Interim assessment

on damages to telecommunication infrastructure and resilience of the ICT ecosystem in Ukraine

Acknowledgements

Disclaimers

This report has been produced based on the information and data collected as of August 2022. Since August 2022 the telecommunication infrastructure might have suffered additional damages that have not been documented in this document. Any final assessment of the damages may be only elaborated once the war comes to an end. The analyses and recommendations in this report are based on desk research, sets of information and opinions collected from interviews undertaken and materials provided by the Administration of Ukraine and other local stakeholders. Conducting onsite missions, with the aim of validation of information and data provided by the Administration and other national stakeholders was not feasible due to the ongoing war.

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Abbreviations and acronyms

ADSL	asymmetric digital subscriber line
AMS-IX	Amsterdam Internet Exchange
BICS	Telecommunication company
BT	British Telecom
BTK	The Information and Communication Technologies Authority of Türkiye
CAGR	compound annual growth rate
CC	country Code
CDMA	code division multiple access
CERT	computer incident response team
CMU	Cabinet of Ministers of Ukraine
COVID	coronavirus disease
CPA	centre of public administration
DDoS	distributed denial-of-service
DE-CIX	carrier- and data-centre-neutral Internet exchange point
DQL	digital quality of life
DTEL-IX	Digital Telecommunication Internet Exchange of Kyiv
DVB	digital video broadcasting
DWDM	dense wavelength-division multiplexing
EDP	European Data Portal
EMF	Electromagnetic field
EPAM	Software Engineering Company
ETT	Eurotranstelecom
ETTN	optical fibre technology
EU	European Union
EUR	EURO
EWE TEL	Telecommunication Service Provider, Germany
FM	frequency modulation
FTTB	Fibre to the building
FTTH	Fibre to the home
FTTX	Fibre to the premises
G2	second generation
G3	third generation
G5	fifth generation
GB	gigabyte
GCI	ITU Global Cybersecurity Index
GDP	gross domestic product

GHz	gigahertz
GNI	gross national income
GPON	gigabyte passive optical network
GCI	Global Cybersecurity Index
ICT	information and communication technologies
IDP	internally displaced persons
IMT	International Mobile Telecommunications
ISP	Internet service provider
IT	information technology
ITC	International Telecommunication Company
ITU	International Telecommunication Union
IXP	Internet exchange point
JSC	Joint Stock Company
KA-SAT	high-throughput telecommunication satellite of VIASAT
KPN	Dutch landline and mobile telecommunication company
KSE	Kyiv School of Economics
LLC	limited liability company
LTE	Long Term Evolution
M2M	machine-to-machine
MÁSMÓVIL	Spanish telecommunication company
WIMAX	worldwide interoperability for microwave access
MDTU	Ministry of Digital Transformation
MFAU	Ministry of Foreign Affairs
MHz	megahertz
MHEWS	multi-hazard early warning system
MIMO	multiple input multiple output
MNC	mobile network code
MNO	mobile network operator
MVNO	mobile virtual network operator
MUX	multiplexer
NB-IoT	narrowband Internet of Things
NBS	national broadband strategy
NCEC	National Commission for the State Regulation of Electronic Communications, Radiofrequency Spectrum and the Provision of Postal Services
NDC	national destination code
NEQSOL	holding, international group of companies operating across industries
NETP	National Emergency Telecommunication Plan

NGO	non-governmental organization
NRA	national regulatory authority
NREN	National Research and Education Network
NRI	Network Readiness Index
NSTU	Kharkiv Regional Directorate
NTNOC	National Telecommunication Networks Operation Center
O2	British telecommunication service provider
OECD	Organisation for Economic Co-operation and Development
OTT	over-the-top
PDH	plesiochronous digital hierarchy
PEOPLEnet	CDMA operator in Ukraine
PIONIER	Polish national research and education network
PJSC	public joint-stock company
PL-IX	Neutral Commercial Internet Exchange Point of Poland
PON	passive optical network
PRJSC	private joint-stock company
RADA	parliamentary TV channel
RES	resolution
RETN	tier 2 ISP in Europe
RF	radiofrequency
RIA	Ukrainian company
RRS	radio relay station
RRT	Radio Broadcasting, Radio Communication and Television Concern
RS	radio station
RTBS	radio television base station
RTS	radio television station
SAT	satellite
SCM	system capital management
SDH	synchronous digital hierarchy
SFR	French telecommunication company
SID	Bank of Slovenia
SIM	subscriber identity module
SL-IX	Internet exchange point
SMS	short message service
SSSCIP	State Service of Special Communications and Information Protection of Ukraine
SUMIN	Ministry of Transport and Communication of Lithuania

TELAS	Ukrainian association of telecommunication operators
TIM	Italian telecommunication company
TLD	top-level domain
TRC	Ukrainian broadcaster
UA	Ukraine
UA-IX	Internet Exchange Network in Ukraine
UAH	Ukrainian Hryvnia
UAR-NET	Internet service provider
UCRF	Ukrainian State Center of Radio Frequencies
UMTS	Universal Mobile Telecommunication System
UN	United Nations
URAN	Ukrainian Research and Academic Network
USD	United States dollar
USPA	Ukrainian Sea Ports Authority
VEGA	national telecommunication operator of Ukraine
VEON	Dutch-domiciled multinational telecommunication services company
WB	World Bank
WIMAX	worldwide interoperability for microwave access
WLL	wireless local loop
WM	medium wave transmitter

I. Executive summary

Information and communication technology (ICT) infrastructure in Ukraine has become a major target of attacks, including cyberattacks, since the start of the war on 24 February 2022. Widespread destruction of critical systems and facilities, and the failure of telecommunication services, prompted ITU to commit to promoting "the adoption of measures for ensuring the safety of life through the cooperation of telecommunication services". In particular, ITU committed to producing this interim assessment on damages to telecommunication infrastructure and resilience of the ICT ecosystem in Ukraine. The assessment is carried out in response to Resolution 1408 of the ITU Council on assistance and support to Ukraine for rebuilding its telecommunication sector[1], Resolution A/RES/ES-11/1[2] of the United Nations General Assembly on aggression against Ukraine, and Resolution 34 (Rev. Dubai, 2018) of the ITU Plenipotentiary Conference on assistance and support to countries in special need for rebuilding their telecommunication sector.

This report has been produced based on the information and data collected as of August 2022. The analyses and recommendations in this report are based on desk research, sets of information and opinions collected from interviews undertaken and materials provided by the Administration of Ukraine and other local stakeholders. Due to the ongoing war, neither ITU nor any of the authors have conducted onsite missions or direct observations to validate the information and data provided by the Administration and other national stakeholders. Further, the telecommunication infrastructure might have suffered additional damages since August 2022 that are not reflected in this document. Any final assessment of the damages may be only elaborated once the war comes to an end.

The overall aim of the report was to determine the nature and extent of the losses, damages and harm caused by the war to the ICT ecosystem of the country and to serve as a basis to ensure ITU technical assistance for Ukraine is as effective as possible. It is intended that the assessment in this report will encourage ITU Member States to make contributions to support efforts to rebuild Ukraine's telecommunication infrastructure and technical capacity.

The report provides information about sustainability and resilience of the telecommunication market, supported by timely amendments to the policies and regulations, and deployment of emergency plans and measures by State authorities. Finally, the report develops recommendations on the actions required to effectively restore/rebuild the ICT infrastructure.

The report states that at the level of public and private policies, and emergency measures, the Ukraine telecommunication sector has proven to be resilient, however:

- ICT networks of operators were partially and, in some instances, fully destroyed or occupied;
- within a period of six months of war, 1123 cyberattacks were reported, targeting all the sectors of the economy of Ukraine, including IT and telecommunications;
- as of July 2022, 12.2 per cent of homes lost access to mobile communications services (3.1 per cent partially), 11 per cent of base stations of mobile operators were out of service and 20 per cent of the country's telecommunication infrastructure was damaged or destroyed;
- the economic losses of the telecommunication sector have been estimated to be more than USD 0.1 billion;
- telecommunication companies provide 22 per cent fewer services, which has resulted in reduced income and revenues;
- USD 1.79 billion is needed to restore the telecommunication sector;

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[1] https://www.itu.int/md/S22-CL-C-0095/en

[2] UNGA Resolution "Aggression against Ukraine", dated 02.03.2022. This resolution can be retrieved at A/RES/ES-11/1

- direct damage of telecommunication facilities, networks, systems, and equipment is estimated at USD 0.71 billion.[3]

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[3]   https://thedigital.gov.ua/news/svitoviy-bank-otsiniv-zbitki-ukrainskogo-telekom-rinku-u-26-mlrd

II.   Introduction

This report has been produced based on the information and data collected as of August 2022. The analyses and recommendations in this report are based on desk research, sets of information and opinions collected from interviews undertaken and materials provided by the Administration of Ukraine and other local stakeholders. Due to the ongoing war, neither ITU nor any of the authors have conducted onsite missions or direct observations to validate the information and data provided by the Administration and other national stakeholders. Further, the telecommunication infrastructure might have suffered additional damages since August 2022 that are not reflected in this document. Any final assessment of the damages may be only elaborated once the war comes to an end.

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The war on Ukraine since 24 February 2022 has heavily destroyed telecommunication and critical infrastructure across the country. ICT systems and industrial facilities continued to suffer from targeted attacks throughout September 2022, causing severe damage and service interruption for millions of households as well as private and public institutions.

An updated list of communities located in the war-affected areas was approved by the Ministry of Defence and published by the Ministry of Reintegration[4] on 30 August 2022. It outlines 330 communities (out of 1 469) from nine regions of the country, namely: Donetsk (66), Kharkiv (56), Dnipropetrovsk (9), Luhansk (37), Zaporizhia (60), Kherson (49), Mykolaiv (26), Sumi (22) and Chernihiv (5).[5] According to Kyiv regional State Administration, more than 50 per cent of the communities of the region (35 out of 69) were destroyed, among them: Buchanska, Irpinska, Gostomelska, Borodyanska, Makarivska, Velikodymerska and Piskicska. Critical levels of destruction were also reported in the communities of Odesa and Mykolaiv regions, and Malynska, Narodytska and Gladkovytska communities of the Zhytomyr region.

According to the Ministry and the Committee of the Digital Transformation of Ukraine, based on the assessment of damages carried out jointly by the Ministry of Digital Transformation, National Commission for the State Regulation of Electronic Communications, Radio-frequency Spectrum and the Provision of Postal Services (NCEC), the Kyiv School of Economics and the World Bank (WB)[6], the biggest telecommunication losses are concentrated in the East of Ukraine. Operators providing services in the regions suffered losses, including, Kharkiv (22per cent), Zaporizhzhia (18per cent), Donetsk region (17per cent), Kherson (10per cent), Chernihiv (6per cent), and Luhansk (7per cent).[7]

The economic losses of the telecommunication market have been estimated to be more than USD 0.1 billion, with companies providing 22 per cent fewer services than before the start of the war. As of July 2022, 12.2 per cent of settlements completely (and 3.1 per cent partially) lost access to mobile communications, with 11 per cent of base stations of mobile operators out of service.[8] Three out of seven operators providing mobile communication services (Kyivstar, Vodafone Ukraine, Lifecell, 3Mob, Intertelecom, PeopleNet and Lycamobile)[9] and 961 out of 4482 fixed Internet providers of Ukraine are under occupation/de-occupation.

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4   https://www.minre.gov.ua/doc/doc/95

5   https://minre.gov.ua/news/onovleno-aktualnyy-perelik-gromad-u-rayonah-boyovyh-diy-na-tot-ta-tyh-shcho-v-otochenni-15

6   https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099445209072239810/p17884304837910630b9c6040ac12428d5c

7   Answers to the ITU Assessment Report Questionnaire designed for the State Authorities

8   https://thedigital.gov.ua/news/svitoviy-bank-otsiniv-zbitki-ukrainskogo-telekom-rinku-u-26-mlrd

9   https://kyivstar.ua/, https://www.vodafone.ua/, https://www.lifecell.ua, http://3mob.ua/, https://www.intertelecom.ua/, http://peoplenet.ua/, https://www.lycamobile.ua/uk/

It is estimated that up to 100 per cent of the ICT networks are destroyed in the war-affected territories of the country.[10]

Some USD 1.79 billion is needed to restore the telecommunication sector to the level it was in January 2022. Direct damage of telecommunication facilities, networks, systems, and equipment is estimated at USD 0.71 billion.[11]

A comprehensive study has been conducted to assess damages to Ukraine's telecommunication and critical infrastructure and services in response to the ITU commitment to promote the adoption of measures for ensuring the safety of life through the cooperation of telecommunication services[12].

Instant universal access to digital infrastructure, and availability of reliable and affordable fixed and mobile broadband connectivity have become a basic requirement for Ukrainians to survive and adapt to the new reality. They enable households, businesses, and government institutions to continue working, learning, receiving medical support and accessing various social platforms.

To have a picture that is both precise and thorough, yet also broad enough to provide a comprehensive overview of the damages caused by the attacks on Ukraine, including cyberattacks, this report presents the country landscape assessment of Ukraine, with a particular emphasis on connectivity data collection practices, resilience of the market, telecommunication and critical network infrastructures. Three areas key to post-coronavirus disease(COVID-19) pandemic and post-war recovery are considered: education, health, and jobs, with an emphasis on natural or man-made disaster resilience and emergency preparedness, the levels of which are determined from the country's Emergency Communications Checklist, as part of the ITU Guidelines on Developing National Emergency Telecommunication Plans.

Furthermore, a set of recommendations has been drafted to assist the Government of Ukraine to develop, update, and effectively implement comprehensive information and communication technology (ICT) strategies, to ensure that digital infrastructure and ecosystems support recovery efforts adequately, in line with global best practices and other policy tools developed by ITU and other relevant organizations.

Ukraine has provided ITU with a thorough list of its most urgent needs, which is presented in the annex to this report. Among other things, the list comprises a series of radio equipment tools, technical facility and broadcasting instruments, various types of fibre-optic cables, and software for video surveillance. When drafting this report, it became apparent that including this list was the best way to convey to the international community the urgent and unprecedented needs of Ukraine in the light of the damages caused to its ICT/telecommunication sector. This list was created in direct response to the heavy attacks experienced by Ukraine. But the course of the war has evolved and changed since it began, so the list is not exhaustive, as it does not reflect all the current needs of the ICT sector of the country. Nevertheless, the report serves as a concrete example of how the international community's effort could be translated into tangible support.

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[10] Answers to the ITU Assessment Report Questionnaire designed for the State Authorities

[11] https://thedigital.gov.ua/news/svitoviy-bank-otsiniv-zbitki-ukrainskogo-telekom-rinku-u-26-mlrd

[12] ITU Council Resolution 1408 on Assistance and support to Ukraine for rebuilding their telecommunication sector.

III.   Objective and methodology

This section provides an overview of the methodology used and introduces the structure of this study. The elaboration of the assessment report started from phase one of the ITU Connect2Recover initiative on "A methodology for identifying connectivity gaps and strengthening resilience in the new normal".[13] The initiative was recognized as an appropriate foundation for detecting breaches and impediments at country level that hamper the use of broadband networks and digital technologies to respond to, and to mitigate, the damage inflicted by the war.

When it comes to assessing damages caused by man-made hazards, lack of unified terms of reference is a constraint. So, the methodology in this report is adapted and further elaborated, allowing the discovery of connectivity gaps caused by the war, and the evaluation of the sustainability and resilience of the ICT ecosystem.

The objective of the study is to carry out an assessment on the impact of the war on Ukraine, describe the ICT infrastructure losses and damages, and encourage public and private sectors of Member States to join their efforts and engage in rebuilding Ukraine's ICT ecosystem and technical capacity in accordance with the needs and necessities of the country. To fulfil the objective of the study, this methodology provides the guidelines to undertake the following work:

1   Identify and combine existing and new sources for the collection of data on broadband/ narrowband and digital technology, focusing on:

   -   coverage or access/availability (geographic/population);

   -   analysis of adoption and usage rates;

   -   specific locations such as schools, healthcare facilities, and government facilities with low access/adoption/usage rates;

   -   specific groups, such as women and girls or persons with disabilities, that have low access/adoption/usage rates, etc.

   Conduct analysis of the impact of the war on the state of the ICT ecosystem, including fixed and mobile infrastructure, television, radio and satellite networks, and Internet service provider facilities, backbone coverage, and international connectivity. Results from the ITU Interactive Transmission Maps, where applicable, will be taken into consideration.

2   Assess sustainability and resilience of operator networks in Ukraine. Carry out Internet resiliency assessment of telecommunication networks, critical infrastructure, and governments/markets (with particular emphasis on network and critical infrastructure).

3   Carry out analysis of the prevailing national emergency plan, multi-hazard early warning system, emergency telecommunication plans and network recovery programmes of the operators, with a view to identifying bottlenecks and gaps, considering the best international practices and submitting applicable recommendations (as appropriate).

4   Investigate and report on the actions taken by the operators and / or policy-makers to help restore the affected infrastructure and identify future steps anticipated to fully restore the networks, also noting the timelines for such activities, as well as any critical inputs, measures or requirements (as appropriate) for those plans or actions to be achieved.

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[13]   https://www.itu.int/en/ITU-D/Pages/connect-2-recover.aspx

5   Identify policies and regulations (spectrum, funding, licensing, facility access) that Member States can adopt to increase the resilience of ICT to cope with disrupting events and be better prepared for the new normal.

6   Identify efforts and options to increase adoption and usage of broadband technologies and strengthen network resilience.

This report is developed based on inputs from various sources:

- the connectivity data have been retrieved from ITU official databases and are used for the description of the status-quo of Ukraine's ICT infrastructure in the pre-war period;

- the questionnaire for the collection of primary statistical data was created by the experts and addressed to the State Service of Special Communications and Information Protection of Ukraine (SSSCIP), which assembled and submitted answers including data on population and country level Internet resilience (comprised of operator/ISP network resilience, critical infrastructure resilience and market resilience), impact of the war on Ukraine digital ecosystem with details on damages, government/ICT regulator/private sector/civil society efforts to increase resilience, policies and regulations for future hazards;

- the desk research, with secondary information on damages caused by the war in Ukraine, has been retrieved from comments of Ukraine officials to media, interviews of operators and from official information published by research centres and by governmental agencies.

To sum up, the report incorporates concrete deliverables:

1. A methodology for the analysis and standardization of the information, documents, facts and figures collected as part of the course of evaluation of the damaged telecommunication infrastructure in Ukraine.

2. Assessment of the current situation/resilience of the impact of attacks including cyberattacks, on Ukraine's ICT ecosystem.

3. A report on actions undertaken in Ukraine by stakeholders to restore the networks, including bringing in international support (for example from the satellite operators), emphasizing the main challenges and various methods of their resolution.

4. Recommendations for a more resilient ICT network in the aftermath of the war.

5. A summary of the ICT restoration needs and advice to the larger group of stakeholders involved in the process of consultation and close coordination with ITU.

IV. Background of Ukraine

IV.I Country overview

Population: 41 130 400 (February 2022 estimate)[14]

Households: 14 549 200 (2022 estimate)[15]

GDP: UAH 5 459 574 m / USD 149.3 billion [16] (2021 estimate[17])

Area: 603 628 km^2

Capital city: Kyiv

Official EU language: Ukrainian

Currency: Hryvnia (UAH)

Country code: 380

Internet TLD: .ua / укр

Fixed-telephone subscriptions: 2 283 (2021)

Fixed-telephone subscriptions per 100 inhabitants: 5.51 (2021)

Mobile-cellular telephone subscriptions: 55 926 (2021)

Mobile-cellular subscriptions per 100 inhabitants: 135.03 (2021)

Fixed-broadband subscriptions: 7 566 (2021)

Fixed-broadband subscriptions per 100 inhabitants: 18.27 (2021)

Mobile-broadband subscriptions: 33 184 (2021)

Mobile-broadband subscriptions per 100 inhabitants: 80.12 (2021)

IV.II Development of the telecommunication market

Sustainable technological market development is a foundation and a backbone for every aspect of the global economy acting as a fundamental enabler for businesses, consumers, and citizens. Universal access to the next generation ICT infrastructure (fixed, mobile, wireless, satellite) is imperative for advancing sustainable development. It requires policies and governance approaches that reinforce the resilience and responsiveness of societies, assess risks to citizens and protect consumers.

Ukraine's telecommunication market experienced significant change, when, in June 2021, telecommunication service provider Datagroup, operating one of the largest fibre-optic networks of the country, completed its acquisition of Volia. Vodafone Ukraine, meanwhile, declared its intention to become a quad-play provider of telecommunication services after having acquired both Cable TV-Finance and Vega, which operates fixed-broadband and telephony networks in Odesa and Kyiv.

Fourth generation (4G) networks provide modern telecommunication services in Ukraine including rural areas and along main roads and have increased the volume of services and the number of users with Internet access. As well as modern electronic services, 4G networks give access to government services, e-commerce, e-health, and education, as well as growing demand for machine-to-machine and Internet of Things services

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[14]   https://index.minfin.com.ua/ua/reference/people/

[15]   https://www.ukrstat.gov.ua/operativ/operativ2020/gdvdg/sdhd/sdhd_2022.xls

[16]   The National Bank of Ukraine, exchange rate on 07/09/2022

[17]   https://ukrstat.gov.ua/operativ/operativ2021/vvp/vvp_kv/vvpf_21_ue.xls

among banks, security service providers, housing, communal service providers, transport and logistics companies.[18]

Key developments[19] of the market throughout 2021-2022 included:

- Mobile termination rates regulation by NCEC, effective from October 2020;

- Kyivstar with Huawei trialled LTE using tri-band Carrier Aggregation (CA) technology in the 900 MHz, 1 800 MHz, and 2 600 MHz bands, achieving data speeds over 800 Mbit/s;

- Vodafone Ukraine launched NB-IoT services in partnership with Danube Freight Company, Liana, and BTK-Tsent Komplekt;

- Mobile network operators (MNOs) Lifecell, Kyivstar, and Vodafone Ukraine joined together in an infrastructure sharing agreement to accelerate the deployment of LTE networks in rural areas;

- Extensive 4G rol-lout from 2018 to 2022, as part of the memorandum[20] signed between the government and operators, brought mobile network coverage to an estimated 91.6 per cent of the population and stimulated further proliferation of e-services in the public and private sectors;

- Expansion of 4G mobile telecommunication network coverage by using the International Mobile Telecommunications (IMT) radio technology in the 900 MHz, 1 800 MHz and 2 600 MHz bands;

- Intertelecom has started closing down its CDMA-based wireless services due to its inability to meet the cost of LTE licence fees required to proceed with a nationwide deployment;

- Datagroup announced a USD 20 million network modernization programme in partnership with Cisco;

- Ukrtelecom in partnership with Iskratel and Slovenian banks launched a EUR 12 million fibre-optic network expansion programme to provide gigabit-capable connectivity to more than 300 locations with 530 000 households and around 1.3 million people across Ukraine;

- The number of users of modern electronic services in various areas of the digital economy and digital society increased (e-Gov, e-health, e-education, e-democracy, e-ticket, bank - ID, mobile - ID, Google Pay, Apple Pay, etc.);

- Growing consumer demand for machine-to-machine (M2M) and Internet of Things (IoT) services, including as part of the implementation of smart city building programmes.[21]

Competition in the ICT sector is highly consolidated with 4 760 players.[22] Most Ukrainian operators, including Datagroup, UAR-NET, Kyivstar, Ukrtelecom, Eurotranstelecom, Farlep-Invest, Vodafone Ukraine and Omega Telecom, are active in the international wholesale, domestic wholesale and retail market segments, and continue to enjoy significant market share with high levels of competition and innovation ranging from mass-market entertainment to high-end business connectivity.

Three major operators lead the wireless market, Kyivstar (VEON), Vodafone Ukraine (NEQSOL), Lifecell (Turkcell) and smaller national players (with around 3 per cent of the market), together cover 99.9 per cent of the population of Ukraine with mobile-cellular access and 91.6 per cent of the population with at least 3G mobile network access.[23] Market diversity is complemented by mobile virtual network operators (MVNO)

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18 https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Publications/2022/Digital%20Development/Digital%20Development%20Country%20Profile_Ukraine_final_02.22.pdf

19 https://www.budde.com.au/Research/Ukraine-Telecoms-Mobile-and-Broadband-Statistics-and-Analyses

20 https://www.kmu.gov.ua/news/uryad-pidpisav-memorandum-shcho-zabezpechit -pokrittya-4g-na-90-teritoriyi-ukrayini

21 NCEC 2021 Annual Report

22 Answers to the ITU Assessment Report Questionnaire designed for the State Authorities

23 ITU Ukraine Statistics dashboard

and wireless local loop (WLL) operators (Velton Telecom, Intertelecom, International Telecommunication Company (ITC)/CDMA Ukraine, Telesystems of Ukraine/PEOPLEnet, etc.).[24]

The fixed broadband market is represented by the "big six" with Ukrtelecom (SCM Group), operating ADSL+ and optical fibre and covering more than 2 300 settlements; Kyivstar, with fibre-to-the- building (FTTB) in more than 118 cities; Volia, the largest cable TV operator, with point of presence in more than 33 cities; Triolan, with hybrid fibre-optic/coaxial cable services in about 11 cities; Vega (a former sister company of Ukrtelecom, now part of Vodafone Ukraine), with a presence in about 90 cities and PJSC Datagroup.

Some of the largest national operators shaping the domestic wholesale market and providing dark optical fibre and capacity leasing are: PJSC Ukrtelecom, Omega Telekom, Atracom, PJSC Datagroup, PJSC Farlep-Invest (VEGA) and Eurotranstelecom Ltd (ETT). Widespread and accelerated deployment of the mobile broadband networks and next generation technologies led to considerable growth of the volume of wholesale traffic in the country, leading to an increased number of local Internet exchange points (IXPs) (22 in total, of which there are 5 in Kharkiv, 2 in Donetsk, 1 in Mariupol and 1 in Zaporizhzhia[25]) that facilitate local exchange of traffic among operators and release the trunk backbone capacity for the transit of international traffic.

Figure 1: Ukraine transmission map with terrestrial fibre transmission links and IXPs[26]
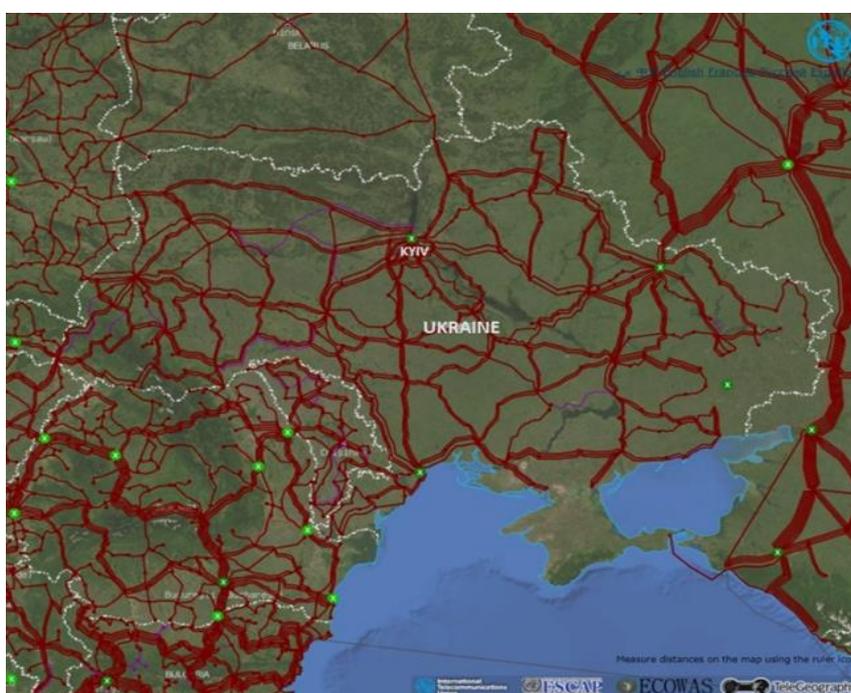
Source: ITU

With regard to the international wholesale market, Ukraine's deregulated international interconnectivity is robust, with at least one interconnection with all seven neighbouring countries, of which five are interconnected through two or more physically separate cross-border routes (Figure 1). Ukraine's thirteen international Internet Exchange Points (IXPs) of which three IXPs are located in Kharkiv, two in Donetsk and two in Odessa[27] connect with major international traffic exchange points, including DE-CIX, Germany and

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24   https://www.globalmonitor.us/product/ukraine-telecommunication-market-report

25   Internet Exchange Map

26   https://www.itu.int/itu-d/tnd-map-public/

27   ITU Interactive Terrestrial Transmission/ESCAP Asia-Pacific Information Superhighway Maps

AMS-IX, Netherlands. UA-IX[28], GigaNET[29] and DTEL-IX[30], which are among the largest IXPs in Ukraine. Of the major carriers, Telia, Orange, Cogent, Vodafone and Hurricane Electric have multiple points of presence and some lease fibre-optic networks.

The optical fibre wholesale market is dominated by Atrakom LLC, Eurotranstelecom LLC, Naftogaz and Ukrtelecom, which provide nationwide fibre-optic backbone infrastructure thus ensuring continuous network operation by means of redundancy and resilience.

The wholesale market is additionally comprised of the State-owned enterprises and municipalities registered as wholesale operators, some of which are: JSC Ukrainian Railways (Ukrzaliznytsia), the Ukrainian Sea Ports Authority (USPA), the Ukrainian Sea Port "Yuznyi", National Nuclear Energy Generating Company "Energoatom". These cumulatively possess more than 10 000 km of unutilized non-commercialized fibre-optic infrastructure and some of them have international cross-border connections with neighbouring peers.

Ukrenergo, the State-owned transmission system operator, utilizes SDH network technology over its fibre-optic network and plans modernization towards dense wavelength division multiplexing (DWDM). Ukrzaliznytsia exploits more than 8 000 km of fibre-optic cable, of which 2 500 km belongs to the company and 5 600 km is leased from third-party telecommunication operators. Ukrgaztekhsvyaz (a branch of Ukrtransgaz) provides full range of ICT services (except mobile) to the gas transmission subsidiaries of Ukrtransgaz and Ukrtransnafta and possesses around 4 000 km of fibre-optic network, utilizing PDH and SDH technologies, and planning reconstruction and deployment of DWDM.

The capital investments of fixed and mobile operators in the telecommunication sector in 2020 amounted to some UAH 14.3 billion (about USD 391 million[31]), up from UAH 11.7 billion (about USD 320 million[32]) in 2019[32], out of the total amount (including annual foreign investment in telecommunications) of over UAH 16.13 billion, (about USD 441 million[32]). The capital investments of mobile operators in 2021 amounted to UAH 10.4 billion (about USD 284 million[32]).

Capital expenditure on the new broadband network infrastructure rollout throughout the country was decreased after 24 February 2022, as network deployments were slowed or suspended to ensure the engineers' health and safety during the war. However, the expenditure soared in the war-affected regions.

Despite the negative global economic trends caused by the COVID-19 pandemic, the telecommunication industry witnessed strong growth and increased revenues. In 2021, as the country adjusted to a new reality of life, where users adopted work-from-home practices, business hour fixed- and wireless-broadband consumption grew significantly.

Revenues obtained from all telecommunication services amounted to UAH 81.021 billion[33] (about USD 2.2 billion [32]), and increased in 2021 by almost 10 per cent compared to 2020 and by 25 per cent compared to 2019.[34] In 2021, the largest share of revenues were registered by mobile communications (66.0 per cent) followed by fixed access to the Internet (19.5 per cent). Revenue from the provision of mobile communication services increased by 14 per cent and amounted to UAH 53.46 billion (about USD 1.5 billion [32]), whereas fixed access to Internet amounted to UAH 15.81 billion (USD 432 million[32]).

In the first quarter of 2022, three of the largest mobile network operators reported growth in their financial indicators, mostly due to fulfilment of their 4G licence obligations related to expansion of 4G network

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[28] Ukrainian traffic exchange network | (ix.net.ua)

[29] Giganet: Ukrainian Internet Exchange

[30] DTEL-IX. A carrier neutral Internet Exchange in Ukraine

[31] The National Bank of Ukraine, official exchange rate on 07.09.2022

[32] https://www.itu.int/en/ITUD/Statistics/Dashboards/Pages/Digital-Development.aspx

[33] NCEC 2021 Annual Report

[34] https://www.itu.int/en/ITUD/Statistics/Dashboards/Pages/Digital-Development.aspx

coverage throughout Ukraine; increase of network capacity; growth in the number of users and uptake in the first two months of the year; and extensive usage of the roaming services.

IV.III   Review of the digital ecosystem of Ukraine

Since 2019, Ukraine has made a significant breakthrough in digitalization of public services. The world's first passports in a smartphone, introduction of digital driver licences, the fastest digital signature enabled business registration have been made possible as a result of "The State in a Smartphone" programme, implemented by the Ministry of Digital Transformation, together with other ministries and international organizations.[35]

As part of "Decentralization" - the public administration reform of Ukraine, with the support of the EGOV4UKRAINE Project, under the framework of the "U-LEAD with Europe" programme [36], the Ministry of Digital Transformation created and implemented "Trembita"[37] - a system of electronic interaction of the state electronic information resources that creates a connection between registers and their information systems, and implements mechanisms for secure data exchange, representing one of the key elements of the infrastructure for the provision of electronic services to citizens and businesses, and providing convenient, unified access to the data of state registers. The basis of the "Trembita" system is the improved Estonian data exchange platform X-ROAD, which is the foundation of the Estonian digital society. The implementation of the "Trembita" system made it possible to significantly simplify administrative services, and deploy various applications such as: "e-Baby", ID14, "e-HomeRegistration", verification of an individual tax number, and an e-certificate in a mobile app. Currently, the "Trembita" system is being developed with the support of the EU4DigitalUA Project "Interoperability, e-services and cyber security", to incorporate a solution for monitoring access to personal data.

The interface between citizens and government is ensured through the "Diia" online platform and mobile application, that reflects the attitude to e-governance in Ukraine. Launched in February 2020, the interface enables 26 digital services through the mobile application and 99 services in total on the "Diia" platform. The e-governance access is designed to exercise everyone's right to electronic services and information on administrative and other public services, and contact with State bodies and executive authorities, local governments, enterprises, institutions and organizations (in accordance with the Law of Ukraine "On Citizens' Appeals"). It also provides information from national electronic information resources, necessary for the provision of services, as well as for monitoring and evaluating the quality of services.

Since its launch, the "Diia" portal has been visited by more than 19 million people. It provides a single point of entry (the user's e-office) that allows citizens to access and obtain information about their property, vehicles, land, real estate, private entrepreneur status, information about their debts (if any), voter information, employment records, and user tax information. Currently, 14 public registers are integrated into the user's e-office on the Portal Diia.

According to the latest research, the mobile application of the portal is the most popular mobile applications in Ukraine, attracting 54 per cent of all registered Internet users (over 18 million[38]), with almost 13 million users receiving the international COVID vaccination certificate, and about 70 per cent of families using the e-Baby service. Since the launch of the Individual Entrepreneur automatic registration service, it has been used by more than 135 thousand people. Under the "e-Support" programme, 4 921530 people signed up for assistance, though this was temporarily suspended during martial law. The "e-Support" programme attracts 9 342019 users.

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35   https://thedigital.gov.ua/news/ukraintsi-naybilshe-doviryayut-programi-derzhava-u-smartfoni-ta-tsifrovizatsii-opituvannya-reyting

36   https://decentralization.gov.ua/cnap/prohrama-u-lead-z-yevropoiu-f

37   https://dir.gov.ua/projects/trembita

38   https://www.ukrinform.ua/rubric-technology/3556364-u-dii-vze-18-miljoniv-koristuvaciv-mincifri.html

In April 2022, the Ministry of Digital Transformation of Ukraine launched a new Diia mobile application service to register internally displaced persons (IDPs). This automated service processes all applications very quickly.[39] Diia also helps to restore documents that have been lost as a result of the war. The Diia platform incorporates a list of all services that citizens might need to use as a result of the war.[40]

Widespread implementation of the electronic services contributed to the decrease in corruption and saved Ukrainians 14.7 billion hryvnias in 2020-2021.[41]

Furthermore, the Ministry of Digital Transformation has driven the creation of the Diia City – a special legal and tax space for IT business that makes it easier and less expensive to manage and operate business. This move was an effort to make the Ukraine a European IT hub and to increase the IT sector part of the GDP from 4 to 10 per cent, and increase income to USD 16.5 billion [42].

The country-wide Diia City gives companies in the Ukraine a special tax regime, more flexible employment conditions and additional instruments for investment protection and corporate management. It was launched on 8 February 2022 and as of 4 August, there were 311 resident companies including Reface, Roosh, Monobank, MacPaw, Ajax Systems, Revolut, EPAM Systems, Samsung, Genesis, NiX Solution, Softserve, Sigma. Software, RIA.com, Rozetka. [43]

The process of the sustainable digital transformation of Ukraine and integration of digital technologies into all areas of business has been heavily affected by the war, which has invoked martial law in the country and temporarily suspended development, implementation and accessibility of certain electronic services. Temporary restrictions have been applied to the access of the National Open Data Portal.

The government is constantly working to achieve a balance between safeguarding the interests of national security and defence (with a large number of targeted cyberattacks directed towards State information resources and critical infrastructure) and ensuring transparency and accountability for decisions affecting its citizens, not least the increased demand for public electronic services related to relocation, loss of documents, and so on.

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[39] https://www.undp.org/uk/ukraine/press-releases/україна-запускає-новий-електронний-сервіс-для-внутрішньо-переміщених-осіб

[40] https://guide.diia.gov.ua/thematic-area/zakhyst-hromadian-pid-chas-viyny

[41] https://www.ukrinform.ua/rubric-economy/3399904-smigal-za-dva-roki-ekonomia-vid-onlajnposlug-stanovit-147-milarda.html

[42] https://www.ukrinform.ua/rubric-technology/3399849-zavdaki-diacity-castka-it-u-vvp-ukraini-moze-zrosti-z-4-do-10-zelenskij.html

[43] https://city.diia.gov.ua/registry/resident

V. Impact of the war on the ICT sector of Ukraine

V.I Fixed and mobile telecommunication industry

Since the beginning of military attacks, with the purpose of using the facilities in its interests and for its own needs, the aggressor either destroyed completely or seized the regular operation of public and private terrestrial telecommunication and critical infrastructure in the temporarily occupied and war-affected territories of Ukraine. Fifteen providers of electronic communication networks and services reported complete loss of control over their networks and equipment. The scale of destruction in the areas, where active hostilities have taken place, is estimated at 100 per cent.[44]

The aggressor unilaterally changed the international numbering system defined by the International Telecommunication Union in Recommendation ITU-T E.164 (11/2010)[45] and Recommendation ITU-T E.212 (09/2016)[46] and the national numbering system of Ukraine, by introducing new national destination codes (NDC) for the temporarily occupied and war-affected territories of Ukraine and using them under the country code (CC) [7], allocated by ITU to the Russian Federation and the Republic of Kazakhstan. Ukraine NDCs [71], [72] and a mobile network code (MNC) [99] as well as NDCs [978], [941], [958], [949], [959], [990], [365] and [869] have been used by fixed and mobile communication networks operating for the benefit of an aggressor in the temporarily occupied territories of Crimea, Sevastopol, Donetsk, Luhansk, Kherson and Zaporizhzhia regions by switching to the international numbering system of the Russian Federation.[47]

In March 2022, Ukrtelecom reported significant deterioration of the geographical level of fixed-broadband service coverage in Ukraine, namely 59 per cent in Zaporizhia Oblast, 62 per cent in Donetsk Oblast, 68 per cent in Chernihiv Oblast and 74 per cent in Kharkiv Oblast, with presence of service in all the regions except of Luhansk. Overall, the level of the fixed-broadband network availability has been estimated at 89 per cent [48]. According to the half-year report of the company the losses constitute 426 millions of hryvnias.[49] Moreover, this is not the full sum, as it does not consider the losses in terms of the operating profit of Ukrtelecom, which was not received due to the suspension of business, and currently amounts to at least UAH 14 million (about USD 382 842[50]) per month.

Vodafone Ukraine reported that communications network damages have occurred mostly in the east, north and south of the country. Telecommunication infrastructure and facilities were affected in Donetsk and Luhansk regions, Kharkiv, Sumy and Kherson regions[51]. According to the first quarter operational status of the company, Vodafone Ukraine network maintained" a high level of network stability, with less than 10 per cent of telecommunication infrastructure out of operation. Due to the mass migration of Ukrainians within the country and abroad, the company reported the loss of about 400 000 subscribers.[52] As of 29 July 2022,

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[44] Answers to the ITU Assessment Report Questionnaire designed for the State Authorities

[45] https://www.itu.int/rec/T-REC-E.164-201011-I

[46] https://www.itu.int/rec/dologin_pub.asp?lang=f&id=T-REC-E.212-201609-I!!PDF-E&type=items

[47] https://nkrzi.gov.ua/index.php?r=site/index&pg=87&language=uk

[48] https://cip.gov.ua/ua/news/cherez-aktivni-boiovi-diyi-ta-yikh-naslidki-sposterigayetsya-suttyeve-pogirshennya-geografichnogo-rivnya-pokrittya-poslugami-povidomlyaye-ukrtelekom

[49] https://ukrtelecom.ua/about/accounting/regulyarna-kvartalna-informatsiya/zvit-za-2-y-kvartal-2022-roku/Звіт_2кв_W.pdf

[50] The National Bank of Ukraine, exchange rate on 07/09/2022

[51] https://interfax.com.ua/news/general/819845.html

[52] https://www.commsupdate.com/articles/2022/06/01/vodafone-ukraines-subscription-base-dropped-by-half-a-million-in-q1-but-revenue-still-increased/

the company estimated financial loss incurred because of damaged infrastructure at UAH 2 billion (about USD 55 million[53]).[54]

In April, after having performed about 3 000 repair works with 450 technicians in 110 cities (more than 1 100 settlements) and more than 10 km of optical cable restored, almost 90 per cent of the fixed-broadband network of Kyivstar was reported to be working. By August 2022, more than 30 km of fibre-optic cable had been restored and the number of repair works increased to 4 000.[55] As for the mobile cellular network, about 7-10 per cent [56] of base stations of Kyivstar are reported to be out of operation from time to time, forcing telecommunication traffic engineering towards operational nodes, thus ensuring seamless rerouting and optimization of network performance. However, the service provision continues to be disrupted due to power outages and partial or full damage of infrastructure in temporarily occupied regions of the country. In the first quarter of 2022, the company estimates losses of about 20 per cent.

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20 per cent of the country's telecommunication infrastructure was damaged or destroyed, in particular, more than 3 700 base stations of mobile operators were completely or partially suspended.

Source: SSSCIP, Ukraine, 10 June, 2022

Four and a half months of war have led to around 30 000 trips by Lifecell repair teams to restore suspended operation of base stations in various regions, with 80 to 90 repair crews working daily. Most (91.7per cent) of Lifecell telecommunication network equipment is reported to work stably throughout Ukraine. The operator observed a changed pattern and a significant increase of roaming and mobile broadband traffic, and dramatically expanded the 2G telecommunication network capacities for 400 settlements, and increased access to high-speed 3G and 4G mobile broadband networks in more than 100 settlements. In order for the mobile network to meet the increased demand for data services, Lifecell, with the support of State authorities, provided LTE coverage in the 2100 MHz range. Increased demand for services throughout Ukraine has been dealt with by means of introducing eSIM cards and increasing sales offices by 20 per cent.[57] The main problem for the continuous operation of the network incurring complete disconnection of communication in places of active hostilities are caused by power outages. The estimated loss to the operator is more than UAH 1 billion (about USD 27 million[54]). [58]

According to the "Report on direct damage of the infrastructure, indirect losses of Ukraine's economy, inflicted by the war, and a preliminary assessment of the country's financial needs for reconstruction and recovery", prepared as part of the activities of the Loss Audit Working Group of the National Council on restoration of Ukraine from the consequences of the war, the assessment of the digital infrastructure of the country as of August 2022, is outlined in Table 1.[59]

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[53]   The National Bank of Ukraine, exchange rate on 07/09/2022

[54]   https://mind.ua/publications/20244885-milyardi-u-vidnovlennya-zv-yazku-yak-mobilni-operatori-dolayut-naslidki-vijni

[55]   https://kyivstar.ua/uk/mm/news-and-promotions/kyyivstar-za-pivroku-splatyv-57-mlrd-grn-podatkiv-ta-investuvav-ponad-16-mlrd

[56]   https://www.bbc.com/ukrainian/features-61120584

[57]   https://vctr.media/ua/mobilnij-zvyazok-pid-chas-vijni-yak-lifecell-pid-obstrilami-remontuye-bazovi-stancziyi-139649/

[58]   https://biz.nv.ua/ukr/markets/yak-ukrajina-zalishilas-online-50251862.html

[59]   https://kse.ua/wp-content/uploads/2022/07/NRC_CLEAN_Final_Jul1_Losses-and-Needs-Report.pdf

Table 1: Direct and indirect losses of digital infrastructure due to the war on Ukraine and a preliminary assessment of what the sector needs to recover, in monetary terms

Type of losses	Measure-ment unit	Quantity of objects (baseline)	Quantity of damaged objects	Estimation of losses (UAH billion)	Estimation of losses (USD billion)
Direct damages					
Fixed line operators	unit	4162	726	9.3	0.3
Mobile operators	-	-	-	6.1	0.2
Total direct losses of the ICT industry	**UAH billion**			**15.4**	**0.6**
Indirect losses					
Reduction of fixed-line operators' income	UAH billion	-	-	9.4	0.3
Reduction of mobile operators' income	UAH billion	-	-	22.7	0.8
Total indirect losses of the ICT industry	**UAH billion**	**-**	**-**	**32.1**	**1.1**
The need for recovery	UAH billion				
Restoration of operators' Infrastructure	UAH billion	-	-	21.6	0.8
Restoration of operators' work/activities	UAH billion	-	-	6.4	0.2
General preliminary need for recovery		**-**	**-**	**28.0**	**1.0**

Source: Ministry of Digital Transformation, NCEC, operators of electronic communication networks

Figure 2: Distribution of out-of-service base stations of mobile telecommunications as of August 2022
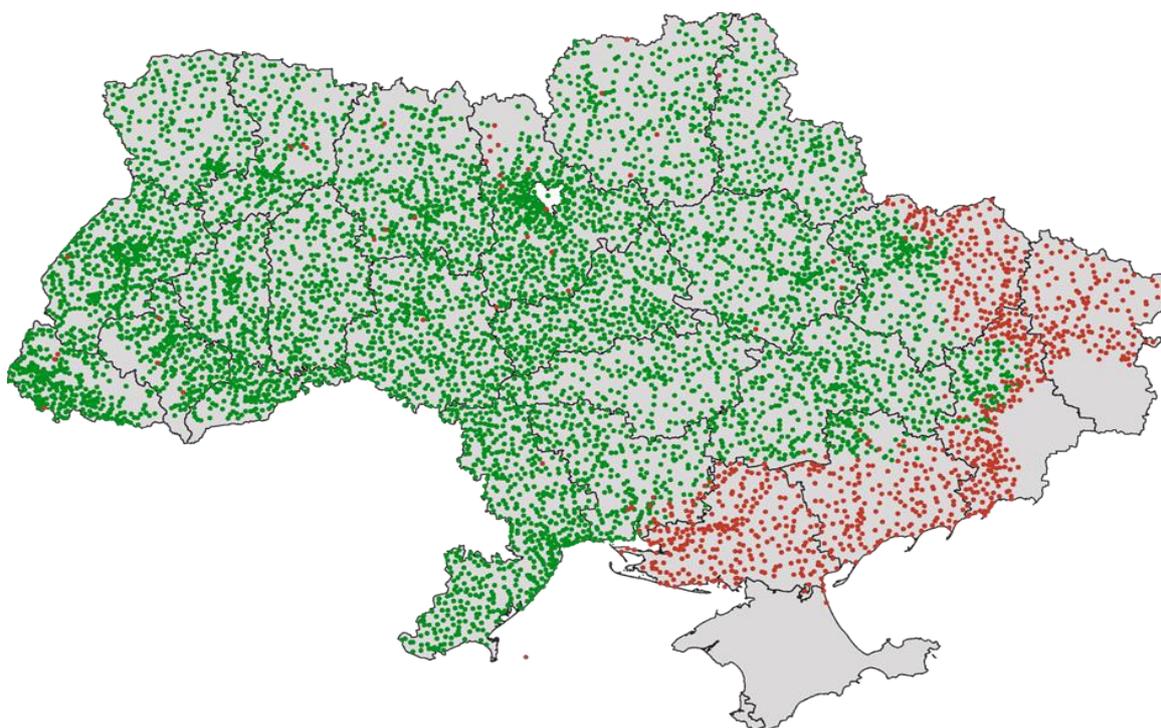
Source: KSE Institute

The quality of data transmission over fixed broadband networks decreased by an average of 13 per cent (estimated as of 1 May 2022). Almost 11 per cent of the total number of the base stations of mobile operators are out of service.

Over a single month, the total number of non-working base stations has increased by 700. Across the country, the quality of data transmission over mobile broadband networks as of May 2022 decreased on average by 26 per cent.

The total cost of damaged ICT infrastructure is estimated at USD 0.6 billion, incurring losses equivalent to USD 1.1 billion, and the reconstruction and recovery needs amount to USD 1 billion

Source: KSE Institute, Kyiv School of Economics, Ukraine, August, 2022[60]

The trunk network providers Atracom and Vega reported availability of their services in most of the territory. War-inflicted damages of the networks in Kyiv, Boyarka, in some districts of Kharkiv and most of Chernihiv have been eliminated instantly, however the power outages continue to remain a constant problem.

Datagroup-Volia reported 13 948 applications for accidents and damage to the network, 45 per cent of which were reported during the first month of the military aggression. Despite the increased need for additional capacity, the network continues to provide an acceptable level of service in 22 regions of the country.

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60 https://kse.ua/about-the-school/news/direct-damage-caused-to-ukraine-s-infrastructure-during-the-war-has-reached-over-110-4-bln-minimum-recovery-needs-for-destroyed-assets-188-bln/

Vega has received 1 864 customer calls due to service impairment, of which 1 601 have been restored, but some sections of fibre-optic cable remain extensively damaged in Kherson, Mykolaiv and Dergachy, which cannot be repaired due to lack of logistics, demining of territories and constant shelling[61].

Lack of electricity is the main reason for communication loss, followed by breaks in fibre-optic lines and physical destruction of equipment and facilities

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Source: BBC News Ukraine, April 2022[62]

Universal access to the telecommunication networks and access to trustworthy sources of information have proven to be major challenges during the war. For example, in the attempt to block access to Ukrainian web resources, the aggressor invaded the office of Status, a Kherson-based Internet service provider, intimidating and forcing the company to connect its equipment to Russian networks.[63]

V.II   TV, radio and satellite industry

Since February 2022, a number of Ukrainian TV channels, including the four biggest broadcasters 1+1 Media, 2+2, 24 Kanal, and TRC Ukraina have switched over to the signal of the Parliamentary TV-channel "RADA" and began broadcasting a 24/7 united newscast called "United News" ("Єдині новини"), which is promptly providing comprehensive information from the different regions of the country[64][65].

A series of military attacks on television towers in major cities in Ukraine (Kyiv, Rivne, Vinnytsia) have been reported by the SSSCIP. As a result of shelling, more than two dozen television substations were completely or partially destroyed and the hardware was heavily damaged, incurring temporary suspension of broadcasting channels in almost 46 settlements of the country and resulting in interrupted delivery of news, and depriving the civilian population of access to warnings about threats of air strikes and information about evacuation vehicles, humanitarian corridors, and so on.[66][67].

Furthermore, as a consequence of reorganization and technical intervention in transmission equipment, eight settlements of Ukraine were switched over to receive a transborder broadcasting signal from the Russian Federation[68]. Within three weeks of the start of the conflict, the Ukraine State Center of Radio Frequencies (UCRF) recorded 43 instances of using frequency resources and operating radio equipment without having authorized or assigned corresponding licences.

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61   https://mind.ua/publications/20239534-internet-provajderi-pid-chas-vijni-bezlich-poshkodzhen-vidnovlyuemo-merezhi-247-tarifi-ne-pidvishchuemo

62   https://www.bbc.com/ukrainian/features-61120584

63   https://cip.gov.ua/en/news/okupanti-shantazhem-i-pogrozami-zmushuyut-ukrayinskikh-provaideriv-pidklyuchatisya-do-rosiiskikh-merezh

64   https://deadline.com/2022/02/ukraine-media-groups-join-together-for-united-news-urge-world-to-turn-off-russian-channels-1234960684/

65   https://1plus1.ua/novyny/grupa-11-media-dolucilasa-do-spilnogo-informacijnogo-efiru-kraini-edini-novini

66   https://cip.gov.ua/ua/news/rosiiski-okupaciini-viiska-obstrilyali-televezhu-v-kiyevi

67   https://cip.gov.ua/ua/news/vranci-16-bereznya-okupanti-obstrilyali-televezhu-koncernu-rrt-u-vinnici

68   https://cip.gov.ua/ua/news/telebachennya-v-ukrayini-za-misyac-viini-za-poperednimi-ocinkami-rosiya-zavdala-shkodi-infrastrukturi-na-sumu-ponad-600-mln-grn

On 13 March 2022, the Cabinet of Ministers of Ukraine adopted Resolution No. 303 "On the Termination of State Supervision (control) Measures and State Market Supervision under the Martial Law".[69] Since then, spectrum monitoring and inspection of radio equipment at the stations has been halted and materials related to violations of the use of the radio resources were not compiled.[70]

The Radio Broadcasting, Radio Communication and Television Concern (RRT) of Ukraine, in charge of the operational functioning of the network infrastructure, consisting of 500 antenna-mast structures, over 12 000 km of microwave links, 1 173 TV transmitters and 341 radio transmitters and a satellite communication centre[71], took extensive measures to restore broadcasting in Ukraine. As of 17 August 2022, the telecommunication infrastructure of the RRT Concern included[72]:

− Lugansk region: 19 facilities located in the temporarily occupied territories are partly blacked out and not be able to broadcast programmes.
− Donetsk region: 4 facilities are located in the temporarily occupied territories. 5 facilities broadcast Ukraine television and radio programmes: Kramatorsk, Pokrovsk, Kostyantynivka, Bakhmut, Chasiv Yar. In the meantime, the operation of both analogue transmitters with a power of up to 20 kW and digital transmitters of up to 1 kW, as well as a radio in the FM range, is ensured. RTS Chasiv Yar operates a 25 kW medium-wave (WM) transmitter at a frequency of 873 kHz, broadcasting Ukraine Radio programmes and covering the entire Donetsk and Luhansk regions. The best reception is in the morning and evening.
− Zaporizhzhya region: 12 facilities in the temporarily occupied territory. RTS Orihiv was damaged and blacked out (de-energized). Ukraine programmes RTBS Zaporizhzhya and RTS Novomykolaivka broadcasting via DVB-T2 (MUX-1, MUX-5) and UR-1 were transferred from RTS Orihiv.
− Kherson region: The whole region is temporarily occupied.
− Mykolaiv region: 3 facilities, − RTS Snigurivka, RRS Berezneguvate and RS Luch, are blacked out and not able to broadcast. As a result of damaged power lines and transmission equipment, the powerful 400 kW SX transmitter operating at a frequency of 549 kHz in RS Luch Mykolaiv branch of the RRT Concern is out of service. The restoration of its operation would ensure the delivery of truthful information about events in Ukraine to citizens not only in the Kherson region, but also in Crimea.
− Kharkiv region: 5 facilities in the temporarily occupied territory. Nine facilities broadcast Ukraine programmes. RTBS Kharkiv has damaged technical and other buildings that cannot be restored. The buildings are missing roofs, ceilings, windows, doors, and parts of walls. The television tower suffered damage to its metal structures, which significantly reduced its load-bearing capacity and made further safe operation impossible.
− Chernihiv region: All radio and television stations of the Chernihiv branch of the RRT Concern are broadcasting television and radio programmes in accordance with the licences of the TRC, as well as analogue television transmitters that have been additionally included since 24 February 2022. As a result of prolonged hostilities in the city at RTBS Chernihiv, both the technical building of the station and the 156 m high tower with RF feeders were damaged, but promptly restored by the RRT staff.
− Sumy region: Broadcasting has been restored except of RTBS Bilopylla and RTBS Trostyanets, which suffered significant destruction and where restoration work is ongoing.

According to preliminary estimates of RRT, the damage to the TV and radio infrastructure amounts to more than UAH 600 million (about USD 16 million[73]).

European stakeholders are heavily involved in the process of rehabilitation of the damaged infrastructure in Ukraine. For instance, the Radio Broadcasting and Television Center of the Republic of Lithuania handed over 10 FM radio transmitters and 9 digital TV transmitters to RRT as humanitarian technical assistance for the

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[69] https://zakon.rada.gov.ua/laws/show/303-2022-п#Text

[70] Answers to the ITU Assessment Report Questionnaire designed for the State Authorities

[71] https://www.rrt.ua/concern/index/about/

[72] Inputs of the RRT Concern

[73] The National Bank of Ukraine, exchange rate on 07/09/2022

restoration of Ukraine radio and TV broadcasting. The equipment will support the network in Mykolaiv, Odessa, Poltava, Rivne, Sumy, Chernihiv, Dnipropetrovsk and Kharkiv regions[74].

In parallel to this, as part of the cooperation of the SSSCIP and RRT of Ukraine with Emitel, the leading radio and TV operator of the Republic of Poland, Ukraine will strengthen its broadcasting network with four powerful digital TV transmitters, three FM transmitters and antenna systems, contributing to the successful recovery of destroyed infrastructure[75].

V.III   IT industry

Ukraine's economy is currently defended by more than 85 per cent of IT professionals, of which 2 per cent joined the Armed Forces of Ukraine and 5 per cent are directly involved in the fight in the fields of cybersecurity and support of critical infrastructure facilities. Most IT professionals (70 per cent) work in relatively safe regions of Ukraine and abroad out of a total of around 285 000 IT specialists. In the first quarter of 2022, the sector demonstrated exceptional resilience, with most companies resuming project related obligations towards their clients and 77 per cent of companies retaining the same volume of contracts. The industry remains financially stable, continues to pay taxes, gets involved in large humanitarian aid and heavily contributes towards the recovery of the economy.[76]

V.IV   Cyberspace

Since 24 February 2022, Ukraine has been aggressively fighting cyberterrorism, cyberespionage and cybercrimes which pose a direct threat to vital interests of the country. The number of cyberattacks during the war tripled compared to the previous year.[77] The government and local authorities, media platforms, security and defence sectors as well as critical and ICT infrastructure became targets of DDoS attacks, fishing e-mails and intrusive malware.

On the first day of the war in Ukraine thousands of Viasat satellite modems in the country went out of operation due to a high volume of targeted, malicious traffic flow, which overwhelmed the Viasat KA-SAT network devices, incurring huge loss of communication for military and critical infrastructure facilities[78].

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[74] https://cip.gov.ua/ua/news/litovci-dopomagayut-ukrayini-vidnovlyuvati-tele-ta-radiomovlennya-u-regionakh-yaki-postrazhdali-vid-bombarduvan-okupantiv

[75] https://cip.gov.ua/ua/news/polsha-dopomozhe-ukrayini-vidnovlyuvati-zruinovanu-sistemu-peredavachiv-tele-ta-radiomovlennya

[76] https://itukraine.org.ua/en/how-the-it-industry-is-contributing-to-ukraines-victory.html

[77] https://cip.gov.ua/ua/news/kilkist-kiberatak-pid-chas-viini-zrosla-vtrichi

[78] https://www.reuters.com/world/satellite-outage-caused-huge-loss-communications-wars-outset-ukrainian-official-2022-03-15/

Figure 3: Cyberattacks in the first seven months of the war

Source: SSSCIP

In March 2022, Ukrtelecom reported a powerful cyberattack on its infrastructure, which caused connectivity to collapse by 13 per cent, with nationwide disruption and 15 hours of service downtime[79]. Around the same time, a powerful hacker attack was carried out on Ukraine Railway (Ukrzaliznytsia) communications services which provides telephony and online ticket sales services. Between February and August 2022, 1 123 instances of full-scale cyberattacks were reported by the SSSCIP[80]. The Ministry of Defense of Ukraine, together with the State Intelligence Service and other authorities, are effectively responding to any further cyberthreats.

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[79] https://cyberpeaceinstitute.org/news/ukraine-100-days-of-war-in-cyberspace/

[80] https://cip.gov.ua/en/news/bilshe-tisyachi-raziv-atakuvali-ukrayinu-vorozhi-khakeri-za-chas-viini

VI.   Sustainability and resilience of the ICT sector

VI.I   The need for emergency plans, policies and regulations

Emergency situations can involve natural or man-made hazards and disasters that can damage ICT infrastructure, including those caused by pandemics, hurricanes and severe storms, earthquakes and flooding, wars, biological/chemical threats, cyberattacks, civil disorders, and terrorism. Each cause can impact telecommunication and critical networks and the delivery of online services very differently for example the COVID-19 pandemic showed the limitations of networks through increased demand for telecommunication services for remote work, entertainment and personal communication.

Emergency situations demonstrate the need to have nationwide emergency plans and systems that ensure ICT network sustainability and resilience; that help maintain institutional collaboration, including maintenance of ICT networks; and that enable people to be informed about hazards and the emergency measures needed to save lives.

Such emergency plans and systems support recovery efforts by facilitating the exchange of life-saving information, which increases resilience of all citizens and especially the most vulnerable. Governments and responsible public institutions equipped with emergency systems and flexible, controlled, timely and efficient plans, can implement an array of emergency measures.

In the face of natural or man-made hazards, government in collaboration with the public sector institutions concerned enforce various advanced and proactive disaster management and risk reduction emergency measures to increase sustainability and resilience of the ICT ecosystem by administering and directly managing access to spectrum (licensed or unlicensed for the period of emergency), pricing of services (free messages, roaming or Internet prices, etc.), access to the critical and ICT infrastructure (accelerating access to rights-of-way), ensuring network resilience (including ICT network protection, security, rebuilding) and investment (funding for broadband connections), thus contributing towards uninterrupted operation of deployed infrastructure, networks and services.

Monitoring hazards and delivering vital information in a timely manner is critical for both decision-making and emergency response. Nationwide emergency plans and systems (including, but not limited to, the National Emergency ICT/Telecommunication Plan (NETP) and the multi-hazard early warning system (MHEWS)) establish standard operating procedures, promote coordination, and allow for swift and efficient response.

Emergency systems, applications and services, therefore, ensure better responsiveness and control for emergency response (alerts, nearest connectivity) and can influence productivity in all sectors including education, health care, agriculture, business, defence and security.

The following sections describe existing and newly implemented emergency policies and regulations, the enforcement of which has revealed Ukraine's ability to maintain telecommunication services, and demonstrating exceptional resistance and resilience of the ICT ecosystem.

Nonetheless, the Government of Ukraine should review existing emergency policies and measures to include contingency plans for a full range of disasters from natural hazards to man-made causes.

Key recommendation

Ukraine is advised to have a national emergency telecommunication plan in place that includes *contingency plans for a full range of disasters* caused by natural or man-made hazards.

VI.II   Global network resiliency platform measures and initiatives

Emergency measures

National Emergency Telecommunication Plan

Resolution No. 812 on "Some Issues of Operational and Technical Management of Telecommunication Networks in Emergency Situations, state of Emergency and the Martial Law Conditions" was approved by the Cabinet of Ministers of Ukraine in June 2004. It defines the procedure for operational and technical management of telecommunication networks in emergency situations, state of emergency and martial law, and mandates the establishment of the National Telecommunication Networks Operation Center (NTNOC).[81]

In the event of emergency situations in telecommunication networks, the general management of the system of operational and technical management of telecommunication networks is carried out by the permanent branch commission on technogenic and environmental safety and emergency situations, which is formed and acts as an advisory body and which includes representatives of the State Special Communications Administration and experts in the field. The main tasks of the commission are:

− continuous and effective management of telecommunication networks in emergency situations, state of emergency and martial law;
− functioning of telecommunication networks with specified parameters, including monitoring for uninterrupted provision of telecommunication services;
− functioning of civil defence notification systems;
− increasing the reliability and efficiency of telecommunication networks;
− organization and implementation of measures for operational restoration, elimination of damage or overloads of telecommunication networks using available resources of telecommunication networks, and ensuring control over the implementation of these measures;
− priority allocation, reservation and restoration of telecommunication resources in the interests of the State system of government communication, the national system of confidential communication and special consumers;
− analysis of the reliability and stability of the functioning of telecommunication networks, development of proposals for the improvement of public telecommunication networks and their submission to the State Special Communications Administration.[82]

Multi-hazard early warning system

The State-wide automated system of both centralized and decentralized notification of the threat of occurrence or event of emergency situations is comprised of a set of organizationally and technically combined software and technical means, such as electronic communication networks, telenetworks and audio and audiovisual message processing and transmitting systems, intended for timely delivery of signals and information to the authorities, enterprises and the population.

It is governed by Article 30 of the Code of Civil Protection of Ukraine[83] and Resolution No.733, dated 27.09.2017, adopted by the Cabinet of Ministers of Ukraine "On the approval of the Regulation on the organization of notification of the threat of occurrence or occurrence of emergency situations and communication in the field of civil protection"[84], with further amendments introduced in 2020, 2021 and 2022 and carried out by the State Emergency Service.

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[81]   https://zakon.rada.gov.ua/laws/show/812-2004-п#Text

[82]   https://zakon.rada.gov.ua/laws/show/812-2004-%D0%BF#Text

[83]   https://zakon.rada.gov.ua/laws/show/5403-17#Text

[84]   https://zakon.rada.gov.ua/laws/show/733-2017-%D0%BF#Text

Special notification systems are created and function at the level of the relevant administrative-territorial units (national, territorial, local and special local) for the attention of executive authorities, local self-government bodies, enterprises, institutions, organizations, management bodies and civil defence forces, as well as at the nuclear plants, on hydrotechnical structures of the Dnieper and Dniester Cascades and in the areas of their possible catastrophic flooding, on main product pipelines, etc., providing transmission of "Attention to all" signal and voice or text messages via radio broadcasting nodes, street loudspeakers, devices for launching electric sirens, traffic horns to the authorities and technicians in charge of the industrial zone and mass population in the area of possible damage.

Delivery of special warning signals and notification is also carried out through JSC "NSTU", State and public television and radio companies, communal, electronic communication operators, regardless of the form of ownership, using their television, fixed, mobile and broadcast networks.

AjaxSystems, on the initiative of the IT-company stfalcon.com and with the support of the Ministry of Digital Transformation of Ukraine released the "Air Alarm" application, version 4.0 which notifies the start and end of five types of alarms: air alarm, artillery shelling, street fights, chemical threat and radiation danger.[85] The Kyiv city application "Kyiv Digital" warns about aerial threats.[86]

Table 2 summarizes the emergency measures of the country.

Table 2: Summary of emergency measures

Emergency measures	Indicator
- National Emergency Telecommunication Plan (NETP) that includes contingency plans for a full range of disasters caused by natural or man-made hazards	☑
- Multi-hazard early warning system (MHEWS)	☑
- Resources to handle increased voice and data traffic	☑
- Toll-free numbers for emergency services	☑

Government / ICT regulator efforts to increase resilience

National roaming

With the purpose of ensuring uninterrupted electronic communication services for the security and defence sectors of Ukraine and the entire population of the country during wartime, the NCEC, the National Telecommunication Networks Operation Center (NTNOC) of the State Service of Special Communications and Information Protection of Ukraine, TELAS (ТЕЛАС), the Ministry of Digital Transformation of Ukraine together with mobile operators PJSC Kyivstar, PRJSC Vodafone Ukraine and LLC Lifecell worked out a joint temporary solution and, in March 2022, adopted Order No.92 "Regarding ensuring the implementation of mutual settlement for the provision of national roaming services", regulating activation of national roaming services on the territory of the whole country, *free of charge*, for voice communication, SMS services, Internet access

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85   https://thedigital.gov.ua/news/zastosunok-povitryana-trivoga-yakiy-zavantazhili-11-mln-raziv-poperedzhatime-pro-khimichnu-ta-radiatsiynu-nebezpeku

86   https://kyiv.digital/start

and calls to the short numbers 101, 102, 103, 104, 1545, applicable to the cases of absence of a mobile network coverage of a home operator.[87][88]

International roaming

In order to alleviate the consequences of the humanitarian crisis caused by the mass migration of the population of Ukraine, with an estimated 4.2 million refugees registered abroad as of April 2022, EU and Ukraine operators, including those providing transit where relevant, united in a joint effort to voluntarily and bilaterally lower wholesale roaming charges and lower the wholesale charges for terminating international calls through commercial agreements, to enable the sustained provision of affordable connectivity to refugees from Ukraine. That coordinated approach minimizes additional costs for both EU and Ukraine operators, while enabling each to cover their respective costs, in order to enable as best as possible communication for refugees or displaced persons.

The Joint Statement has been signed by Kyivstar PJSC, Vodafone Ukraine PJSC , and Lifecell LLC from Ukraine and by Altice Portugal, BICS, Bouygues Telecom, BT (EU operations), Colt Technology Services, Deutsche Glasfaser, Deutsche Telekom, Elisa, Enigma System, Enreach, EWE TEL, Fastweb, Iliad Group, KPN, Liberty Global, Grupo MÁSMÓVIL, MVNO Europe on behalf of its members, Neterra, Nuuday, O2, Orange, Play, Plume, Polkomtel, Proximus, SFR, T-Mobile Netherlands, Tele2, Telefonica, Telenor, Telia Company, Three Group, TIM, Transatel and Vodafone from the EU. [89]

Furthermore, EU operators have distributed and will continue distributing millions of SIM cards free of charge to allow Ukraine citizens to stay connected in the EU. The EU operators have offered free or heavily discounted international calls and SMS to Ukraine, have enabled free outbound roaming for EU customers in Ukraine, have provided Wi-Fi connectivity and charging at central points where refugees gather, have offered the donation of essential equipment to Ukrainian operators and maintained essential international connection nodes.[90]

Access to electric power facilities

Since the introduction of martial law, in response to the requests from suppliers of electronic communication networks and services regarding issues of payment for access to the infrastructure of electric power facilities during wartime, the NCEC together with the SSSCIP, the Ministry of Digital Transformation, the National Technical University, and the Ministry of Energy of Ukraine adopted Order No. 137 dated 03.24.2022 "On Amendments to the Methodology for Determining Fees for Access to the Infrastructure Elements of the Electric Power Plant", with a supplemented clause in section IV 13. For the duration of the legal regime of martial law in Ukraine and 60 days after its termination or cancellation, the amount of the periodic fee for access to infrastructure elements of electric power facilities using the carrying capacity of buildings, structures and one support is 1 kopeck per month.[91]" This measure will assist providers of electronic communication networks and services to continue their work, ensuring stability of trunk lines, integrity of data transmission channels, support and provision of Internet connections and services to the population and authorities." [92]

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87 https://nkrzi.gov.ua/index.php?r=site/index&pg=99&id=2262&language=uk

88 https://cip.gov.ua/en/news/zaprovadzhennya-vnutrishnoukrayinskogo-roumingu-she-odin-vazhlivii-krok-yakii-bulo-zrobleno-na-pochatku-povnomasshtabnogo-vtorgnennya-rosiyi-v-ukrayinu-dlya-zabezpechennya-zv-yazku

89 https://digital-strategy.ec.europa.eu/en/library/joint-statement-eu-and-ukrainian-operators-help-refugees-ukraine-stay-connected

90 https://ec.europa.eu/commission/presscorner/detail/en/IP_22_2371

91 https://zakon.rada.gov.ua/laws/show/z0361-22#Text

92 https://nkrzi.gov.ua/index.php?r=site/index&pg=99&id=2300&language=uk

Spectrum policies

Rapid Issuance of spectrum temporary authorizations

In line with presidential Decree No.64 of February 2022 "On the introduction of martial law in Ukraine" approved by the law of Ukraine dated 24.02.2022 No.2102-IX "On the approval of the Decree of the President of Ukraine",[93] due to the mass migration and large concentration of people in rural and western border areas of Ukraine incurring significant increase in traffic and network load, based on corresponding requests from the mobile operators, the NCEC supported and NTNOC initiated the process of assigning the rights of temporary use of radio frequency bands *free of charge*, and *rent-free* (monthly rent for the relevant radio frequency bands would amount to UAH 24 million (about USD 656 301[94]) in the bands 1 935-1 940/2 125-2 130 MHz for Lifecell LLC, 1 940-1 945/2 130-2 135 MHz for Vodafone Ukraine PJSC and 1 945-1 950/2 135-2 140 MHz for Kyivstar PJSC for international mobile communications in 3G and 4G standards.[95]

In addition, the NCEC adopted Decisions No.3 dated 24.02.2022 "On the approval of the temporary procedure for the use of radio-frequency spectrum by special and general users during a special period and under conditions of emergency or the martial law"[96] and No.4 "On the approval of the temporary procedure for implementation of temporary restrictions on the use of radio equipment, radiating devices, radio-electronic means and special-purpose radiating devices in the entire territory of Ukraine or in particular regions thereof under emergency conditions or the martial law".[97]

Extension of the licence terms for the use of the spectrum

On 16 August 2022, the Verkhovna Rada of Ukraine adopted in the second reading draft law No. 7486 "On Amendments to Certain Laws of Ukraine Regarding the Improvement of Governance in the Field of Electronic Communications"[98] which, in particular, proposes to amend the Law of Ukraine "On Electronic Communications" by adding provisions on: automatic extension of validity for licences for the use of the radio-frequency spectrum and permits for the use of the numbering resource for the period of the martial law in Ukraine or in some of its localities, introduced in accordance with the Law of Ukraine "On the Legal Regime of the Martial Law", and within six months after termination or cancellation thereof licences for the use of the radio-frequency spectrum and permits for the use of the numbering resource; granting powers to the regulatory body to further extend validity after the expiry of the prior extension period; extension of the terms of validity of licences due to the martial law; extension of validity terms of permits for the use of the numbering resource in connection with martial law.

On the same date, draft Law No. 7487 on amendments to some legislative acts of Ukraine on ensuring conditions for the development and restoration of electronic communication networks was adopted.

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[93] https://zakon.rada.gov.ua/laws/show/2102-20#Text

[94] The National Bank of Ukraine, exchange rate on 07/09/2022

[95] https://nkrzi.gov.ua/index.php?r=site/index&pg=99&id=2250&language=uk

[96] https://nkrzi.gov.ua/index.php?r=site/index&pg=482&id=10036&language=uk

[97] https://nkrzi.gov.ua/index.php?r=site/index&pg=482&id=10037&language=uk

[98] https://itd.rada.gov.ua/billInfo/Bills/Card/39857

Minimization of the regulatory and reporting obligations of licensees

Taking into account the Law of Ukraine № 2115-IX "On the Protection of the Interests of the Entities Submitting Accounting Reports and Other Documents during the Period of the Martial Law or the State of War"[99] and the Law of Ukraine № 2118-IX "On Amendments to the Tax Code of Ukraine and Other Legislative Acts of Ukraine Regarding the Specifics of Taxation and Submission of Accounting Reports during the Period of the Martial Law",[100] on 4 February 2022, the NCEC issued an official clarification:

- Accounting reports covering the entire non-reporting period shall be submitted to the NCEC by providers of electronic communication networks and/or services in electronic form within three months after the termination or abolition of martial law or the state of war.

- During the period of martial law or a state of war, as well as within three months after its termination, administrative and economic sanctions provided for by the law of Ukraine 1089-IX "On Electronic Communications"[101] shall not be applied to providers of electronic communication networks and/or services for non-submission or late submission of the accounting reports.

- Providers of electronic communication networks and services that do not have the physical possibility to submit accounting reports within the period specified by the Law due to direct consequences of their involvement in hostilities are exempted from administrative and economic sanctions provided for by the Law of Ukraine "On Electronic Communications" and are to submit the reports no later than one month after the end of such consequences that made it previously impossible.

- During the period of martial law or the state of war, the NCEC does not control the timeliness and completeness of the accounting reports submitted.

- Providers of electronic communication networks and/or services that can submit accounting reports ahead of the time stipulated in paragraphs 1 and 3 of this clarification are advised to submit such reports within the established procedure through the Electronic Reporting System.

Table 3: Summary of spectrum policies

Spectrum policies	Indicator
- Rapid issuance of spectrum temporary authorizations	☑
- Accelerated spectrum allocations and assignments	☑
- Extension of spectrum license terms	☑
- Minimizing licensees' regulatory and reporting obligations	☑

Content distribution support measures

Ukraine has demonstrated remarkable TV and radio infrastructure resilience, offering free access to TV channels via alternative platforms, such as regional terrestrial multiplexes MUXes (1-5), satellite transmission with a receiver and a dish, Youtube via Internet, OTT boxes, and various online platforms, such as Diia.[102] Ukraine has been successful in all the indicators related to content distribution support measures.

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99 https://ips.ligazakon.net/document/t222115

100 https://ips.ligazakon.net/document/T222118

101 https://zakon.rada.gov.ua/laws/show/1089-20

102 https://cip.gov.ua/ua/news/u-misti-rivne-okupanti-obstrilyali-televezhu-koncernu-rrt

Table 4: Summary of content distribution support measures

Content distribution support measures	Indicator
- Government information and advisories	☑
- Television and radio stations disseminating health, safety, and educational content	☑
- Creation of local news platforms	☑
- Applications to disseminate health information	☑
- Commitments from social platform companies to limit spread of disinformation and fake news	☑

Private sector and civil society efforts to increase resilience

Advance preparation, planning, and stress tests

Having observed an accumulation of troops in the border areas of Ukraine a couple of months before the war started, the ICT sector of Ukraine took preparatory measures for increasing resiliency of the critical and telecommunication networks and systems in anticipation of a military attack.

Lifecell effectively utilized a plan of action drafted to respond to natural or manmade hazards, including armed military aggression, partly shaped and adjusted to reflect the events of 2014[103]:

- a coordination centre of employees responsible for various areas of company activities has been created;
- staff have been continuously trained and instructions have been given to strengthen cybersecurity;
- detailed recommendations have been given to staff in the event of an emergency;
- a close contact has been established with State authorities, specialized structural entities and security specialists for the prompt reaction to possible threats;
- office archives and documentation have been moved from the eastern to western offices of Ukraine;
- critical network equipment has been relocated and installed in western Ukraine by means of dynamic load distribution avoiding telecommunication service interruption;
- network redundancy has been addressed at the level of main elements and data transmission channels;
- network continuity action plans have been updated regularly.

All Lifecell development and planning since 2014 have anticipated the possibility of a military scenario, and Kyivstar and Vodafone Ukraine took extensive precautionary advance measures of strengthening system and network infrastructure resilience for an emergency situation, for example[104]:

- a plan for rapid response to possible incidents and problems was developed;
- bandwidth of the fixed network was augmented and tested for resistance to extreme loads;

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[103] https://vctr.media/ua/mobilnij-zvyazok-pid-chas-vijni-yak-lifecell-pid-obstrilami-remontuye-bazovi-stancziyi-139649/

[104] https://www.bbc.com/ukrainian/features-61120584

- radio network capacity was increased in western Ukraine;
- backup communication nodes and channels of the transport network in Ukraine and beyond were organized;
- in order for repair works to be carried out promptly, additional supplies of network and auxiliary equipment and spare parts were acquired in advance.

Availability measures

Acceptable level of service

In the first few days of the war, traffic fluctuations and load on some networks increased by 30 to 50 per cent, reaching peak values of network congestion[105].

Urban to rural mass migration of mobile-cellular and mobile-broadband users as well as relocation of subscribers and businesses to western regions of the country incurred changes of adoption and usage patterns of telecommunication services and created an immediate need to redesign network architecture such as by deploying new base stations and by increasing bandwidth.

The network load has been rebalanced and eventually returned to a normal state due to exceptional resilience of the market and the ICT network infrastructure through:

- instant re-routing, i.e. traffic engineering and redistribution towards other service provider networks;
- introduction of speed throttling for private subscribers and some bandwidth-hungry applications;
- prioritization of service availability for the Ukraine military and critical infrastructure facility use;
- instant restoration of damaged infrastructure by network providers;
- operation of isolated base stations with diesel generators.

Although most of the war-affected areas of Ukraine suffered devastating destruction and loss of both mobile communications, and fibre-optic cable infrastructure, the resilience of the telecommunication network was restored and strengthened through access to Elon Musk's Starlink, a low-Earth orbit space technology operating with over 3 000 satellites located at an altitude of 540 to 570 km above the earth's surface and providing high-speed Internet with download rates exceeding 136 Mbit/s and median latency of just 43 milliseconds.[106]

Around 12 000 terminals (transceivers) have been delivered to Ukraine upon the request of the Ministry of Digital Transformation, the software of which has been upgraded to avoid signal jamming (interference) between the terminal and a satellite and adapted for use on a battlefield. A firmware update enabled terminals to be powered by a car cigarette lighter socket[107], allowing officials and citizens of war-affected territories to communicate with each other and the world.[108] Some of the fixed and mobile base stations of the largest operators were upgraded and connected to the Starlink satellite transport network to restore mobile network coverage in the remote and inaccessible war-affected territories of the country.

Table 5 summarizes availability measures taken by fixed and mobile network operators and Internet service providers to support network resilience in Ukraine.

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[105] https://mind.ua/openmind/20244781-pochuti-vsih-z-yakimi-problemami-stikayutsya-operatori-v-nalagodzhenni-zvyazku

[106] https://www.bbc.com/ukrainian/news-60583913

[107] https://www.wired.com/story/starlink-ukraine-internet/

[108] https://www.cnbc.com/2022/05/02/ukraine-official-150000-using-spacexs-starlink-daily.html

Table 5: Summary of availability measures

Availability measures	Indicator
- Acceleration of network deployments/restoration in urban/rural areas	☑
- Release of additional capacity on mobile, fixed, wireless and satellite networks	☑
- Expedited deployment of fixed-wireless networks	☑
- Extended connectivity for health care providers and schools	☑
- Waiver of rights-of-way fees	No data

Affordability measures

Telecommunication market self-regulation and resilience

Market self-regulation and self-consistency was observed in March 2022, when network operators switched to bypass mode, allowing uninterrupted telecommunication services to users who could not otherwise afford them. The numbers reached almost 420 000 individuals or 35 per cent of users with zero balance on their account. At the same time, the forced migration of citizens abroad has reduced significantly the number of active users and revenues.[109]

The ICT sector has been actively involved in humanitarian programmes and activities, providing direct humanitarian aid to the population through various public and private platforms. Within the framework of the United-24 fundraising platform initiated by the president of Ukraine, Kyivstar has committed to allocating UAH 300 million (about USD 8.2 million[110]) for the modernization and construction of the State's digital infrastructure, development of new technologies and strengthening of the State's cyberdefence systems.[111] This is in addition to UAH 33 million (about USD 902 414[111]) that has been already transferred to charitable funds and UAH 420 million (about USD 11.5 million[111]) of free services provided for its subscribers.

As of the end of April 2022, Vodafone Ukraine was reported to have connected 13 million subscribers to free services inside Ukraine, worth of UAH 230 million (about USD 6.3 million[111]) and offered free services (including roaming) for its customers located abroad, worth of UAH 330 million (about USD 9 million[111]). Within the framework of partnership and cooperation with the State authorities, the company sent 170 million information SMS, as well as UAH 160 million (about USD 4.4 million[111]) of humanitarian and direct financial aid.[112]

Lifecell has been supporting its subscribers with a number of basic telecommunication services at no additional charge. The operator has been providing an additional 60 minutes a day to numbers in Ukraine to its subscribers. In addition, subscribers who were forced to leave Ukraine received 5 GB of mobile Internet in 30 countries around the world within the period of March and April 2022. Additional equipment has been installed in temporary bomb shelters to improve mobile network access.[113]

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[109] https://mind.ua/publications/20239534-internet-provajderi-pid-chas-vijni-bezlich-poshkodzhen-vidnovlyuemo-merezhi-247-tarifi-ne-pidvishchuemo

[110] The National Bank of Ukraine, exchange rate on 07/09/2022

[111] https://kyivstar.ua/uk/mm/news-and-promotions/kyyivstar-vydilyaye-300-milyoniv-gryven-dlya-vidnovlennya-cyfrovoyi

[112] https://www.vodafone.ua/news/rezultati-vodafone-u-1-kvartali-2022-roku-vpliv-viyni

[113] https://www.lifecell.ua/en/announcements/739

Table 6 summarizes the affordability measures taken by public and private entities in support of the market resilience of the country.

Table 6: Summary of affordability measures

Affordability measures	Indicator
– Discounted services and devices for low-income consumers	☑
– Commitment not to shut off service for unpaid bills	☑
– Free connectivity at community centres	☑
– Free outdoor public Wi-Fi hotspots	☑
– Free 4G/Wi-Fi routers for students*	☑
– Zero-rated education and other content	☑
– Reduced sale tax on broadband services	No data
– Free device charging schemes	☑

* The Ministry of Digital Transformation is launching a free Wi-Fi network project in the shelters of educational institutions. The primary plan is to cover general educational institutions: schools, gymnasiums, lyceums; eventually covering, kindergartens and vocational schools. The project is implemented with donations from equipment manufacturers and Internet providers.[114]

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[114] Answers to the ITU Assessment Report Questionnaire designed for the State Authorities

VII. Data collection and validation

VII.I ITU data status

ITU is the official telecommunication agency of the United Nations tasked, among other things, to collect and be the central source for ICT statistical data. With this system in place, ITU ensures the quality and reliability of all data collected from governmental bodies, such as ICT ministries, national regulatory authorities and national statistical offices. ITU collects data through questionnaires including ICT infrastructure and access data), price data and data on access to and use of ICTs by households and individuals.

In relation to ITU collected data required for this assessment report, the 2022 data collection will not be available until 2023.

In other words, even though this assessment report extensively utilized and analysed all the available sets of ITU data for Ukraine, information for 2022 was transmitted by Ukraine to ITU via a specifically designed questionnaire.

VII.II Broadband coverage and availability data

In times of natural or man-made disasters, the instant universal access to reliable and affordable digital and critical ICT infrastructure and services is of primary importance and reflects the changed needs of the local population.

Meaningful connectivity depends on a number of factors. The most important are availability and affordability as these are also the strongest determinants of another factor of connectivity, uptake. Looking more in depth at these three dimensions, the ITU report on "The status of connectivity in nine non-EU countries of Europe region"[115], prepared in the context of the ITU Regional Forum for Europe on Meaningful Connectivity[116] held in March 2021, gives a retrospective view at how these factors evolved and shows Ukraine's position compared to regional peers.

Three criteria prove particularly indicative with regard to the availability of connectivity, and this is where Ukraine witnessed an extension of services, both demographically and geographically, achieving significant improvements over the past years in important indicators.

Percentage of the population covered by at least an 4G/LTE/WiMAX mobile network

According to the latest ITU data, 91.6 per cent of the total population of Ukraine was covered by at least 3G mobile cellular network in 2021 and the same per cent of the individuals were located within a range of LTE/WIMAX cellular network.

The results of 2021 showed that coverage of Ukraine by 4G networks in the 900 MHz, 1 800 MHz and 2 600 MHz radio frequency bands was significantly expanded by Vodafone Ukraine PJSC, Kyivstar PJSC and Lifecell LLC. The expansion took place due to the increase in the coverage of 4G communication both in populated areas of Ukraine and along main roads. As part of the development of their activities, mobile network operators are gradually introducing technological innovations that allow expansion of the list of services provided to consumers.[117]

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[115] https://www.itu.int/en/ITU-D/RegionalPresence/Europe/Documents/Events/2021/Meaningful%20Connectivity/Report%20-%20The%20Status%20of%20Connectivity%20in%209%20non-EU%20countries%20of%20Europe%20region_final_clean.pdf

[116] https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Pages/Events/2021/MC/Default.aspx

[117] NCEC 2021 Annual Report

Figure 4: Population coverage by 4G mobile communication technology in 2021

Source: NCEC 2021, Ukraine

As of 31 December 2021, the highest percentage of settlements covered by 4G networks included Kyiv, Chernihiv, Sumy, Kharkiv, Poltava, Lviv, Khmelnytskyi, Zhytomyr and Vinnytsia regions, and with the lowest - Donetsk, Luhansk, Zakarpattia and Chernivtsi regions (Figure 4).

Ukraine is one of two non-EU countries of the Europe region with less than a 95 per cent coverage rate. Nevertheless, it exhibited extraordinary growth in coverage over the period from 2015 to 2021, with no 4G coverage in 2015, to 78.1 per cent of the population covered in 2019, 87.15 per cent in 2020, and 91.6 per cent in 2021.

There is a noticeable deterioration of 4G mobile communication coverage in the war-affected regions of the country.

Table 7: Impact of the war on population coverage with 4G mobile communication technology

| % of population with 4G coverage			
The largest operators of mobile communication services	January 2022	May 2022	July 2022
Mobile Operator 1	97%	93%	89%
Mobile Operator 2	89%	86%	84%
Mobile Operator 3	75%	71%	70%

Source: Ministry of Digital Transformation of Ukraine

During the period of martial law in Ukraine, the 4G coverage maps were temporarily unavailable for security reasons.

The estimated proportion of households with Internet access at home

The availability of Internet at home is a challenge in Ukraine. About 21 per cent of households remained without Internet as of 2020, placing the country among the three least advanced regional peers for that year. However, there has been a stable increase of coverage since 2011 with an average yearly growth of 5.6 percentage points. As a result, the share of Internet availability in households reached 65.8 per cent in 2019, and 79.3 per cent in 2020 (Figure 5), with 86 per cent of urban and 66 per cent of rural distribution, surpassing the world average of 65.7 per cent in 2020.

In December 2021, only 5.3 per cent of households in populated areas have been reported not having technical means to access fibre-optic networks, whereas in February 2022 this indicator decreased to 3 per cent. (the specified data are given without a financial assessment of uptake capability of the households).[118]

Figure 5: Households with Internet access at home in 2020
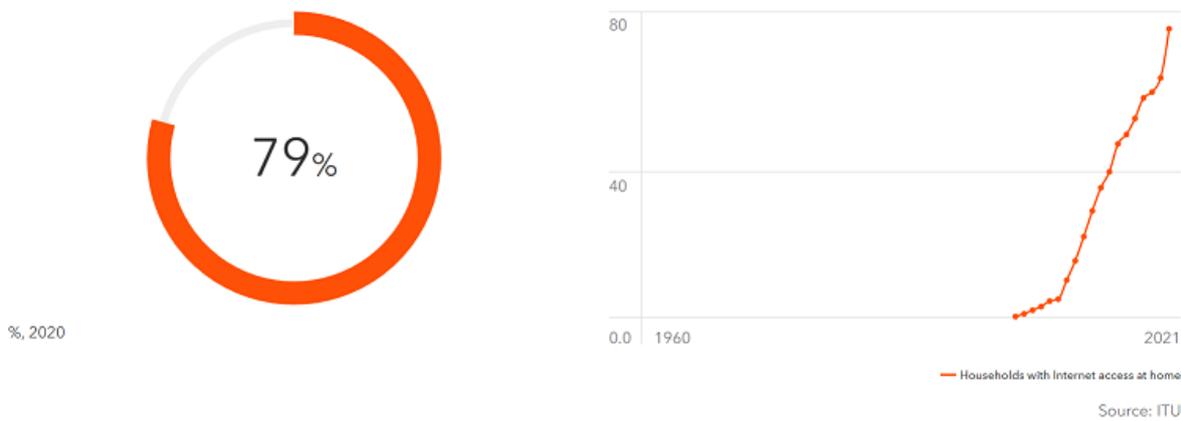
Source: ITU

Number of fibre connections per 100 inhabitants

This parameter, though closely related to uptake, seeks to provide an indication on reliable Internet penetration at the premises level (home or business), relative to the number of citizens.

Figure 6: Fixed-broadband subscriptions by technology in 2020
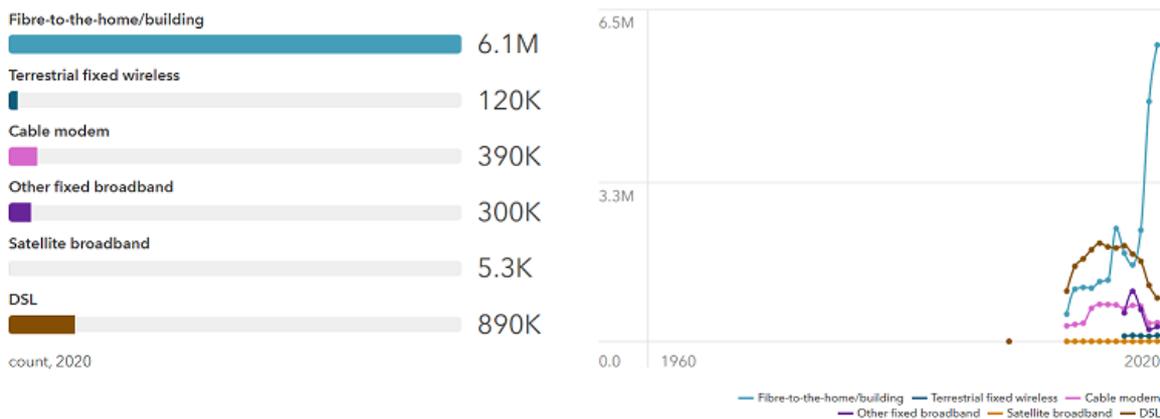
Source: ITU

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[118] Answers to the ITU Assessment Report Questionnaire designed for the State Authorities

Fixed-broadband access in Ukraine is provided using a mixture of technologies, namely optical fibre, copper communication lines, coaxial cable, satellite channels and wireless access, where the largest share is made up of the connections using FTTx and xPON technologies. In 2020, Ukraine reported almost 6.1 million FTTH/B (Figure 6) subscriptions, up from 4.91 million in 2019. According to the NCEC 2021 Annual Report, FTTx connections amounted to 4.1 million lines and xPON connections to 2.3 million, constituting 54 per cent and 30.3 per cent of all connections.

VII.III   Affordability data

Ukraine provides relatively affordable Internet access when applying the Broadband Commission target for prices of entry-level broadband services to be kept below 2 per cent of monthly GNI p.c.

In 2021, the data-only mobile broadband basket cost was 1.47 per cent of GNI p.c. for a monthly allowance of 2GB (Figure 7), which ranked the country 85th globally (up from 2020, with 1.54 per cent of GNI p.c. and a global ranking of 89th place)[119].

Figure 7: Data-only mobile broadband basket in 2021
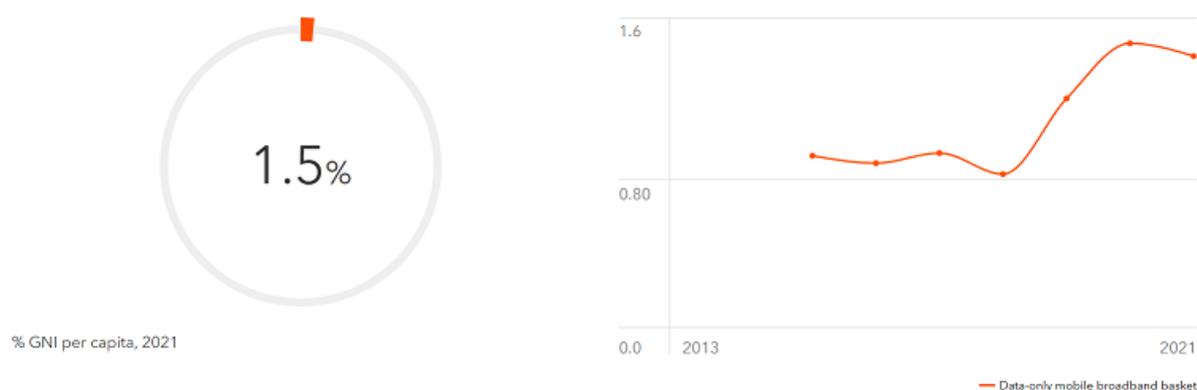
Source: ITU

Meanwhile, in 2021 the country was ranked 57th globally based on fixed-broadband basket cost of 1.76 per cent of GNI p.c. for a 5GB Internet data cap (Figure 8), (down from 56th place in 2020, with the fixed-broadband basket cost of 1.60 per cent of GNI p.c., for a 5GB Internet data cap)[120].

Figure 8: Fixed-broadband basket in 2021
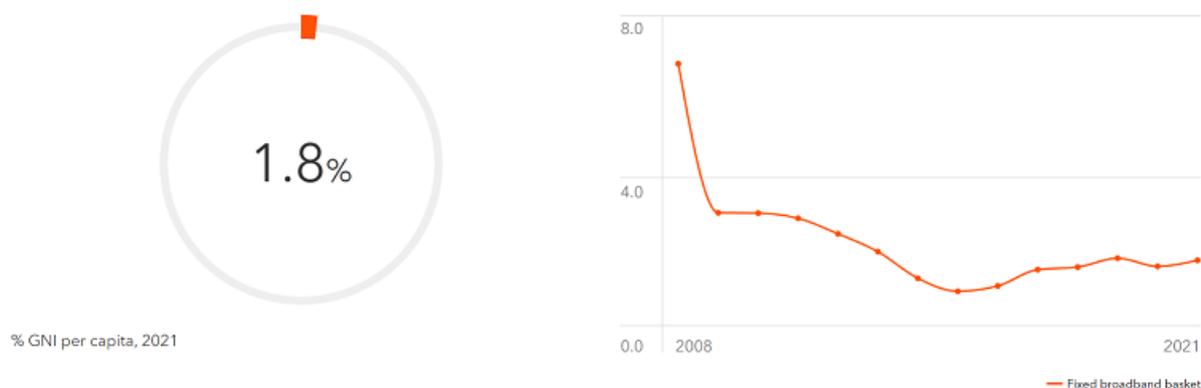
Source: ITU

Even though the country achieved the Broadband Commission affordability target of 2 per cent for both the data-only mobile-broadband and fixed-broadband basket costs, Ukraine is still far from reaching the Europe

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[119] https://www.itu.int/en/ITU-D/Statistics/Dashboards/Pages/IPB.aspx

[120] https://www.itu.int/en/ITU-D/Statistics/Dashboards/Pages/IPB.aspx

region average of 0.51 per cent nor the world average of 1.25 per cent of monthly GNI per capita on data-only mobile broadband basket cost, and 1.28 per cent of GNI per capita on fixed-broadband basket cost.[121]

Moreover, the in-depth analysis revealed that there is a significant part of the population that could not afford broadband in the Eastern part of Europe. In Ukraine, the share of the population who cannot afford any of the baskets is around 30 per cent.[122]

VII.IV   Broadband adoption and usage

Connectivity uptake is reflected in the quantity of subscriptions to broadband plans as well as the ubiquity and use of Internet-connectivity capable devices. Ukraine has a weaker position in comparison to regional peers, even though it demonstrated relatively good performance on the affordability and availability indicators.

Fixed-broadband subscriptions per 100 inhabitants

Over the last decade, the number of fixed-broadband subscriptions in Ukraine in absolute figures grew from 3.2 million to 7.6 million, with a slight decline of numbers in 2021 compared to the peak of 7.8 million subscribers registered in 2020, and the per 100 inhabitants indicator showed growth with a compound annual growth rate (CAGR) of 10.14 per cent.

Figure 9: Fixed-broadband subscriptions per speed tier and in absolute figures
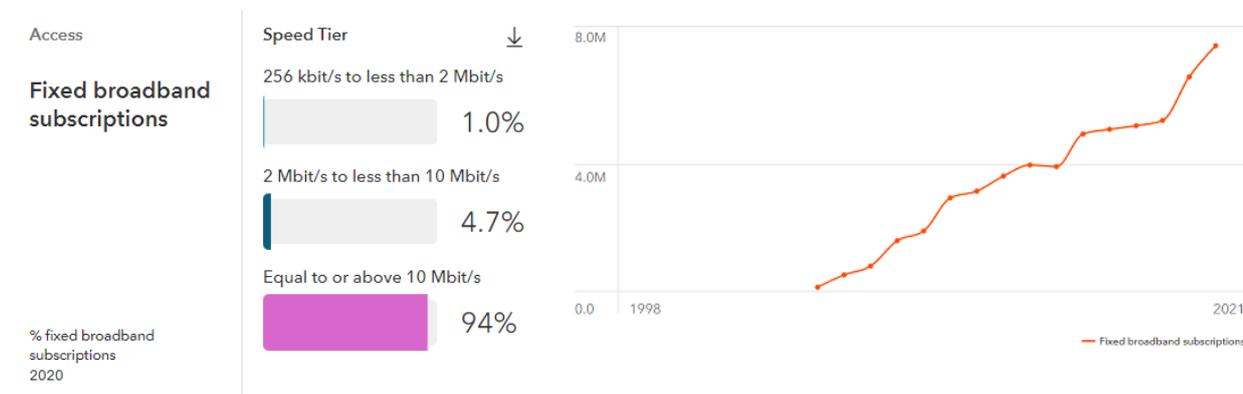
Source: ITU

Meanwhile, the number of active mobile-broadband subscriptions per 100 inhabitants during the same period has registered an annual growth with a CAGR of 33.7 per cent.[123]

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[121] https://www.itu.int/en/ITU-D/Statistics/Dashboards/Pages/IPB.aspx

[122] https://www.itu.int/en/ITUD/Statistics/Documents/publications/prices2020/ITU_ICTPriceTrends_2020.pdf

[123] https://www.itu.int/en/ITUD/Statistics/Dashboards/Pages/Digital-Development.aspx

Figure 10: Fixed-broadband subscriptions per 100 inhabitants in Ukraine vs Europe and World in 2020
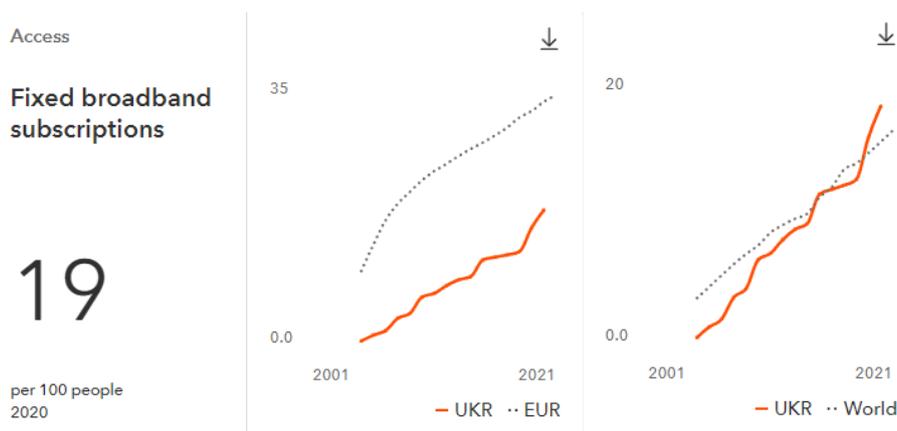
Source: ITU

In 2021, Ukraine reported 18.27 fixed-broadband subscriptions per 100 inhabitants, down from 18.62 in 2020 (Figure 10), exceeding the world average of 16.7 fixed-broadband subscriptions per 100 inhabitants, but still behind the Europe average of 34.7 for the same year.

Active mobile-broadband subscriptions per 100 inhabitants

Even though, in 2020, the number of active mobile-broadband subscriptions per 100 inhabitants reached 85.3, which represented an increase of almost 81 per cent compared to 2018 and surpassed the world average of 77.3, this result still fell below the Europe region average of 101.5 subscriptions per 100 inhabitants for the same year (Figure 11).

Figure 11: Active mobile-broadband subscribers per 100 inhabitants in Ukraine vs Europe and World
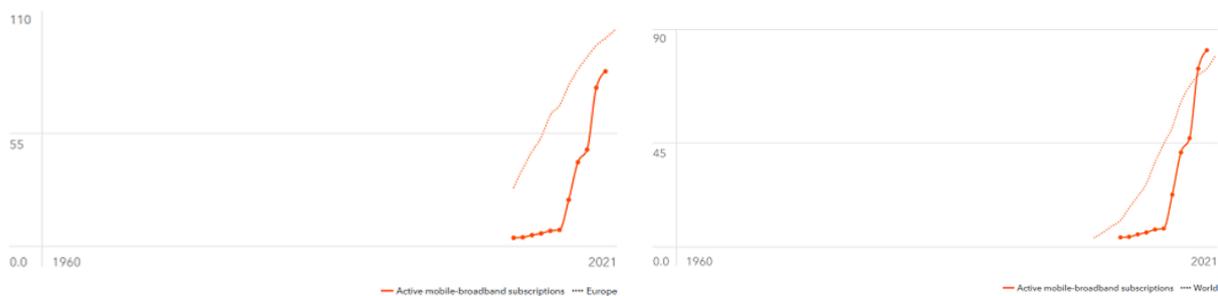
Source: ITU

The numbers experienced a downward trend in 2021 registering 80.12 active mobile-broadband subscriptions per 100 inhabitants, falling behind the world average of 83.2 and European average of 105.3. This can be explained by the roll-out of fixed-broadband networks and respective service availability.

Figure 12: Active mobile-broadband subscriptions in absolute numbers and by type in 2020
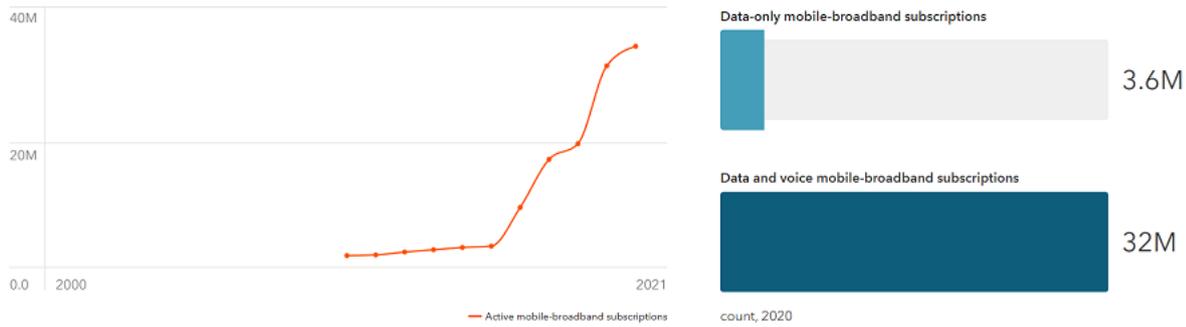
Source: ITU

With the total number of mobile-cellular subscriptions of almost 56 million and active mobile-broadband subscriptions at above 33 million in 2021, the number of mobile-cellular subscriptions per 100 inhabitants was 135.03 (up from 121.94 in 2011), whereas mobile-broadband subscriptions per 100 inhabitants dropped to 80.12.

Estimated proportion of households with a computer

The pattern of moderate but stable increases is observed in the case of the share of estimated proportion of households with a computer. In 2020, this share reached 66.2 per cent, with 75 per cent urban and 47 per cent rural distribution, experiencing a CAGR of 7.8 per cent since 2011. Between 2015 and 2018, the average CAGR for the nine non-EU countries of Europe was 0.6 per cent. However, Ukraine was among six countries that demonstrated positive growth.

Figure 13: Estimated proportion of households with a computer in 2020
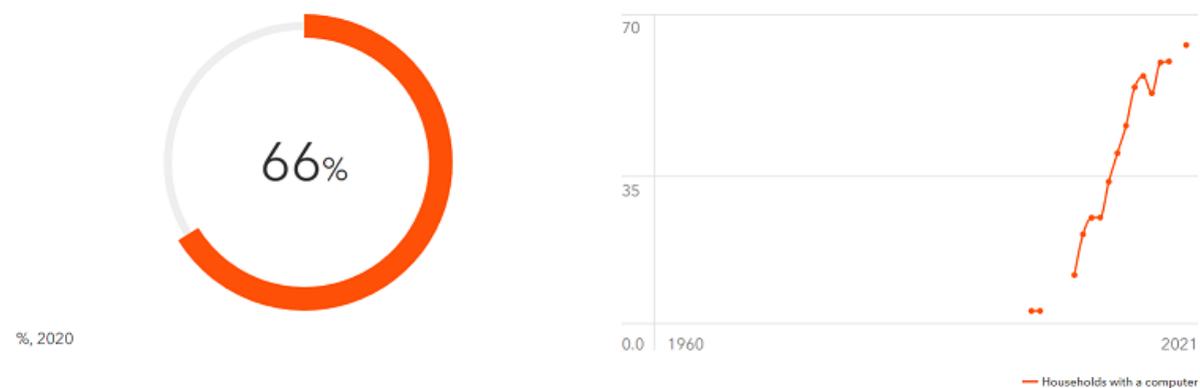
Source: ITU

Internet users (as per cent of the population)

ITU data reports that 75.04 per cent of people in Ukraine used the Internet in 2020[124]. The number of Internet users has grown steadily over the past decade with an average of 5 per cent (rounded) increment per year.

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[124] https://www.itu.int/en/ITUD/Statistics/Pages/stat/default.aspxhttps://www.itu.int/en/ITU-D/Statistics/Dashboards/Pages/Digital-Development.aspx

Figure 14: Individuals using the Internet in Ukraine vs Europe and World
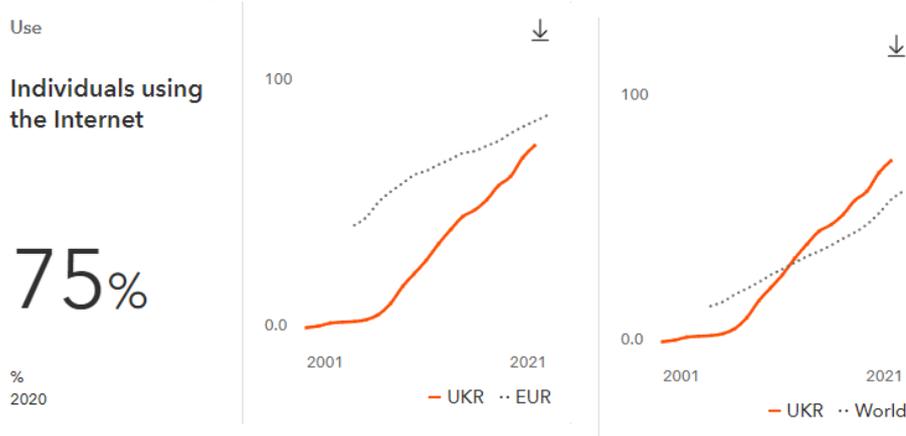
With this trend, the estimated figures for Internet users for 2021 and 2022 are expected to be between 80.2 per cent and 85.3 per cent, approaching the Europe region average of 87.2 per cent for 2021[125]. Over the span of the last five to six years, the number of individuals surfing the Internet at least once per week has grown by almost a quarter of the total population of the country.

Figure 15 shows a comparison of basic indicators of ICT access and usage in Ukraine during the years 2015, 2017, 2019, 2021.

Figure 15: The basic indicators of ICT access and usage in Ukraine
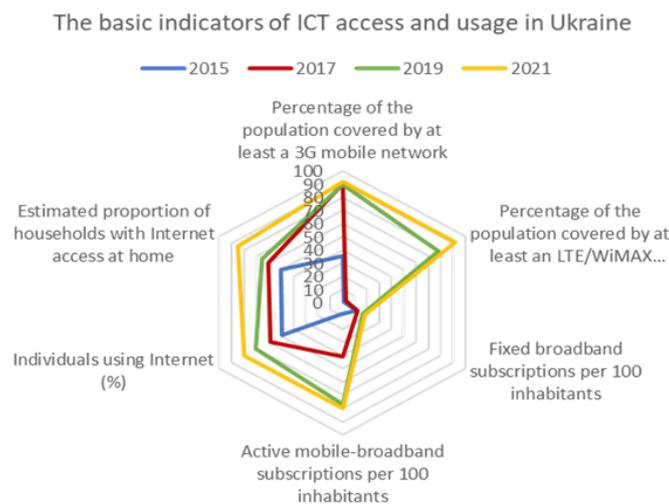
Table 8 summarizes a set of ITU telecommunication and Internet indicators that reflect Ukraine's position in a European and global context (encompassing 46 countries of Europe region[126][127]). While on many fronts, Ukraine finds itself well above World averages, there remains a non-negligible gap on some key indicators for Europe region averages.

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125 https://www.itu.int/en/ITUD/Statistics/Documents/facts/FactsFigures2020.pdf

126 https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Pages/MemberCountriesEurope.aspx

127 https://www.itu.int/en/ITU-D/Statistics/Documents/facts/FactsFigures2021.pdf

Table 8: Key ICT Indicators in Ukraine in comparison to the European and World average

Key indicators (2021)	Ukraine	Europe	World
Fixed-telephone subscribers per 100 inhabitants	5.51	31.2	11.2
Mobile-cellular subscribers per 100 inhabitants	135.03	118.2	109.9
Active mobile-broadband subscribers per 100 inhabitants	80.12	105.3	83.2
Coverage by at least 3G (% of population)	91.60	98.5	95.0
Coverage by at least LTE/WiMAX (% of population)	91.60	98.7	87.6
Individuals using the Internet (%)	75.04*	87.2	62.5
Households with Internet access at home (%)	79.25*	87.6*	65.7*
Fixed-broadband subscribers per 100 inhabitants	18.27	34.7	16.7
Fixed-broadband subscribers by speed tiers, % distribution:			
– 256 kbit/s to 2 Mbit/s	1.0*	0.3*	1.8*
– 2 to 10 Mbit/s	4.7*	6.4*	6.7*
– equal to or above 10 Mbit/s	94*	92.3*	89.9*

* Latest data available for 2020

Source: ITU[128][129]

VII.V   Community anchor locations

Higher education institutions are fully connected to high-speed broadband Internet, reinforced by a fully-fledged 230 km Ukraine Research and Academic Network (URAN) integrating over 100 R&D and educational institutions (220 points of presence), operating its own 300 km long metropolitan area fibre-optic network in 16 Ukraine cities and 80 km cross-border fibre-optic lines from Lviv to the Ukraine-Poland border.[130]

Vocational education institutions, youth centres[131] and network of education hubs, State institutions and buildings, some industrial enterprises and institutions of the National Academy of Sciences of Ukraine have full access to broadband network connectivity through the Ukraine Academic and Research Network (UARnet[132]), which operates in all regional centres of the country through backbone nodes interconnected by 10 Gbit/s data transmission channels via the Internet traffic exchange network UA-IX. Total capacity of external channels of the Uarnet network is more than 100 Gbit/s.

According to the official statistics of the State Statistics office of Ukraine[133], as of 5 September 2021, the state of connection to the Internet of general secondary education institutions is shown in Table 9.[134]

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[128] https://www.itu.int/en/ITUD/Statistics/Dashboards/Pages/Digital-Development.aspx

[129] https://www.itu.int/en/ITU-D/Statistics/Documents/facts/ITU_regional_global_Key_ICT_indicator_aggregates_Oct_2021.xlsx

[130] URAN - General information

[131] Перелік Центрів України (youthcenters.net.ua)

[132] Про Уарнет - Уарнет (uar.net)

[133] https://ukrstat.gov.ua/

[134] Answers to the ITU Assessment Report Questionnaire designed for the State Authorities

Table 9: The state of connection to the Internet of general secondary education institutions

Category	Number	Percentage
Public and private general secondary education institutions (total)	13 991	100
Public and private general secondary education institutions connected to the Internet	13 979	99.91
General secondary education institutions with an Internet speed of 100 Mbit/s and more:	2 672	19.10
wireless access	2 046	14.62
broadband access	2 376	16.98
using wireless and broadband access at the same time	1 750	12.51
General secondary education institutions with an Internet speed of less than 100 Mbit/s:	11 307	80.82
including less than 30 Mbit/s	3 045	21.76
FTTx, PON, ETTN fibre-optic cable	8 580	61.33
Other connection technologies	5 399	38.59

Source: SSSCIP

Access to the resources of the non-Ukraine segment of the Internet is provided both through upstream providers ("Level3", "Global Crossing", "Cogent", "RETN") and through European Internet traffic exchange nodes "DE-CIX", "AMS-IX ", "PL-IX", "SL-IX" and parity channels with European trunk providers. UARnet also has a direct 10 Gbit/s access channel to Poland's NREN PIONIER academic network.

For primary and secondary educational institutions, 99.9 per cent of public and private schools are connected to the Internet, of which 19 per cent have access to speeds of 100 Mbit/s and above, through FTTX, PON, ETTN fibre-optic technologies.

Other community anchor points are being connected via the State fibre-optic deployment programme called Internet Subvention. As of August 2022, around 7 178 institutions of social infrastructure were connected to high-speed Internet and covered by Wi-Fi networks for the first time, among them: more than 1 000 schools, 622 preschool education institutions, 2 174 cultural centres, 11 art schools, 958 libraries, 1 855 dispensaries, 20 hospitals, 63 fire departments, 6 police stations, and 453 institutions in charge of administrative services (CPAs, village councils, etc.).

The Internet Subvention programme dashboard is constantly updated with the newly connected social institutions and facilities (Figure 16).

Figure 16: Internet Subvention Dashboard: Social institutions connected to the optical network
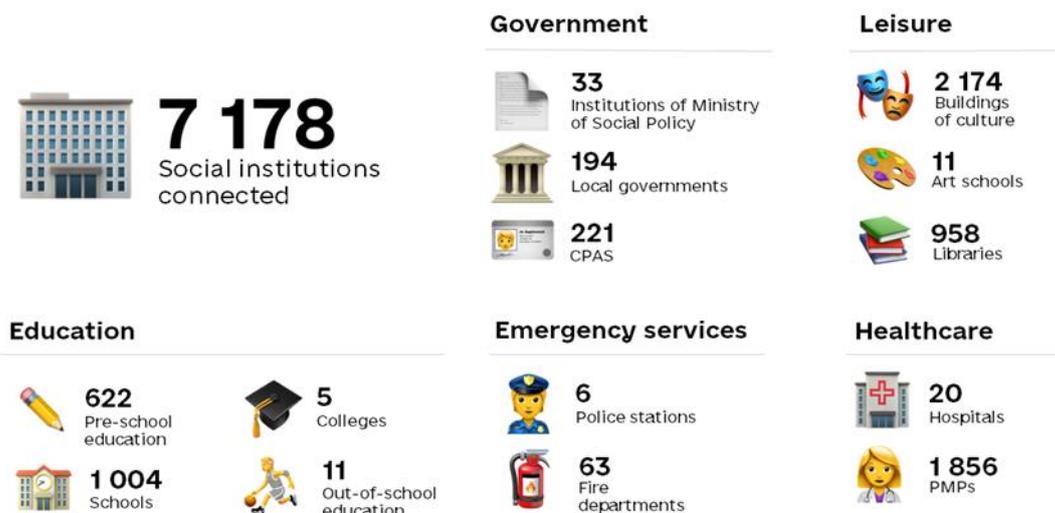
When the Internet Subvention programme was launched, only 86.7 per cent of preschool and secondary educational institutions were located in settlements with fibre-optic connections, whereas in 2022 that figure had increased to 92.2 per cent.

In August 2022, the Ministry of Digital Transformation announced an initiative aiming at improving digital resilience of community anchor points, such as kindergartens, schools, vocational schools, colleges, universities and temporary shelters. This included the distribution of routers and the necessary equipment for high-speed Internet received free of charge from telecommunication companies.[135]

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[135] https://thedigital.gov.ua/news/wi-fi-v-ukrittyakh-osvitnikh-zakladiv-yak-doluchitisya-do-proektu-mintsifri

VIII.   Policy and regulation

VIII.I   National strategies

In 2018, there was a marked prioritization of the ICT industry by the Government of Ukraine, when various ICT programmes for public health care, education, finance, taxation, transportation, and entrepreneurship were put in place.[136]

In January 2018, the Government of Ukraine and the State Agency for E-Governance of Ukraine published the Digital Agenda for Ukraine 2020 (digital strategy) that set out the basic principles for the establishment and basis for the development of legal regulation of the digital space. This digital strategy identified priorities for innovative public policy for the next four years: i) telecommunication and ICT infrastructure; ii) digital skills; III) e-market; iv) digital governance; v) innovation and R&D; vi) trust and cybersecurity; vii) benefits from ICT for society and the economy.[137][138]

To validate and accelerate implementation of the strategy, the Concept of Development of the Digital Economy and Society of Ukraine for 2018-2020 and the Plan of Measures for its implementation was approved by Order No.67-p of the Cabinet of Ministers of Ukraine. The main goal of these documents is to remove barriers to the digital transformation of Ukraine.[139]

The document established the priority sectors and suggestions for digital development in Ukraine, with a particular focus on: a) stimulating the economy and attracting investments, b) the basis for the transformation of domestic industries into competitive and efficient ones due to their "digitalization", c) solving the problem of the "digital divide", bringing "digital" technologies closer to citizens, including by ensuring citizens' access to broadband Internet, especially in villages and small towns, d) creation of new opportunities for realization of human capital, development of innovative, creative and "digital" industries and businesses, e) development of export of "digital" products and services (IT outsourcing). [140]

Relevant strategic directions reflected in the normative legal acts aimed at addressing the defined objectives include:

-   Decree of the President of Ukraine No. 497/2019 of 8 July 2019 "On some measures to improve access to mobile Internet";

-   Order of the Cabinet of Ministers of Ukraine No. 1272-r dated 4 December 2019 "On Approval of the Action Plan on Creation of Conditions for Development of Mobile Broadband Access";

-   Order of the Cabinet of Ministers of Ukraine dated 4 December 2019 No. 1413-r "On Approval of the Action Plan on Deregulation of Economic Activities and Improvement of Business Climate";

-   Decree of the President of Ukraine No. 242/2019 of 17 May 2020 "On ensuring conditions for the implementation of mobile communication system of the fifth generation";

-   Order of the Cabinet of Ministers of Ukraine No. 1189-r of 30 September 2020 "On approval of the action plan to improve the quality of mobile communications services for 2020-2022".

In 2019, Ukraine was included in the European Commission's Digital Government Factsheets 2019, thus becoming the fourth non-EU or European Free Trade Association country to cover the review. This marks huge progress in digital services achieved as part of the implementation of "*The Strategy for Integration into*

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[136] https://joinup.ec.europa.eu/sites/default/files/inline-files/SC64_D05.01_Digital_Government_Factsheets_Ukraine_vFINAL2_0.pdf

[137] http://www.e-ukraine.org.ua/media/Lviv_Minich_2.pdf

[138] https://www.itu.int/dms_pub/itu-d/opb/pref/D-PREF-THEM.19-2021-PDF-E.pdf

[139] https://www.kmu.gov.ua/npas/pro-shvalennya-koncepciyi-rozvitku-cifrovoyi-ekonomiki-ta-suspilstva-ukrayini-na-20182020-roki-ta-zatverdzhennya-planu-zahodiv-shodo-yiyi-realizaciyi

[140] https://zakon.rada.gov.ua/laws/show/67-2018-%D1%80?lang=uk#Text

the EU Single Digital Market and the Plan of Measures for its Implementation", developed as stipulated in Annex XVII to the EU-Ukraine Association Agreement, particularly in the electronic communications sector.

The main strategic policy documents in the field of electronic communications, apart from the legislative framework, are:

- *The Programme of Activities*, approved by Resolution No. 471 of the Cabinet of Ministers of Ukraine in June 2020,[141] with the objectives covering:

    a) development of Internet access networks, creation of conditions for the fourth and fifth generations mobile technologies;

    b) provision of access to high-speed Internet access for social infrastructure institutions, local authorities and citizens;

    c) creating opportunities for the development of fibre-optic networks by improving the legislation on the conditions of providers and access to the infrastructure;

    d) bringing to European standards of operator's equipment emission standards, certification of subscriber equipment and quality indicators;

    e) monitoring the Internet coverage of the territory of Ukraine and the quality of broadband access to the Internet;

    f) optimizing the use of radio frequency resource;

    g) improvement of State backbone optical networks management;

    h) simplifying working conditions for small and medium-sized operators and telecommunication providers;

    i) increasing access and empowering people to use the Internet safely and effectively, both for personal development and for running their own businesses, by improving digital skills.

- *The National Economic Strategy* for the period until 2030, approved by Resolution No. 179 of the Cabinet of Ministers of Ukraine in March 2021,[142] with a goal of "Ensuring development of competitive telecommunication market providing high quality ICT services", achievement of which envisages: improvement of telecommunication infrastructure, introduction of new technologies in telecommunications, support for construction of telecommunication infrastructure in commercially unprofitable regions, optimization of tariffs and rents for the radio frequency resource and improvement of legislation and regulation of the sector.

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[141] https://zakon.rada.gov.ua/laws/show/471-2020-п#Text

[142] https://zakon.rada.gov.ua/laws/show/179-2021-п#Text

Currently the goals of the broadband development and penetration are set out in Table 10.

Table 10: Broadband development and penetration goals

Digital Economy dimension	MDTU CMU Program* 2023	Goals 2023	UA Economic Strategy 2030 **	Goals 2030
Connectivity	Informatization of society (development of Internet connectivity)	- 95% of the population has mobile broadband access with a speed of at least 2 Mbit/s - 75% of households use fixed broadband Internet access at a speed of at least 30 Mbit/s - 95% of rural households have the technical ability to connect to fixed broadband Internet access at a speed of at least 100 Mbit/s - 95% of social infrastructure institutions and local governments are connected to broadband Internet access at a speed of at least 100 Mbit/s	Ensuring development of a competitive telecommunication market that provides high quality ICT services.	- 95% of the population has mobile broadband access with a speed of at least 50 Mbit/s - 75% of households use fixed broadband Internet access at a speed of at least 100 Mbit/s - 99% of the population of Ukraine is provided with the technical ability to connect to fixed broadband access at a speed of 1 Gbit/s - 99% of social infrastructure institutions and local governments are connected to fixed broadband access at a speed of at least 1 Gbit/s.

* Programme of Activities of the Cabinet of Ministers of Ukraine, approved by Resolution No. 471, of 12 June, 2020

** The National Economic Strategy 2030, approved by the Cabinet of Ministers of Ukraine by the Resolution No. 179 of 3 March 2021

Source: SSSCIP

Furthermore, for the purpose of extending broadband services outside of the economically profitable urban centres to rural and remote areas, closing the broadband coverage gap at the level of public institutions and individual households and improving broadband affordability and penetration, the Ministry of Digital Transformation developed an Action Plan for the Development of Broadband Internet Access for 2021-2022, approved by the Decree of the Cabinet of Ministers of Ukraine dated 08.09.2021 No. 1069-p.[143] The main objective of the Action Plan is to provide universal broadband coverage for all the citizens, with speeds of at least 100 Mbit/s, upgradable to gigabit speed by 2030. To implement the Action Plan, amendments to the regulatory and legal acts that simplify access to the infrastructure were developed.

Currently, the Ministry of Digital Transformation of Ukraine with the assistance of the EU Support for Broadband Ukraine Project (Stantec)[144] is developing the National Broadband Strategy of Ukraine (NBS), which is the strategic policy document containing the analysis of the status of fixed and mobile broadband in the country, the challenges and objectives for national broadband deployment, regulatory, financial, and technical directions, and the implementation and monitoring of broadband rollout, particularly of the high-speed fibre-optic networks and 5G technology.

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[143] https://zakon.rada.gov.ua/laws/show/1069-2021-p#Text

[144] Input of the Electronic Communications Policy Department of the Ministry of Digital Transformation

VIII.II   Spectrum harmonization and government actions on EMF regulation

Given that 4G auctions were conducted in 2018, some private stakeholders are reluctant to invest in next-generation technologies for the moment. Even though some 5G-related commercial progress has occurred, part of the telecommunication sector in Ukraine is currently focused on the development of 4G and the expansion of Internet services in rural areas[145]. With this in mind, and due to the lack of funding in NCEC for scientific research to determine the cost of radio frequency resources in the 700 MHz and 3 400 to 3 800 MHz bands, in early August 2021, the Cabinet of Ministers of Ukraine adopted an amendment to the Decree on Approval of the action plan for the introduction of the 5G mobile communication technology in Ukraine,[146] which postponed the launch of 5G networks to 2022.

In order to advance the deployment of next-generation technologies, the original legal framework for electromagnetic field levels of 1996 has been amended on the basis of Order No. 2760[147] of the Ministry of Health of Ukraine in November 2020, authorizing the maximum permissible levels of radiation for high (30-300 MHz), ultra-high (300-3 000 MHz) and very high (30–300 GHz) frequency bands by a factor of 10 – from 10 μW/cm² to 100 μW/cm².

In response to public electronic petition No. 22/092038-ep[148] on Banning the implementation of 5G due to its extremely negative impact on health, published in April 2020, an order has been issued by the President of Ukraine in July 2020, addressed to the Prime Minister of Ukraine and the Chairman of NCEC, to resolve the issue and provide the public with the appropriate information on the impact of next-generation mobile technologies and networks. In August 2020, by Decision No. 304, the NCEC approved its action plan[149] to fulfil the President's mandate in taking actions on a number of EMF-related challenges. Some of the steps included:

-    providing protocols for the measurement of EMFs by operators;

-    public consultations with suppliers of radio equipment;

-    developing and approving the procedure for the relevant bodies in the Ukraine Ministry of Health to measure compliance with EMF levels at the request of citizens;

-    adopting national standards that are necessary to assess the impact of EMF from cellular base stations on humans;

-    carrying out regular measurements within the Ministry of Health to monitor EMF levels during the deployment of 5G networks;

-    introducing a warning sign to signal the presence of a source of non-ionizing radiation and the relevant danger level for humans;

-    additional medical research on the effects on humans of non-ionizing radiation from 5G stations;

-    rising awareness on the impact of mobile radio technologies on human health.[150]

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[145] https://www.itu.int/en/myitu/Publications/2021/10/12/12/56/5G-implementation-in-non-European-Union-countries-of-theEurope-region

[146] https://www.kmu.gov.ua/npas/pro-vnesennya-zmin-do-planu-zahodiv-shchodo-vprovadzhennya-v-ukrayini-sistemi-ruhomogo-mobilnogo-zvyazku-pyatogo-pokolinnya-930-040821

[147] https://zakon.rada.gov.ua/laws/show/z0488-96?lang=en#Text

[148] Заборонити впровадження 5G через вкрай негативне його впливання на здоров`я! Електронні петиції — Офіційне інтернет-представництво Президента України (president.gov.ua)

[149] National Commission for State Regulation of Electronic Communications, Radio Frequency Spectrum and Provision of Postal Services|2020 (nkrzi.gov.ua)

[150] Національна комісія, що здійснює державне регулювання у сферах електронних комунікацій, радіочастотного спектра та надання послуг поштового зв`язку|Новини (nkrzi.gov.ua)

## VIII.III   Public and private broadband development initiatives

Internet subvention

In 2021, the Ministry of Digital Transformation of Ukraine launched the Internet Subvention programme for fibre-optic network roll-out in rural areas. A budget of UAH 483.8 million (about USD 13 million[151]) was approved for distribution to 670 municipalities for the implementation of the government initiative.[152]

The local self-government bodies in the regions held tenders for the construction of the fibre-optic network with a capacity of connecting each social institution with a minimum speed of 100 Mbit/s as well as creation of public Wi-Fi zones. The local communities apply for their villages to be connected via an online form created by the State authorities[153].

The programme is aimed to encourage fixed broadband network operators to connect sparsely populated areas comprising 1.5 million Ukrainians in 3 652 villages (670 territorial communities) and more than 11 000 social facilities, such as schools, kindergartens, medical institutions, libraries and remote workplaces.[154]

Figure 17: Internet subvention dashboard: Villages and population connected to the fibre-optic network
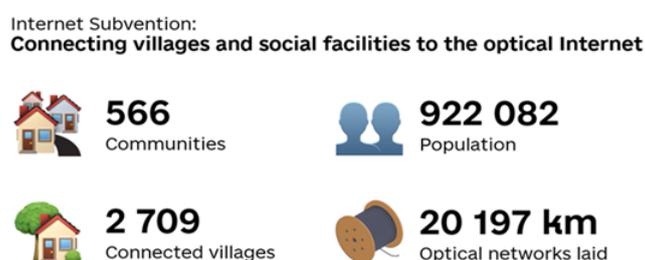
The progress of the realization of the programme is available at the public dashboard.[155]

As of 24 August 2022, 2 709 villages had been connected to the Internet for the first time covering 922 082 people in 566 communities.[156]

Almost a year earlier, Iskratel, PJSC Ukrtelecom and SID Bank signed an agreement to build a fibre-optic Internet network (GPON) to connect the rural areas of Ukraine under a two-year network construction project. This project has received total investment of almost UAH 200 million (about USD 5.5 million [153]). The project included the manufacture of more than 2 000 km of fibre-optic cables and the installation of modern certified telecommunication equipment.[157]

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[151] The National Bank of Ukraine, exchange rate on 07/09/2022

[152] https://thedigital.gov.ua/news/ponad-milyon-ukraintsiv-zmozhut-pidklyuchitisya-do-optichnogo-internetu-v-2021-rotsi-zavdyaki-proektu-internet-subventsiya

[153] https://bb.gov.ua

[154] https://thedigital.gov.ua/news/internet-kozhnomu-ukraintsyu-kabmin-zatverdiv-rozpodil-koshtiv-internet-subventsii-dlya-670-gromad

[155] https://datastudio.google.com/u/0/reporting/1fd597ee-b1bd-4c8e-b249-a922ea9f1e4e/page/bJibC

[156] https://datastudio.google.com/u/0/reporting/1fd597ee-b1bd-4c8e-b249-a922ea9f1e4e/page/p_d0iu2exnoc

[157] https://www.itu.int/en/myitu/Publications/2021/10/12/12/56/5G-implementation-in-non-European-Union-countries-of-theEurope-region

5G Development initiatives and commercial trials

May 2019 marked an official start of the 5G deployment initiative. In line with presidential Decree No. 242/2019[158] on "Ensuring the conditions for the implementation of the 5G mobile communication system" and NCEC Decision No. 529 on the approval of the 5G implementation plan and allocation of relevant frequencies,[159] 5G-suitable wireless spectrum has become available in the 3 400 MHz-3 600 MHz range on a competitive or tender basis.

Meanwhile, Vodafone Ukraine announced its readiness to launch 5G tests,[160] and Lifecell in partnership with Ericsson tested 5G mobile technology in Kyiv in the 28 GHz frequency range. Through Ma-MIMO, a peak download speed of 25.6 Gbit/s was reached in the ultra-high frequency range of 28 GHz[161]. Between December 2019 and May 2020, Ericsson and Lifecell conducted 5G tests using the 3.5 GHz band in seven operator points of sale in six Ukrainian cities: Kyiv, Dnipro, Kharkiv, Lviv, Odesa and Cherkasy[162].

In April 2020, Vodafone Ukraine completed testing of AirScale equipment from Nokia on its LTE network in Kyiv. The 5G-ready equipment was tested in the 1 800 MHz and 2 600 MHz bands, achieving connectivity speeds as fast as 525 Mbit/s[163]. In July 2020, Vodafone Ukraine and Kyivstar signed a memorandum of intent on network sharing for exchange of the 900 MHz spectrum in eight Ukraine regions[164]. The agreement covers both passive and active infrastructure on mobile networks and should result in an acceleration of LTE technology coverage of Ukraine, reaching rural areas and main roads[165].

At the end of the third quarter of 2021, Vodafone Ukraine and Nokia disclosed tests achieving a peak mobile data speed of 772 Mbit/s by aggregating four carrier frequencies – LTE-1800 20 MHz 4x4, LTE-2100 10 MHz 4x4, LTE-2600 10 MHz 4x4 and LTE-900 5 MHz 2x2 – using a commercial base station and existing frequency allocations.

Finally, in October 2021, the first 5G Lab was launched in Unit.City - a test zone in the techno park in Kyiv. It is a joint project of the Ministry of Digital transformation, Vodafone Ukraine and Huawei.[166]

VIII.IV   Cybersecurity strategy

The national Cybersecurity Strategy of Ukraine, approved by Presidential Decree No. 447,[167] entered into force in August 2021 and was named as one of the top priorities in the national security system. With a growing number of cyberthreats that accompanied the development of next-generation telecommunication infrastructure and information and communication technologies as well as intensity of interstate confrontation and intelligence, the need to build a resilient, balanced and effective national cybersecurity strategy emerged, one capable of adapting to the changes in the security environment and guaranteeing safe functioning of cyberspace for the citizens of Ukraine. This strategy reflects some of the major cyber challenges and threats the country faces in cyberspace:

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[158] УКАЗ ПРЕЗИДЕНТА УКРАЇНИ №242/2019 — Офіційне інтернет-представництво Президента України (president.gov.ua)

[159] https://www.itu.int/en/myitu/Publications/2021/10/12/12/56/5G-implementation-in-non-European-Union-countries-of-theEurope-region

[160] Vodafone Ukraine confirms plans to launch 5G communication tests in H2 2019 - May. 20, 2019 | KyivPost

[161] EN_Press_release_5G Demo_Test_Ericsson_lifecell.pdf

[162] В шести городах Украины протестируют 5G (internetua.com)

[163] Vodafone Украина протестировал оборудование Nokia AirScale в 4G-сети Киева на частотах 1800 и 2600 МГц, достигнув скорости мобильного интернета 525 Мбит/сек - ITC.ua

[164] Ukrainian operators begin joint LTE-900 expansions - Developing Telecoms

[165] Kyivstar and Vodafone Ukraine partnership: offering 4G networks to rural areas – Inside Telecom - Inside Telecom

[166] https://tech.liga.net/telecom/novosti/v-ukraine-poyavilsya-5g-rasskazyvaem-podrobnosti

[167] On the decision of the Council of National |... from 26.08.2021 No 447/2021 (rada.gov.ua)

– militarization of cyberspace and the development of cyber weapons, capable of conducting cyberattacks including subversive and intelligence gathering activities in cyberspace to support hostilities;

– the impact of the COVID-19 pandemic on economic activity and social behaviour, which led to the rapid transformation and remote organization of a significant segment of social relations with the widespread use of electronic services and information and communication systems;

– hybrid aggression against Ukraine in cyberspace, with constant innovation in the arsenal of offensive cyber weapons, the use of which can have irreversible destructive consequences;

– cybercrime, which harms information resources, social processes, citizens, and which reduces public confidence in information technology and leads to significant material losses;

– cyberespionage, related to the theft for political, economic or military purposes of sensitive information and the implementation of intelligence and subversive activities etc.

Furthermore, the strategy sets clear priorities for ensuring Ukraine's cybersecurity and strategic goals, such as creating effective cyberdefence, counteraction to cybercrime, intelligence and subversive activities in cyberspace and cyberterrorism, development of asymmetric deterrence tools to deter aggressive actions in cyberspace against Ukraine.

The cybersecurity incident response in Ukraine is being handled by the Computer Emergency Response Team (CERT-UA), a special subdivision of the State Service of Special Communications and Information Protection of Ukraine. Its tasks are defined at the legislative level by the Law of Ukraine "On the Basic Principles of Cybersecurity of Ukraine"[168]

In order to improve the state of cybersecurity and prevent cybercrime, in March 2022 the Verkhovna Rada of Ukraine voted to amend Articles 361 and 361-1 of the Criminal Code of Ukraine, which authorizes external specialists to get involved in searching and eliminating shortcomings, gaps, errors and vulnerabilities in software products and information and communication systems[169].

In July 2022, Decree 787 established the State service for the protection of critical infrastructure and ensuring the stability of the national system of Ukraine. The legal grounds for developing the draft of this Decree are the requirements of the Law of Ukraine "On Critical Infrastructure". The newly created central body with executive power will have a special status, the activities of which will be directed and coordinated by the Cabinet of Ministers of Ukraine. It will ensure the formation and implementation of State policy in the field of critical infrastructure protection and ensuring resilience of the national system.

VIII.V   International benchmarks

Global Cybersecurity Index (GCI)

The ITU Global Cybersecurity Index 2020[170], published in 2022, gives Ukraine an overall cybersecurity score of 65.93, somewhat below from the Europe region average of 80.7 for the same year, and ranks the country 39th in the Europe region and 78th globally. This index is a trusted reference that measures the commitment of countries to cybersecurity at a global level and raises awareness of the importance and various dimensions of cyber issues and assesses a country's ICT sector resilience and reliability[171].

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[168] https://www.itu.int/dms_pub/itu-d/opb/str/D-STR-GCI.01-2018-PDF-E.pdf

[169] https://cip.gov.ua/ua/news/parlament-dozvoliv-zaluchati-nezalezhnikh-it-fakhivciv-do-testuvannya-vrazlivostei-informaciinikh-sistem

[170] https://www.itu.int/epublications/publication/D-STR-GCI.01-2021-HTM-E/

[171] https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Publications/2022/Digital%20Development/Digital%20Development%20Country%20Profile_Ukraine_final_02.22.pdf

The overall score is based on five main pillars, which shape the inherent building blocks of a national cybersecurity culture that includes:

- laws and regulations on cybercrime and cybersecurity;

- implementation of technical capabilities through national and sector-specific agencies;

- national strategies and organizations implementing cybersecurity;

- awareness campaigns, training, education, and incentives for cybersecurity capacity development;

- partnerships between agencies, firms, and countries.

Figure 18: GCI of Ukraine, 2020

Source: ITU

ITU ICT Regulatory Tracker

From a regulatory standpoint, Ukraine currently scores 78 in the ITU ICT Regulatory Tracker[172], placing the country in 38th place among 43 European countries and at the 92nd place among 193 countries considered for the 2020 ranking.

The ITU Tracker pinpoints the changes taking place in the ICT regulatory environment. It facilitates benchmarking and the identification of trends and gaps in ICT legal and regulatory frameworks and allows decision-makers to make the case for further regulatory reform towards achieving a vibrant and inclusive ICT sector.[173]

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[172] https://app.gen5.digital/tracker/metrics

[173] https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Publications/2022/Digital%20Development/Digital%20Development%20Country%20Profile_Ukraine_final_02.22.pdf

The ICT Regulatory Tracker is composed of 50 indicators grouped into four clusters:

Table 11: The ICT Regulatory Tracker, Ukraine

ICT Regulatory Tracker group clusters	Ukraine score	Max score
Regulatory authority (focusing on the functioning of the separate regulator)	16	20
Regulatory mandates (who regulates what)	15	22
Regulatory regime (existing regulation in major areas)	22	30
Competition framework for the ICT sector (level of competition in the main market segments)	25	28
Overall score	**78.00**	**100**

Source: ITU

Ukraine is positioned among the group of countries with a *Third-Generation regulatory regime (G3)*. The country reached this position in 2018 and is among 7 per cent of Europe region countries with this level of regulatory regime. The country's overall result is significantly lower than the Europe region average score of 85.3, but is slightly above the world average of 71.9.

Recently, ITU launched a reviewed Fifth Generation of regulation benchmark, focused on collaboration among different stakeholders in the ICT sector and with other sectors of the economy.

Figure 19: ICT Regulatory Tracker, Ukraine in 2007: 44.83 (G2) vs 2020: 78 (G3)

Source: ITU

The G5 Benchmark takes data from 193 countries, expands to cover four pillars, with 70 indicators taken into account: national collaborative governance, digital development toolbox, digital economic policy agenda and policy design principles.

Table 12: G5 Benchmark 2021, Ukraine

G5 benchmark pillars	Ukraine scores	Europe average
National collaborative governance	9.26	20.37
Digital development toolbox	9.72	18.74
Digital economic policy agenda	10.49	14.52
Policy design principles	12.04	13.97
Overall score	**41.51**	**67.60**

Source: ITU

According to the latest data, Ukraine scores 41.51 in the G5 benchmark, with transitioning level of readiness for the digital transformation, which leaves a lot of space for improvement if compared to Europe region average of 67.60[174].

This positions Ukraine on the 119th place and within 42.5 per cent of the countries with the same level of readiness, among 193 countries and suggests that there is still room for improvement.[175]

Figure 20: G5 Benchmark 2021, Ukraine
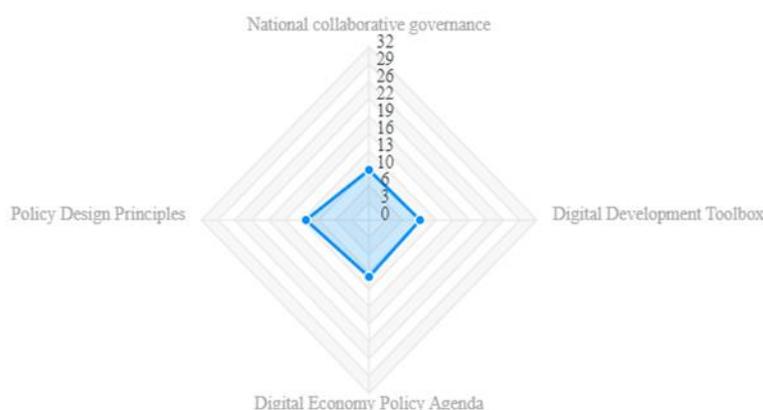
Source: ITU

Speedtest global index

In accordance with the order of the Administration of the State Service of Special Communications and Information Protection of Ukraine dated 20 September 2021 No. 576 "On Approval of Requirements for the Quality Level of Mobile Communication Services" (registered in the Ministry of Justice of Ukraine on 6 October 2021 under No. 1298/36920), the levels of quality indicators of Internet access services have been established, in particular:

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[174] https://digitalregulation.org/wp-content/uploads/Final-version_clean_E.pdf

[175] https://app.gen5.digital/benchmark/metrics

- the average speed of data transmission in the direction from the base station to the terminal equipment (*Download*) only for radio technology "International Mobile Telecommunications – IMT" (UMTS and subsequent releases (asr)), LTE (asr)): not less than 2 Mbit/s;

- the average speed of data transmission from the terminal equipment to the base station *(Upload)* only for radio technology "IMT" (LTE (asr), 5G NR (asr)): not less than 0.5 Mbit/s;

- *latency* between sending and receiving packets in both directions only for radio technology "IMT" (UMTS (asr), LTE (asr)): no more than 130 ms;

- *jitter* only for radio technology "IMT" (UMTS (asr), LTE (asr)): no more than 50 ms;

- *packet loss* only for radio technology "IMT" (UMTS (asr), LTE (asr)): no more than 2 per cent until 31 December 2022, and no more than 1 per cent after 1 January 2023.

Figure 21: Ukraine median speeds of July 2022
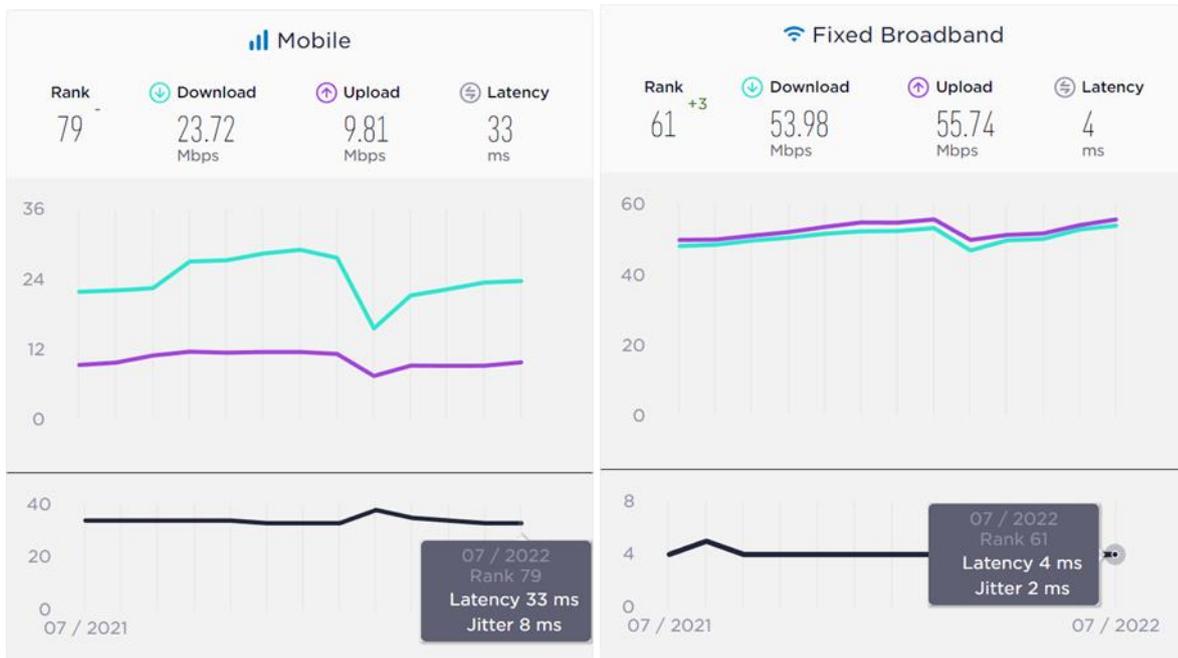
Source: Speedtest

In terms of fixed-broadband speed, the country ranks 61 in the Speedtest global index[176], with 53.98 Mbit/s median download, 55.74 Mbit/s upload speed and a latency of 4 ms registered in July 2022. As for the mobile broadband for the same period, it ranks 79, with median download speed of 23.72 Mbit/s, upload speed of 9.81 Mbit/s and a latency of 33 ms.

Digital Quality of Life Index 2021 (DQL)[177], published by Surfshark in 2021, ranks Ukraine at 47th place in the world among 110 countries (in 2020, Ukraine ranked 65 out of 85 countries).

The European Data Portal (EDP)[178] has published the seventh annual Open Data Maturity Report 2021 on the level of development of the field of open data. Ukraine took 6th place among 34 countries (in 2020, Ukraine took 17th place out of 35 countries).

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[176] https://www.speedtest.net/global-index/ukraine#fixed

[177] https://surfshark.com/dql2021?country=UA

[178] https://data.europa.eu/en/dashboard/2021#country-overview

Networked Readiness Index (NRI)[179], published by the Portulans Institute together with the World Information Technology and Services Alliance, ranks Ukraine at 53rd place among 130 countries (in 2020, Ukraine took 64th place among 134 countries).

VIII.VI   Clear definition and targets

This part of the study describes the necessity and advantages in developing and effectively updating ICT goals and targets that stimulate and promote implementation of comprehensive ICT policies that impact the development of social and economic aspects of life. Diligent and comprehensive ICT planning, including wide consultation of stakeholders, and consideration of international benchmarks and best practices of the leading examples around the world, should ensure faster recovery after the war, pandemic, or other possible recovery situations.

It is important to evaluate ICT targets, definitions, and goals and to check whether policy-related commitments are clearly set in the leading national strategic documents. Targets should be fit for purpose, ambitious and achievable. The institutional set-up and governance should be able to guide and implement ICT policy with a pace that positively impacts competition, both supply and demand side, and cope with regulation and financing of the ICT ecosystem.

Ukraine is divided into administrative units called regions (oblast). There are 24 regions in Ukraine, at least 10 of those are affected by the war and not all ICT infrastructure damage has been properly assessed. This study relies on the information provided by the Government of Ukraine on the ICT network landscape that has been affected by actions of war.

The ongoing conflict has a negative effect on the ability of the public sector, related to the ICT sector, to define and adjust ICT targets, definitions and goals. Moreover, Ukraine's present economy and budget has limited financing capabilities for the ICT sector due to forecasted diminishing GDP figures, negative impact on revenue and investment possibilities, etc. As a direct consequence of the war, ICT operators have lost income and revenue, and GDP has been severely impacted with reported losses of USD 5 to 7 billion a month[180].

In Ukraine, one of the main documents related to ICT is a Concept Paper on Digital Economy and Digital Society Development in Ukraine for 2018-2020 (with amendment for 2021-2022)[181] developed by the Ministry of Digital Transformation. The updated version of this Concept Paper will outline future actions on the ICT landscape and will reflect the work needed to rebuild damaged ICT networks Due to the war. Future ICT planning should form a solid base to clearly set ambitious targets, foresee institutions, stakeholders and actors responsible for concrete target implementation and financing.

Updating national ICT documents and setting new strategic objectives should be ensured with the following goals:

- Provide citizens with basic ICT services, especially close to war zones.

- Maintain and protect ICT infrastructure in the territory that is not affected by war.

- Foresee clear goals and actions to be undertaken when the war is over.

- Identify funds for the Government of Ukraine to finance measures for ICT rebuilding and development.

Rebuilding of ICT networks in times of war is very difficult. Martial law in Ukraine means that the public and private sectors are less able to change and develop ICT strategic objectives. Nonetheless, the process of

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[179] https://networkreadinessindex.org/country/ukraine/

[180] https://www.washingtonpost.com/national-security/2022/08/16/zelensky-interview-transcript/

[181] https://zakon.rada.gov.ua/laws/show/67-2018-%D1%80#Text   and   https://zakon.rada.gov.ua/laws/show/1069-2021-%D1%80#Text

rebuilding ICT networks destroyed or stolen during the conflict (mobile or television towers) should be planned to offer ICT network and service coverage to the public.

Short/medium term targets in ICT rebuilding and development can be viewed as transitional and can be divided into periods of time (3, 9, 18 months, etc.) and coverage by territory/area. Such short/medium term strategic objectives should allow for gradual progress and be ready for the ICT planning process when peace is restored. Public and private sectors should be prepared to ensure transition from reactive short/medium term to proactive long-term planning, involving all stakeholders, with the objective to transform public ICT networks into a modern and resilient ICT system while using principles of good governance and fostering the supply and demand side of ICT service usage.

Key recommendations

- It is recommended that Ukraine's ICT strategic objectives and targets should be adjusted to ensure basic ICT needs (including TV, radio) of citizens during the war and to ensure progress in ICT growth and development when the war is over.
- Short-term national ICT strategic objectives should be developed by a working group from representatives of the public and private sectors.
- In the short/medium term, it is recommended to foresee areas where it is possible to (re)build ICT networks ensuring resilience, public warning/emergency systems for development of ICT infrastructure in the future.
- Public and private sectors should be invited to cooperate on development, innovation, and implementation of a national public warning/emergency telecommunication system.
- New regulatory models should be developed and implemented during the transitional period (until the war is over).
- Objectives should be set to increase public ICT usage from pre-war figures with modern and resilient ICT networks.
- The public and private sectors should cooperate to develop full coverage of Ukraine as set out in the spectrum licences.
- After the war, ICT strategy development should be based on an open and transparent process with significant intergovernmental coordination and where necessary in cooperation with international organizations and partners.

VIII.VII   Good governance

Ukraine has an effective cybersecurity strategy[182] as outlined in the Concept Paper of Digital Economy and Digital Society Development in Ukraine[183] (until the end of 2022) (Concept on Digital Economy). The broadband strategy was in the development stage prior to the war, and measures set out in the Concept on Digital Economy will have to be revisited and adjusted.

Nonetheless, the Government of Ukraine has taken the following measures[184] related to network repair, resilience, and security:

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[182]   Presidential Decree No.447 entered into force in August 2021

[183]   https://zakon.rada.gov.ua/laws/show/67-2018-%D1%80#Text   and   https://zakon.rada.gov.ua/laws/show/1069-2021-%D1%80#Text

[184]   Answers to the ITU Assessment Report Questionnaire designed for the State Authorities

− Established the National Telecommunication Networks Operation Center[185] (NTNOC), procedures of operational and technical management of telecommunication networks were approved for management of telecommunication networks in emergency situations, state of emergency and martial law, which defines operational and technical management and emergency repair works to telecommunication networks.

− Implemented a national free of charge roaming network for citizens.

− Temporarily transferred mobile operators to unused frequency bands for IMT.

− Made proposals to grant powers to the national regulator (NCEC)[186] to extend validity of spectrum licences after the expiry of the prior extension period.[187]

− Blocked autonomous systems and main Internet resources, which were used to retransmit unauthorized channels in Ukraine.

− Connected shelters to round-the-clock Wi-Fi coverage with the help of market players.

− Continues to sustain ICT infrastructure in the emergency regime of operational and technical management of electronic communication networks.

Good governance, which involves the development and implementation of an ICT strategy through open and transparent processes is slower and more difficult to plan in times of war. It is recommended to base strategic planning that affects the ICT sector and market on combined data from various sources. Ukraine should strive for the highest standards in governance including:

− To set minimal ICT strategic objectives in terms of services and usage and align strategic documents that allow timely and steady development of the ICT infrastructure and services in the time of war (including zones of war and areas close to war zones).

− To continue with the NTNOC[188] working group to quickly build and repair public ICT networks to best suit public needs both during and after the war.

− To have strategic plans to ICT infrastructure development when peace is restored.

− To redraft ICT strategic objectives and plans through an open and transparent process when peace is restored that involves participation and input from all relevant stakeholders from governmental organizations, the private sector and civil society.

− To continue to strengthen the independence of the national regulator (NCEC[189]), without any political or private sector influence.

The Government of Ukraine could also continue with an NTNOC working group that includes all stakeholders involved in ICT infrastructure recovery during war time. Such a working group should function only during the period of war to perform regular assessment of ICT availability and prepare recommendations on further development and implementation of urgent ICT measures that are vital for the functioning of society, especially in anchor locations such as hospitals, police stations and libraries.

In general, it is recommended to limit the number of strategic documents related to ICT to allow to ensure responsibility for the actions envisaged, a more effective control of implementation, and accountability for

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[185] https://zakon.rada.gov.ua/laws/show/812-2004-%D0%BF#Text

[186] *National Commission for the State Regulation of Electronic Communications, Radiofrequency Spectrum and the Provision of Postal Services*

[187] Draft law No. 7486 "On Amendments to Certain Laws of Ukraine Regarding the Improvement of Governance in the Field of Electronic Communications" which, in particular, proposes to amend the Law of Ukraine "On Electronic Communications"

[188] https://zakon.rada.gov.ua/laws/show/812-2004-%D0%BF#Text

[189] State Regulation of Electronic Communications, Radiofrequency Spectrum and the Provision of Postal Services (NCEC)

the results. It is advisable to keep all national strategic documents in the field of ICT aligned, especially those related to issues of cybersecurity, network resilience, digital transformation, broadband, etc.

Sound financial management is an important factor in good governance. Solutions envisaged in national strategic documents rely on financial accountability. It is important that strategic objectives in ICT development are aligned with the ability to finance ICT projects on time. National institutions responsible for ICT planning and development should foresee and match financing needs with ICT strategic objectives that must be implemented. In the areas affected by war and where it is necessary to rebuild basic ICT networks (including TV and radio), especially in anchor locations, the Government of Ukraine should seek financial cooperation and support from international partners (e.g. OECD, World Bank and ITU).

Competition is essential to any market. The ICT sector can benefit from competition policy by providing better coverage and services, competitive pricing, etc. The Government of Ukraine should strengthen legislation to ensure competition in the ICT sector using examples of best practice from around the world.

There is also a need to continue competence and capacity building for public sector employees related to ICT development and strategic objectives.

Key recommendations

- In the short/term period (during the time of war), it is recommended to base ICT policy development on latest data and information on damage, and to ensure a minimum set of ICT services to the public, with responsibility put in the hands of a working group created from public and private sector stakeholders to best reflect public ICT needs and to (re)build network capacity.
- It is recommended to use close cooperation and involvement between ministries, agencies and relevant stakeholders in an open and transparent manner to adjust ICT strategy objectives in order to advance the (re)building of public ICT infrastructure, especially to strengthen backbone and last-mile connections and coverage.
- In the long run (after the war), it is recommended to update ICT strategy objectives based on technology neutral principles.
- It is recommended to foster competition as the driver of the ICT sector development through regulation and legislation.
- It is recommended to continue competence and capacity building for public sector employees related to development of ICT strategic objectives, in addition to areas of social cohesion within the country that ICT can help to foster.
- It is recommended to appoint a single entity in government that will lead with strong inter-governmental coordination and support for successful development and implementation of the ICT policy objectives.

VIII.VIII   Supply and demand stimulation

Supply interventions are usually described as an ability of the country to implement clear and enforceable competition policies with coherent and comprehensive rules for spectrum access, investment in infrastructure and support of community networks. Where demand side or demand stimulation traditionally is understood as access to affordable devices and services for low-income households and anchor institutions, national digital skills programming, and development of locally relevant content.

On the supply side, policies should ensure competition throughout the supply chain as policies should both promote competition and protect against abuse of market power. Spectrum should also be made available for fixed and mobile connectivity. Various models can be adopted in respect to financing where investment is necessary for the promotion of ICT infrastructure and services. Core network infrastructure, such as

backbone networks, Internet exchange points (IXPs) and submarine cables can be funded through private investment and through public-private partnerships.

In the absence of viable private-sector investment, governments should consider investing in core network infrastructure, with access sold on a non-discriminatory (wholesale open access) basis. In instances of market failure (such as in high-cost rural areas), governments can subsidize deployment of fixed and mobile last-mile networks through separate programmes. Such fund recipients should be required to deploy broadband throughout the concession area:

- subsidies should be open to all qualified competitors and available on a technology-neutral basis;

- subsidies should be allocated through a competitive process, such as reverse auctions;

- fund recipients should be held accountable for meeting quantifiable targets and should be rewarded for beating buildout deadlines.

Mechanisms for funding universal service subsidies should minimize marketplace distortions and ensure that funds are not diverted to other government programmes, and universal service funds should be administered independently.

ICT infrastructure in Ukraine that is not affected/destroyed by actions of war should be capable of ensuring the throughput of calls and data, and as much as possible be integrated with ICT networks in war zones in order to ensure the best possible set of ICT services to the public.

Due to the war, there might be a need to try new and creative options for (re)building the public ICT infrastructure. This ICT infrastructure should be versatile, resilient, and protected as much as possible. It could require larger financing assets than usual development of ICT infrastructure in times of peace.

There is a need for redundant ICT network elements, including television towers in war zones and/or close to war zones. There is a need for trained/specialized staff that is capable of (re)building ICT networks in war zones or close to those areas.

As a short/medium term goal, the public and private sector should cooperate and strive to ensure that a minimum of ICT services are available to Ukraine citizens in or close to the war zone. in addition, all possible incentives such as free of charge service should be used in areas affected by the war. The public and private sector should also be ready and put strategies in place to ensure the minimum of service to Ukraine citizens when they return to their homes after the war.

In the long term, Ukraine should promote new technologies and business models, and subsidize the deployment of last-mile fixed and mobile infrastructure (gray zones) where the market is failing to provide connectivity to certain areas or groups of individuals, such as persons with disabilities and older persons. Where necessary, responsible institutions should set and implement programmes related to basic and/or advanced digital skills programming. Also, programmes developing locally relevant applications and content should be encouraged and supported, where necessary.

Key recommendations

- It is recommended to ensure connectivity in public places and anchor locations such as community centres, schools, hospitals, stations, police stations, hospitals, libraries and regional government institutions.
- It is recommended to develop a multi-year national broadband or ICT plan with clear, ambitious, and achievable policy-related commitments and quantifiable supply- and demand-side targets.
- It is recommended, during the war, that the Government of Ukraine should set minimum standard for public ICT services, including television and radio, and to ensure best possible coverage by ICT services.
- It is recommended, after the war, that the Government of Ukraine assess the effectiveness of its emergency spectrum policy and related measures, determine when/how they may be retained, evolved or discontinued, and develop a longer-term plan to stimulate network restoration and investment towards affordable and universal broadband connectivity.
- It is recommended to develop and encourage "dig-once" policy objectives, ensuring that all market players cooperate in placing ducts, cable, etc. together while sharing the costs.
- It is recommended to increase availability of ICT services in the gray areas of coverage, where return on investment is low and market players would not invest without incentives.
- It is recommended to carefully select and protect locations for the installation of Internet exchange points (IXPs).

VIII.IX Monitoring

Monitoring and evaluating programmes are encouraged and should be ensured by the main institutions responsible for ICT planning and implementing. Again, monitoring and evaluating in the time of war is an exercise that has its limitations, but it is necessary to keep track of the current situation and development in order to make specific interventions where and when possible. The Government of Ukraine should try to revert to regular data collection exercises at least once per year and to hold an open and transparent assessment, to review progress at least every two years and to be prepared to course-correct and update the plan in response to changed conditions.

IX.   Conclusion

Since 24 February 2022, the war has caused considerable damages and destruction of the ICT infrastructure in more than 10 out of 24 regions of Ukraine, which has significantly deteriorated the state of connectivity in the country and heavily affected the ICT operators and the population. Intermediate assessment of the scale of losses and damages is being carried out monthly. Complete and exhaustive evaluation and estimation of the destruction and recovery needs will not be possible until full liberation of the occupied regions.

The Ukraine Government considers the restoration of ICT infrastructure as a high priority, as it has a potential to boost the economy and social life in the country considering the severe losses to GDP (estimated at USD 5 to 7 billion per month). Since the start of the war, Ukraine public and private sectors have been involved in the repair of telecommunication and critical networks, however, full-scale rehabilitation and reconstruction can only commence after clearing the war-affected territories from missile debris, mines, and explosive objects and rebuilding electric power supply networks and systems. These factors may hamper a quick recovery of the ICT infrastructure in some of the regions of Ukraine.

Meanwhile, Ukraine, with support of the international community, continues the process of rebuilding and maintaining ICT infrastructure and connection to anchor locations (e. g. police stations, hospitals, libraries and schools), as well as in or close to still inhabited war zones. There is a need to restore ICT connectivity and modernize telecommunication networks and systems in Ukraine. On the positive side, with careful planning efforts and international financial support, there is a possibility to (re)build a leading-edge next-generation network and services infrastructure in Ukraine.

This interim assessment has been produced based on the information and data collected as of August 2022. Since August 2022 the telecommunication infrastructure might have suffered additional damages that have not been documented in this document. Upon the conclusion of the war, the full evaluation of damages should be carried out. In order to make relevant calculations and precise estimations of the financial needs necessary for reconstruction and modernization of the ICT infrastructure, regular dialogue between a broader group of stakeholders, including operators and public institutions, shall be established. The full rehabilitation of the ICT networks can be based on the green field roll-out best practices of the leading countries in the world. Where possible, Ukraine can experiment with creation of "sandbox" areas for innovative regulations and services and later evolve with development of the backbone networks and advancement of 5G technologies.

X.   Annex

The following set of files present the lists of most urgent needs provided by Ukraine to the international community as of June 2022. Among other things, these lists comprise a series of radio equipment tools, technical facility and broadcasting instruments, various types of fibre-optic cables, and one type of software for video surveillance.

These lists should be treated as living documents and serve as the open call to the international community to help Ukraine in addressing the urgent and unprecedented needs considering the current telecommunication damages it experiences every day.

CIP.xlsx   Radio   UCRF.xlsx   Software.xlsx   Broadcast.xlsx   Technical facilities
              equipment.xlsx   (means).xlsx