaddy Green Towers (IGT), an international telecommunications and energy infrastructure firm, was poised to surpass KSGM with 1,500 towers built and 2,900 more under contract with Telenor and Ooredoo in the third quarter of 2015. The firm is financed by Dubai-based Alcazar Capital Limited, a venture capital firm whose principals also founded Golden Towers, one of Viet Nam's largest independent tower companies.[66] In addition to its Telenor and Ooredoo contracts and institutional financing, IGT received in January 2016 a US$122 million loan from the Dutch development bank FMO.[67]
- **Apollo Towers:** Apollo Towers Myanmar, founded by a former CEO of the French telecommunications firm Orange Group and the American private equity firm TPG, has built 1,040 towers and is under contract to construct an additional 1,827 towers for Telenor. Apollo Towers represents one of the largest American investments in Myanmar's telecommunications sector, having secured approval in 2015 for a US$250 million loan from the U.S. government's development finance arm, the Overseas Private Investment Corporation.[68, 69] Additionally, Apollo Towers raised US$30 million in equity from Myanmar Investments International Ltd., a Singapore-registered, Myanmar-backed investment firm founded in 2013.[70]

[65] Schwaninger (2015).

[66] IGT's other financial backers include Lebanon's MI Group, an investment holdings group that is also a principal owner of Dubai's Investcom; MTN, a South African telecommunications firm with revenues of US$14.89 billion; Barons Telelink, a local Myanmar company; Sprint; Helios; and others. For information on MTN, see MTN Group Ltd., *Financial Results for the Year Ended December 2014*, https://www.mtn.com/Investors/FinancialReporting/Documents/ANNUALREPORTS/2014/Booklet/Annual_results_booklet_2014.pdf, (accessed on January 5, 2016).

[67] The FMO loan was syndicated across a number of European development banks: the German investment corporation DEG (a subsidiary of the German development organization KfW), France's Proparco (subsidiary of Agence Française de Développement), the United Kingdom's state-owned CDC Group, the Belgian Investment Company for Developing Countries (BIO), and the Austrian development bank, Oesterreichische Entwicklungsbank (OeEB). Steve Gilmore, "IGT Raises US$122 million for Telecoms Tower Building," *Myanmar Times*, January 11, 2016, http://www.mmtimes.com/index.php/business/technology/18419-igt-raises-122m-for-telecoms-tower-building.html, (accessed on January 5, 2016).

[68] OPIC, "Information Summary for the Public," 2015, https://www.opic.gov/sites/default/files/files/apollo-public-info-summary.pdf, (accessed on January 5, 2016).

[69] The U.S. sponsors of the loan are the private equity firms TPG and Tillman Global Holdings LLC, founded in New York City to enter Myanmar's mobile market. In January 2016, TPG and Tillman were in extended negotiations over a separate US$3.5 billion deal to purchase 45,000 towers from Reliance Communications Ltd., an Indian telecommunications firm with US$10 billion in total assets. Himank Sharma, "Reliance Communications Expects to Seal Mobile Tower Deal in 2 weeks," *Reuters*, January 25, 2016, http://in.reuters.com/article/rcom-mobile-tower-sale-idINKCN0V31ED, (accessed January 5, 2016).

[70] In 2015 Myanmar Investments International raised US$20 million on the London Stock Exchange Clare Hammond, "Myanmar Investments Raises US$20 Million in London as it Lines Up Projects," *Myanmar Times*, July 22, 2015, http://www.mmtimes.com/index.php/business/15612-myanmar-investments-raises-20-million-in-london-as-it-lines-up-projects.html, (accessed January 5, 2016).

Questions of land ownership and restrictions on usage have been a major obstacle for mobile tower companies.

- **Pan Asia Towers:** Pan Asia Majestic Eagle Ltd., also known as Pan Asia Towers, built 1,250 towers for Ooredoo with US$85 million in direct financing from DBS Bank, ING Bank, OCBC Bank, Standard Chartered Bank, and Sumitomo Mitsui Banking Corporation.[71] Pan Asia Towers' shareholders, who include founders and principals of Boston-based American Tower Corporation and Berkshire Hathaway-backed Indonesian tower giant Protelindo, entered the tower business 25 years ago, operating in international markets including Brazil, Indonesia, Mexico, and the United States. They have implemented over 25,000 telecommunication tower sites worldwide.
- **edotco:** In October 2015, edotco spent US$221 million to acquire Digicel's 75 percent stake in Myanmar Tower Company, which had built 1,220 towers for Ooredoo. Edotco, a subsidiary of Axiata Group Berhad, a Malaysian telecommunications firm with subsidiaries throughout Southeast Asia, plans to quadruple its tower count in Myanmar.[72]
- **Eco-Friendly Towers:** Eco-Friendly Towers (EFT in the figure above) is a subsidiary of local conglomerate Young Investment Group and is contracted to build 700 towers for Telenor.
- **Myanmar Infrastructure Group:** Myanmar Infrastructure Group is a subsidiary of Singapore Windsor Holdings and has a US$39 million contract to build 503 towers for Ooredoo and lease over a 15-year term.[73]

MOBILE OPERATOR LAND ACQUISITION

Questions of land ownership and restrictions on usage have been a major obstacle for mobile tower companies. Like many nations that have experienced armed conflict and high mobility, Myanmar's land records are found in paper Union and township government files, if there are any land records at all. Myanmar lacks functional cadastral or civil court systems capable of adjudicating land claims.[74] Myanmar's mobile tower industry has dispersed its activities more pervasively than any other industry. In some cases, the arrival of mobile operators in rural areas is the most robust interaction local residents have ever had with a multinational corporation, often skewing power relations between negotiating parties and leading to disputes over land claims.

Mobile network operators and mobile tower companies also rely on a large number of smaller contractors for everything from siting to clearing land, to delivering raw materials and workers, to providing diesel fuel for generators, to erecting towers. These sub-subcontractors are a mix of

[71] "Pan Asia Majestic Eagle Limited (PAMEL) Enters Into First Ever Non-Recourse, Cross Border Financing in Myanmar," *PR Newswire*, September 30, 2014, http://www.prnewswire.com/news-releases/pan-asia-majestic-eagle-limited-pamel-enters-into-first-ever-non-recourse-cross-border-financing-in-myanmar-277685381.html, (accessed January 5, 2016).

[72] Axiata Group Berhad reports 260 million customers and US$5.7 billion in revenue in 2014; http://www.axiata.com/corporate/group-profile/.

[73] Zwe Wai, "Singapore Windsor Bags 39m Ooredoo Tower Contract for Myanmar," *Deal Street Asia*, http://www.dealstreetasia.com/stories/singapore-windsor-bags-39-m-ooredoo-tower-contractsingapore-windsor-bags-39-m-ooredoo-tower-contract-for-myanmar-6503/, (accessed on January 5, 2016).

[74] Myanmar Centre for Responsible Business (2015).

local, Chinese, Ukrainian, Turkish, Norwegian, Indian, and Bangladeshi firms. One tower project might have as many as a half dozen different subcontractors. Having so many players involved on often remote and logistically challenging projects complicates coordination and quality control.

Tower construction companies typically negotiate 15-year land leases with claimant owners. The average cost to erect a 60-meter, 11-ton steel tower with a concrete foundation ranges between US$60,000 and US$100,000 each. Monthly leases are US$1,500 to US$2,500 per tenant, of which landlords receive US$100 to US$300 per month.[75]

Unclear Processes and Standards for Land Acquisition

Often land is protected by various government authorities or classified for agricultural use, and must be reclassified before it can be leased, thus increasing the time and money for each tower project.[76] Land policy analysts in Myanmar acknowledge this is a decades-long project.[77] Apart from unclear land titles, Myanmar's land policy framework is further complicated by various categories of state land, including farmland, grazing land, religious land, freehold land, and others.[78] Competing claims on ownership or control of land are frequent.

In 2013 the World Bank developed an Environmental and Social Management Framework (ESMF) for telecommunications companies.[79] The framework set out standards for negotiation of commercial land leases without coercion or duress, providing for due diligence to be taken to determine rightful ownership without recourse to eminent domain or forced land removal by government parties. The ESMF also recommended that rural populations' informal claims on land be honored by telecommunications companies, owing to lack of land tenure policies.

According to the Myanmar Centre for Responsible Business's 2015 sector-wide impact assessment, the process still contains flaws. Tower and fiber projects have taken place where individuals and communities claim no informed consultation or participation about land acquisitions or construction projects had taken place. Many communities were not informed about which companies were involved in projects. Other communities reported that workers with tower and fiber companies lived in residents' homes without providing compensation. Residents also complained about generator noise and safety concerns, including poorly built towers, exposed electrical lines, and diesel fumes.[80]

Despite the World Bank's framework for responsible behavior by telecommunications companies, the Myanmar Center for Responsible Business reports that the process still contains flaws, with individuals and communities reporting continued lack of participation in tower-siting and construction decision making.

[75] Interviews with tower company and subcontractor executives, 2015–2016.

[76] Myanmar Centre for Responsible Business (2015b), 142–143.

[77] Interview with U.S. consulting firm Tetratech, currently working on land policy reform in Myanmar, in Yangon, January 2016.

[78] Myanmar Centre for Responsible Business (2015b), 143.

[79] World Bank, "Myanmar - Telecommunications Sector Reform Project: Environmental and Social Management Framework," 2013, http://documents.worldbank.org/curated/en/2013/11/18620207/myanmar-telecommunications-sector-reform-project-environmental-social-management-framework, (accessed January 5, 2016).

[80] Myanmar Centre for Responsible Business (2015b), 149.

Conflict Increases The Complexity of Site Acquisition and Tower Management

Despite ongoing multiparty peace negotiations, Myanmar remains riven by a series of insurgencies, inter-communal conflicts, and overlapping territorial claims by ethnic political parties, all of which complicate tower site access and acquisition. Armed clashes continue in Kachin, Shan, Rakhine, and other states and regions, complicating the logistics of accessing communities and through-paths for ICT infrastructure installation. The Landmine and Cluster Munition Monitor ranks Myanmar third after Colombia and Afghanistan for the highest casualty rates caused by landmines and munition between 1999 and 2014.[81]

Telecommunications operators and tower companies use various methods to determine security risks in areas in which they operate, including asking government officials and established local networks. Industry executives also share such information informally to safeguard operations and labor resources.[82] While reports of outright attacks on tower company workers or their subcontractors are rare, there have been occasional cases of sabotage to telecommunications networks causing outages and service delays.[83]

In addition, telecommunication operators and tower companies face political risks similar to those faced by many extractive industries working in conflict zones. These risks include having to negotiate access to areas controlled by competing authorities in Myanmar, many of whom have committed documented human rights violations. Telecommunications industry operators claim to use self-enforced codes of conduct to observe human rights, including the ESMF.

With all these factors in mind, the following steps could significantly strengthen site acquisition and tower management in the next 18 months.

For immediate action within 3–6 months:

- The government should provide the MOTC rights of way on publicly held lands for installation of critical telecommunication networks.
- All privately built infrastructure should be required to post signage indicating ownership, contract information, and contacts of government regulators.
- Telecommunications industry actors should formalize cooperative efforts to geolocate threats to safety in real time, including mapping landmines and explosive remnants locations, and sharing data with government and nongovernmental organizations (NGOs) working on landmine removal.

[81] Myanmar has reported 3,745 casualties and 396 deaths caused by landmines and other explosive remnants between 1999 and 2014. Landmine and Cluster Munition Monitor, *Myanmar/Burma Casualties and Victims Assistance*, last updated November 10, 2015, http://www.the-monitor.org/en-gb/reports/2015/myanmar_burma/casualties-and-victim-assistance.aspx.

[82] Claire Hammond, "Telecoms Companies Take on Landmines," *Myanmar Times*, September 18, 2015, http://www.mmtimes.com/index.php/business/technology/16557-telecoms-companies-take-on-landmines.html.

[83] Interviews with tower company and subcontractor executives, 2015–2016.

For implementation within 6–12 months:

- The MOTC should adopt clearer rules for mobile tower land acquisition along the lines of the World Bank's ESMF guidance. Rules should set out standard processes for due diligence investigations of land tenure, public hearings regarding usage, and identification of telecommunications companies, partners, and subcontractors involved. The MOTC should also establish an equitable complaint and arbitration process for aggrieved parties.
- The MOTC should require all permits and contracts for land use to be made public, preferably in digital form. The MOTC and Chief Information Officer (CIO, discussed in Section 4 below) could also require telecommunications operators to support the Land Core Group and other international NGOs working on land issues to assist efforts to establish cadastral baselines.

For implementation within 12–18 months:

- The MOTC should also establish and enforce engineering standards for all towers and other passive infrastructure as well as a regular inspection process and sanctions regime to ensure compliance.

ENERGY FOR MOBILE TOWERS

In the near future, growth in demand for power from Myanmar's mobile telecommunications network is expected to be significant (Figure 3). Yet Myanmar is one of the least electrified countries in Southeast Asia. A meager 29 percent of the country's population had access to grid electricity as of July 2013. Rural electrification in Myanmar stood at about 25 percent as of 2013, according to data published by Myanmar's Ministry of Electric Power. Yangon, the most populated region of the country, had the highest electrification rate at 67 percent, followed by Nay Pyi Taw at 54 percent, and the Mandalay region at 31 percent. As of 2012, the total installed power generation capacity in Myanmar was 3,896 MW (megawatts), 67 percent of which is provided by hydropower plants (2,780 MW) and 29 percent supplied by gas-fired power plants (996 MW).

The limited reach of Myanmar's electrical grid means that telecommunications operators have to deploy much of their network in off-grid areas and rely on diesel-based sources to power their network. The energy costs to mobile operators are significant. Groupe Speciale Mobile Association (GSMA) estimated that the annual diesel requirement would grow from 25 million liters in 2014 to 116 million liters by 2017 in order to power up the entire network of off-grid and unreliable grid sites and that corresponding carbon dioxide (CO_2) emissions would be 67,370 tons and 310,676 tons in 2014 and 2017, respectively.[84]

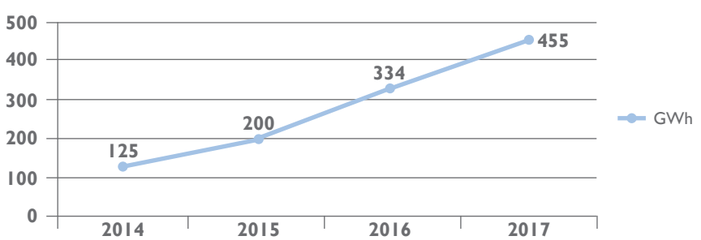
The limited reach of Myanmar's electrical grid means that telecommunications operators have to deploy much of their network in off-grid areas.

Mobile operators employ various approaches to power their towers. Some invest their own capital to finance energy generation; others enter into agreements with third-party energy producers to generate power at the tower site and sell to the mobile operator or tower company. A few tower companies or their third-party energy service companies (ESCOs) provide surplus power to surrounding communities, but this appears to be the exception. So far, MPT, Telenor, and Ooredoo appear to be embracing a mix of solely-owned and operated tower energy solutions and third-party ESCO models to distribute surplus power to surrounding communities.

In lieu of an adequate electrical grid, GSMA has encouraged telecommunications operators to embrace a variety of energy solutions including solar, wind, biomass, fuel-cell technology, and micro-hydropower plants to realize savings and minimize environmental impacts.

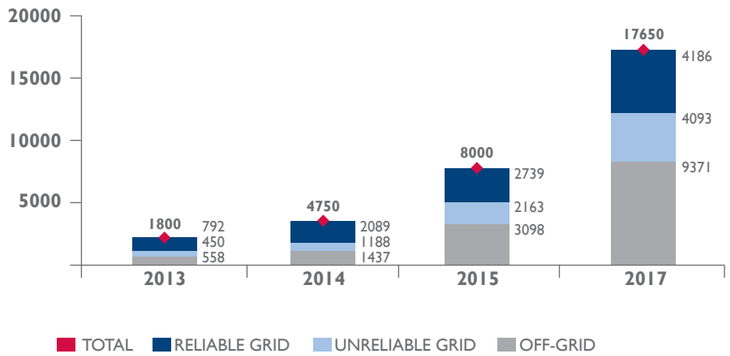
The need for power at tower sites could be used as an opportunity for interministry cooperation between the MOTC and the Ministry of Electrical Power and Energy to work out solutions for rural off-grid power. So far, however, the sustainability of tower energy solutions is in doubt as rapid mobile market share growth appears to be the main motivator at work. Government fuel subsidies also undermine the competitiveness of alternative energy sources.

FIGURE 3: GROWTH IN POWER NEEDS OF MOBILE NETWORKS



Source: GSM Association and International Finance Corporation (2014), 20.

FIGURE 4: SIZE OF OFF-GRID AND UNRELIABLE-GRID NETWORK



Note: The vertical axis indicates numbers of towers.

Source: GSM Association and International Finance Corporation (2014, 21).

[84] GSM Association and International Finance Corporation (2014, 20)

Power needs of tower companies have been addressed on an informal basis, driven mainly by mobile operators' agendas and without due attention to efficiencies that could emerge from collocation of infrastructure. While some tower companies have installed alternative energy generators including solar and hydropower, diesel power remains the default.

The following steps could help address these issues.

For implementation within 18–24 months:

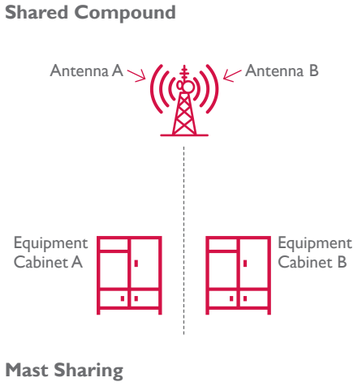
- The CIO (see Section 4 below), MOTC, and the Ministry of Electrical Power and Energy should work with the telecommunications companies, their builder contractors, and ESCOs to develop industry standards for mobile tower energy generation and distribution.
- The CIO and MOTC should actively support efforts of international NGOs and telecommunications firms to finance green energy alternatives for mobile towers through partnerships, tax incentives, and subsidies via the Universal Service Obligation.[85]
- The Ministry of Electrical Power and Energy, the MOTC, and telecommunications operators should develop energy plans in coordination with ICT coverage plans in order to maximize efficiencies and augment both sectors.

MOBILE INFRASTRUCTURE SHARING

Mobile network infrastructure sharing can provide many benefits, including cost reduction, reduced demand for land, improved network penetration, and minimized environmental impacts. Such sharing may be of physical tower sites, the towers (or masts, a nearly synonymous term) themselves, radio access networks, or core networks. An example is depicted in Figure 5 of two telecommunications operators sharing one tower/mast, with distinct antennae at the top.

In Myanmar Ooredoo and Telenor initially agreed on a plan, "Project Optima," in which Telenor would act as an anchor tenant and Ooredoo would collocate equipment on towers.

FIGURE 5: TOWER/MAST SHARING BY TWO MOBILE OPERATORS



Note: The terms "tower" and "mast" are virtually synonymous.

Source: GSM Association (2012)

[85] "Universal service" is an economic, legal, and business term used mostly in regulated industries, referring to the practice of providing a baseline level of services to every resident of a country. A "universal service obligation" is a regulatory requirement stipulating reasonable coverage throughout a given territory. For more information, see section below on Myanmar's universal service obligation.

That strategy originally floundered over lease rate disagreements, varying load requirements, and other competitive issues. The first phases of tower building focused on increasing network coverage and market share; few towers had more than one tenant. In some cases, tower companies erected multiple towers within range of one another, wasting financial resources, creating unsightly obstructions, and generating unnecessary noise and pollution because of multiple diesel generators. In other cases, telecommunications companies share space on a single tower, but use separate energy generation companies with resultant negative environmental impacts.

As demand for networks increases and cell splitting is required in the years to come, the telecommunications companies may be more inclined to share passive infrastructure and power generation. However, some of the tower sites constructed lack the necessary structural capacity for multiple tenants.[86] In 2014, of 1,800 cell sites erected by MPT at that time, fewer than 100 were suitable for collocation. Some ICT companies also complain that telecommunications operators and tower owners discourage collocation of network infrastructure on their towers by charging unreasonable rates for leases. They also say government agencies are unresponsive to their complaints about price gouging.[87]

While the independent build-out of towers means telecommunications operators may be covering more ground more quickly, it also means that in many areas there will be no competition for services. In some areas, telecommunications companies are duplicating efforts. While this introduces competition between tower companies and telecommunications firms operating in the same coverage areas, market inefficiencies may result in price increases for consumers. In other cases, tower and power firms are creating an oversupply of facilities.

The government should encourage more sharing of passive infrastructure and energy generation to increase competition and minimize environmental impacts of tower infrastructure.

The following steps could help address these issues.

For immediate action within 3–6 months:

- The MOTC should encourage more sharing by telecommunications networks and passive infrastructure firms to create more efficiencies and competition. This could include mandating tower-sharing in certain areas.
- The MOTC should also require towers to be erected with enough structural capacity for multiple tenants.

COLLOCATION OF NETWORK INFRASTRUCTURE

Telecommunications companies are not the only firms that use fiber optic wire.[88] The need for fiber optic wire

[86] Osmotherly (2015), 170.

[87] Interviews with executives from Internet service providers in Yangon, 2015.

[88] Fiber optic is the basic substance of the Internet, a sensor that serves as a foundational link between all other sensors. Fiber optic wire is thinner than a human hair, made of glass, clad in a protective sheath, and designed to carry modulated light signals (which are converted into what we call "data"). A single strand can carry a petabit (10^{15} bits) of information per second over a distance of 50 kilometers; see Telcordia, *GR-409, Generic Requirements* (Issue 3), 2015. Increasingly, signals float through the air, but they are usually destined to be channeled through fiber optic wire.

in other infrastructure sectors presents opportunities to leverage capital and effort to accelerate the build-out of networks. Myanmar's lack of infrastructure is a challenge in many ways, but one way that it could benefit rapid ICT development is by creating collocation and right-of-way policies. Taking a "dig once" approach and linking projects can foster critically needed interministerial capabilities, enhance planning processes, and create higher quality infrastructure.[89]

The best candidates for collocation projects are railways, roads and highways, electricity transmission systems, pipelines, and irrigation channels. Railways are heavy users of communication and sensor equipment, including fiber optics, for traffic-monitoring, signaling, and telecommunication. Railways have therefore often installed large-scale fiber optic networks along their rights of way. Deploying fiber along roads enables access to the network for maintenance purposes. Fiber is also key for intelligent transport systems.

High-voltage electricity transmission systems use fiber optics in optical ground wire on transmission lines for both grounding and communication purposes. Electricity utilities use these lines for communication and monitoring power transmission lines. Fiber is also strung overhead and bundled with power lines. These fiber lines are often sold or leased to third parties for data transmission.

Fiber is also commonly deployed along water, gas, or oil pipelines. Fiber is used for internal communication by utilities and to monitor infrastructure for leaks or breakage. Fiber is also used to monitor finer modalities—pressures, temperatures, pace of movement—in real time to prevent infrastructure failures and provide information crucial for repair work.[90]

Critically for Myanmar, a nation prone to floods, typhoons, tsunamis, heat waves, earthquakes, and other disasters, fiber optic is also essential for large-scale environmental monitoring and disaster warning systems. Coastal and submarine cables, for example, track climate over time to monitor climate change. They can also detect tectonic activity and water displacement in advance of a tsunami.

Despite the clear cost and functionality advantages of collocation of ICT and other kinds of infrastructure, Myanmar's government—Myanmar's largest landholder—is hampered in realizing these benefits by rigid, often competitive, and sometimes corrupt ministerial fiefdoms. The government's largest landholders, including the Ministries of Defense, Transportation and Communications, Agriculture Livestock and Irrigation, Transport, Home Affairs, Construction, and Religious Affairs, local townships, and state/region administrations routinely, and inexplicably, refuse ICT right of way requests by tower companies and telecommunications operators. Tower companies also report cases of rent-seeking by government officials. According to tower company executives, the Ministry of Natural Resources and Environmental Conservation has been an unusual and positive government standout in providing access to lands and enabling the current tower building boom.[91]

Myanmar's government—Myanmar's largest landholder—is hampered in realizing these benefits by rigid, often competitive, and sometimes corrupt ministerial fiefdoms.

[89] United Nations Economic and Social Commission for Asia and the Pacific (2014).

[90] Inaudi and Glisic (2010).

[91] Interviews with Myanmar government officials, international advisors, and telecommunications industry executives in Nay Pyi Taw and Yangon, 2015–2016.

Even in cases when government has provided ICT installation on government lands, those leases are rarely registered properly and officially designated land-use is rarely altered, leaving lessees vulnerable to contract violations. Tower company officials estimate that only 15 percent of all leases of government land are officially registered. Even leases that are registered often misstate lease terms.

The following steps could ameliorate some of these challenges.

For implementation within 12–18 months:

- The government should develop a default collocation policy for all government-funded infrastructure and construction projects. This dig-once collocation policy should include strong rights-of-way legislation mandating that the MOTC participate in all infrastructure plans so that trenches, ducts, fiber, and other telecommunications infrastructure are included in as many government projects as possible. One way this can be achieved is by granting the MOTC automatic rights of way whenever any other utility or state agency is granted a right of way. Additionally, access mandates should be monitored and enforced to ensure compliance.
- Transparency can also create constituencies for network deployment and increase interagency cooperation within the government. The MOTC should also establish a national atlas of all available passive infrastructures, including ducts, dark fiber, poles, transmission lines, pipes, and others that could be used to deploy fiber.
- The government should also keep an interagency[92] database of all civil engineering work with potential for passive infrastructure deployment.
- The MOTC should prioritize the establishment of an emergency network office to govern the deployment of climate monitoring, emergency warning, and disaster preparedness fiber systems. This process also relies on interagency opportunities for collocating ICT and other infrastructure.
- The government should implement blanket change of use waivers for lands currently leased by telecommunications operators and tower companies, standardize tower site lease agreements, and enforce standard lease registration processes.

LIMITED INTERNATIONAL GATEWAYS

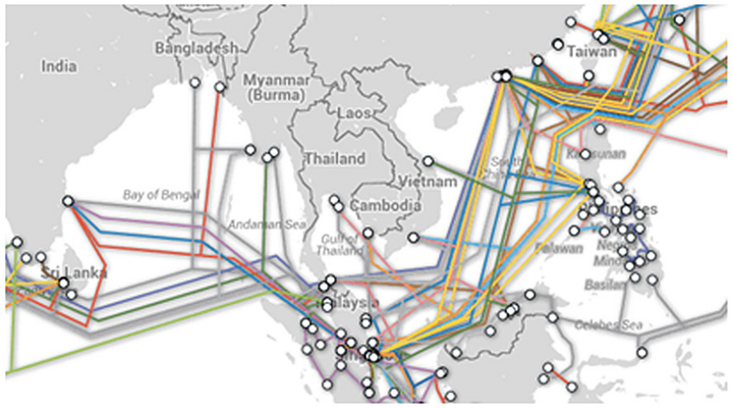
Despite the expansion of internal mobile networks, Myanmar's lack of international gateways to global networks still limits ICT growth. Currently MPT owns the only active transoceanic international gateway—a fiber optic spur linking Myanmar to the SEA-ME-WE-3 cable (see map in Figure 6)—for which it charges bandwidth prices 7 to 10 times higher than those in Singapore and double those in Thailand.[93] In January 2016, Singapore-based telecommunications

Despite the expansion of internal mobile networks, Myanmar's lack of international gateways to global networks still limits ICT growth.

[92] See the discussion below on a proposed infrastructure interagency taskforce for collocation in the ICT Logistics and Transport section.

[93] Naomi Gingold, "Alcatel Joins Myanmar Undersea Internet Cable Project," *Frontier*, http://www.frontiermyanmar.net/en/business/alcatel-joins-myanmar-Internet-cable-project.

FIGURE 6: MAP OF ASIAN SUBMARINE CABLES



Note: Three lines are depicted from Myanmar. On the west is the existing MPT spur that links Myanmar to the existing SEA-ME-WE-5 cable. Of the two lines to the south, one links to the existing SEA-ME-WE-3 cable, while another is the proposed connection to MYTHIC, linking Myanmar to Thailand and Malaysia.

Source: Telegeography, "Submarine Cable Map," http://www.submarinecablemap.com/, (accessed on January 5, 2016).

firm Campana Group announced a contract with undersea cable company Alcatel-Lucent Submarine Networks, a subsidiary of Nokia, to deploy a submarine cable system dubbed MYTHIC (Myanmar-Malaysia-Thailand International Connection). By the end of 2017 the two-fiber pair, 1,600-kilometer submarine cable system will link Myanmar to Satun in southern Thailand with connectivity to Singapore, Hong Kong, and beyond, with a design capacity of 20 terabytes per second. This carrier-neutral link will be the second publicly leased international fiber optic line out of Myanmar. The company may also build an extra branch to Penang in Malaysia for increased redundancy and resilience.

Telenor and Ooredoo have installed terrestrial international gateways. Telenor has three international long-haul connections, each supporting 10 to 30 Gbps (gigabits per second), two between Myanmar and Thailand and one to China. A planned fourth line will connect Myanmar to India. All three operators lease one another's bandwidth for international traffic. Ooredoo also has two links to Thailand and one to China. At least one of Ooredoo's connections with Thailand is service on a MPT-owned cable. Along their spans, these terrestrial international lines vary in quality, and all three operators have contended with occasional service disruptions and high latencies due to severed international links.

In January 2016 the MOTC released draft guidelines on international gateway services to increase the number of cross-border links and Internet speeds.[94]

INTERNET AND BROADBAND IN MYANMAR

The Internet remains a relatively untapped market in Myanmar. Most users access the Internet through mobile data connections. Only 2.2 percent of households had Internet links in 2013, 0.27 percent of households had fixed-line broadband subscriptions, and 1.2 percent of Myanmar's population used the Internet. Speeds offered are about 16,744 Mpbs, one of the worst rates in Asia.[95] Access remains limited to relatively large population centers, despite the fact that 70 percent of Myanmar's population lives in rural areas.

As of December 2015, the MCIT listed more than 100 telecommunications and Internet service providers (ISPs) that had been issued licenses, only a fraction of which—particularly cross-border and international ISPs—were actively providing data services, in part due to lack of clarity about ISP regulations.

The difficulty of accessing the Internet is further constrained by relatively low computer literacy levels, low English proficiency,[96] and little awareness of online applications beyond Facebook, Viber, and WeChat. Estimates of current usage of the Internet by Myanmar residents vary. According to Internet World Stats, an Internet statistics aggregator and database, there were 7.1 million Internet users in Myanmar as of 2015.[97] Meanwhile, Telenor Myanmar announced in 2015 that 55 percent of its mobile subscribers were data users.[98]

Another reason for low Internet usage is cost, exacerbated by limited competition in the supply of data services. As of December 2015, the MCIT listed more than 100 telecommunications and Internet service providers (ISPs) that had been issued licenses, only a fraction of which—particularly cross-border and international ISPs—were actively providing data services,[99] in part due to lack of clarity about ISP regulations. The small number of ISPs in Myanmar and constraints on bandwidth have led to high prices for service. Unlike the telecommunications industry, most ISPs are locally owned and charge fees that are out of reach for most Myanmar residents. ISPs include:

[94] Republic of the Union of Myanmar, Ministry of Communications and Technology, *Guidelines on Provision of International Gateway Facility Services*, "Draft," Notification Number 00/2015, October 2015, http://www.mcit.gov.mm/sites/default/files/Guidelines%20on%20Provision%20of%20International%20Gateway%20Facility%20Services(DRAFT).pdf, (accessed on January 5, 2016). Catherine Trautwein, "Gateway Guidelines to Boost Telecoms," *Myanmar Times*, January 15, 2016.

[95] Nam, Cham, and Halili (2015), 15.

[96] English remains the dominant language of the Internet.

[97] Internet World Stats, http://www.Internetworldstats.com/asia.htm#mm, (accessed on January 5, 2016).

[98] Claire Hammond, "'Competition, Watch Out' Says Telenor Myanmar CEO, as Subs Over 10 Million," *Myanmar Times*, July 23, 2015, http://www.mmtimes.com/index.php/business/technology/15630-competition-watch-out-says-telenor-myanmar-ceo-as-subs-over-10-million.html.

[99] http://www.mcit.gov.mm/news/licence-issued-list1112201 5.html.

TABLE 2: EXAMPLES OF INTERNET SERVICE PROVISION IN MYANMAR

Internet Service Providers in Myanmar
MPT, the dominant, state-owned provider, charges US$50 for home installation and an annual fee of US$50. Monthly rates range between US$17 and US$80 depending on speed, which ranges from 512 Kbps (kilobits per second) to 2.5 Mbps. Faster fiber optic Internet connections range between US$200 and US$1,000, and monthly service ranges between US$100 and thousands of dollars per month for speeds up to 100 Mbps, in addition to an annual US$60 fee.[100]
Yatanarpon Teleport (YPT), the former state-owned provider of last mile "fiber-to-the-home" connections, is now a private firm owned by a large number of high-profile local shareholders, many of whom have links to the government. In 2015, YPT partnered with Telenor to establish a direct exchange with Google Global Cache, a content delivery network with an Internet exchange in Singapore.[101] The service increases Internet speeds by storing high-bandwidth and high-demand content at Internet exchanges at closer geographical proximity to users.[102]
Redlink is a private company owned by U Toe Naing Mann, the son of the former military general and Parliament speaker. Redlink charges US$500 for installation, plus US$125 monthly and a US$60 annual fee for a connection of 2 Mbps. Redlink, which offers fiber to the home and WiMax (Worldwide Interoperability for Microwave Access) connections, often relies on YTP for last mile connections.
CDNetworks: In 2015, KDDI Group partnered with CDNetworks, a South Korean cloud and cybersecurity firm, to establish a "point of presence"—a set of servers located in Myanmar that would be linked to a global network and cloud services. By caching duplicate content within Myanmar, CDNetwork users will be able to access content more quickly.[103] CDNetworks also provides access to its own branded and affiliated content, including e-commerce sites, online gaming, and mobile applications.[104]
Frontiir, a partner of Cisco Systems Inc., is an enterprise service provider best known for providing technological solutions to the Myanmar-hosted 27th Southeast Asian Games (SEA Games) in 2013. Frontiir provided wifi and a networked verification and information system at 26 SEA Games venues in four Myanmar cities at a time when 3G mobile was practically nonexistent. Frontiier uses mesh networks[105] and other alternative solutions to overcome Myanmar's lack of last mile fiber connections and other obstacles.
Bluewave, a joint venture between Bluewave Broadband Servicess Pte. Ltd. in Singapore and Myanmar Technology Gateway, was established in 2015 to provide "over-the-top" satellite broadband services to businesses.[106] Bluewave will use Eutelsat Communications' EUTELSAT 70B satellite to provide national coverage for Myanmar with download speeds starting at 512 Kbps and going up to 12 Mbps.
Hughes Network Systems, LLC announced a deal in November 2015 to provide a ground control satellite link for KBZ Gateway Co. Ltd., a subsidiary of Myanmar's KBZ Group of Companies Ltd., for an enterprise-grade, 100 Mbps broadband network in Myanmar. Hughes is a global satellite broadband provider headquartered in the United States. KBZ is a local firm with 80,000 employees in finance, aviation, agriculture, and tourism.

[100] http://www.mpt.com.mm/en/product-services/mobile/fixed-line-Internet/.

[101] https://peering.google.com/about/faq.html.

[102] For example, prior to the Google Global Cache arrangement, a YouTube user in Myanmar might have been connected to servers in Iceland or the United States, instead of Singapore. The extra distance and additional passage through various global exchanges increases latency and cost.

[103] http://www.prnewswire.com/news-releases/cdnetworks-helps-customers-reach-the-untapped-mainland-southeast-asia-market-with-fast-secure-websites-and-mobile-access-300116387.html.

[104] CDNs (content delivery networks) improve web performance and efficiency by locating content closer to users, eliminating the need for international server connections. This also allows ISPs to reduce wholesale bandwidth costs, savings that can eventually be passed along to customers. Ai Lei Tao, "Myanmar Internet Gets Boost with Content Delivery Network," *Computer Weekly,* September 7, 2015, http://www.computerweekly.com/news/4500253015/Myanmar-Internet-gets-boost-with-content-delivery-network, (accessed at January 5, 2016).

[105] http://www.meshnetworks.com/.

[106] According to Wikipedia, over-the-top content is the delivery of audio, video, and other media over the Internet without the involvement of a multiple-system operator in the control or distribution of the content. See https://en.wikipedia.org/wiki/Over-the-top_content.

The proliferation of new electronic devices and use of content-rich applications such as video and GIS (geographic information system) are driving the need for more efficient use of the broadband spectrum.

As mentioned above, the MCIT issued draft guidelines on the provision of international gateway facility services in early 2016.[107] The guidelines attempt to guard against monopolization of critical Internet gateway infrastructure. They also seek to foster competition in two ways: (1) by limiting international gateway licensees to no more than a 10 percent ownership share in another licensee providing the same services; and (2) by prohibiting officers associated with gateway licensee entities from holding shares in another authorized entity holding a gateway license.

The following steps could improve Internet and broadband services.

For immediate action within 3–6 months:

- The government should continue to provide licenses to ISPs as liberally as possible. While the MOTC might consider use-it-or-lose-it provisions in order to make sure that licensees actually provide the services they apply to provide, the government should allow the market to separate quality providers from more poorly performing ones.
- The MOTC should encourage highly trafficked content providers to set up local servers to decongest local networks.
- The MOTC should encourage local hosting of content that is fundamental to enterprise and social development. This should be done by facilitating licensing and in some cases by providing subsidies and in-kind services. For example, the MOTC could actively encourage Internet service providers to host content locally (e.g., Wikipedia, academic journals, health blogs, civil education, information on climate change or disaster management, and other content provided for the public good) in order to increase network efficiencies and make particularly beneficial information more accessible.

MYANMAR'S SPECTRUM

The proliferation of new electronic devices and use of content-rich applications such as video and GIS (geographic information system) are driving the need for more efficient use of the broadband spectrum.[108] For example, Telenor forecasts mobile SIM penetration in Myanmar to reach 140 percent (70 percent real subscriber penetration at two SIMs per each subscriber) by 2020.[109]

To address this looming constraint, the MOTC published a draft of its spectrum roadmap in February 2016.[110] The white paper is an umbrella

[107] Republic of the Union of Myanmar, Ministry of Communications and Technology, *Guidelines on Provision of International Gateway Facility Services*, "Draft," Notification Number 00/2015, October 2015, http://www.mcit.gov.mm/sites/default/files/Guidelines%20on%20Provision%20of%20International%20Gateway%20Facility%20Services(DRAFT).pdf.

[108] Electromagnetic waves are characterized by frequency of their oscillations—their wavelengths. The electromagnetic spectrum includes, in order of increasing frequency and decreasing wavelength: radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, x-rays, and gamma rays. *Broadband spectrum* concerns radio waves that range from 10 kHz (kilohertz) (30 kilometers wavelength) to 100 GHz (gigahertz) (3 millimeters wavelength). Radio spectrum is divided into frequency categories or bands reserved for single or compatible use. Some frequencies are better or worse at penetrating physical obstacles like walls or precipitation. Others are better at traversing long distances. Higher frequencies, for example, are especially good at transmitting greater amounts of data, but have less range and penetrative ability. Within each band individual transmitters often use separate frequencies to avoid interference. See http://www.gsma.com/spectrum/what-is-spectrum/. Many wireless technologies occur around 400MHz (megahertz) to 4GHz, creating more demand but limited capacity for this portion of spectrum.

[109] Telenor white paper on Spectrum, October 14, 2015, cited in http://www.mcit.gov.mm/sites/default/files/mcit%20Roadmap%20for%20Consultation%20Part%202_0.pdf.

[110] MCIT, Spectrum Roadmap: Meet the Needs Over Next 5 Years (Yangon, February 1, 2016).

document that outlines Myanmar's spectrum planning needs over the course of the next five years for land mobile radio systems, point-to-point and point-to-multipoint systems, commercial radio systems, and broadband fixed networks. The roadmap identifies several spectrum initiatives requiring attention, including the need to allocate more spectrum for 4G services, point-to-area systems, government use, public safety, point-to-point microwave systems, broadband fixed systems, broadcast signals (including medium, high, very high, and television frequencies), and satellite.

Myanmar has no spectrum-sharing agreements with neighboring countries. The roadmap also identifies the need to coordinate with neighboring governments to avoid spectrum interference. Mobile operators in Thailand, for example, use nearly all available spectrum along Myanmar's border, preventing licensed telecommunications companies from fully exploiting their spectrum licenses. The same problem occurs on the Chinese border, though only MPT was attempting to operate in that area as of February 2016.

MPT occupies the largest amount of spectrum (70MHz [megahertz]), 30MHz more than Ooredoo and Telenor. MPT has agreed to relinquish 5MHz @ 900MHz. Ooredoo and Telenor received 10MHz licenses in the 900MHz band and 30MHz licenses in 2100MHz band. Spectrum below 1GHz (gigahertz) is preferred for mobile coverage and in-building penetration due to its reliability and cost efficiencies.[111] MPT has 40MHz of spectrum below 1GHz, compared to its competitors which have 10 MHz each.

FIGURE 7: SPECTRUM LICENSES OF MYANMAR'S MOBILE TELECOMMUNICATIONS OPERATORS

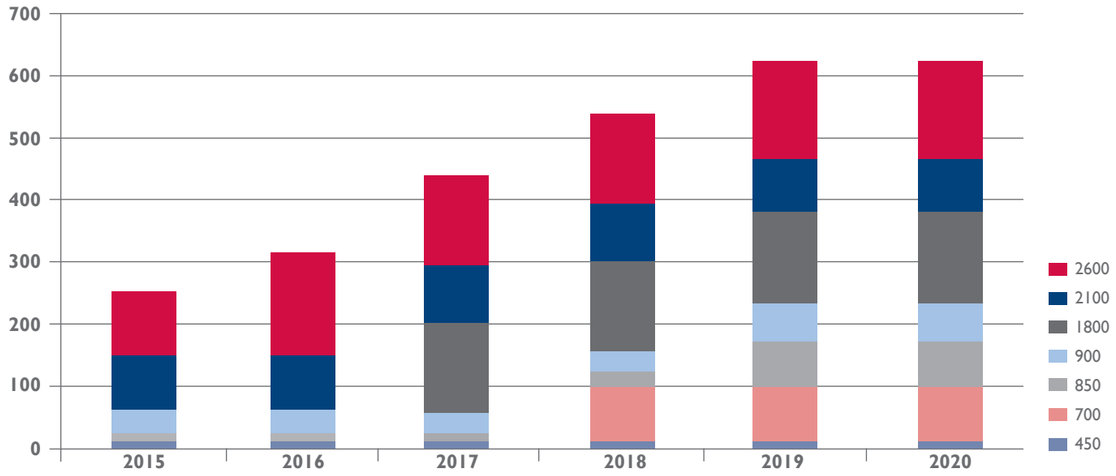
Frequency Band	Licensee	Technology	Uplink (MHz)	Downlink (MHz)	BW (MHz)
450 MHz	MPT	CDMA	453.35–457.1	463.35–467.1	2 X 3.75
850 MHz	MPT	CDMA	825–835	870–880	2 X 6.25
900 MHz	MPT	GSM	900–915	945–960	2 X 10[32]
	Ooredoo	GSM	890–895	935–940	2 X 5
	Telenor	GSM	895–900	940–945	2 X 5
2100 MHz	MPT	WCDMA	1935–1950	2125–2140	2 X 15
	Ooredoo	WCDMA	1950–1960 (1965)	2140–2150 (2155)	2 X 15
	Telenor	WCDMA	1965–1975 (1980)	2155–2165 (2170)	2 X 15

Source: MCIT, "Spectrum Roadmap: Meet the Needs Over Next 5 Years" (Yangon, February 1, 2016)."; BW stands for bandwidth, CDMA stands for Code Division Multiple Access, and WCDMA stands for Wideband Code Division Multiple Access.

The roadmap sets forth a five-year plan for spectrum release so that stakeholders, including prospective sector entrants, industry licensees, and the general public, can strategically prepare and access market dynamics and the government can maximize spectrum use and value. The plan takes into account operators' desire to deploy 4G LTE to support increasing data traffic.

[111] As cited in MCIT's "Draft Spectrum Roadmap for Consultation," 2015.

FIGURE 8: CURRENT AND EXPECTED SPECTRUM RELEASE PLANS



Note: Vertical axis depicts numbers of projected licensees.

Source: MCIT, Spectrum Roadmap, 64.

The need for more spectrum is evident: only 14 percent of Myanmar's population was using mobile phones as of 2015. Subscriber growth is expected to reach 38.5 million subscriptions by 2020 as operators expand to rural areas. Smartphones, which account for 80 percent of Telenor and Ooredoo users, will continue to dominate the market and demand high amounts of data bandwidth.[112]

Telenor reports that its voice traffic grew 90 percent in the first half of 2015, but data usage grew a stunning 200 percent. Fifty-five percent of Telenor subscribers are data users on a monthly basis, and web browsing consumes 43 percent of all data costs, followed by Facebook at 24 percent, and 14 percent for streaming video. Games account for 8 percent, while other uses (at 11 percent) round out total data consumption on Telenor's network.[113]

The Ministry of Information has authority over broadcasting, including Myanmar's four television broadcasters: Myanmar Radio & Television, Myawaddy, analog television (VHF Band III 174 – 230MHz), and digital television (UHF Band IV 470 – 686MHz). The roadmap plans a phased transition to digital terrestrial television to free up more broadcasting spectrum. Digital video compression allows for more efficient use of spectrum than analog signals, resulting in a digital dividend of conserved bandwidth in the Band III range that could be redeployed for broadband applications.

[112] Vivek Roy, "Myanmar's Mobile Market Sees Phenomenal Growth After Liberalization," Ovum press release, March 12, 2015, http://www.ovum.com/press_releases/myanmars-mobile-market-sees-phenomenal-growth-after- liberalization/, (accessed on January 5, 2016).

[113] Wayan Vota, "Wow, Myanmar is Going Straight to Smartphones," ICTworks, September 30 2015, http://www.ictworks.org/2015/09/30/wow-myanmar-is-going-straight-to-smartphones/, (accessed on January 5, 2016).

The following steps could help address these needs and challenges.

For implementation within 6–12 months:

- Given the increasing convergence of digital media and the government's intention to transition from analog broadcasting to digital terrestrial television, the Ministry of Information's broadcast media governance authorities should be folded into the MOTC's portfolio and its spectrum powers should revert to the PTD.
- The PTD should complete its transition to the MCRC in order to establish the independence of the MOTC's civilian spectrum regulator as soon as possible. The CIO (see Section 4 below) and the MOTC should immediately liberalize the sector by privatizing MPT.
- The government should develop a broadband spectrum plan as it has developed a radio spectrum plan in the interest of providing a greater connectivity, diversity of services, and increased ICT enterprise investment.

For implementation within 12–18 months:

- The government should engage in bilateral negotiations with telecommunications regulators in Thailand, China, India, Bangladesh, Laos, regional forums (ASEAN, ASEAN Plus Three), and the International Telecommunication Union (ITU) to harmonize spectrum allocation and compliance to minimize economic losses and maximize spectrum efficiency.
- The PTD should switch from analog television to digital to free channels in Band III and make them available for auction and improved rural connectivity.[114]
- The PTD should continue to monitor spectrum usage including ongoing network deployment, subscriber traffic, and technology usage in order to respond appropriately with spectrum allocation policies.

[114] This is an accepted method throughout the world to upgrade television communications—by switching from traditional analog signals—to more reliable and efficient digital signals. Analog television signals travel long distances, but they are prone to fading, distortion, and signal interference. In addition to being less reliable than digital signals, analog VHF and UHF signals take up valuable bandwidth. For example, digital technology can fit four or more channels into a signal analog channel.

THIS PAGE IS INTENTIONALLY LEFT BLANK

4. ICT GOVERNANCE IN MYANMAR

The effectiveness of Myanmar's ICT system could be enhanced by the development of a coordinated strategy that addresses the need to increase interoperability among government-owned ICT networks, interministerial collaboration on ICT policies and e-government applications, and the need to incentivize the expansion of mobile networks into underserved geographies and populations of the country.

INTEROPERABILITY AND INTERMINISTERIAL ICT GOVERNANCE

Interagency coordination is vital to implement ICT-enabled reforms.

Myanmar's government is a hierarchical body with extremely rigid separation among agencies. Few institutions apart from the military and the president's office have any ability to work across departments and agencies. There is no agency in Myanmar like the U.S. Department of the Treasury or the Office of Management and Budget that coordinates interagency tasks below the presidential level. This creates a challenge and an opportunity for ICT proponents.

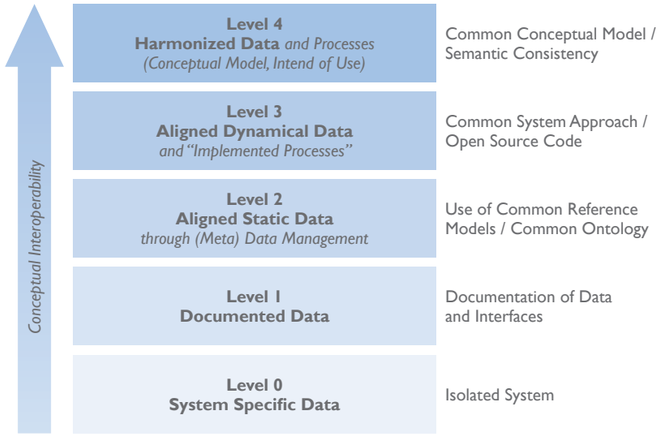
Although many government agencies have computers, most of them are not networked and are outdated.[115] Again, Myanmar's ICT greenfield advantage is in play since most government functions still rely on face-to-face or paper communication, but that advantage is in jeopardy. As of February 2016, Myanmar's government and its international partners were engaged in a variety of separate, and in many instances uncoordinated, e-government, web portal, ICT training, and network solutions procurement activities. While such activities reveal an admirable desire to modernize government systems, in the end such disparate processes are likely to result in an inefficient tangle of walled-off platforms and networks unable to coordinate with each other—a pattern not dissimilar to government's siloed administration.

Interagency coordination is vital to implement ICT-enabled reforms. Efficiencies in cost, coordinated action, speed, and other advantages offered by digitization will be lost unless interagency planning is fundamental to all ICT-enabled reforms. The transformative power of ICT systems in government institutions relies upon clear lines of authority, rational decision-making processes, and sequential implementation across government.

The government's digital requirements provide an opportunity to design its information architecture from the ground up. Among the primary principles to be considered is interoperability. Interoperability in the context of ICT is the ability of

[115] Field research and interviews with government officials and international advisors, 2015.

FIGURE 9: CONCEPTUAL LEVELS OF INTEROPERABILITY



Source:Tolk and Maguira (2003).

disparate and diverse organizations to interact digitally in the service of mutually beneficial goals.

Interoperable ICT systems rely on common processes and shared standards regarding language, access protocols, cybersecurity, administrative processes, data storage, procurement, and training. Technological neutrality and adaptability are also important hallmarks of interoperable systems. Information-sharing is a core function of interoperable systems. For example, for communications, the government should consider mandating that documents be written in English or Myanmar3, a Unicode font that can, unlike Zawgyi, be supported by global commercial software and hardware providers, including Apple, Google, and Microsoft. Implementation of TCP/IP (Transmission Control Protocol/Internet Protocol) and the HTTP (Hypertext Transfer Protocol) also guarantees that products implementing the protocols can interoperate. Document support for formats such as the OpenDocument Format ensures that such documents are accessible and editable with all applications supporting that format. Linux is similarly an open-source operating system that works on most servers, mainframe computers, Android devices, and super computers. These are free standards and thus can be implemented by all vendors. Cloud services and other shared network structures are also fundamental tools for interoperability so that various agencies can access common data for coordinated processes.

Competitive markets incentivize vendors to ensure as much interoperability as possible, but when a few big vendors dominate a market, innovation often takes a backseat to efforts to consolidate market share. Interoperability reinforces transparency and neutrality in government procurement.

Interoperability also requires collaborative approaches to information architecture as all agencies must adhere to standard protocols, policies, and technical standards across government (Figure 9). Other principles of interoperable approaches include shared and re-usable ICT assets—for example, core information systems stored on cloud services accessible across government agencies.

In Myanmar, where the digital landscape is relatively new, the government has an important role to play because the public sector will be among the most significant users of ICT services and in a position to influence market share of various technology vendors. In the interest of fair competition and access, the government should adopt procurement strategies that encourage innovation and competition. Purchasing interoperable hardware, software, and services ensures the government is not locked into a single vendor's product and that consumers and companies dealing with the government agency can also use other kinds of software. By promoting open standards, the government can even help to incentivize larger companies to become more open and contribute to a healthier information ecosystem.

By promoting open standards, the government can even help to incentivize larger companies to become more open and contribute to a healthier information ecosystem.

Interoperability is also a benefit of cloud systems and a building block of big data and Internet of Things processes in that it encourages greater access to a larger number of systems by a larger number of institutions and users. By standardizing data inputs and processes, interoperability enables operations that are efficiently scaled and collaborative.

The following steps could help address these issues.

For implementation within 3–6 months:

- The government should establish a Union-level chief information officer (CIO) within the Office of the President. This position should have the rank of presidential advisor and a mandate to drive technological reform across government. The government should also establish an ICT policy advisory board (IAB) comprised of private sector entrepreneurs, ICT experts, and a number of deputy CIOs who are embedded within ministries and both houses of Parliament.
- The CIO's authority over telecommunications infrastructure design should be ensured by creating a dedicated ICT project management office under the MOTC.
- The MOTC's ICT function should be primarily executive—as an implementer of communications infrastructure and policy. All information communications technology policy formulation should be under the purview of the CIO and the IAB, but with expanded authority delegated by the president. The CIO and his or her deputies should form an interministerial agency with primary authority over ICT policy implementation functions within the MOTC and implementation of ICT plans across all government agencies.
- State and regional CIOs should be appointed as well, housed within state and regional ministries of finance and reporting directly to the chief ministers' offices and the General Administration Department (GAD) executive secretaries to coordinate ICT reforms at local levels.
- The Union-level CIO and the IAB should be empowered to support and direct the MOTC and other relevant ministries to prioritize and drive ICT policy implementation across government and to set best ICT practices, priorities, and standards.

- The Union-level CIO and the IAB should be responsible for identifying, developing, and coordinating multiagency projects to improve government services through the use of ICT. They should also be tasked to work with Parliament's Communications Consultancy Selection Committee to increase technical assistance resources for ICT reform efforts.
- The Union-level CIO should also be a member of the Ministry of Planning and Finance's Public Expenditure and Financial Accountability Steering Committee.
- Deputy CIOs attached to other government ministries should report directly to their respective ministers and to the Union-level CIO.
- The government should establish an ICT project management office (IPMO) to accelerate and coordinate ICT infrastructure policy design, regulation, and deployment. The IPMO should operate under the authority of the Union-level CIO with officers appointed by the CIO to expand and institutionalize the work of the World Bank's Public-Private Infrastructure Advisory Facility (PPIAF) in ICT infrastructure development.
- The IPMO should liaise with the National Telecommunications Infrastructure Committee, established by the 2013 *Telecommunications Law*, to develop standards for infrastructure design, procurement, and deployment. The IPMO should have design, engineering, procurement, budgeting, and management expertise to identify, authorize, and manage all ICT collocation projects across sectors and ministries. The IPMO should be empowered to lead interministerial and international coordination, and should report directly to the Office of the President.
- The IPMO should be headed by the minister of the MOTC, along with representatives from the Ministries of Planning and Finance, Construction, Commerce, Agriculture Livestock and Irrigation, Border Affairs, Defense, Education, Electrical Power and Energy, Foreign Affairs, Health, and, on an as-needed basis, other ministries engaging in infrastructure development.
- The IPMO should also have representatives at the state/region level to liaise with state and regional GAD executive secretaries, the Ministries of Planning and Finance, Electrical Power and Energy, Industry, Agriculture Livestock and Irrigation, and Border Affairs, as well as with state/region-level Development Affairs Organizations.
- The MOTC minister should report directly to the Union-level CIO, who should then provide regular briefings on IPMO activities to the Office of the President. The IPMO should also report on a regular basis to the Standing Pyithu Hluttaw Transport, Communications, Construction, and Industry Committee as well as to state and regional Hluttaws when there are ongoing local projects.[116]

[116] The Hluttaw is the parliament in Myanmar. The Pyithu Hluttaw is the lower house of Myanmar's parliament.

For implementation within 6–12 months:

- The government should adopt interoperable approaches to the procurement of hardware and software systems in order to increase efficiencies within government and foster greater competition and innovation in Myanmar's ICT market.
- The government should require digital documents to be written either in English or Myanmar3, a Unicode font, so that Myanmar's digital ecosystem is supported by global software and hardware providers, and so Myanmar content is searchable by global search engines and databases.

For implementation within 18–24 months:

- The CIO, the MOTC, the Ministries of Planning and Finance, Construction, Border Affairs, and other ministries involved in infrastructure development should form an infrastructure interagency taskforce for collocation of all infrastructure. This entity could also be established instead as a stand-alone project development agency. In either form, it should have a dedicated office for ICT collocation.

E-GOVERNMENT

E-government can stimulate economic growth, promote social inclusion, and improve and expand government service delivery. E-government can also facilitate deeper democratic impulses by increasing access to public information and by eliciting interactions between government agencies and citizens, and among citizens. E-government can also combat corruption and catalyze innovative approaches by making a broader portion of society aware of government activities and by providing platforms for greater participation by citizens.

Internationally, e-government has developed in stages along a similar trajectory, often beginning with a basic "bulletin board" model in which government agencies simply post information they deem appropriate online with no interaction. A second stage usually features minimal interaction and service delivery. For example, a government agency might provide online forms or online contact information. The third stage entails electronic transactions, including financial transactions. The fourth stage might feature interoperability functions or consolidation of services—one-stop-shops—within a single web portal. The most advanced stage of e-governance would facilitate democratic feedback mechanisms: interactive functions including complaint processes, collaborative interactions with policymakers, or crowd-sourced citizen engagement with government.[117]

Myanmar's eVisa program, implemented by the Ministry of Immigration and Population in September 2014, is among the most popular and widely used e-government platforms so far.[118]

[117] For a sample of international best e-government practices, see United Nations, "E-Government for the Future We Want," *United Nations E-Government* Survey *2014* (United Nations, New York, 2014).

[118] Htun Htun Minn, "IT Firm Invests US$17 million for E-Visa System," *Myanmar Business Today,* September 8, 2014, http://www.mmbiztoday.com/articles/it-firm-invests-17-million-myanmar-e-visa-system.

The ministry entered into a 10-year US$17 million joint venture with Myanmar Ease Net Co. to complete the system, which originally included 43 countries.

Myanmar is currently working with the South Korean government and the American consulting firm KPMG to establish e-government platforms, including a national portal currently awaiting cabinet approval. As mentioned earlier, in October 2015 the Ministry of National Planning and Economic Development's Central Statistical Organization established the Myanmar Statistical Information System, with assistance from the Korea International Cooperation Agency. The web portal aggregates more than 300 datasets on trade, investment, demographics, and national income in Burmese and English.

The Union Election Commission also collaborated with the International Federation of Electoral Systems, The Asia Foundation, and Phandeeyar to create national digital voter lists, candidate information, and data visualization applications. The government also posted census information online with the help of NGO partners.

One Map Myanmar, a project to compile national spatial data analysis on an online map, was initiated in August 2015 with the assistance of the Swiss Agency for Development Cooperation, the Swiss Embassy in Myanmar, the Centre for Development and Environment, the University of Bern (Switzerland), and Myanmar-based Land Core Group.

Myanmar's goal should be to digitally enable all government services, starting with the services in greatest demand, including fee payments, licensing requirements, or inquiries about services. The government should strive to build digitally connected constituencies and learn to engage with them over time in an expanding range of online activities.

The following steps could help move efforts in a positive direction.

For immediate action within 3–6 months:

- The newly appointed CIO should work across ministries and other agencies to harmonize all ministry websites and online resources and consolidate them on a national portal.
- The government should identify the large-scale service delivery functions that can most easily and cheaply be digitized and provided on smartphones. It should then commission apps and portals for those functions on a triage basis.
- Apart from prioritized online service delivery, Myanmar should continue to expand the range of government information disseminated online in pursuit of a more informed populace. The information made available should include all public statements, official itineraries, tenders, regulations, fiscal budgets, government master plans, meeting minutes, legislative proposals, and new laws. Government agencies should also improve online public relations efforts by posting news items and press releases, as well as by maintaining updated blogs to better inform Myanmar's citizenry.

For implementation within 6–12 months:

- The government should expand and strengthen its online presence, moving from simple one-way, government-to-citizen communication, to basic interactive functions, then to transactions (including financial), and finally to digitally-enhanced democratic engagement and crowd-sourced policymaking.

Myanmar's goal should be to digitally enable all government services, starting with the services in greatest demand.

One of the objectives of the 2013 law in Myanmar is to broaden telecommunications service access by expanding the telecommunication network throughout the entire country and facilitating the development of the Myanmar telecommunication sector.

UNIVERSAL SERVICE OBLIGATION

Recognizing the difficulty of providing mobile network coverage to 53 million people, more than 70 percent of whom live in rural areas without access to reliable transport or electricity, the government included in its 2013 *Telecommunications Law* a provision for a universal service obligation (USO). USOs and universal service funds (USFs) work from the premise that markets and for-profit telecommunications corporations will not always extend service to underserved areas without sufficient financial incentives. Globally, USFs are collected by a variety of means, including levying taxes on telecommunications firms' profits or adding USF fees to spectrum license pricing. USOs and USFs, however, have dubious records of success. A 2013 survey of 64 USFs found that most USFs are "inefficient and ineffective, with more than US$11 billion waiting to be disbursed between them."[119]

One of the objectives of the 2013 law in Myanmar is to broaden telecommunications service access by expanding the telecommunication network throughout the entire country and facilitating the development of the Myanmar telecommunication sector. The focus will initially be on target services or providing one-time subsidies to incentivize private sector providers to enter remote local markets for long-term provision of commercial services.[120] In particular, the law provides the MOTC with the ability to establish various mechanisms to fulfill USOs, including a USF.

Successful USFs require highly flexible regulatory frameworks able to adjust to changing structural and economic conditions, and with allowance for funds to be allocated to other ICT-related purposes, such as training or stakeholder consultations. Successful USFs are technology neutral, insulated from political interference, and guided by clearly defined governance structures accountable to impartial, credible authorities. One best practice USF is found in Colombia, where the USF is fiscally independent from the government budget. Projects are awarded through a public bidding process and implemented in a timely and transparent manner. Chile and Paraguay also have successful USFs and have rolled unused surplus funds back into their treasuries.

Given the challenges faced by Myanmar's regulatory agencies in the ongoing network expansion, initiating rural expansion projects under the USO framework would likely overtax limited government capabilities.

Given the challenges faced by Myanmar's regulatory agencies in the ongoing network expansion, initiating rural expansion projects under the USO framework would likely overtax limited government capabilities. Furthermore, the requirements of

[119] Ladcomm Corporation (2013). The report estimates that one-third of USFs surveyed had not distributed any of the levies they had collected; fewer still had disbursed everything they collected, resulting in lost opportunity costs for already struggling economies. Poor planning appeared to be the main culprit; USFs were established with little analysis of actual level of needs or plans for expenditure of funds. Political intervention from other government agencies also frustrates attempts by USF administrators to use monies to expand ICT networks to underserved people. This is often due to poor accountability safeguards and because the disconnected communities USFs are designed to serve are often the most marginalized constituencies.

[120] Republic of Union of Myanmar. Draft Terms of Reference, Provision of Consulting Services to Design and Implement Pilots of the Universal Service Strategy of Myanmar. http://www.mcit.gov.mm/sites/default/files/TOR%20Universal%20Service%20Strategy%20and%20Pilots.pdf, (accessed January 5, 2016).

universal service are still unclear in Myanmar since telecommunications companies and tower firms have yet to complete their initial network build-outs. Although it is unlikely that mobile operators will manage to cover all of Myanmar's population and territories, it would be difficult to anticipate which areas will require government intervention until network expansion levels off in about three years.

The challenges are significant, but so are the opportunities. The following steps could help address these issues.

For immediate action within 3–6 months:

- The government should delay full implementation of the USO and collection of USF until commercial networks have been established and rural coverage gaps are more evident, probably in 2018–2020. In the interim, USF administrators should carefully plan the rollout.
- In the meantime, the government should consider providing a different, preparatory role for the USO, focusing on research, outreach, and digital constituency building. A lack of planning and poor understanding of community needs has led to USF failures internationally. As a result, Myanmar's USF administrators should hold hearings and conduct site visits to gauge the needs of its rural communities. USF administrators should also act as ombudsmen for outlying communities that have mobile coverage in order to keep abreast of service problems and act as interlocutors between civil society organizations, citizens, and the MOTC. USF administrators should also commission research into new technologies to enhance ICT coverage in rural areas, including point-to-multipoint technologies, mesh networks, and aerial communications networks (e.g., drone-, satellite- and balloon-born 4G LTE).
- USF administrators should seek charitable and development funding from international NGOs, aid organizations, and corporations to augment their research into new network technologies for rural communities.

For implementation within 6–12 months:

- USF administrators should partner with technology firms to conduct research and pilot programs in search of new network technologies that can provide ICT services to rural populations.

CYBERSECURITY

Secure computer networks start with rational, resilient, compartmentalized network architectures. Such network architectures require a hierarchical planning process and whole-of-government approach to information system design, procurement, security protocol development, training, and management. Effective cybersecurity also requires network providers to have maximum real-time visibility of computer networks and the institutions, individuals, and devices using those networks.

Cybersecurity, like other aspects of ICT governance, requires centralized coordination and inter-ministerial authority at a high level.[121]

[121] See the Interoperability and Interministerial ICT Governance section above.

Myanmar's cybersecurity challenges are structural ... Its computer networks have developed in an ad hoc fashion and no centralized government authority exists to secure them.

Internationally, cybersecurity is often the domain of a CIO with supra-ministerial powers.[122] In some cases, the CIO is attached to government agencies in charge of defense or finance. Other structures place the CIO at the presidential or prime ministerial level. The key commonality across many effective government approaches to cybersecurity is overarching, whole-of-government authority to design, implement, and manage cybersecurity policies.

In Myanmar, cybersecurity has traditionally been the responsibility of its security agencies. Cybersecurity does in fact address sovereign and law enforcement responsibilities, such as the protection of critical infrastructure. However, threats and safeguards often fall within the domain of information policy and administrative oversight, hence the need for a CIO with authority over cybersecurity. Cybersecurity threats exist on a continuum and in the interests of cultivating innovation and assuring civil liberties, a range of flexible government approaches should be developed.

Effective cybersecurity regimes must be consistently applied across networks and continually upgraded and adapted, which is why strong central control is essential from a management point of view. In Myanmar, this will require the development of new cybersecurity capabilities in law enforcement, in judicial institutions, and at the policy level. Some nations, including France, the United Kingdom, and the United States have addressed deficits in cybersecurity expertise by promoting national training programs and industrial policies, including leveraging public procurements to support cybersecurity small and medium enterprises (SMEs).[123]

Myanmar's cybersecurity challenges are structural. The government has yet to assess its current ICT assets, establish a coherent network architecture, or draft legislative frameworks and assign responsibilities to maintain and protect that architecture. Its computer networks have developed in an ad hoc fashion and no centralized government authority exists to secure them.

The Myanmar Computer Emergency Response Team (MMCERT) under the MOTC is currently charged with disseminating advice, best practices, and technical advice regarding cybersecurity. MMCERT also posts updates regarding known software security vulnerabilities and is a member of the Asia Pacific Computer Emergency Response Team and the International Multilateral Partnership Against Cyber Threats. However, MMCERT lacks the necessary expertise, funding, and legal authorities. MMCERT does not have the administrative whole-of-government authority it requires to satisfy its mandate.

The Information Technology and Cyber Security Department (ITCSD) appears to play a similar role in securing government networks, but again, the agency appears to have little influence outside of the MOTC and the Ministry of Information. The ITCSD is currently developing a draft cyber-crime law based on the ITU Toolkit for Cybercrime

[122] Organization for Economic Cooperation and Development (2012), 37.

[123] Ibid, 23.

Legislation. The latter was developed in conjunction with the American Bar Association,[124] incorporating elements of India's and Tanzania's cybercrimes laws. The Ministries of Home Affairs and Information are also involved in drafting the new law, which may clarify the ITCSD's authority over cybersecurity. The new law would also supersede elements of the *Electronic Transaction Law* and the *Computer Science Development Law*, which have been used to prosecute people for political speech.

As of January 2016, a second draft telecommunications law, written by an outside advisor, was also in circulation within the MOTC. The government is also receiving technical assistance from the European Union to develop cybersecurity regulations in line with the Council of Europe Convention on Cybercrime.[125] Myanmar has also worked with the Asian Development Bank (ADB), the Japanese International Cooperation Agency (JICA), China, and ASEAN to improve its cybersecurity framework. The World Bank also plans to provide technical assistance to the MOTC on cybersecurity through 2019.

The extent to which these various efforts around cybersecurity are coordinated or compatible is unclear.

Speech Restrictions Do Not Secure Cyber

Laws restricting freedom of expression and peaceful assembly continue to be used to arrest and imprison people engaging in peaceful activities, including online dissent. These laws include the 1908 *Unlawful Associations Law*; the 1950 *Emergency Provisions Act*; the 1923 *Official Secrets Act*, and various articles of the *Penal Code*.

Article 505b of the *Penal Code* is currently one of the most commonly used provisions to arrest and sentence people for peacefully expressing their views; it is often used in conjunction with other laws. In October 2014, two activists from the community-based Movement for Democracy Current Force were sentenced to two years imprisonment under Article 505b for writing a letter expressing the need for an election of an interim government.[126]

Myanmar's sole legislative measure covering cybersecurity is the *Electronic Transaction Law*, which outlaws hacking but also establishes offenses for online content that are defined more broadly than in Myanmar's criminal code. The law also lacks safeguards for freedom of expression. In addition, it restricts or outlaws practices that well exceed restrictions under international law regarding freedom of expression, such as the sending or distributing any information detrimental to the security of the state, law and order, community peace and tranquility, national solidarity, the national economy, or national culture.[127]

No Lawful Interception Policy

Myanmar has no legal framework governing lawful interception in the area of alleged cybercrimes and

[124] International Telecommunication Union and the American Bar Association (2010).

[125] Council of Europe. *Convention on Cybercrime*.(CETS 185) 2001, http://www.europarl.europa.eu/meetdocs/2014_2019/documents/libe/dv/7_conv_budapest_/7_conv_budapest_en.pdf, (accessed on January 5, 2016).

[126] Myanmar Centre for Responsible Business (2015b), 66.

[127] Ibid., 133.

the PTD has inconsistent policies for handling law enforcement's data requests. Telecommunications companies say they routinely receive requests from law enforcement to produce digital evidence in support of criminal allegations. Telenor has established an internal interception policy, but it is unclear what would happen if government disagreed with the company's protocol.[128]

Human rights organizations have also revealed that the government has contracted with Internet surveillance firms in the past, including Blue Coat and Fortinet, raising questions about the propriety of American cybersecurity firms conducting business with a government under U.S. sanctions.

These issues require prompt attention. The following steps could be useful building blocks for longer-term efforts to address the underlying needs and challenges.

For immediate action within 3–6 months:

- The government should repeal laws that infringe upon free speech rights, including the *Electronic Transaction Law*.
- The CIO and the Ministry of Home Affairs should draft a new cybersecurity law with a clear and equitable lawful interception framework with judiciary and legislative reforms addressing privacy rights, search and seizure, and due process.
- Communications surveillance should be limited in scope and duration, and applied only when there is suspicion of serious criminal conduct.
- Electronic surveillance should be governed by an impartial judicial authority with real power to check police powers. Surveillance powers should apply to all citizens, residents, and other entities in an equitable and predictable manner defined by law.
- The new cybersecurity law should outline mechanisms for control, management, and protection of strategic e-governance infrastructure and other critical assets, including government-owned networks, data centers, intellectual property, and application program interfaces (APIs).[129]
- The law should also designate the CIO as the nation's prime authority on cybersecurity matters.

For implementation within 12–18 months:

- The government should initiate a process to identify critical risks to ICT assets and establish information security protocols to protect government and government-held personal and enterprise data.

INTELLECTUAL PROPERTY PROTECTIONS

Intellectual property (IP) laws are vital to the ICT sector because they provide important assurances to start-ups and established Internet ventures that their property will be safeguarded in accordance with the rule of law. Strong IP regimes provide investors with confidence to invest in research

[128] Interview with Telenor executives in Yangon, 2015.

[129] Application program interfaces are the routines, protocols, and tools used to build software and applications.

and development and employment, particularly in the ICT sector. Patent protection, copyright, and trademark protections prevent companies from stealing competitors' products. These protections also encourage greater research and development overall, seeding innovation, investment, and jobs, especially among SMEs.

In Myanmar, the IP system is undeveloped and government does not have an intellectual property office. Most IP disputes are settled out-of-court and only a few of the cases that do go to trial are ever reach the Supreme Court on appeal. Myanmar's existing laws only provide remedies to aggrieved trademark proprietors. Consumers do not have standing to sue or to be represented in legal proceedings concerning trademarks. Myanmar also lacks legal provisions for consumer protection.

Myanmar has no trademark registration act or official trademark registration office. Rights of parties setting up rival claims to ownership of a trademark are determined by courts in accordance with the principles of common law. Myanmar also lacks an operational law on patents and industrial designs. This means that goods can be produced, commercially used, and traded without permission of the people or companies who hold relevant patents or design rights outside Myanmar. Consequently, most entrepreneurs have to invest large amounts to register their trademarked materials under the 1945 *Burma Patents and Design Act* (since repealed) and the 1946 *Burma Patents and Designs Emergency Provisions Act* to protect them from any illegal patent and design action related to their business. Patent and design legislation is not enforced in Myanmar.

Myanmar is, however, a party to intellectual property agreements established by the World Trade Organization (WTO), ASEAN, and the World Intellectual Property Organization (WIPO). As a member of WTO and ASEAN, Myanmar is responsible for abiding by the Agreement of Trade-Related Aspects of Intellectual Property Rights (TRIPS) and the ASEAN Framework Agreement on Intellectual Property Cooperation of 1995. Under these agreements, Myanmar pledged to pass legislation in accordance with the TRIPS Agreement by July 2013. However, in June 2013, the WTO extended that deadline to July 2021.[130]

In Myanmar, the IP system is undeveloped and government does not have an intellectual property office.

Myanmar's Ministry of Science and Technology and the Ministry of Commerce are working to develop a better IP regime with WIPO, the WTO, JICA, the Asian Patent Attorneys Association, and ASEAN. The Ministry of Science and Technology is in charge of and has completed drafting the necessary domestic legislation called for by the WIPO. English and Burmese versions of these draft IP laws (*Trademark Law, Patent Law, Industrial Design Law,* and *Copyright Law*) were sent to the Union-level Attorney-General's Office for scrutiny in June 2014.[131]

With support from WIPO, JICA, the Japan Patent Office, and the Japan External Trade Organization, civil servants have received preliminary training to strengthen their ability to efficiently conduct their duties under the forthcoming IP Office of Myanmar (IPOM). IPOM is to be established after enacting the IP laws. It will have four main departments: policy and strategic planning, IP, education and awareness, and finance and administration.

The following steps could help address these issues.

For immediate action within 3–6 months:

- The government should establish an intellectual property office and a trademark registry.
- The government should pass legislation establishing enforceable intellectual property protections, including a trademark law, patent law, industrial design law, and copyright law in accordance with the TRIPS Agreement.

PREPARING AN ICT-ENABLED WORKFORCE

Myanmar lacks an adequate professional workforce, especially in the technical professions required in the ICT sector: engineers, electricians, architects, physicists, data scientists, lawyers, and accountants. Myanmar also lacks adequately trained civil service professionals to carry out the functions of government, particularly in such technical matters as ICT procurement, broadband management, and spectrum allocation.

To implement ICT policies and operate advanced ICT assets, Myanmar must improve its human resources, most immediately by liberalizing visa and citizenship requirements to allow more skilled workers and technology entrepreneurs to gain easier access to the economy.

In Myanmar two ICT universities and 24 government computer colleges offer degrees in ICT-related subjects. A significant number of private and international, university-affiliated training centers and schools also provide degrees in ICT. Collaborations with international organizations also provide training, including capacity-building programs by the Myanmar Computer Federation; joint ICT training programs with Singapore, Japan, and India; the Japan-Myanmar e-Learning center in MICT Park; and various scholarship programs.[132] Mobile communications is expected to employ approximately 66,000 full-time equivalent employees in Myanmar, and an estimated additional 24,000 full-time jobs will be created in the wider economy.[133]

Many of the jobs likely to be created as Myanmar industrializes will require technical and vocational education and training (TVET), with specific instruction in science, technology, engineering, and math (STEM), but these skills are in very limited supply today in Myanmar. Only 0.5 percent of upper secondary students enrolled in TVET, for example.[134] TVET is key for adult training, which will be required in the near-term while school-aged children make their way through reformed educational institutions.

The following steps could help address these issues.

[130] Asian Patent Attorneys Association (2014).

[131] Ibid.

[132] See http://www.mcfmyanmar.org.

[133] Deloitte and Ericsson (2012), 5.

[134] Organization for Economic Cooperation and Development (2012) 12.

For immediate action within 3–6 months:

- Incentivize private firms to offer ICT skills training for employees by publicly recognizing outstanding efforts, providing tax credits to firms that invest in ICT skills training, and providing preferential status in procurement processes to firms with effective ICT training programs and highly technically skilled employees.

For implementation within 12–18 months:

- The Ministry of Education should use technology to systematically reform vocational education administration, teacher training, and instruction on ICT.
- The government should partner with international organizations and CSOs to encourage the development of social media and mobile applications to promote STEM literacy.

DIASPORA FOR ICT DEVELOPMENT

Diasporas are another national labor resource that can be leveraged to improve transnational trade and investment networks and provide skills transfers and cultural linkages to their countries of origin.[135] Diasporas also have direct economic impacts on countries of origin through the remittances they send back.

Myanmar's decades of neglect of its educational system, economic stagnation, political strife, and violent conflict led to the exodus of many of its most mobile and capable citizens, which, in turn, resulted in a brain drain that has impoverished its labor pool. The under-developed nature of Myanmar's human resources is most evident in technical fields, including the ICT sector. As many as 3 million Myanmar nationals live abroad,[136] many with access to educational and professional opportunities unavailable in Myanmar.[137]

Myanmar should improve its immigration policies for the benefit of Myanmar diaspora communities abroad seeking to re-engage with or return to their origin nation. Burma's 1982 *Citizenship Law* does not allow dual citizenship and those holding foreign passports need a visa to return to Myanmar. Such visas require approvals from the Ministries of Home Affairs, Foreign Affairs, and Immigration. Business visas are generally restricted to 70 days with indefinite provisions for renewal. Anyone wishing to reinstate their citizenship faces additional hurdles, as the government lacks a clear repatriation procedure. Furthermore, an unknown number of people remain on government blacklists due to their suspected involvement in political dissent. The Myanmar government and its development partners should acknowledge the transnational nature of Myanmar identity and the value of skilled Myanmar workers living abroad by encouraging reforms of citizenship, permanent resident, and labor requirements to allow easier access to Myanmar by its diaspora communities abroad.

[135] Plaza and Ratha (2011).

[136] Egreteau (2012).

[137] According to UNESCO's Institute of Statistics, 6,388 Myanmar students were enrolled abroad. The top five destinations were, in descending order, Thailand (1,481), Japan (1,133), United States (914), Turkey (864), and Australia (679). See United Nations Education, Cultural and Scientific Organization (UNESCO) Institute of Statistics http://www.uis.unesco.org/EDUCATION/Pages/international-student-flow-viz.aspx.

Apart from reforming citizenship and immigration policies, Myanmar and its development partners can support the efforts of web portals, news sites, podcasts, blogs, social media, and other digital media directed at, and chronicling, Myanmar's diasporas. Such platforms should be multidirectional—informing Myanmar's diasporas about events and trends in Myanmar, while consolidating those disparate communities in Asia, the Middle East, and the West, as well as sharing diaspora experiences and perspectives with audiences in Myanmar itself.

Such digital exchanges can help mediate important debates about national values and priorities and shape discourses around national identity. Since diasporas are inherently diverse communities they often model the kind of pluralistic discourse required of mature democracies, especially when they themselves have been exposed to democratic societies. Diasporas' involvement can have bracing effects on the politics, economies, and culture of their origin nations.

Diasporas and their origin nations benefit economically through public-private partnerships that leverage diasporas' skillsets and international assistance to increase trade and investment between diasporas and their home nations. Professional and industry groups, as well as religious and ethnic communities abroad, link with their origin nations by using ICT to strengthen and expand diaspora networks.

The following steps could get things moving in the right direction.

For immediate action within 3–6 months:

- The government should liberalize visa and citizenship requirements for Myanmar diaspora members in order to attract more skilled workers and potential investors.
- Allow dual citizenship for Myanmar diaspora members.
- Abolish government blacklists against Myanmar opposition figures abroad.
- Conduct online outreach programs to attract highly-skilled Myanmar diaspora members to Myanmar's ICT sector.
- Promote skills transfer programs between diaspora ICT professionals and local Myanmar ICT professionals, modeled on programs such as the International Organization for Migration's Migration for Development in Africa program, and the United Nations Development Program's Transfer of Knowledge Through Expatriate Nationals program.

5. OPPORTUNITIES FOR SECTORAL ICT INNOVATION IN MYANMAR

Myanmar has the lowest level of foreign direct investment in ASEAN.

This section provides an overview of the transformational roles that ICT applications can play in key sectors of Myanmar's society.

ICT AND FINANCE[138]

Myanmar has the lowest level of foreign direct investment in ASEAN due to economic sanctions, onerous financial system constraints, poor regulatory frameworks, and poor ICT infrastructure. What FDI has been approved is concentrated in the oil and gas sector. Approved FDI into the telecommunications sector has taken an increasingly large role, having attracted US$2.8 billion since 2013, but altogether investment still falls well short of demand for capital in Myanmar.[139]

Economic Impacts of Sanctions

Sanctions continue to have adverse impacts on Myanmar's economy, particularly international trade, despite the United States and Europe having lifted or waived some restrictions. The U.S. Treasury's Office of Foreign Assets Control has designated dozens of individuals and companies on the Specially Designated Nationals list, with whom Americans must avoid financial dealings.[140] Financial institutions weigh the potential upside in a nascent developing economy against the risk of being fined and publicly castigated for doing business with corrupt people or entities. As a result, many American institutions avoid investing in Myanmar altogether. For example, the Yangon Stock Exchange was launched in December 2015 with assistance from Japanese firms, but because it is partly owned by Myanma Economic Bank, a sanctioned entity, American firms cannot trade on it. Only six companies are listed on the new exchange.[141]

Myanmar Payment Union and Points-of-Sale

Since 2012 MasterCard and Visa have established in Myanmar 450 automated teller machines (ATMs) and 2,500 point-of-sale devices, of which 1,665 belong to the Myanmar Payment Union (MPU) network.[142]

[138] For a fuller treatment of challenges facing Myanmar's banking and financial sector, see Turnell (2016).

[139] Damien Dujacquier, "Advancing Myanmar's Telecom Infrastructure," *Myanmar Times*, September 8, 2015, http://www.mmtimes.com/index.php/opinion/16415-advancing-myanmar-s-telecom-infrastructure.html.

[140] U.S. Department of the Treasury, *Resource Center: Specially Designated Nationals List*, webpage, https://www.treasury.gov/resource-center/sanctions/SDN-List/Pages/default.aspx.

[141] Clare Hammond, "Six Companies to Trade on Yangon Stock Exchange," *Myanmar Times*, January 7, 2016, http://www.mmtimes.com/index.php/business/18058-six-companies-to-trade-on-yangon-stock-exchange.html.

[142] Valenti, Galloway, and Moe Pwint (2014).

MPU started its operations in September 2012 and has become a national payment brand. All MPU cardholders can have access to any ATM of all member banks and also make payments at any point-of-sale of all member banks for goods and services they purchase. Since 2013, China Union Pay and Japan Credit Bureau cards can also be used at MPU terminals.

Nonetheless in Myanmar, transferring cash is usually just a matter of transporting banknotes from one place to another, often by bus. The *hundi* system, a system "… in which monetary value is transferred through a network of dealers or brokers from one location to another" (Turnell 2016), is the second-most common method of moving money across significant distances.[143]

Interbank Transfers and Real-Time Gross Settlements

The Central Bank of Myanmar (CBM) plans to develop electronic payment and settlement systems to allow electronic interbank transfers, as well as the use of debit and credit cards. With the support of the International Monetary Fund (IMF) and JICA, the CBM is establishing a real-time gross settlement (RTGS) system and a banking network for electronic funds transfer (EFT), as well as necessary reporting systems. The first electronic transfer providers to enter Myanmar since these reforms were introduced are Western Union, Xpress Money, MoneyGram, Maybank, International Money Express, and Singapore Post. Since January 12, 2013, 9 domestic banks and 280 agents across Myanmar have received transfers from about 500,000 Western Union agents in 107 countries, and Xpress Money's services are available from about 120 locations to Myanmar.[144]

JICA and the IMF are also working with the CBM to implement RTGS for bank-to-bank electronic settlements. Many banks still use a paper-based manual clearing system. RTGS will link all private banks, including foreign banks, and will utilize the MPU network. Interbank EFTs require an automatic clearing system that Myanmar does not yet have, so EFT is not yet available in Myanmar.

Mobile Money: Banks versus Telecommunications

Myanmar has drafted regulations and license frameworks to allow mobile money. Currently several pilot programs are operating, including Telenor's Wave Money and Ooredoo's Pite San mobile applications. However, the CBM has yet to approve mobile money regulations, due to lobbying by local banks that seek to place restrictions on the telecommunication industry's involvement in finance.[145]

Local banks in Myanmar traditionally adhered to a low-volume, high-value customer model. This allowed them to weather sanctions and operate under regulations that set high barriers to entry for foreign financial institutions. This arrangement limited competitive threats to local banks but did not provide an impetus for them to modernize, grow beyond their bases in Yangon and Mandalay, or pursue Myanmar's vast unbanked potential customers, estimated to be more than 90 percent of the population. Telecommunications operators, however, do have an immediate financial interest in high-volume, low-value customers. Unlike Myanmar's local banks, they have the resources to build out a network to capture large shares of Myanmar's informal economy.

Myanmar has drafted regulations and license frameworks to allow mobile money.

Despite the desires of local banks to be players in mobile money, multinational telecommunications firms have more technological resources and more reach into the market. Still, banks will remain an important element of Myanmar's development because they will be needed to support small business enterprises and other investments necessary for the development of Myanmar's economy. Furthermore, the involvement of banks in mobile money could increase competition and make financial services more affordable for consumers.

The Benefits of Mobile Money

Mobile money has the potential to free up capital and generate higher levels of remittances, further integrating Myanmar's financial system with global financial flows. Because mobile money requires scale to succeed, the most revolutionary aspect of its establishment in Myanmar will be the rapid expansion of the use of formal banking services by the population and the resulting unprecedented capture of personal data. In addition to mobile phone, Internet usage, and geospatial data, mobile money operators will also have access to digital financial information of millions of new Myanmar identities, their spending behaviors, income, assets, and other vital information. The formalization of a significant portion of Myanmar's economy will allow retailers to understand Myanmar's markets better and will help the government predict revenues. Credit histories will become more visible, enabling better discernment of risks, opportunities, and, eventually, credit markets.

Mobile money, located at the nexus of finance and telecommunications, also catalyzes a rich set of stakeholders, including payment companies like RedDot and Visa, e-retail, shopkeepers, liquidity management firms, and a host of other potential start-ups. Mobile money also enables broader financial inclusion for women, young people, the elderly, the disabled, and remote consumers. Mobile money can also spark technological innovations around e-retail, digital accounting, near-field communications to access digital wallets, biometrics, and interoperability.[146]

Passage of the *Financial Institutions Law* in January 2016 has set the stage to fully implement mobile money and to accelerate Myanmar's economic growth. The *Financial Institutions Law* established mobile money operators as "non-bank financial institutions" in which traditional banks can only have limited ownership—less than 5 percent.

Studies show initial revenues from mobile pay are relatively modest, with startup operating costs amounting to seven times revenue for the first years of mobile money deployment. Within five years, profits typically amount to around 2 percent. But after that time, profit margins are typically 20 percent or more.[147] And finally, mobile money establishes a platform for services beyond payments, including remittances, insurance, savings, and lending.

[143] Foerch, Om Ki, San Thein, and Waldschmidt (2015).

[144] Wong (2016).

[145] Interviews with CEOs of Telenor, Ooredoo, and WAVE Money in Yangon 2015.

[146] Near-field communications is a wireless technology that permits data transfer over short distances, primarily used to connect electronic devices, and make contactless payment, access, and ticketing transactions. See International Telecommunication Union (2013).

[147] Almazan and Vonthron (2014).

Remittances

Many Myanmar people engage in migrant labor as cross-border traders, students, and smugglers. When they send remittances back to Myanmar they often do so informally, bypassing both international financial sanctions and Myanmar laws requiring them to remit through the Myanmar Foreign Trade Bank. Having to use informal networks to remit money back to Myanmar costs the diaspora. The global average cost to send money is about 8 percent. However, some of Myanmar's diaspora benefits from its origin nation's proximity to Singapore, one of the world's cheapest remittance corridors.[148]

While mobile money could greatly reduce the cost of domestic remittances, it is unlikely to have much of an effect on international remittances, particularly because Myanmar remains under partial financial sanctions. Furthermore, the *Financial Institutions Law* expressly precludes mobile money operators from engaging in foreign currency exchange practices. Globally, the value of international remittances through mobile phones accounted for less than 2 percent (US$10 billion) of global remittance flows ($542 billion) in 2013.[149] The CBM should approve mobile money regulations and allow licensees to initiate mobile financial transactions.

The following steps could help address these issues.

For immediate action within 3–6 months:

- The government should fully authorize operator-neutral (also referred to as "operator agnostic") mobile money nationally. International telecommunications operators should be encouraged, but not required, to develop partnerships with local banks, as Telenor has done with Yoma Bank. Such partnerships enable capacity building in the financial sector.

For implementation within 12–18 months:

- The government should model e-payments and enhance financial formality by mandating direct wage deposits for government contractors and employees.
- The government should allow mobile money operators to handle foreign remittances in order to draw more investment from the Myanmar diaspora and foreign investors.

ICT FOR AGRICULTURE[150]

Agriculture is Myanmar's most vital and under-invested sector. About 70 percent of the population is rural and over half of the workforce is employed in agriculture, which contributes about one-third of GDP.[151] Myanmar is one of Asia's largest nations, with 67.6 million hectares of surface area (65.3 million hectares of land area). Arable land accounts for 10.8 million hectares (16.5 percent of land area). Forests comprise 46.1 percent of land area, or 30 million hectares.[152]

[148] Ibid.

[149] Juniper Research (no date).

[150] For a fuller treatment of challenges facing Myanmar's banking and financial sector, see National Economic and Social Advisory Council (2016).

[151] Haggblade et al. (2013).

[152] All figures are from the World Bank, *World Development Indicators*.

Official agricultural data are mainly on paper and siloed between various departments.

Given the rapid proliferation of mobile smartphones, Myanmar agriculture's least-expensive leapfrog opportunity is the expansion of rural broadband and the improvement of digital data collection and management.

Myanmar enjoys a significant competitive advantage due to its river systems that provide 24,000 cubic meters per capita of renewable freshwater each year—10 times the level available in China and India and double the amount in Viet Nam, Thailand, and Bangladesh. The country's diverse topography and microclimates also enable it to produce an impressive variety of crops, livestock, and fish. Its geographic location gives it access to some of the world's largest markets, including China and India. Yet Myanmar agriculture has been neglected in terms of public expenditure and private investment, particularly research and development.

At the root of Myanmar's agricultural challenges is a lack of sectoral oversight, a dearth of agricultural knowledge, and few means to disseminate that knowledge. Myanmar currently spends less than any other nation on agricultural research, only six cents for every US$100 of agricultural output, compared to US$0.41 and US$0.53 in Asia and the developing world respectively in 2000. Myanmar also has fewer research staff than any other ASEAN member states: as of 2008, 62 and 224 doctoral and master's degree-holders, respectively.[153] Myanmar's agricultural extension services, designed to disseminate new knowledge and techniques to farmers, are inadequately resourced and lack access to digital networks. Online market intelligence is also virtually nonexistent in Myanmar. Information about pricing and supply comes in a one-way flow from Chinese dealers and other middlemen who set prices. As agricultural liberalization continues and new markets are opened, accurate real-time (digital) pricing information will be vital.

Official agricultural data are mainly on paper and siloed between various departments, including the Central Statistical Organization, the Planning Department, the Livestock Breeding and Veterinary Department, the Department of Fisheries, the Department of Population, the Department of Labor, and the Settlement and Land Records Department.[154] Few agricultural stakeholders find government statistics credible, with production estimates for rice differing by as much as 50 percent.[155]

Mobile for Agricultural Development

Given the rapid proliferation of mobile smartphones, Myanmar agriculture's least-expensive leapfrog opportunity is the expansion of rural broadband and the improvement of digital data collection and management. Internationally, mobile applications for development currently in use have been shown to improve access to market information, leading to higher prices and demand for produce. Mobile agriculture apps have also been used to monitor climate shifts and disease outbreaks. Mobile phones can also improve extension services by disseminating agricultural knowledge and accurate assessments of pastures and crops, leading to higher yields, improved access to markets, and reduced exploitation by middlemen.[156, 157]

[153] Haggblade et al. (2013).

[154] Sanyu Consultants Inc. (2013).

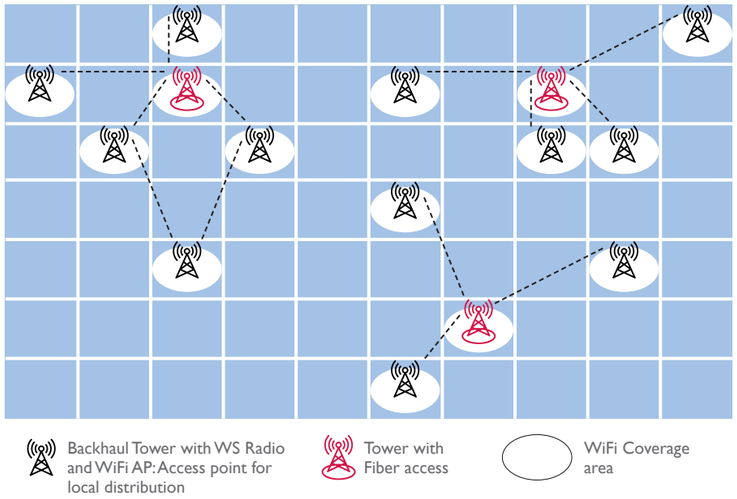
[155] Haggblade et al. (2013).

[156] Qiang, Kuek, et al. (2012).

[157] World Bank (2011).

The challenge for mobile technologies in rural Myanmar, however, is that installation of fiber networks in remote areas is expensive, and thus coverage is scarce.

FIGURE 10: TV WHITE SPACE (WS) MESH NETWORK FOR RURAL BACKHAUL



Source: Kumbhkar, Islam, Mandayam, and Seskar (2015).

Myanmar's best opportunity to link technology with agriculture is in opening up portions of the country to broadband experimentation, particularly local-scale, white space backhaul,[158] low altitude,[159] aerial,[160] 4G LTE networks,[161] and local-scale cellular backhaul and mesh networks.[162] White space refers to portions of licensed radio spectrum that are not always used by licensees—discontinued analog television signals, for example—and thus can be used for other purposes without causing signal interference. Signals at these TV frequencies between 2.4GHz and 5GHz airwaves have propagation characteristics suitable for travelling long distances over hills and around/through buildings. White space systems have been known to provide as much as 16Mbps throughput. Low-orbit satellite, balloon, and solar drone technologies promise to provide speeds of 100Mbps or more. Mesh backhaul networks coupled with fiber can increase the value of network deployment in remote areas. These prospective technologies have the added benefit of being extremely energy efficient.

[158] White space networks take advantage of disused long-distance television spectrum radio waves to link internet signals between broadcast towers (represented here in black) and towers connected to fiber or satellite connections. See Kumbhkar, Islam, Mandayam and Seskar (2016).

[159] Jonathan Vanian, "Behind the Scenes with Facebook's New Solar-Powered Internet Drone and Laser Technology," *Fortune*, July 30, 2015, http://fortune.com/2015/07/30/facebooks-solar-power-drone-Internet-earth/, (accessed on January 5, 2016).

[160] Maddie Stone, "Elon Musk's Space Internet Plan Is Moving Forward," *Gizmodo*, 13 June 2015, http://gizmodo.com/elon-musks-space-Internet-plan-is-moving-forward-1711008007, (accessed on January 5, 2016).

[161] PTI, "Sri Lanka to buy 25% stake in Google's Project Loon for high-speed Internet," *Indian Express*, 1 February 2016, http://indianexpress.com/article/technology/tech-news-technology/sri-lanka-to-buy-25-stake-in-googles-project-loon-for-high-speed-Internet/#sthash.kkk1PwQV.dpuf, (accessed on January 5, 2016).

[162] Akyildiz, Wang, and Wang (2005).

Digital agricultural networks could help smallholder farmers create new virtual constituencies, give them access to greater pools of knowledge and skills, and help them locate resources.

Digital agricultural networks could help smallholder farmers create new virtual constituencies, give them access to greater pools of knowledge and skills, and help them locate resources. Over time, building up stores of digitized agricultural data can provide guidance for investors and policymakers, particularly when seeking appropriate inputs like agricultural infrastructure, mechanization, and training. Mapping agricultural production flows, rainfall, sunlight, soil conditions, demographics, and other environmental variables can rationalize the location and specification of transport systems, irrigation, storage facilities, electricity generation and distribution, and retail markets. Knowing more about where farmers are located and which crops and livestock they are producing will enable the clustering of mechanized agricultural inputs like shared tractors, processing facilities, and electrical grids.

Digitize Extension Services

Myanmar will also need to revamp its network of agricultural laboratories, universities, extension facilities, and certification institutions to drive sectoral improvements, raise production standards, and develop more capable human resources—primarily agronomists, data scientists, and engineers. Digital technology can help connect agricultural institutions and create knowledge paths. Myanmar should also work closely with key partners in the private and public sectors in regions where e-agriculture is already a fixture including Japan, South Korea, China, Singapore, Thailand, India, Europe, and the United States. Myanmar can use digital technology to take advantage of knowledge transfer, capacity-building programs, and institutional links with agriculturally focused donor agencies, universities, and corporations. Such partnerships will also facilitate the opening of new markets and the diversification of produce and livestock.

Policymakers and implementers should consider the following measures to encourage progress in this sector.

For immediate action within 3–6 months:

- To facilitate the expansion of rural broadband, the PTD should reserve a portion of the broadband spectrum made available by the government's planned analog switchover from traditional to digital television.

For implementation within 12–18 months:

- The CIO and the USF should promote innovation in rural connectivity and e-agriculture by inviting technology corporations, academic institutions, donors, and NGOs to use Myanmar, or regions thereof, to test and develop experimental ICT platforms.

For implementation within 18–24 months:

- The Ministry of Agriculture and the Ministry of Education should facilitate e-learning for rural populations and farmers by revamping agricultural curricula at its universities and colleges with agriculturally focused ICT instruction.

- The Ministry of Agriculture should establish a clearinghouse for mobile agricultural applications for knowledge transfer, pricing and environmental data, agricultural productivity monitoring, and other vital sector requirements.
- The Ministry of Agriculture and the Central Statistical Organization should digitize sector data collection and analysis processes, with a focus on mobile phone applications.
- The Ministry of Agriculture should conduct smartphone-, drone- and satellite-enabled agro-ecological zone mapping.

ICT-ENABLED EDUCATION

Myanmar's 30-year, long-term Education Development Plan, launched in 2001, provides the main planning framework for the higher education subsector.[163] The plan consists of 36 action programs across 6 priority areas. The priority areas are: human resource development, the utilization of technology, the expansion of research, the development of lifelong learning, the promotion of quality, and the preservation of national identity and national values.

Myanmar is currently developing a new national educational policy, but so far the Comprehensive Education Sector Review has given scant attention to the potential role of ICT in education in Myanmar. Frameworks for education and training policymaking are disjointed and decentralized among many government agencies and international partners. Effective policy making is also hindered by a lack of accurate information and data because educational institutions lack the necessary ICT tools.

Fiber optic and mobile technology will make it possible for remote schools, particularly teachers, principals, and parents, to use basic ICT tools like email, chats, cloud storage, and even voice- and video-conferencing to share educational resources, distribute management directives, and catalyze collaborative educational practices. Digitizing administrative records, including physical plant maintenance records, budgets and payroll, attendance, grading, and other data can help build core ICT skills among teachers and school managers, support accounting systems to guide reforms, prevent corruption, and inculcate an ethic of data-driven educational practice.

ICT for Scaled Teacher Training and Instruction

Use of ICT in Myanmar's educational context should emphasize educational management and teacher training. ICT in classrooms should mainly be used at higher educational levels and by older age groups. Elementary schools will benefit from employing a lighter touch on ICT, with teachers in lower grades intermediating online materials and mainly using soft-skill techniques (voice, chalk, pencils, and paper). Secondary and post-secondary institutions should be fully equipped with ICT hardware and software, or have access to similarly equipped ICT hubs.

Myanmar must prioritize investment in its higher education institutions to support the training of teachers and production of new Myanmar-language teaching materials. Myanmar schools should also teach English, Cantonese, and Mandarin. ICT can be used to augment capacity-building efforts by providing digital access to distance learning programs and collaborative partnerships provided by teaching universities and colleges abroad. Those partnerships should focus on drafting curricula that emphasize STEM. Within Myanmar, those same ICT tools can extend the reach of centralized teacher training programs and disseminate teaching materials to teachers by emailing documents, placing them in cloud accounts, or otherwise distributing cost-efficient digitized texts.[164] ICT tools should also be used for teacher-teacher, teacher-student, and teacher-parent collaboration.[165]

Providing Internet access to all of Myanmar's educational institutions will be a slow process since the entire system will require extensive infrastructure improvements, particularly schools' access to power. The cost of supplying equipment to all of Myanmar's schools and students will likely be prohibitive in the medium term, which is why access to ICT hardware should be prioritized for educators. Realistically, widespread use of technology-focused learning approaches in the classroom is a more distant goal. As an interim step, the Ministry of Education could introduce a "mobile first" policy, whereby the development and procurement of new educational resources and materials (such as service training programs, classroom curricula, lesson plans, and digital textbook guides for teachers) would be digitally based.

Most immediately, Myanmar can leverage regional and international exchanges and educational resources to accelerate its STEM educational development.

ICT Hubs for Skills Development and Access

Myanmar should set up ICT hubs for better Internet access and focused computer skills training for students, educators, and professionals. ICT hubs should be diverse—with differing emphases and priorities—but should have common entry points for those seeking basic ICT skills, connectivity, and a technologically-focused community. ICT hubs should also be as public as possible, with collocations on school and university campuses, as well as store-fronts, community centers, and stand-alone sites. ICT hubs should coordinate with Myanmar's educational institutions in order to support national skills development programs and to accelerate the modernization of Myanmar's workforce.

Scholarships, Education Grants, Exchanges, and Fellowships

Most immediately, Myanmar can leverage regional and international exchanges and educational resources to accelerate its STEM educational development. The ASEAN Credit Transfer System is designed to increase student mobility within the subregion and boost human resources. The ASEAN International Mobility for Students Program (formerly known as the Malaysia-Indonesia-Thailand credit transfer project) is a useful model that could be extended to other ASEAN states, including Myanmar. Singapore also offers ASEAN scholarships for General Certificate of Education Advanced-Level qualifications and undergraduate scholarships at

[163] Myanmar's 30-year education plan is discussed in Zobrist and McCormick (2013).

[164] Read (2015).

[165] Burns (2011),.

Singapore's three universities. Norway and Sweden have also sponsored dozens of Myanmar master's degree candidates at Bangkok's Asian Institute of Technology. Brunei has in the past provided scholarships for Myanmar students and training programs for new Ministry of Foreign Affairs bureaucrats.[166]

Donor and international aid agencies, including the World Bank, Japan and Australia, are also contributing significantly to Myanmar's educational development. The United States Agency for International Development (USAID) has also sponsored programs to enable Myanmar students to gain associate and master's degrees at American universities. USAID should consider expanding such programs and including additional U.S. institutions with strong STEM resources, particularly agricultural, marine, climatology, forestry, and computer science research institutions. The State Department's U.S.-ASEAN Innovation in Science through Partners in Regional Engagement (INSPIRE) initiative is another resource Myanmar could use to improve cross-border scientific collaboration and scientific enterprise.[167]

Universities in Myanmar should be given more autonomy to invite and host visitors. The current system of ministerial approval for visitors is a highly centralized system that must be relaxed if real change is to come to Myanmar. Relaxing ministerial control over faculty exchanges, particularly visits to Myanmar universities by U.S. faculty, would be one small but important step in the right direction. Myanmar should also enter into exchange framework agreements with the Institute for International Education, ASEAN, and other organizations representing institutions of higher learning internationally.

Cultivate a "Knowledge Mediasphere"[168]

One feature of Myanmar's media environment is that, until recently, it has been state-controlled. While liberalization of most media platforms is a much desired outcome for the proliferation of new voices, perspectives, and innovation, centrally controlled media have their benefits, particularly in an educational and development context.

In the industrialized world, the British Broadcasting Corporation (United Kingdom) and the Public Broadcasting System (United States) have long played a role in transmitting basic literacy skills and moral education to children. In Asia, China, Bangladesh, and India also have developed centrally planned educational media programs using television, radio, and the Internet to build their knowledge bases.[169]

Myanmar should also consider how to best utilize its existing state media resources for educational, rather than ideological, purposes. Some of the most promising mass education models combine campus-based instruction with ICT-enabled peer sharing and distance learning methodologies to reach scale.[170]

[166] Yonezawa, Kitamura, Meerman, and Kuroda (2014), 154–155.

[167] http://www.state.gov/r/pa/prs/ps/2012/11/200822.htm

[168] Valk, Rashid, and Elder (2010).

[169] Ibid.

[170] Burns (2011), 190.

Myanmar's educator communities should also consider partnerships with software developers in order to seed the nation's cybersphere with a knowledge-driven ethic. Myanmar's language requirements necessitate development of locally produced software. These language requirements are a barrier. However, in an environment in which mobile uptake has been so rapid and expansive, there is an opportunity for careful planning and coordination of software development. A concerted focus on mobile-based gamification,[171] for example, could help create a knowledge-driven ecosphere on social media and on mobile platforms in a fashion similar to the way educational programs have been used in broadcast media.[172, 173, 174]

The following steps could help address these issues.

For immediate action within 3–6 months:

- Instead of fully connected schools, the Ministry of Education and the MOTC should set up ICT connectivity hubs for better Internet access and focused computer skills training for students, educators, and professionals. ICT hubs should be diverse, with differing emphases and priorities, and publicly accessible.
- The Ministry of Education should leverage regional and international exchanges and educational resources to accelerate STEM educational development. Examples include the ASEAN Credit Transfer System, the ASEAN International Mobility for Students Program, and other transfer and exchange programs.
- Relax ministerial control over faculty exchanges, particularly over visits to Myanmar universities by U.S. faculty. Myanmar should also enter into exchange framework agreements with the Institute for International Education, ASEAN, and other organizations representing institutions of higher learning internationally.

For implementation within 6–12 months:

- The MOTC should work with the Ministry of Education to provide schools with basic modular ICT networks for administrative functions.
- Myanmar's educator communities and CSOs should collaborate with software developers to seed the nation's mobile cybersphere with ICT-infused pedagogy. As an alternative to the children's public television, the Ministry of Education and the MOTC should focus on gamifying mobile applications and social media to disseminate STEM and other educational content.

For implementation within 18–24 months:

- The Ministry of Education should incorporate ICT approaches—particularly distance learning—into its teacher training curricula.

[171] Gamification refers to the application of game-design elements and game principles in non-game contexts.

[172] Kumar et al. (2011).

[173] Kam, Mathur, Kumar, and Canny (2009).

[174] Tulloch (2014).

- The Ministry of Education should develop and procure online "mobile first" educational resources, including service training programs, classroom curricula, lesson plans, and digital textbooks.

E-HEALTH AND MEDICAL INFORMATICS

Myanmar's Health Information System is based on a data collection regimen that began in 1978. Basic health staff collect data manually using standardized paper forms on monthly, quarterly, and annual bases and collate that information at the local facility where they are collected. Consolidated data are then sent to the township health department, the Department of Health Planning, and the relevant regional or state health department. Statistics are disseminated through print publication of annual health statistics reports. Hospital information is collected monthly from public hospitals and disseminated through printed annual hospital statistics reports. The Health Information System also collects information on hospital infrastructure and administration, public health, human resources, and medical logistics. The Central Statistical Organization has responsibility for compiling, analyzing, and disseminating health statistics.[175] The private health sector is less forthcoming with data and there is no legislative or regulatory requirement to direct private institutions' collection of data or to mandate the collection and sharing of that data with the government.

The Ministry of Health (MOH) has no central database for the health workforce, but some MOH departments have their own, non-networked databases.[176] Registries of doctors, dentists, nurses, midwives, and other medical professionals are compiled by certification authorities including the Myanmar Medical Council, the Myanmar Dental and Oral Medical Council, the Myanmar Nurse and Midwife Council, and the Traditional Medical Council.

The government intends to introduce an electronic information system, but spotty electricity, limited availability of Internet services, and cybersecurity concerns have delayed the implementation of digital recordkeeping. The Health Management Information System under the Department of Health Planning is the main digital information system of MOH, with data on health staff and facilities at all levels. The system relies on recently distributed computers, fiber-optic lines, and asymmetrical digital subscriber lines (ADSLs) located in main population centers. Medical ICT infrastructure is less well established in rural areas where computer hardware may exist, but data are collected manually. Despite the existence of 3G networks at many medical facilities, email and Internet usage remain minimal.[177] ICT equipment maintenance is hampered by limited availability.

Only routine service statistics, vital registration, and surveillance data are available. The MOH Medical Records Department maintains a digital medical records system. It can be found at some tertiary-level teaching hospitals and some state and regional hospitals, but it cannot be considered to be a fully integrated system. In many hospitals, computers are not networked at all or have rudimentary ADSL lines. Better technical and financial

Myanmar's Health Information System is based on a data collection regimen that began in 1978.

[175] Tangcharoensathien and Patcharanarumol (2014), 51.

[176] Ibid, 91.

[177] Ibid, 90–91.

support is required for development of tools, hardware and software for communication, data transfer, data processing and analysis, and database establishment and maintenance.[178] Myanmar needs to develop a comprehensive e-health strategic plan, including performance standards, monitoring and evaluation mechanisms, and benchmarking.

E-health practices emphasize the development, use, and impact of electronic health record (EHR) systems. EHRs are patient-centric medical records, including patients' medical histories, details of recent care, images, scanned documents, and administrative data such as bed management and commission data. EHRs are usually used by clinicians, administrators, and patients themselves.[179] Digitizing medical records creates the added benefit of interoperability with other systems. EHRs improve staff productivity, reduce patient wait times, increase staff satisfaction, and provide higher quality data to relevant personnel. Laboratory information management systems have decreased the time it takes to communicate results and improved the laboratory productivity. Pharmacy information systems reduce the time needed to order medications and provide easy access to past information. This is useful for forecasting medication requirements in order to purchase it at a lower price, which is particularly relevant for drug-resistant illnesses including tuberculosis, malaria and HIV. These systems also reduce error rates. Studies have shown that fingerprint and barcode scanners reduce the time it takes to locate records. Patient tracker systems and automated reminder systems reduce the time devoted to medical follow-ups and increase healthcare program attendance. Digital data collection also saves money compared to paper-based systems.[180]

The government should take advantage of Myanmar's rapid uptake of mobile smartphones and use of social media, particularly Facebook and Viber, by conducting ICT-enabled epidemiological monitoring.

Investment in Medical Research, E-health Literacy

In order to take advantage of ICT enablers that exist for the health sector, Myanmar's Ministry of Health must invest in informatics training and build ICT literacy among medical practitioners and administrative staff. The government should identify international exchange programs, distance learning programs, and scholarships available for health workers, as well as partnerships with private health industry entities, NGOs, academic institutions, and hospitals. The Ministry of Health must also work with Myanmar's institutions of higher learning to make ICT a core component of medical education curricula and build capacity for mid-career training of Myanmar's medical professionals.

Improving Health Surveillance with Big Data

The government should take advantage of Myanmar's rapid uptake of mobile smartphones and use of social media, particularly Facebook and Viber, by conducting ICT-enabled epidemiological monitoring. Studies have shown that social media analytics can identify and even predict outbreaks at levels comparable to the analysis of the Behavioral Risk Factor Surveillance System, a global standard for epidemiological surveillance. Studies show that for a fraction of the cost of traditional research, health informatics experts can, theoretically, analyze Myanmar social media to locate and

[178] Ibid.

[179] Black, Car, Pagliari, Anandan, Cresswell, et al. (2011), 5.

[180] Børtveit (2014), 11.

even predict epidemic-level health problems including diabetes, obesity, parasitic infections, and other illnesses.[181]

In addition to monitoring health challenges, health officials should strive to relay important public health messages, including outbreak warnings and preventive care information, through multiple channels, including broadcast, print, SMS, and social media.

Mobile for E-health

Mobile should be a key channel for health workers in Myanmar. Mobile technology can provide rich health informatics by using apps for survey dissemination and data collection, photo uploads, and GPS information capture. Mobile technologies are also used to deliver health-promoting messages, to improve clinic visit attendance for culturally sensitive health issues such as breast cancer, and to increase patient retention in care, treatment, and prevention programs. Mobile health interventions include psychiatric disorders, wellness and prevention, surveillance of outbreaks, infant feeding, drug adherence, and measuring the impact of health interventions.[182]

Outsource E-health Data Collection; Phased Network Implementation

Myanmar should design a migration plan that leaves in place current health systems to minimize disruption and concurrently manages the phase-in of a digitally-enabled health system. The centerpiece of such a plan must be the creation of a unified health data system. To achieve this, the government should avoid piecemeal technological fixes. Rather, the Ministry of Health should employ outside consultants, including international health care providers and informatics organizations, to establish a comprehensive, cloud-based EHR system and a process for staged national implementation. The migration to e-health practices should begin with retraining of medical practitioners, administrators, and procurement professionals on systems and information management. The government should introduce system-wide online collaboration processes, including agency communications, skills- and knowledge-transfer, and networked administrative functions, including resource and financial management.

ICT to Protect Against Pharmaceutical Counterfeiting

The Ministry of Health should consider adopting technologies for the authentication and tracking of pharmaceuticals, including Mobile Product Authentication (MPA) systems.[183] MPA technology comprises infrastructure and a business interface, designed to verify the authenticity of medications. Registered products are packaged with authentication codes, instructions, and a number to which SMS messages are sent to a server for automated verification. The system allows both pharmaceutical companies to monitor their products along supply chains and health services providers to protect against ineffective and counterfeit drugs. Examples of branded MPA services include Sproxil, which is built on the IBM SmartCloud platform, and mPedigree Networks, which uses HP Labs. Other techniques include applying scratch-code stickers to medicine packages which customers use to authenticate drugs by calling a dedicated helpline.

[181] Velasco et al. (2014).

[182] Vital Wave Consulting (2009), 9–14.

[183] Isah (2012).

Thus, logistics will be a core area of growth for Myanmar. It lies at the intersection of major sea lanes and dynamic, partially landlocked neighboring economies.

The following steps could help address these issues.

For immediate action within 3–6 months:

- The Ministry of Health should consult with the MOTC on its national health plan and the development of an ICT-enabled workforce and a unified health data system.

For implementation within 12–18 months:

- The Ministry of Health should work with international partners, private consultants, and the Ministry of Education to develop new ICT-enabled ("mobile first") educational programs at medical schools and on-the-job training for medical practitioners and administrative staff. Critical skills should include digital informatics.
- The Ministry of Health should work with NGO and CSO public health partners, as well as Facebook, Twitter, Viber, WeChat, MPT, Telenor, and Ooredoo, to develop a social media-based epidemiological surveillance system to monitor public health.
- The Ministry of Health should work with NGO and CSO public health partners as well as Facebook, Twitter, Viber, WeChat, MPT, Telenor and Ooredoo to develop a digital public health campaign office for advocacy and public health messaging.

For implementation within 36–42 months:

- The Ministry of Health should develop a digitized, interoperable unified health data system, including an electronic health record, a laboratory information management system, a pharmacy information system, and a Mobile Product Authentication system.

E-LOGISTICS AND TRANSPORT[184]

Myanmar lacks logistics systems, including streamlined one-stop-shop operations, ICT-enabled customs procedures, electronic transfer and storage of vital documents, and road, rail, and maritime accountability systems. Overall, Myanmar's logistics and transport facilities suffer from a dearth of sensors and data. Thus, logistics will be a core area of growth for Myanmar. It lies at the intersection of major sea lanes and dynamic, partially landlocked neighboring economies. It has abundant extractive resources and agricultural goods for export, and its consumer demand for imports is growing.

Logistical Infrastructure vs. Logistical Activity

Myanmar needs large investments in physical infrastructure including new and rehabilitated airports, roads, rail lines, river and maritime facilities, freight terminals, and a host of other construction projects to accommodate the current and the anticipated future demand.[185]

As in other sectors in need of reform, Myanmar has latecomer advantages. It can leap forward with new infrastructure development, unburdened by significant infrastructure legacies that often complicate logistics reforms elsewhere. It has the opportunity to develop holistic, integrated, ICT-enabled plans. This would include drafting transport infrastructure plans that leverage regional trade infrastructure frameworks and take advantage of the latest data on demographic trends, economic growth forecasts, environmental frameworks, and demand projections. Data-driven analyses will drive plans for new infrastructure construction to ease logistics constraints. Logistical data will highlight efficiencies that can be imposed even on existing substandard transport

[184] For a fuller treatment of challenges facing Myanmar's freight logistics sector, see Arnold (2016).

[185] Shibata (2014).

infrastructure. By making relatively light upfront investments in sensors and ongoing investments in data analysis, logistics providers can calibrate logistics systems and improve efficiencies, even prior to infrastructure upgrades. Fiber optics, cameras, pressure plates, and other sensors are fundamental components of logistical infrastructure.

Sensor Technologies for Logistics

Myanmar should implement an intelligent transportation system (ITS) to inform large-scale transport infrastructure improvements and guide more efficient logistical practices. ITS is an Internet of Things application that centrally coordinates and analyzes data from various sensor systems including GPS, radio frequency identification (RFID), wireless sensor networks, ubiquitous sensor networks (USNs), cameras, audio detection devices, smartphone trackers, Bluetooth detection, and road-embedded inductive loops to spatially and temporally track freight and passenger flows.[186, 187]

When integrated with social media applications, broadcast media, variable signage, dynamic traffic signals, and other logistic data dissemination systems, ITS alters flows and supply chain activities to facilitate more efficient use of existing infrastructure. Logistical sensors enable predictive systems that allow for just-in-time shipments, activity-based planning, precise lot control, traceability of agricultural and livestock products, and other efficiencies. ITS depends on a variety of wireless technologies including radio modem signals on UHF and VHF, short-range IEEE (Institute of Electrical and Electronics Engineers) 802.11 protocols and dedicated short range communications standards, mesh networks, WiMax, GSM (Global System for Mobile communication), and 3G.

As Myanmar builds new transport infrastructure, sensor technologies should be embedded in every project as well as back office systems to analyze data collected by those sensors for evidence-based infrastructure and logistical solutions. Beyond transport logistics, other applications of RFID and various sensor networks include identity management chips in passports and other ID cards, livestock tags, health patient management, and supply chain tracking.[188]

ICT-enabled Logistics Policy

Integrated logistics systems require investment in technology and careful cross-sector and local/national whole-of-government approaches. Myanmar's development plans should include ICT-based logistical improvements with an eye on becoming a regional logistics enabler. While Myanmar, like many developing nations, spreads transport responsibilities across various agencies, this approach creates interagency obstacles. Logistical leaders like Japan, South Korea, and Singapore have created unitary agencies for logistics to coordinate transport activities and focus logistics policies. Myanmar should do the same.

A Dedicated Logistics Agency

A dedicated logistics agency with the authority to set digitally-enhanced intermodal transport policies would inform all infrastructure planning and manage logistical operations in real time. This agency should also have a strong presence beyond the Ministry of Transport and the Ministry of Rail Transport, including the Ministry of Commerce, the Ministry

As Myanmar builds new transport infrastructure, sensor technologies should be embedded in every project as well as back office systems to analyze data collected.

[186] Castro and Kuse (2002).

[187] Becker, Jedermann, and Timm-Giel (2010).

[188] Myo Min Aung, Chang, and Won (2012).

of Communications and Information Technology, the Ministry of Foreign Affairs, Ministry of Immigration and Population, the Ministry of Energy, the Ministry of Livestock, Fisheries, and Rural Development, the Ministry of Border Affairs, and others.

Electronic Data Interchange and Other Customs Reforms

A recent study of Myanmar's illicit capital flows found that trade misinvoicing is among the largest measurable components of illicit financial flows and capital flight.[189] Myanmar's long borders with Thailand, Bangladesh, India, and China are porous and inadequately regulated, and its customs systems are dysfunctional. Illicit border trade imperils Myanmar's reform efforts because it frustrates the government's attempts to implement sustainable extractive practices, labor reforms, human rights, and revenue generation schemes. This in turn impacts Myanmar's ability to fund health, education, and other vital sectors.

Automating customs procedures can generate finer-grained data on goods and people, underscoring Myanmar's opportunity to become a data-driven society. Myanmar should streamline transactions between various logistical actors nationally (i.e., across state and regional boundaries) and internationally (i.e., across borders with neighboring trading partners) by using automated verification processes including Electronic Data Interchange and other machine-to-machine applications.[190]

Customs automation, including the implementation of real-time world market pricing risk analysis systems, would allow customs officials to determine whether or not the price of a good falls within a reasonable price band relative to the norm for such transactions, and to do so efficiently. Many developing nations outsource this and other automated customs functions to minimize the risk of corruption and ease the flow of goods across borders.

Finally, Myanmar should remove tariffs on goods obtained through Internet purchases in order to boost trade volume and incentivize regional e-commerce innovation.

With so many areas demanding attention, the following measures could be a good place to start.

For immediate action within 3–6 months:

- The MOTC, the Union-level CIO, and IPMO should participate in all logistical infrastructure planning and construction in accord with collocation policy.[191]
- The PTD should reserve spectrum for logistical infrastructure requirements.
- The government should remove tariffs on Internet purchases to boost regional e-commerce and trade.

For implementation within 18–24 months:

- As suggested earlier with regard to interministerial collaboration, an interagency taskforce should be established for collocation of infrastructure.
- The government should develop a national intelligent transport system to inform large-scale transport infrastructure.
- The Ministry of Border Affairs should implement an Electronic Data Interchange system and other automated customs systems to enable real-time, market pricing analyses.

[189] Kar and Spanjers (2015), 31.

[190] Castro and Kuse (2002).

6. POLICY RECOMMENDATIONS

The table below regroups in matrix format all recommendations made in the paper by topic and timeframe.

TABLE 3: COMPLETE LIST OF RECOMMENDATIONS

Topic	Within 3–6 Months	In 6–12 Months	In 12–18 Months (or more)
POLICIES FOR MYANMAR'S ICT INFRASTRUCTURE			
Mobile Operator Land Acquisition	The government should provide the MOTC and telecommunications infrastructures rights of way on publicly held lands for installation of critical telecommunication networks. All privately built infrastructure should be required to post signage indicating ownership, contract information, and contacts of government regulators. Telecommunications industry actors should formalize cooperative efforts to geolocate threats to safety in real time, including mapping landmines and explosive remnants locations, and sharing data with government and nongovernmental organizations (NGOs) working on landmine removal.	The MOTC should adopt clearer rules for mobile tower land acquisition along the lines of the World Bank's ESMF guidance. Rules should set out standard processes for due diligence investigations of land tenure, public hearings regarding usage, and identification of telecommunications companies, partners, and subcontractors involved. The MOTC should also establish an equitable complaint and arbitration process for aggrieved parties. The MOTC should require all permits and contracts for land use to be made public, preferably in digital form. The CIO and the MOTC could also require telecommunications operators to support the Land Core Group and other international NGOs working on land issues to assist efforts to establish cadastral baselines.	The MOTC should also establish and enforce engineering standards for all towers and other passive infrastructure as well as a regular inspection process and sanctions regime to ensure compliance.
Energy for Mobile Towers			**For implementation within 18–24 months:** The CIO, the MOTC, and the Ministry of Electrical Power and Energy should work with the telecommunications companies, their builder contractors, and ESCOs to develop industry standards for mobile tower energy generation and distribution. The CIO and the MOTC should actively support efforts of international NGOs and telecommunications firms to finance green energy alternatives for mobile towers through partnerships, tax incentives, and subsidies via the Universal Service Obligation. The Ministry of Electrical Power and Energy, the MOTC, and telecommunications operators should develop energy plans in coordination with ICT coverage plans in order to maximize efficiencies and augment both sectors.

Topic	Within 3–6 Months	In 6–12 Months	In 12–18 Months (or more)
Mobile Infrastructure Sharing	The MOTC should encourage more sharing by telecommunications networks and passive infrastructure firms to create more efficiencies and competition. This could include mandating tower-sharing in certain areas. The MOTC should also require towers to be erected with enough structural capacity for multiple tenants.		
Collocation of Network Infrastructure			The government should develop a default collocation policy for all government-funded infrastructure and construction projects. This dig-once collocation policy should include strong rights-of-way legislation mandating that the MOTC participate in all infrastructure plans so that trenches, ducts, fiber, and other telecommunications infrastructure are included in as many government projects as possible. One way this can be achieved is by granting the MOTC automatic rights of way whenever any other utility or state agency is granted a right of way. Additionally, access mandates should be monitored and enforced to ensure compliance. Transparency can also create constituencies for network deployment and increase interagency cooperation within the government. The MOTC should also establish a national atlas of all available passive infrastructures, including ducts, dark fiber, poles, transmission lines, pipes, and others that could be used to deploy fiber. The government should also keep an interagency database of all civil engineering work with potential for passive infrastructure deployment. The MOTC should prioritize the establishment of an emergency network office to govern the deployment of climate monitoring, emergency warning, and disaster preparedness fiber systems. This process also relies on interagency opportunities for collocating ICT and other infrastructure. The government should implement blanket change of use waivers for lands currently leased by telecommunications operators and tower companies, standardize tower site lease agreements, and enforce standard lease registration processes.

Topic	Within 3–6 Months	In 6–12 Months	In 12–18 Months (or more)
Internet and Broadband in Myanmar	The government should continue to provide licenses to ISPs as liberally as possible. While the MOTC might consider use-it-or-lose-it provisions in order to make sure that licensees actually provide the services they apply to provide, fundamentally, the government should allow the market to separate quality providers from more poorly performing ones. The MOTC should encourage highly trafficked content providers to set up local servers to decongest local networks. The MOTC should encourage local hosting of content that is fundamental to enterprise and social development. This should be done by facilitating licensing, and in some cases by providing subsidies and in-kind services. For example, The MOTC could actively encourage ISPs to host content locally (e.g., Wikipedia, academic journals, health blogs, civil education, information on climate change or disaster management, and other content provided for the public good) in order to increase network efficiencies and make particularly beneficial information more accessible.		
Myanmar's Spectrum		Given the increasing convergence of digital media and the government's intention to transition from analog broadcasting to digital terrestrial television, the Ministry of Information's broadcast media governance authorities should be folded into the MOTC's portfolio and its spectrum powers should revert to the PTD. The PTD should complete its transition to the MCRC in order to establish the independence of the MOTC's civilian spectrum regulator as soon as possible. The CIO and the MOTC should immediately liberalize the sector by privatizing MPT. The government should develop a broadband spectrum plan as it has developed a radio spectrum plan in the interest of providing a greater connectivity, diversity of services, and increased ICT enterprise investment.	The government should engage in bilateral negotiations with telecommunications regulators in Thailand, China, India, Bangladesh, Laos, regional forums (ASEAN, ASEAN Plus Three), and the International Telecommunication Union to harmonize spectrum allocation and compliance to minimize economic losses and maximize spectrum efficiency. The PTD should switch from analog television to digital to free channels in Band III and make them available for auction and improved rural connectivity. The PTD should continue to monitor spectrum usage including ongoing network deployment, subscriber traffic, and technology usage in order to respond appropriately with spectrum allocation policies.

Topic	Within 3–6 Months	In 6–12 Months	In 12–18 Months (or more)
POLICIES FOR MYANMAR'S ICT GOVERNANCE			
Interoperability and Interministerial ICT Governance	The government should establish a Union-level chief information officer (CIO) within the Office of the President. This position should have the rank of presidential advisor and a mandate to drive technological reform across government. The government should also establish an ICT advisory board (IAB) comprised of private sector entrepreneurs, ICT experts, and a number of deputy CIOs, who are embedded within ministries and both houses of Parliament. The CIO's authority over telecommunications infrastructure design should be ensured by creating a dedicated ICT project management office under the MOTC. The MOTC's ICT function should be primarily executive—as an implementer of communications infrastructure and policy. All information communications technology policy formulation should be under the purview of the CIO and the IAB, but with expanded authority delegated by the president. The CIO and his or her deputies should form an interministerial agency with primary authority over ICT policy implementation functions within the MOTC and implementation of ICT plans across all government ministries. State and regional CIOs should be appointed as well, housed within state and regional ministries of finance and reporting directly to the chief ministers' offices and the General Administration Department (GAD) executive secretaries to coordinate ICT reforms at the local level. The Union-level CIO and the IAB should be empowered to support and direct the MOTC and other relevant ministries to prioritize and drive ICT policy implementation across government, to set best ICT practices, priorities, and standards. The Union-level CIO and the IAB should also be responsible for identifying, developing, and coordinating multiagency projects to improve government services through the use of ICT. They should also be tasked to work with Parliament's Communications Consultancy Selection Committee to increase technical assistance resources for ICT reform efforts. The Union-level CIO should also be a member of the Ministry of Planning and Finance's Public Expenditure and Financial Accountability Steering Committee.	The government should adopt interoperable approaches to the procurement of hardware and software systems in order to increase efficiencies within government and foster greater competition and innovation in Myanmar's ICT market. The government should require digital documents to be written either in English or Myanmar3, a Unicode font, so that Myanmar's digital ecosystem is supported by global software and hardware providers, and so Myanmar content is searchable by global search engines and databases.	**For implementation within 18-24 months:** The CIO, the MOTC, the Ministries of Planning and Finance, Construction, Border Affairs, and other ministries involved in infrastructure development should form an infrastructure interagency taskforce for collocation of all infrastructure. This entity could also be established instead as a stand-alone project development agency. In either form, it should have a dedicated office for ICT collocation.

Topic	Within 3–6 Months	In 6–12 Months	In 12–18 Months (or more)
	Deputy CIOs attached to other government ministries should report directly to their respective ministers and to the Union-level CIO. The government should establish an ICT project management office (IPMO) to accelerate and coordinate ICT infrastructure policy design, regulation, and deployment. The IPMO should operate under the authority of the Union-level CIO with officers appointed by the CIO to expand and institutionalize the work of the World Bank's Public-Private Infrastructure Advisory Facility (PPIAF) in ICT infrastructure development. The IPMO should liaise with the National Telecommunications Infrastructure Committee, established by the 2013 *Telecommunications Law,* to develop standards for infrastructure design, procurement, and deployment. The IPMO will have design, engineering, procurement, budgeting, and management expertise to identify, authorize, and manage all ICT collocation projects across sectors and ministries. The IPMO should be empowered to lead interministerial and international coordination, and, in matters requiring such, it should report directly to the Office of the President. The IPMO should be headed by the minister of the MOTC, along with representatives from the Ministries of Planning and Finance, Construction, Commerce, Agriculture Livestock and Irrigation, Border Affairs, Defense, Education, Electrical Power and Energy, Foreign Affairs, Health, and, on an as needed basis, other ministries engaging in infrastructure development. The IPMO should also have representatives at the state/regional level to liaise with state and regional GAD executive secretaries, and the Ministries of Planning and Finance, Electrical Power and Energy, Industry, Agriculture Livestock and Irrigation, and Border Affairs, as well as with state/region-level Development Affairs Organizations. The MOTC minister should report directly to the Union-level CIO, who should then provide regular briefings on IPMO activities to the Office of the President. The IPMO should also report on a regular basis to the Standing Pyithu Hluttaw Transport, Communications, Construction, and Industry Committee as well as to state and regional Hluttaws when there are ongoing local projects.		

Topic	Within 3–6 Months	In 6–12 Months	In 12–18 Months (or more)
E-Government	The newly appointed CIO should work across ministries and other agencies to harmonize all ministry websites and online resources and consolidate them on a national portal. The government should identify large-scale service delivery functions that can most easily and cheaply be digitized and provided on smartphones. It should then commission apps and portals for those functions on a triage basis. Apart from prioritized online service delivery, Myanmar should continue to expand the range of government information disseminated online in pursuit of a more informed populace. This should include all public statements, official itineraries, tenders, regulations, fiscal budgets, government master plans, meeting minutes, legislative proposals, and new laws. Government agencies should also improve online public relations efforts by posting news items and press releases, as well as by maintaining updated blogs to better inform Myanmar's citizenry.	The government should expand and strengthen its online presence, moving from simple one-way government-to-citizen communication, to basic interactive functions, then to transactions (including financial), and finally to digitally-enhanced democratic engagement and crowd-sourced policymaking.	
Universal Service Obligation	The government should delay full implementation of the USO and collection of USF until commercial networks have been established and rural coverage gaps are more evident, probably in 2018–2020. In the interim, USF administrators should carefully plan the rollout. In the meantime, the government should consider providing a different, preparatory role for the USO, focusing on research, outreach, and digital constituency building. A lack of planning and poor understanding of community needs has led to USF failures internationally. As a result, Myanmar's USF administrators should hold hearings and conduct site visits to gauge the needs of its rural communities. USF administrators should also act as ombudsmen for outlying communities that have mobile coverage in order to keep abreast of service problems and act as interlocutors between civil society organizations, citizens, and the MOTC. USF administrators should also commission research into new technologies to enhance ICT coverage in rural areas, including point-to-multipoint technologies, mesh networks, and aerial communications networks (e.g., drone-, satellite- and balloon-born 4G LTE). USF administrators should seek charitable and development funding from international NGOs, aid organizations, and corporations to augment their research into new network technologies for rural communities.	USF administrators should partner with technology firms to conduct research and pilot programs in search of new network technologies that can provide ICT services to rural populations.	

Topic	Within 3–6 Months	In 6–12 Months	In 12–18 Months (or more)
Cybersecurity	The government should repeal laws that infringe upon free speech rights, including the *Electronic Transaction Law*. The CIO and the Ministry of Home Affairs should draft a new cybersecurity law with a clear and equitable lawful interception framework with judiciary and legislative reforms addressing privacy rights, search and seizure, and due process. Communications surveillance should be limited in scope and duration, and applied only when there is suspicion of serious criminal conduct. Electronic surveillance should be governed by an impartial judicial authority with real power to check police powers. Surveillance powers should apply to all citizens, residents, and other entities in an equitable and predictable manner defined by law. The new cybersecurity law should outline mechanisms for control, management, and protection of strategic e-governance infrastructure and other critical assets, including government-owned networks, datacenters, intellectual property, and application program interfaces. The law should also designate the CIO as the nation's prime authority on cybersecurity matters.		The government should initiate a process to identify critical risks to ICT assets and establish information security protocols to protect government and government-held personal and enterprise data.
Intellectual Property Protections	The government should establish an intellectual property office and a trademark registry. The government should pass legislation establishing enforceable intellectual property protections, including a trademark law, patent law, industrial design law, and copyright law in accordance with the TRIPS Agreement.		
Preparing an ICT-Enabled Workforce	Incentivize private firms to offer ICT skills training for employees by publicly recognizing outstanding efforts, providing tax credits to firms that invest in ICT skills training, and providing preferential status in procurement processes to firms with effective ICT training programs and highly technically skilled employees.		The Ministry of Education should use technology to systematically reform vocational education administration, teacher training, and instruction on ICT. The government should partner with international organizations and CSOs to encourage the development of social media and mobile applications to promote STEM literacy.

Topic	Within 3–6 Months	In 6–12 Months	In 12–18 Months (or more)
Diaspora for ICT Development	The government should liberalize visa and citizenship requirements for Myanmar diaspora members in order to attract more skilled workers and potential investors. Allow dual citizenship for Myanmar diaspora members. Abolish government blacklists against Myanmar opposition figures abroad. Conduct online outreach programs to attract highly-skilled Myanmar diaspora members to Myanmar's ICT sector. Promote skills transfer programs between diaspora ICT professionals and local Myanmar ICT professionals, modelled on programs such as the International Organization for Migration's Migration for Development in Africa program and the United Nations Development Program's Transfer of Knowledge Through Expatriate Nationals program.		
OPPORTUNITIES FOR SECTORAL ICT INNOVATION IN MYANMAR			
ICT and Finance	The government should fully authorize operator-neutral (also referred to as "operator agnostic") mobile money nationally. International telecommunications operators should be encouraged, but not required, to develop partnerships with local banks, as Telenor has done with Yoma Bank. Such partnerships enable capacity building in the financial sector.		The government should model e-payments and enhance financial formality by mandating default direct wage deposits for government contractors and employees. The government should allow mobile money operators to handle foreign remittances in order to draw more investment from the Myanmar diaspora and foreign investors.
ICT for Agriculture	To facilitate the expansion of rural broadband, the PTD should reserve a portion of the broadband spectrum made available by the government's planned analog switchover from traditional to digital television.		The CIO and the USF should promote innovation in rural connectivity and e-agriculture by inviting technology corporations, academic institutions, donors, and NGOs to use Myanmar, or regions thereof, to test and develop experimental ICT platforms. **For implementation within 18–24 months:** The Ministry of Agriculture and the Ministry of Education should facilitate e-learning for rural populations and farmers by revamping agricultural curricula at its universities and colleges with agriculturally focused ICT instruction. The Ministry of Agriculture should establish a clearinghouse for mobile agricultural applications for knowledge transfer, pricing and environmental data, agricultural productivity monitoring, and other vital sector requirements. The Ministry of Agriculture and the Central Statistical Organization should digitize sector data collection and analysis processes, with a focus on mobile phone applications. The Ministry of Agriculture should conduct smartphone-, drone-, and satellite-enabled agro-ecological zone mapping.

Topic	Within 3–6 Months	In 6–12 Months	In 12–18 Months (or more)
ICT-Enabled Education	Instead of fully connected schools, the Ministry of Education and the MOTC should set up ICT connectivity hubs for better Internet access and focused computer skills training for students, educators, and professionals. ICT hubs should be diverse—with differing emphases and priorities—and publicly accessible. The Ministry of Education should leverage regional and international exchanges and educational resources to accelerate STEM educational development. Examples include the ASEAN Credit Transfer System, the ASEAN International Mobility for Students Program, and other transfer and exchange programs. Relax ministerial control over faculty exchanges, particularly over visits to Myanmar universities by U.S. faculty. Myanmar should also enter into exchange framework agreements with the Institute for International Education, ASEAN, and other organizations representing institutions of higher learning internationally.	The MOTC should work with the Ministry of Education to provide schools with basic modular ICT networks for administrative functions. Myanmar's educator communities and CSOs should collaborate with software developers to seed the nation's mobile cybersphere with ICT-infused pedagogy. As an alternative to the children's public television, the Ministry of Education and the MOTC should focus on gamifying mobile applications and social media to disseminate STEM and other educational content.	**For implementation within 18–24 months:** The Ministry of Education should incorporate ICT approaches—particularly distance learning—into its teacher training curricula. The Ministry of Education should develop and procure online "mobile first" educational resources including service training programs, classroom curricula, lesson plans, and digital textbooks.
E-Health and Medical Informatics	The Ministry of Health should consult with the MOTC on its national health plan and the development of an ICT-enabled workforce and a unified health data system.		The Ministry of Health should work with international partners, private consultants, and the Ministry of Education to develop new ICT-enabled ("mobile first") educational programs at medical schools and on-the-job training for medical practitioners and administrative staff. Critical skills should include digital informatics. The Ministry of Health should work with NGO and CSO public health partners, as well as Facebook, Twitter, Viber, WeChat, MPT, Telenor, and Ooredoo to develop a social media-based epidemiological surveillance system to monitor public health. The Ministry of Health should work with NGO and CSO public health partners, as well as Facebook, Twitter, Viber, WeChat, MPT, Telenor, and Ooredoo to develop a digital public health campaign office for advocacy and public health messaging. **For implementation within 36–42 months:** The Ministry of Health should develop a digitized, interoperable unified health data system, including an electronic health record, a laboratory information management system, a pharmacy information system, and a Mobile Product Authentication system.

Topic	Within 3–6 Months	In 6–12 Months	In 12–18 Months (or more)
E-Logistics and Transport	The MOTC, the Union-level CIO, and the IPMO should participate in all logistical infrastructure planning and construction in accord with collocation policy. The PTD should reserve spectrum for logistical infrastructure requirements. The government should remove tariffs on Internet purchases to boost regional e-commerce and trade.		**For implementation within 18–24 months:** As suggested earlier with regard to interministerial collaboration, an interagency taskforce should be established for collocation of infrastructure. The government should develop a national intelligent transport system to inform large-scale transport infrastructure. The Ministry of Border Affairs should implement an Electronic Data Interchange system and other automated customs systems to enable real-time, market pricing analyses.

REFERENCES

Ablott, Matt. 2013. *Foreign Operators Seek to Unlock Burmese Potential: Ooredoo and Telenor Target Asia's Last Untapped Mobile Opportunity.* GSMA Intelligence, https://gsmaintelligence.com/research/2013/09/foreign-operators-seek-to-unlock-burmese-potential/402/, (accessed on January 5, 2016).

Akyildiz, Ian F., Xudong Wang, and Weilin Wang. 2005. "Wireless Mesh Networks: A Survey," *Computer Networks*, 47, 4 (March 15): 445–487.

Almazan, Mireya and Nicolas Vonthron. 2014. *Mobile Money for the Unbanked: Mobile Money Profitability – A Digital Ecosystem to Drive Healthy Margins.* London: GSMA, November, http://www.gsma.com/mobilefordevelopment/mobile-money-profitability-a-digital-ecosystem-to-drive-healthy-margins.

Arnold, John. 2016. *Myanmar's Transport and Logistics Sector: Observations and Recommendations.* Yangon: Nathan Associates.

Arvis, Jean-Francois et al. 2012. *Connecting to Compete: Trade Logistics in the Global Economy, The Logistics Performance Index and Its Indicators.* Washington, DC: World Bank, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2012/07/03/000386194_20120703033114/Rendered/PDF/704170ESW00P120BLIC00LPI020120final.pdf, (accessed on January 5, 2016).

Asian Patent Attorneys Association. 2014. *The Union of The Republic of Myanmar Country Report for IPR Protection in the Year 2014,* 10/MMR/GROUP_REPORT (FULL). Paper presented to the APAA Trademark Committee in Myanmar on September 30, 2014, http://apaa2014.com/download/meeting_material/round_table_meeting_of_recognized_group_representatives/Myanmar%20Group%20Report.pdf, (accessed on January 5, 2016).

Association of Southeast Asian Nations (ASEAN), Public Outreach and Civil Society Division. 2011. *We're Stronger When We're Connected. ASEAN ICT Masterplan.* Jakarta: ASEAN, https://ccdcoe.org/sites/default/files/documents/ASEAN-110101-ASEANICTMasterplan2015.pdf.

Becker, M., Reiner Jedermann, and Andreas Timm-Giel. 2010. "Logistic Applications with Wireless Sensor Networks," *Proc. of HotEmNets,* http://www.sfb637.uni-bremen.de/pubdb/repository/SFB637-T4-10-004-IC.pdf.

Black, A.D., J. Car, C. Pagliari, C. Anandan, K. Cresswell, et al. 2011. "The Impact of eHealth on the Quality and Safety of Health Care: A Systematic Overview," *PLoS Med*, vol. 8, no. 1: e1000387, http://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1000387.

Børtveit, Kenneth. 2014. *An Action Research Study: Introducing ICT's in Developing Countries.* Master's thesis, Norwegian University of Science and Technology, http://www.diva-portal.org/smash/get/diva2:751089/FULLTEXT01.pdf.

Bradley, Joseph, Joel Barbier, and Doug Handler. 2013. *Embracing the Internet of Everything to Capture Your Share of US$14.4 Trillion.* San Jose, California: Cisco, https://www.cisco.com/web/about/ac79/docs/innov/IoE_Economy.pdf, (accessed on January 5, 2016).

Burns, Mary. 2011. *Distance Education for Teacher Training: Modes, Models, and Methods*. Washington, DC: Education Development Center Inc., http://idd.edc.org/sites/idd.edc.org/files/Distance%20Education%20for%20Teacher%20Training%20by%20Mary%20Burns%20EDC.pdf.

Castro, Jun T. and Hirohito Kuse. 2002. "Logistics and Information and Communications Technology (ICT) Policies in the Asia-Pacific Region," *Japan Society of Civil Engineers*, https://www.jsce.or.jp/library/open/proc/maglist2/00039/200306_no27/pdf/23.pdf.

CitizenLab. 2011. *Behind Blue Coat: Investigations of Commercial Filtering in Syria and Burma*. Research brief. CitizenLab, https://citizenlab.org/2011/11/behind-blue-coat/, (accessed on January 5, 2016).

Conrad, Brittany. 2011. *Opportunity and Oppression: Social Movements in Burma and the ICT Catalyst*. Master's thesis, California State University Long Beach, http://pqdtopen.proquest.com/doc/904600498.html?FMT=AI, (accessed January 5, 2016).

Deloitte and Ericsson. 2012. *The Potential Economic Impact of Mobile Communications in Myanmar*. Stockholm: Ericsson, http://www.ericsson.com/res/docs/2012/myanmar-report-2012-13nov.pdf.

Dollar, David. 2015. *China's Rise as a Regional and Global Power: The AIIB and the "One Belt, One Road"*. Brookings, http://www.brookings.edu/research/papers/2015/07/china-regional-global-power-dollar, (accessed on January 5, 2016).

Egreteau, Renaud. 2012. "Burma in Diaspora: A Preliminary Research Note on the Politics of Burmese Diasporic Communities in Asia," *Journal of Current Southeast Asian Affairs,* vol. 31, no. 2: 115–147, http://journals.sub.uni-hamburg.de/giga/jsaa/article/viewFile/547/545.

Ericsson. 2015. *Ericsson Mobility Report*, (November 2015). Ericsson, http://www.ericsson.com/res/docs/2015/mobility-report/ericsson-mobility-report-nov-2015.pdf, (accessed January 5, 2016).

_____, Arthur D. Little, and Chalmers University of Technology. 2013. *Socioeconomic Effects of Broadband Speed*. Ericsson, http://www.ericsson.com/res/thecompany/docs/corporate-responsibility/2013/ericsson-broadband-final-071013.pdf, (accessed January 5, 2016)

Ernst & Young. 2015. *Navigating the Belt and Road: Financial Sector Paves the Way for Infrastructure*. Ernst & Young, August, http://www.ey.com/Publication/vwLUAssets/EY-navigating-the-belt-and-road-en/$FILE/EY-navigating-the-belt-and-road-en.pdf.

Foerch, Thomas, Om Ki, San Thein, and Sophie Waldschmidt. 2015. *Myanmar's Financial Sector: A Challenging Environment for Banks (Updated Version)*. Yangon: Deutsche Gesellschaft für Internationale Zusammenarbeit, February 27, https://www.giz.de/en/downloads/giz2015-en-myanmar-financial-sector.pdf.

GSM Association [Groupe Speciale Mobile (GSMA)]. 2012. *Mobile Infrastructure Sharing.* GSMA: London, http://www.gsma.com/publicpolicy/wp-content/uploads/2012/09/Mobile-Infrastructure-sharing.pdf.

_____ 2014. *Understanding the Internet of Things (IoT)*. GSMA, http://www.gsma.com/connectedliving/wp-content/uploads/2014/08/cl_iot_wp_07_14.pdf, (accessed January 16, 2016).

_____ and International Finance Corporation. 2014. "Sizing the Opportunity: Green Telecoms in Myanmar." In *Green Power for Mobile Bi Annual Report 2014*. GSMA, http://www.gsma.com/mobilefordevelopment/wp-content/uploads/2014/08/GPM_August2014_FINAL.pdf, (accessed on February 5, 2015).

Haggblade, Steven et al. 2013. *A Strategic Agricultural Sector and Food Security Diagnostic for Myanmar*. Prepared for USAID/Burma by Michigan State University and the Myanmar Development Resource Institute's Center for Economic and Social Development (MDRI/CESD), July, http://fsg.afre.msu.edu/Myanmar/myanmar_agricultural_sector_diagnostic_july_2013.pdf.

Hatt, Tim, Kenechi Okeleke, and Mike Meloan. 2015. *Analysis: Closing the Coverage Gap – A View from Asia*. London: GSMA, https://www.gsmaintelligence.com/research/?file=e245c423854fcfd38eeae0a918cc91c8&download.

Inaudi, Daniele and Branko Glisic. 2010. "Long-Range Pipeline Monitoring by Distributed Fiber Optic Sensing," *Journal of Pressure Vessel Technology*, vol. 132 (February), www.princeton.edu/~bglisic/Glisic_Pipeline.pdf, (accessed on January 5, 2016).

Infosys Ltd. 2013. *Republic of the Union of Myanmar: Design of e-Governance Master Plan and Review of Information and Communication Technology Capacity in Academic Institutions*. Project 47158. Asian Development Bank, http://www.adb.org/sites/default/files/project-document/161546/47158-001-tacr-01.pdf.

Isah, Haruna. 2012. *Information and Communication Technology in Combating Counterfeit Drugs*. Cornell University Library, http://arxiv.org/pdf/1211.1242.pdf.

International Telecommunication Union (ITU). 2013. *The Mobile Money Revolution, Part 1: NFC Mobile Payments.* ITU-T Technology Watch Report. Geneva: ITU, May.

_____ and American Bar Association. 2010. *ITU Toolkit of Cybercrime Legislation*. ITU, http://www.cyberdialogue.ca/wp-content/uploads/2011/03/ITU-Toolkit-for-Cybercrime-Legislation.pdf.

Juniper Research. No date. "Mobile Money Transfer & Remittances: Domestic & International Markets 2013–2018." Cited in World Bank, "Migration and Remittances: Recent Developments and Outlook, Special Topic: Forced Migration," October 6, 2014.

Kam, Matthew, Akhil Mathur, Anuj Kumar, and John Canny. 2009. *Designing Digital Games for Rural Children: A Study of Traditional Village Games in India.* Paper presented at CHI 2009 conference in Boston, Massachusetts, April 4–9, 2009, http://www.cs.cmu.edu/~mattkam/publications/CHI2009.pdf.

Kar, Dev and Joseph Spanjers. 2015. *Flight Capital and Illicit Financial Flows to and from Myanmar: 1960–2013*. Global Financial Integrity, September, http://www.gfintegrity.org/wp-content/uploads/2015/09/Myanmar-Report-Final-1.pdf.

Khan, Mushtaq H. 2013. "Technology Policies and Learning with Imperfect Governance." In Joseph Stiglitz and Justin Yifu Lin, eds., *The Industrial Policy Revolution I: The Role of Government Beyond Ideology*. London: Palgrave.

KPMG and Internet and Mobile Association of India. 2015. *India on the Go: Mobile Internet Vision 2017*. Delhi: KPMG, http://rtn.asia/wp-content/uploads/2015/07/Report.pdf, (accessed on January 5, 2016).

Kretschmer, T., M. Cardona, and T. Stobel. 2013. "The Contribution of ICT to Productivity: Key Conclusions from Surveying the Empirical Literature," *Information Economics and Policy*, vol. 3, no. 25.

Kumar, Anuj et al. 2011. *An Exploratory Study of Unsupervised Mobile Learning in Rural India*. Paper presented at the ACM Conference on Human Factors in Computing Systems [CHI] 2010 conference in Atlanta, Georgia, April 10–15, 2010, http://bid.berkeley.edu/files/papers/CHI2010a.pdf.

Kumbhkar, Ratnesh, Namzul Islam, Narayan B. Mandayam, and Ivan Seskar. 2015. *Rate Optimal Design of a Wireless Backhaul Network Using TV White Space*. Cornell University Library, http://arxiv.org/pdf/1409.1661.pdf, (accessed on January 5, 2016).

Ladcomm Corporation. 2013. *Survey of Universal Service Funds Key Findings*. GSMA, http://www.gsma.com/publicpolicy/wp-content/uploads/2013/04/GSMA-USF-Main-report-final1.pdf, (accessed on January 5, 2016).

Meijers, Huub. 2012. *Does the Internet Generate Economic Growth, International Trade, or Both?* United Nations University UNU-MERIT Working Paper Series, No. 2012-050, (accessed January 5, 2016).

Myanmar of Communications and Technology. 2015. "Draft Spectrum Roadmap for Consultation." Nay Pyi Taw.

Myanmar Centre for Responsible Business (MCRB). 2015. *Briefing Paper on Land Issues in Myanmar*. Yangon: MCRB, Institute for Human Rights and Business, and Danish Institute for Human Rights, http://www.myanmar-responsiblebusiness.org/pdf/2015-04-02-LAND-Briefing.pdf.

_____. 2015b. *Myanmar ICT Sector-Wide Impact Assessment*. Yangon: MCRB, http://www.myanmar-responsiblebusiness.org/pdf/SWIA/ICT/2015-06-15-MCRB-ICT-SWIA-Draft-Report_en.pdf, (accessed January 5, 2016).

Myanmar Internet and E-Commerce Investment and Business Guide. 2014. Washington, DC: International Business Publications, Google Books.

Myo Min Aung, Yoon Seok Chang, and Jong-Un Won. 2012. "Emerging RFID/USN Applications and Challenges," *International Journal of RFID Security and Cryptography,* vol. 1, issues 1/2 (March/June).

Nam, Kee-Yung, Maria Rowena Cham, and Paulo Rodelio Halili. 2015. *Developing Myanmar's Information and Communication Technology Sector Toward Inclusive Growth*. ADB Economics Working Paper Series, no. 462. Manila: Asian Development Bank, November, http://www.adb.org/publications/developing-myanmar-ict-sector-toward-inclusive-growth, (accessed on January 5, 2016).

National Economic and Social Advisory Council (NESAC). 2016. *From Rice Bowl to Food Basket: Three Pillars for Modernizing Myanmar's Agriculture and Food Sector.* White paper. Yangon: NESAC, April.

OpenNet Initiative. 2005. *Internet Filtering in Burma in 2005: A Country Study.* OpenNet Initiative, https://opennet.net/studies/burma#toc2b, (accessed January 5, 2016).

Organization for Economic Cooperation and Development (OECD). 2012. *Cybersecurity Policy Making at a Turning Point: Analysing a New Generation of National Cybersecurity Strategies for the Internet Economy*. Paris: OECD Publishing, http://www.oecd.org/sti/ieconomy/cybersecurity%20policy%20making.pdf.

_____. 2012b. *Development Pathways Multi-Dimensional Review of Myanmar Volume 2. In-depth Analysis and Policy Recommendations*. Paris: OECD Publishing, http://dx.doi.org/10.1787/9789264220577-en.

Osmotherly, Kieron. 2015. "The Myanmar Tower Rollout FAQs" (updated June 2015), *TowerXchange,* issue 13, http://www.towerxchange.com/the-myanmar-tower-rollout-faqs-2/, (accessed January 5, 2016).

Pereira, Francis. 2014. *The Role of Information Communication Technology Policies in Economic Development: A Comparison of Select Asian Countries*. Paper presented at the 20th International Telecommunications Society (ITS) Biennial Conference, Rio de Janeiro, Brazil, November 30–December 3, 2014.

Plaza, Sonia and Dilip Ratha, eds. 2011. *Diaspora for Development.* Washington, DC: World Bank.

Qiang, Christine Zhenwei, Siou Chew Kuek, Andrew Dymond, and Steve Esselaar. 2012. *Mobile Applications for Agriculture and Rural Development.* Report no: 96226-GLB. Washington, DC: World Bank, https://openknowledge.worldbank.org/bitstream/handle/10986/21892/Mobile0applica0nd0rural0development.pdf?sequence=1).

Read, Tony. 2015. *Where Have All the Textbooks Gone? Toward Sustainable Provision of Teaching and Learning Materials in Sub-Saharan Africa.* Washington, DC: World Bank.

Rohman, I. K. and E. Bohlin. 2012. "Does Broadband Speed Really Matter as a Driver of Economic Growth? Investigating OECD Countries," *International Journal of Management and Network Economics,* vol. 2, no. 4: 336–356.

Sanyu Consultants Inc. 2013. *Data Collection Survey on Agriculture Sector in the Republic of the Union of Myanmar.* JICA, December, http://www.themimu.info/sites/themimu.info/files/documents/Assesst_Survey_on_Agriculture_JICA_Dec2013.pdf.

Schwaninger, Markus. 2015. *Renewable Power Solutions for Telecommunication Towers in Myanmar.* Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), http://myanmar.ahk.de/fileadmin/ahk_myanmar/renewables/telco_giz.pdf, (accessed on January 5, 2016).

Shibata, Junji. 2014. *Myanmar's National Transport Master Plan: A New Direction*. Japanese International Cooperation Agency (JICA), http://www.jica.go.jp/information/seminar/2014/ku57pq00001nep1r-att/kf20140813_01_01.pdf.

Simonite, Tom. 2015. "Project Loon," *MIT Technology Review*, December, http://www.technologyreview.com/featuredstory/534986/project-loon/, (accessed on January 5, 2016).

Tolk, Andreas and James Maguira. 2003. *The Levels of Conceptual Interoperability Model.* Paper presented at the 2003 Fall Simulation Interoperability Workshop, (Orlando, Florida, September 2003), http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.76.8795&rep=rep1&type=pdf, (accessed on January 5, 2016)

Tangcharoensathien, Viroj and Walaiporn Patcharanarumol. 2014. "The Republic of the Union of Myanmar Health System Review." *Health Systems in Transition*, vol. 4, no. 3, http://www.wpro.who.int/asia_pacific_observatory/hits/series/myanmar_health_systems_review.pdf.

Torre, Andre. 2008. "On the Role Played by Temporary Geographical Proximity in Knowledge Transmission." *Regional Studies*, vol. 42, no. 06: 869–889, https://hal.archives-ouvertes.fr/hal-00514711/document, (accessed January 5, 2016).

TowerXchange. 2015. *Asia Dossier 2015*. http://www.towerxchange.com/wp-content/uploads/2015/10/TX_AsiaDossier_2015.pdf, (accessed January 5, 2016).

Tulloch, R. 2014. "Reconceptualising Gamification: Play and Pedagogy," *Digital Culture & Education*, vol. 6, no. 4: 317–333, http://www.digitalcultureandeducation.com/cms/wp-content/uploads/2014/12/tulloch.pdf.

Turnell, Sean. 2016. B*anking and Finance in Myanmar: Present Realities, Future Possibilities*. Yangon: Nathan Associates.

United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). 2014. *Harnessing Cross-Sectoral Infrastructure Synergies*. ICT and Disaster Risk Division, Staff Working Paper. Bangkok: UNESCAP, http://www.unescap.org/resources/working-paper-harnessing-cross-sectoral-infrastructure-synergies, (accessed January 5, 2016).

United Nations Economic and Social Council Secretariat. 2015. *Asia-Pacific Information Superhighway: For Inclusive and Seamless Connectivity*. Paper presented at the Economic and Social Commission for Asia and the Pacific seventy-first session, Bangkok, May 25–29, 2015. http://www.unescap.org/sites/default/files/E71_16E.pdf.

Valenti, Allessandra, Tommy Galloway, and Moe Pwint. 2014. "Cash in Context: Uncovering Financial Services in Myanmar." Yangon: Myanmar Development Resource Institute's Centre for Economic and Social Development, http://mastercardcenter.org/wp-content/uploads/2015/01/Cash-in-Context-Uncovering-Financial-Services-in-Myanmar.pdf.

Valk, John-Harmen, Ahmed T. Rashid, and Laurent Elder. 2010. "Using Mobile Phones to Improve Educational Outcomes: An Analysis of Evidence from Asia." *The International Review of Research in Open and Distributed Learning*, vol.11, no. 1 (March), http://www.irrodl.org/index.php/irrodl/article/view/794/1487.

Velasco, Edward et al. 2014. "Social Media and Internet-Based Data in Global Systems for Public Health Surveillance: A Systematic Review," *The Milbank Quarterly*, vol. 92, no. 1: 7–33, http://www.milbank.org/uploads/documents/featured-articles/pdf/Milbank_Quarterly_Vol-92_No-1_2014_Velasco.pdf.

Vital Wave Consulting. 2009. *mHealth for Development: The Opportunity of Mobile Technology for Healthcare in the Developing World*. Washington, DC and Berkshire, U.K.: UN Foundation-Vodafone Foundation Partnership, 2009.

Wong, Yvonne. 2016. *Money Matters in Myanmar: Banking and Finance Law and Practice*. LexisNexis.

World Bank. 2011. *ICT in Agriculture: Connecting Smallholders to Knowledge, Networks and Institutions.* E-sourcebook, report no. 64605. World Bank, http://www.ictinagriculture.org/sites/ictinagriculture.org/files/final_book_ict_agriculture.pdf).

_____. 2013. *Myanmar - Telecommunications Sector Reform Project: Environmental and Social Management Framework.* Myanmar: World Bank, http://documents.worldbank.org/curated/en/2013/11/18620207/myanmar-telecommunications-sector-reform-project-environmental-social-management-framework, (accessed January 5, 2016).

Yonezawa, Akiyoshi, Yuto Kitamura, Arthur Meerman, and Kazuo Kuroda, eds. 2014. *Emerging International Dimensions in East Asian Higher Education.* Springer.

Zobrist, Brooke and Patrick McCormick. 2013. "A Preliminary Assessment of Decentralization in Education: Experiences in Mon State and Yangon Region." Discussion Paper No. 1. Yangon: The Asia Foundation, December.