वार्षिक योजना एवं बजट
Annual Plan and Budget

2020

2021

सी-डॉट
C-DOT

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Preface

The Projects chosen for the financial year 2020-21 are either relevant in the national perspective or they meet the emerging market requirements.

This annual plan and budget document for FY 2020-2021 contains the following:
- Physical and financial performance in FY 2019-2020.
- Plan and budget proposal for FY 2020-2021:
  o Executable projects under various technology programs, time targets and budget requirements,
  o Information on technology programs closed, completed projects, project initiatives, and justification for revised estimates, if any.

Chapter-wise contents of the document are as given below:
- Chapter 1 is an executive summary containing an overview and the accomplishments during FY 2019-2020.
- Chapter 2 lists the activities planned for FY 2020-2021, and gives an overview of the programs, and corresponding project executables.
- Chapter 3 details the budget and finance – the resource requirements, budget estimates, and sources of funds.
- Chapter 4 details the programs, the executable projects with associated development plans, time targets and financial requirements.
- This is followed by the annexures in chapter 5, detailing on program-wise and project-wise expenditures. It also mentions the projects that have been closed, the new projects, the projects requiring PoC or pilot demo to be initiated in FY 2020-2021, etc., and provides justifications for Revised Estimates (RE), if any.

All amounts mentioned in this document are in Rupees (₹) in crore, rounded off to two decimal places, unless stated otherwise.

Requirement of maintaining confidentiality of information about CMS, SDCN and Defence-related projects for reasons of national security, results in restricted circulation of hardcopies of this document, and information on these projects blanked out in softcopies in public domain.

Contents

>> C-DOT Confidential <<

Tables

1 Executive summary

C-DOT is the research and development arm of the Department of Telecommunications. It conducts R&D in state-of-the-art telecom technologies and applications. The outcome of R&D programs are converted to usable products by transferring the production knowhow to public and private sector commercial manufacturers.

C-DOT supports multiple engagement models with end users, system integrators and manufacturers such as providing direct turnkey solutions, undertaking collaborative R&D, transferring technology to partners, co-branding products with partners, undertaking custom product development and/or adapting products for specific customer needs.

C-DOT has its headquarters in Delhi and has development centers in Delhi and Bangalore with an employee strength of around one thousand, ninety percent of which are technical manpower.

This document summarizes R&D activities undertaken and their outcomes achieved by C-DOT during FY 2019-20 along with financial performance of the organization.

1.1   Key Technology Achievements During FY 2019-20

1.1.1 Research and Development Activities

R&D activities undertaken during the FY 2019-20 can largely be classified into five major areas which are Communications Security, Wireless & Mobile Communications, Routing & Switching, Optical Communications and Services & Applications.

In the area of Communication Security, the Equipment Identity Register (EIR) project outcome led to launch of public services for tracing lost or stolen mobile phones by the DoT in Maharashtra and Delhi in September and December respectively. This will be followed by pan-India rollout of the services in remaining states. C-DOT's second security initiative relates to the Central Monitoring System (CMS) project which saw onboarding of 16 central lawful enforcement agencies and 4 state police departments onto the C-DOT developed lawful interception system. Third security initiative of C-DOT demonstrated a proof-of-concept (PoC) of an indigenously developed Cyber Space Monitoring Framework (CCSM) for Computer Emergency Response Team - Telecom (CERT-T). This framework enables monitoring of cyber traffic for identifying any potential malicious activities. Consequent upon the PoC, a detailed project report for a pan-India implementation of the CCSM has been submitted to the DoT.

In the area of wireless and mobile communications, C-DOT has developed a converged core network solution which enables delivery of a common set of services to all subscribers irrespective of the access technology they use for connecting to the network. The solution integrates 4G mobile, WiFi, fixed line and Passive Optical Network (PON) access networks into the converged core network solution. The solution is installed in MTNL for conducting field trials at two locations. C-DOT signed up MoUs with 6 academic institutions for promoting research and development in the area of 5G. A joint proposal was put up jointly by C-DOT and MTNL for conducting 5G trials at two locations. Efforts in the WiFi area included successful proof of concept and field trials of C-DOT's C-Sat-Fi solution for Aspirational Villages in Harish Tal and Talli Sethi villages of Bhim Tal block of Nainital district in Uttarakand alongwith BSNL and alongwith BBNL C-DOT had completed the field trial at Gokul Pur and Bir Chandra Nagar Gram Panchayat in TRIPURA. C-DOT has submitted the test report to Secretary Telecom and USOFA administrator. In another development satellite baseband system developed by C-DOT for DRDO was integrated and tested as part of the S-Band earth station equipment. The complete system is shifted to Meerut for operational trials which are ongoing with indigenous satellite developed by ISRO.

In the area of Routing and Switching, C-DOT has already completed pan-India migration of its MAX DSS technology network of approximately 1700 large exchanges to Next Generation Voice-over-IP network for BSNL in 2019. C-DOT has also completed development of medium capacity Top-of-Rack (ToR) switches for Data Center applications. These switches will form the data center fabric for the 4G Core network trials being planned in MTNL. In another project, development of first phase deliverables for custom secure routers for defense applications was completed for DRDO in January 2019. Further for a similar project of DRDO, C-DOT delivered adapted versions of its existing router and switch products to meet requirements of strategic network deployment in March 2019. Equipment was delivered by C-DOT for deployment at 10 more sites to expand the Secure Dedicated Communication Network beyond National Capital Region.

In the area of Optical Communications, C-DOT's 100G DWDM system was installed at 3 locations in a ring configuration in MTNL Delhi and 12 locations in configuration in Railtel. Development of a 1.6 terabit Packet Optical Transport System was completed and offered for internal validation. The development of XGS-PON and NG-PON2 products was completed. XGS-PON was offered to TEC for evaluation. The technology for new variants of GPON (ONT-17A, ONT-24, 8-port OLT line card and 8-port mini-OLT) was transferred to 3 Indian manufacturers. The development and testing of Over-the-top set top box (OTT) was completed. The trial of C-DOT Conditional Access System and Direct To Home set top box were initiated in the Doordarshan network and are in progress.

In the area of Telecom Services and Applications, as emphasized by the Ministry, C-DOT's effort was focused on providing technological solutions to challenges posed to the nation by COVID-19 outbreak. Several solutions were developed to help the nation find a new normal with applications like Video Conferencing to enable working from home, the COVID_19 Quarantined Alert System (CQAS) developed jointly with DoT and Telecom Service Providers for determining current location of COVID quarantined persons and alerting the concerned authorities of their unauthorized movement from the designated area, the Aarogya Setu IVRS back-end application to determine current location and subscriber details of user who call the Arogya Setu helpline numbers, the Samvad mobile application for secure communication between officials taking inputs and making policy and crisis management decisions. C-DOT developed COVID-19 Savdhan for Corona related location-based SMS dissemination in English and Indian regional languages (17 languages supported). More than 45 crores SMSes have been sent for COVID (in 19 states), cyclone Amphan and cyclone Nisarga.

PoC of UN Navigation App (Wayfinder) for phase-1 was successfully completed at C-DOT Delhi campus with 2-D navigation & A-R (Augmented-Reality). The App was handed over to UN, Geneva for E-building. Order for Samvad has been received from the office of Intelligence Bureau and an order from Navy is expected to be received very soon.

1.1.2 Technologies Transferred

In support of government's Make In India and Digital national programs C-DOT promoted the indigenous technology development and manufacturing eco-system by adding one new manufacturing partner and transferring four new technologies to existing manufacturers, taking the total count of technologies transferred to ninety-seven.

1.1.3 Intellectual Property Rights Created

Table 1.1: Intellectual properties and publications

Intellectual Property Asset	Number	Related Project / Product	Subject Invention
Patent Granted	5	Gyan Setu	Method and System of providing Data in a Preferred Laungage of a User (India)
		Interoperable STB	Interoperability Of Set Top Box Through Smart Card(India)
		Generic	A Method And System To Access Multiple Wireless Network Operator's Subscription(India)
		Wi-Fi	Dynamic Channel Selection In IEEE 802.11 Networks (India)
		SGRAN	An Active Infrastructure Sharing System(India)
			Resonance Mitigation In RF High Power Amplifier Enclosure(USA)
		GPON	Interconnecting Optical Line Terminals (OLT) To Optimize the Usage Of Network Resources(India)
		Geo-Intelligence	GIS Based Centralized Fiber Fault Localization System (USA)
Patents Filed	4	C-SAT Fi	System And Method Of Enhancing Number Of Concurrent VoIP Calls Over Low Bandwidth Satellite Link (India)
		WDM	A Method And A Mirrored Serial Interface (MSI) For Transferring Data (USA, UK, Canada, China, Vietnam and Nigeria)
		QKD	Device And Method Of Synchronization In Quantum Key Distribution (QKD) System (India)
		Wi-Fi	Dynamic channel selection in IEEE 802.11 networks (USA , Nigeria)
Copyright filed	9	LTE NMS	Long-Term Evolution – Network management System (LTE-NMS)
		NOFN NMS	Location Management System
			North Bound Interface for GPONNMS
		NOFN NMS	Messenger
		NOFN NMS	Service Network Monitoring System
		NOFN NMS	Fiber Management System

		NOFN	C-DOT Dashboard and Reports
		DVB -S2 Hub Baseband System	DVB-S2 Testbed Software
		DVB -S2 Hub Baseband System	Real Time Optimised DVB-S2 Forward link transmitter for DVB-RCS Hub system
Trademark Granted	5	Generic	C-TEC
		C-SAT Fi	C-SAT Fi
		Wi-Fi	Bamboo Wi-Fi
		NOFN-NMS , GPON-EMS	C-GEMS
		Wi-Fi	PDO
Trademark filed	2	Interoperable STB	
			CiSTB
			C-CAS
		C-SAT Fi	C-SAT Fi
Design filed	2	Set-Top-Box	COSN (Set-top-box)
		ONT-7	ONT-7 (Optical Modem)
Papers presented in the national and international conferences and seminars	6	5G	Antenna for 5G-Industry Perspective Indian Conference on Antennas & Propagation (InCAP 2019), Ahmedabad, India.
		Generic	Interference-Aware Co-channel Transmission over DTV Bands via partial frequency and time overlaps, International Communications Conference-2019, Shanghai, China, 20-24 May 2019.
		Generic	Evaluation of functional splits in terms of optimal number of users served, International Conference on Advanced Computing and Communications (ADCOM 2019), IIIT Bangalore, 5th to 7th September 2019.
		Generic	Link performance evaluation of Uplink Precoded Multiuser MIMO-NOMA system for 5G Communication Networks, International Conference on Advanced Computing and Communications (ADCOM 2019), IIIT Bangalore, 5th to 7th September 2019.
		Generic	Performance Analysis of OpenStack Controller IEEE SmartNets 2019, Sharm El Sheikh, Egypt, 17-Dec-2019 to 19-Dec-2019.
		Generic	Comparison of OpenStack Orchestration Procedures, IEEE SmartNets 2019, Sharm El Sheikh, Egypt, 17-Dec-2019 to 19-Dec-2019.

1.1.5 Business Promotion Activities during FY 2019-20

Participation in Events & Exhibitions

- C-DOT officers attended the World Summit on the Information Society (WSIS) 2019 conference, hosted by ITU in Geneva from 8th to 12th April, 2019.

- Officials from C-DOT attended several meetings held in the office of UN for the UN buildings Internal Mobile navigation App. C-DOT developed the prototype solution and conduct a pilot for the E-building.

- C-DOT participated in Technology Tune, an event organized by Titan in its Factory / Campus at Hosur, Tamil Nadu on 15th and 16th April 2019 and showcased its products like C-DOT mini-PDO and Long Range WiFi.

- C-DOT organized the oneM2M developers' event for IoT startups/companies during 25-26 April 2019 at Bengaluru.

- C-DOT Participated in the 10th edition of Strategic Electronics Summit (SES 2018) – Defence & Aerospace, scheduled on 30th & 31st July, 2019 at Bengaluru and demonstrated its various technologies.

- C-DOT celebrated its 36th Foundation Day on 26th and 27th August 2019 and launched innovative products – (i) C-Sat-Fi (C-DOT Satellite WiFi), (ii) XGSPON (10 G Symmetrical Passive Optical Network) and (iii) C-DOT's Interoperable Set Top Box (CiSTB). Various C-DOT products were exhibited and demonstrated during the occasion.

- C-DOT participated in India Mobile Congress 2019 organized in New Delhi from 14th to 16th October, 2019 and exhibited its products, like, XGSPON, DWDM, C-Sat-Fi, Early Warning System, Quantum Encryption, Router, NMS, CiSTB, Samvad, M2M Solution, 4G Solution, etc. during the three-day exhibition.

1.1.6 Awards Received

C-DOT's innovative approach and excellence were acknowledged by three prestigious awards conferred :

- The ELCINA Defennovation Award 2019 was conferred on C-DOT for excellence in R&D (large Category) for its C-Sat-Fi technology in the 10th edition of Strategic Electronics Summit (SES 2019) for Defense and Aerospace to recognize exemplary contribution in the field of Defense Electronics.

- C-DOT received the second prize for C-DOT Green (Hybrid) Power System – 2KW in 44th ELCINA Award Ceremony.

- 10th Aegis Graham Bell Awards in association with India Mobile Congress felicitated C-DOT for its C-Sat-Fi technology to recognize its outstanding innovation and vision to make India an innovative hub for rising brilliance and virtuosity.

1.2 Financial Snapshot
1.2.1 Financial Performance in FY 2019-20

(₹in crore)

Outlay Planned (RE) : 555.00 Crores		Expenditure : 329.68 (Prov.)
GBS	Planned	350.00
	Provisioned in Budget 2019-20	273.00
	Shortfall vis-à-vis planned	77.00
	GBS Received (RE)	273.00
IEBR	Planned & Provisioned in the Budget 2019-20	150.00
	Accrued till Mar.'20 (based on invoices raised)	64.20 (Prov.)

1.2.2 Budget Plan for FY 2020-21

(₹in crore)

#	Head		Planned amount	Allocated amount
1	GBS[1]	Sought	383.00	
		Allocated in union budget for FY 2020-2021		323.00
2	Internal resources (ToT, royalty, field support receipts, other misc. income)	Planned	110.00	110.00
Total			493.00	433.00
Funds from DoT FOR projects on cyber security for CERT-T, and CEIR			20.00	20.00
Shortfall in funds allocated				60.00

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[1] **Gross Budgetary Support**

2 Technology programs and executable projects in the financial year 2020-21

2.1 Activities in FY 2020-2021: R&D, trials and proliferation of technologies

It is planned to work on the following projects and solutions during FY 2020-2021 with focus on research, development, trials and proliferation of technologies.

2.1.1 Program: Next generation mobile technologies

During FY 2020-21, the focus will be on to establish basic lab infrastructure for 5G-technology-based systems, prototype readiness for 5GNR(5G New radio) NSA (Non standalone) gNB, NB-IoT Base Station.

gNB is the new radio access technology for 5G is called "NR" and replaces "LTE", and the new base station is called gNB (or gNodeB), and replaces the eNB (or eNodeB or Evolved Node B).

It is planned to deliver 5G prototype and testing platform for C-DOT's LTE/5G products, infrastructure readiness of 5G testbed for 5G usecases and successful demonstration of usecases in 5G technology trials.

During the FY 2020-21, it is also planned to initiate a new programs on development of 5G Standalone Core Network (SA) system and data plane analytics. The major activities planned under this program for the year are :

- to establish 5G standalone based Test Bed.
- Field Trial of cloud based next generation firewall and integration testing of user data plane accelerator with 5G nodes

2.1.2 Program: Carrier networks transport technologies for transport and access networks

To address the high bandwidth requirement in the network, R&D efforts are being made to develop system for access, transport or backhaul and metro or aggregation networks.

- In Packet optical transport networks, during the FY 2020-2021, it is also planned to Offer 1.6 Tbps POTP system for TEC validation and Pilot/field trial. It is also planned to prepare 5 nodes of 1.6T for PoC in Telecom Service Povider (TSP) and 3 Nodes of 4.8T for system Integration and Testing
- In TWDM-PON, duuring the FY 2020-21, the following major activities are planned :
  - Offer of XGS-PON (Mini OLT) for ToT.
  - Pilot / field trial commencement for NGPON2 (chasis-based)
  - EMS release and validation of TWDM-PON integrated OLT chassis.
  - Offer for internal validation of XGS-Ring ONT
- Hardware development of 5G FH (Front Haul) OLTs and 5G FH ONTs

2.1.3 Program: Next generation switching and routing systems

The next generation switching and routing system addresses the requirements of very high bandwidth at the core network. R&D efforts are on to develop very high-speed routing systems, enterprise router, L2/L3 switches/router for LAN, MAN and data centre switches.

In FY 2020-2021, pilot trials are planned for MTBR[2] with 100 Gbps transport interface, high-speed router with 100G ethernet interface, compute node with intelligent NIC (network interface card) and 48-port L2/L3 switch, medium-capacity ToR switch. Besides, system integration and testing for high capacity ToR and spine switches, is also planned for the year.

2.1.4 Program: Satellite-based technologies

This program has been undertaken to carry out customised technology development in the satellite domain to cater to specific client requirements.

During FY 2020-2021, customer support will be provided for hub baseband system under the program 'Support for satellite hub baseband for phase-1 and phase-2'.

During the year, integration and testing of enhanced DVB Hub baseband system consisting of DVB-S2 modulator, MF-TDMA demodulator units and IF units will be carried out.

A new program 'Satellite based broadband solution (C-Sat-Fi) has also been initiated under Satellite-based technologies. During the FY 2020-21, efforts will on the PoC, trials, deployment of C-Sat-Fi v1.0.

2.1.5 Program: Centre of Excellence for lawful interception

CoE for lawful interception, set up at C-DOT Delhi under the aegis of MHA[3], aims at continuous upgradation of interception systems to cater for new challenges in the technology.
During the FY 2020-21, the following activities are planned:

- Pilot trial of face detection and recognition engine in controlled and uncontrolled environment for various angles, clothes, disguise, etc., is planned.

- Algorithm development for sentiment and emotion, data-set preparation for sentiment and emotion – in English and Hindi.

- Android and iOS app showing 2D routes in UN buildings in Geneva.

- Deployment of Video Conferencing in Govt. offices

- Implementation of an offline key generation & transfer mechanism for CEM (Converged Encryption Manager) for data encryption.

- Design and development of Quantum Key Distribution (QKD).

2.1.6 Program: Telecom services and applications

This program focuses on the SW-intensive services and applications catering to the emerging trends and customer-specific developments. Development is in progress in the M2M communication. During the FY 2020-2021, it is planned to provide a complete solution comprising of IoT applications and CCSP platform ready for deployment.

In the FY 2020-21, it is planned to initiate C-DOT Converged Service Delivery Platform (C-CSDP) and the following deliverable planned for the year:

- Tested STB with IP streaming, Linear Content Aggregation System.

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[2] **Multi-Terabit Router**
[3] **Ministry of Home Affairs**

2.1.7 DoT projects: CERT-Telecom and CEIR

C-DOT has been entrusted with these projects by DoT:

a. **Cyber security for CERT-Telecom**: Feasibility study and PoC for requisite solution to monitor and protect the country's internet traffic of the order of 3-4 Tbps, with respect to security analysis and threat detection to protect the critical national infrastructure involving telecom infrastructure as its backbone.

b. **CEIR:** Building a central database of all IMEIs used in India so that IMEIs of all stolen, lost or cloned mobile devices can be blocked from accessing the network.

During the year, expansion of Big-Data platform from CERT-lab at C-DOT to full fledge deployment required to cater the full traffic from all ISP gateways is planned to be completed along with the facilitation of cyber forensics, NOC/SOC monitoring and capacity building center as central facility.

In CEIR, roll-out of CEIR pan-India in offline mode is planned besides the development of online interface (Phase-2).

2.1.8 National Security Council secretariat (NSCS) Projects

National Security Council Secretariat (NSCS), a Gov.t of India agency has granted administrative approval and funding to C-DOT for following two Cyber Security Research & Development projects that will lead to development of network security products that can be potentially used by Strategic Government agencies.
The following projects are planned to be initiated :

• PINE: Post-Quantum Inline Network Encryptor – tamper Resistant in-line network encryptor (dual 1G ports) with PQC key exchange and AES 256 cryptography functions is planned to be completed.

• Quantum-secure Smart Video IP Phone- the focus will be on to develop Quantum secure Smart Video IP Phone Product (with custom Hardware boards, Plastic Packaging and necessary software)

2.1.9 Enabling technologies and telecom network

Activities are planned during the year for carrying-out feasibility studies, PoC and trials on emerging telecom technologies, to gain operational insights and applications of technologies and related issues. This scheme helps C-DOT to maintain its position of excellence in telecom R&D, by conducting basic research as well as studies and setting up pilots.

During FY 2020-2021, it is planned to continue feasibility studies for QKD[4,]

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[4] **Quantum Key Distribution**

2.1.10 Program: Enhancements, upgradations, adaptations and technical support for technologies' implementation and roll-outs

Under this program, technical support for C-DOT's developed and deployed technologies is provided, that includes value additions, upgrades and other support services like SW bug-fixes, alternative solutions against component obsolescence and field support.

In FY 2020-2021, activities under this program will include design support for technology enhancements, upgradations to address component obsolescence, feature additions, etc, for developed technologies – SDCN, optical products, NMS, MAX, ATM[5], and OCN, green power supply system, network steganography and network steganalysis.

2.1.11 Sustenance of CMMI Maturity Level 5 and implementation of P-CMM Level 2 practices

Through successive successful appraisals at CMMI Maturity Level 5 and followed up by regular sustenance activities, the organization has achieved stability on activities directly related to product development, in the areas of engineering, technical support, project management and process management – which are also covered in the CMMI framework.

In addition to sustaining the practices corresponding to CMMI process areas, processes are also being defined and put into practice for various other activities in the organization, not under the CMMI umbrella – like, materials management, transfer of technology, SW licensing agreement, legal practices, centralized store management, intellectual property management, etc.

Definition and implementation of people-related processes, under the People CMM (P-CMM[6]) has been initiated and a formal Gap Analysis by external experts have been done.

In FY 2020-2021 the activities planned are:

- SCAMPI pre-appraisal for CMMI ML5
- SCAMPI-An appraisal for CMMI ML5.
- Sustenance of CMMI ML5 practices, improvements and audits will continue.
- Definition and implementation of P-CMM L2 processes

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[5] **Asynchronous Transfer Mode**
[6] **People Capability Maturity Model**

2.2   Summary of technology programs and executable projects

The technology programs with corresponding executable projects planned in FY 2020-2021 are summarised below:

Table 2.1: Technology programs and executable projects

S.No.	Technology program	Executable projects planned in FY 2020-2021
1	Next generation mobile technologies	• Development of 5G systems • Development of 5G Standalone core (SA) network system data plane analytics
2	Carrier networks transport technologies for transport and access networks	• Packet Optical Transport Platform • TWDM PON system
3	Next generation switching and routing systems	• Next generation high-speed routing system • Switching and routing solution for LAN, MAN, enterprise and data centre segment
4	Satellite-based technologies	• Digital Video Broadcasting – 2nd Generation. • Satellite based Broadband solution (C-Sat-Fi)
5	Centre of Excellence (CoE) for lawful interception	• Image and video analytics: face recognition • Capacity enhancement • Quantum-safe cryptography • Short text message analytics • UN navigational application • C-DOT Video Conferencing Solution. • Development of Quantum Key Distribution.
6	Telecom services and applications	• Machine-to-Machine communication • C-DOT Converged Service Delivery Platform
7	Enabling technologies and telecom network	• Study of Quantum Key Distribution
8	DoT projects	• Central Equipment Identity Registrar • Computer Emergency Response Team – Telecom. • C-DOT interception request and approval system
9	NSCS Projects	• Post-Quantum Inline Network Encryptor (PINE) • Development of Quantum Secure Smart Video IP Phone (QSSIPP)
10	Enhancements, upgradations, adaptations and technical support for developed technologies	• Design support for, MAX-NG, optical products, ATM, SDCN, CiSTB, green power supply system, OCN etc. • Technology field implementations and roll-outs
11	Campus infrastructure	• Construction of hostel facilities and dwelling units

3 Budget Estimates

3.1 Overall resource requirements

Activities planned for the year are development, design support, field implementations, and roll-outs of new technologies in the network. To meet the budget requirement during FY 2020-2021 for various R&D projects, product enhancements, technical support activities and campus infrastructure, a sum of ₹513.00 crore (including DOT Projects) has been provisioned as BE[7]. Total manpower resource planned for the year is 1100 persons.

3.2 Category-wise budget summary

Table 3.1: Category-wise budget summary for FY 2020-2021

(₹ in crore)

	Category		Budget for FY 2020-2021
A	Technology programs and executable projects		192.18
B	Enhancements, upgradations, adaptations and technical support for developed technologies		237.08
	1. Design support for developed technolgies	24.52	
	2. CMS support for field roll-out	20.12	
	3. Technology field implementation	192.44	
C	Campus infrastructure		3.00
D	Centre of Excellence for lawful interception (approved by MHA)		22.81
E	**DoT projects**		26.93
F	**C-DOT solution roll-outs in Govt. Departments**		31.00
	TOTAL		**513.00**

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[7] **Budget Estimate**

3.3   Program and project-wise budget summary

Category A: Technology programs and project executables
Table 3.2: Technology programs and executable projects

(₹in crore)

Technology program	Cumulative expenditure upto 31.03.2020 *(prov.)*	Budget for FY 2020-2021 *(prov.)*
Program: Next generation mobile technologies	130.90	61.51
Program: Carrier networks transport technologies for transport and access networks	293.37	42.74
Program: Next generation switching and routing systems	66.58	39.91
Program: Satellite-based technologies	67.55	13.23
Program: Power-efficient and green telecom technologies	23.88	0.00
Program: Telecom services and applications	86.52	16.77
Enabling technologies and telecom networks	1.50	0.39
Total		**174.55**

Category B: Enhancements, upgradations, adaptations and technical support for eveloped technologies
Table 3.3: Enhancements, upgradations, adaptations and technical support for developed technologies

(₹in crore)

Technology program and executable projects		Budget for FY 2020-2021 *(prov.)*
Project: Design support for developed technologies		24.52
Project: Technology field implementations and roll-outs	CMS support for field roll-out	20.12
	Technology field implementation for other technologies	192.44
Program: Enhancements, upgradations, adaptations and technical support for developed technologies		237.08

Category C: Campus infrastructure
Table 3.4: Campus infrastructure

₹in crore)

Program	Cumulative expenditure upto 31.03.2020 *(prov.)*	Budget for FY 2020-2021 *(prov.)*
Campus infrastructure	0.28	3.00

Category D: Centre of Excellence for lawful interception program
Table 3.5: Centre of Excellence for lawful interception program

(₹in crore)

Technology program	Cumulative expenditure upto 31.03.2020 *(prov.)*	Budget for FY 2020-2021 *(prov.)*
Centre of Excellence for lawful interception	32.78	22.81

3.4 Head-wise Budget Estimate for next financial year, Revised Estimate and actual expenses for previous financial year

Table 3.6: Head-wise BE for FY 2020-2021, RE and actual expenditure for FY 2019-2020

(₹in crore)

#	Budget head	Budget and expenses for FY 2019-2020		Budget for FY 2020-2021		
		Budget (RE[8])	Projected expenses upto 31.03.2020 (*provisional*)	INR	FE	Total
A	**Recurring expenses**					
A1	Salary and staff benefits	259.87	244.76	270.33	0.00	270.33
A2	Travel and daily allowances	5.79	2.53	1.64	0.80	2.44
A3	Rent on residential accommodation	2.49	0.00	1.41	0.00	1.41
A4	Office associated costs	45.82	33.49	28.64	12.00	40.64
	Subtotal (A)	**313.97**	**280.78**	**302.02**	**12.80**	**314.82**
B	**Non-recurring expenses**					
B1	Consultancy	5.06	0.20	5.90	0.10	6.00
B2	Component	51.48	18.82	32.95	15.06	48.01
B3	Equipment	91.72	3.15	54.50	25.03	79.53
B4	Software	27.63	6.79	18.60	7.61	26.21
B5	Technical services	9.94	4.18	8.50	0.00	8.50
	Subtotal (B)	**185.83**	**33.14**	**120.45**	**47.80**	**168.25**
C	**Land and building**					
C1	Land and building	0.20	0.10	3.00	0.00	3.00
	Subtotal (C)	**0.20**	**0.10**	**3.00**	**0.00**	**3.00**
	Total (A+B+C)	**500.00**	**314.02**	**425.47**	**60.60**	**486.07**
D	**DoT projects**	**55.00**	**15.66**	**21.93**	**5.00**	**26.93**
	Grant Total (A+B+C+D	**555.00**	**329.68**	**447.40**	**65.60**	**513.00**

3.5 Sources of fund

Table 3.7: Sources of fund in FY 2020-2021

(₹in crore)

#	Head		Planned amount	Allocated amount
1	GBS[9]	Sought	383.00	
		Allocated in union budget for FY 2020-2021		323.00 (note)1
2	Internal resources (ToT, royalty, field support receipts, other misc. income)	Planned	110.00	110.00 (note)2
Total			**493.00**	**433.00**
Funds from DoT FOR projects on cyber security for CERT-T, and CEIR			**20.00**	**20.00**
Shortfall in funds allocated				**60.00**

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[8] **Revised Estimate**
[9] **Gross Budgetary Support**

Note:

1. **GBS allocated for FY 2020-2021 is inadequate and the shortfall is ₹ 60.00 crores. GBS sought is the basis of the annual plan for FY 2020- 2021.**
2. **Anticipated, to be realised during the year.**

4 Technology programs and project development plans

4.1 Next generation mobile technologies

The development of mobile technologies is progressing at an exciting pace. The extensive growth in the use of mobile as a key device for accessing internet and data-based services has led to large-scale worldwide deployments of 3G[10] and 4G[11] networks. 3G and 4G technologies have mainly focused on the mobile broadband use cases providing high data rates and high system capacity. Even though there is a substantial increase in use of data, newer needs have emerged.

The future use will not be just by humans, but also by other connected entities. In fact, a larger amount of traffic is expected from these machine-based communications compared to humans. This is commonly referred to as 'IoT'[12], 'networked society', 'M2M[13] communication' or 'machine-centric communication'.

The technology landscape extending beyond 4G is now looking ahead to address different scenarios and services – higher traffic in office and residential areas, higher densities in subways, malls, stadiums, etc, high-speed mobility for highways, high-speed trains, etc. The services that are expected to be provided are mobile internet service for video streaming, cloud storage and usage services, virtual reality, augmented reality, IoT services like smart home, smart grid, ITS[14], surveillance, etc. The technology beyond 4G is termed 5G[15], which ITU-T[16] calls 'IMT-2020'[17].

This technology program is aimed at R&D in 5G technology-based systems.

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[10] **3rd Generation (wireless communication technology)**
[11] **4th Generation (wireless communication technology)**
[12] **Internet-of-Things**
[13] **Machine-to-Machine**
[14] **Intelligent Transport System**
[15] **5th Generation (wireless communication technology)**
[16] **International Telecommunication Union – Telecommunication (standardisation sector)**
[17] **International Mobile Telecommunications – vision for 2020 and beyond**

4.1.1 Development of 5G systems

Objective	To develop systems based on 5G technology.
Brief description	LTE networks have been widely deployed and increasingly standardised new deployments are going on. Meanwhile, the telecom world has started exploring what 5G should be, mechanisms to implement it and the potential services. The typical scenarios that 5G is expected to address higher traffic in office and residential areas, higher densities in subways, malls, stadiums, etc, high-speed mobility for highways, high-speed trains, etc. The services that are expected to be provided are mobile internet service for video streaming, cloud storage and usage services, virtual reality, augmented reality, IoT services like smart home, smart grid, ITS, surveillance, etc. The critical scenarios and the technology enablers that have been identified are: **Critical scenarios**: • eMBB[18] • eMMTC[19] • URLLC[20] **Key technology enablers for 5G**: • Enhanced radio interface enabling technologies provide better radio interface, namely, advanced modulation, coding and multiple access schemes, • Advanced antenna and multi-site technologies for physical layer enhancements and interference handling for small cell, • Flexible spectrum usage, • STR[21], • Other technologies to enhance the radio interface, • Technologies that support a wide range of emerging services: proximity services, M2M and group communications, • Technologies that enhance user experience: cell edge enhancement, quality of service enhancement, mobile video enhancement, enhanced broadcast and multicast, low latency and high reliability technologies, RLAN[22] interworking, context aware, • Technologies that enhance network efficiency: network-level power management, energy-efficient network deployment, user-centric resource management and allocation, physical layer enhancements and interference handling, • Terminal technologies: interference cancellation and suppression, • Network technologies: technologies to simplify management and improve network reliability, technologies to support ease of deployment and increased network reach, technologies to enhance network architectures, Cloud-RAN[23],

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[18] **Enhanced Mobile Broadband**
[19] **Enhanced Massive Machine Type Communication**
[20] **Ultra-Reliable and Low Latency Communication**
[21] **Simultaneous Transmission and Reception**
[22] **Radio Local Area Network**
[23] **Cloud-based Radio Access Network**

- Technologies to enhance privacy and security.

These technology requirements and enablers listed above are implemented by using some of the critical technology elements to provide 5G. These technology elements are:

- Wireless technologies
  - Novel multiple access: to improve spectral efficiency, connection capability, and latency in various scenarios. Candidate schemes are: SCMA[24], PDMA[25], MUSA[26], NOMA[27], etc.
  - Ultra-dense networking: critical to meet 1000x or higher traffic growth. Research areas are interference suppression, virtual cell, joint access and backhaul.
  - Massive MIMO: to improve the spectral efficiency of multi-user systems by several folds.
  - All-spectrum access: High/low, paired/unpaired, licensed/unlicensed, contiguous/ non-contiguous bands.
  - Flexible duplex, full duplex, FBMC[28], F-OFDM[29], D2D[30], Q-ary LDPC[31], polar codes, network codes, etc.
- Network architecture technologies
  - SDN[32]
  - NFV[33]
  - Cloud-RAN.

5G time-line:

At present, 5G research and standardisation activities are going on. 3GPP[34] Release-15 was finalised in Jun-2018. Leading Vendors have started releasing early prototypes of 5G Systems. Market-ready products are expected in 2020 (3GPP Release-16). ITU standardisation body is also expected to match these timelines with the evaluation and specification of IMT-2020 to be ready by 2020.

5G spectrum:

The spectrum aspects of 5G are still being worked out. It has to interwork with existing technologies, operate across multiple spectrum and also operate in new higher frequency bands. Research is going on in the following spectrum ranges: 28.0 GHz[35], 37.0-40.5 GHz, 42.5-43.5 GHz, 45.5-47.0 GHz, 47.2-50.2 GHz, 50.4-52.6 GHz, 66.0-76.0 GHz, and 81.0-86.0 GHz.

For India, the potential spectrum bands are 3+ GHz, 6 GHz and 28 GHz.

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[24] **Sparse Code Multiple Access**
[25] **Pattern Division Multiple Access**
[26] **Multi-User Shared Access**
[27] **Non-Orthogonal Multiple Access**
[28] **Filter Bank Multi-Carrier**
[29] **Filtered Orthogonal Frequency Division Multiplexing**
[30] **Device-to-Device**
[31] **Low Density Parity Check**
[32] **Software Defined Networking**
[33] **Network Function Virtualisation**
[34] **3rd Generation Partnership Project**
[35] **Giga Hertz**

	C-DOT's 5G roadmap: Since 5G has many different scenarios and multiple technologies, it is critical to first enhance the infrastructure and lab set-up to understand and implement solutions. Some of the key nodes and modules identified are Massive MIMO systems, mmWave[36] wireless systems, Cloud-RAN to provide centralised baseband processing and NB-IoT[37] solutions for M2M communication. In the initial phases, C-DOT will build prototypes for these technologies to get a foothold in 5G landscape, that is, Massive MIMO, Cloud-RAN, NB-IoT and mmWave. The LTE[38] technology which will be upgraded under the 'LTE enhancements' project will be used as a platform to build the next level 5G technology based modules. Interworking with high-speed WiFi will also be included in the roadmap. 5G Use Case Demonstrations and Technology Trials: • The telecom department has initiated the process of rolling out 5G networks in the country, with telecom operators set to begin testing the technology later this year. • The government also announced its intention to focus on three big social sectors for deployment of 5G—education, agriculture and healthcare. • In January 2020, DoT approved prices for the next spectrum auction. • The DoT intends to allocate the trial spectrum to its licensees, which are telecom service providers, who can then choose to partner with telecom equipment vendors for 5G Trials in the country.
Application areas	<u>5G RAN</u> • 5G-technology-based solutions • High bandwidth requirement solutions • D2D and IoT solutions. <u>5G Use Case Demonstrations and Technology Trials</u> 5G technology can be demonstrated in the following verticals: • Healthcare, Education & Governance • AgriTech, Livestock, Environment, Public safety & Disaster Management • Enterprise tranformation, Industry 4.0, Smart cities & Infrastructure • Cyber Security, Banking, Finance & Insurance • Logistics & Transportation, Multimedia & Broadcast • Others - Hardware, Computing etc.
Key deliverables	<u>5G RAN</u> • Cloud-RAN prototypes • NB-IoT prototype • Massive MIMO prototype • mmWave point-to-point solution prototype. <u>5G Use Case Demonstrations and Technology Trials</u> • Demonstration of 5G technology in lab • 5G testbed infrastructure readiness for 5G usecases • Successful demonstration of usecases in 5G technology trial • 5G prototype and testing platform for C-DOT LTE/5G products

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[36] **Millimeter Wave**
[37] **Narrowband Internet-of-Things**
[38] **Long Term Evolution (of universal terrestrial radio access network)**

Status as on 31.03.2020	5G RAN
	• MoU[39] signed with IIT Hyderabad, CeWiT[40], IIT Bombay, IIT Madras, CSIR-CEERI and IIT Roorkee for joint working on 4G and 5G technology components (physical layer, Cloud-RAN, NR[41]).
	• MoU signed with leading UK universities, *viz*, University of Bristol, King's College London, University of Surrey for joint R&D on 5G technologies, 5G test bed, optical technologies, Artificial Intelligence.
	• Discussions are in advance stages for signing MoU with IISc Bengaluru, Eurecom-France, OSA[42]) for joint working in the development of 5G key technology modules (SDN, NFV, high frequency RF[43], MIMO[44], 5G test-bed).
	• Identified key functional blocks, architectural alternatives based on different chip-set vendors.
	• Identified key equipment required for lab infrastructure set-up. Tender release for the procurement of identified technical capital items held up awaiting funds.
	• 5G gNodeB Baseband Unit architecture completed.
	• 5G gNodeB 3.5GHz RRH architecture ready. PALNA module under development.
	• 5G gNodeB Software architecture ready. Potential stack suppliers identified and budgetary quotes received. Need to release RFP for procurement.
	• NB-IOT Physical Layer development: First working release ready.
	• NB-IOT End-to-end feature demonstration: Development in-progress.
	5G Use Case Demonstrations and Technology Trials
	• Application for participating in 5G technology trials submitted (along with MTNL) to DOT
	• Proposed Urban and Rural Usecases presented to DOT for evaluation
	• Trial Spectrum allocation by DOT is awaited
	• Identified key network equipment required and architectural alternatives for the usecases.
	• Discussions with vendor for Core stack reference implementation
	• Discussions with IoT, drone vendors for participating with C-DOT for demonstrating usecases for trials
	• Discussions with IITM/CEWiT, for participation of C-DOT in the indigenous 5G Testbed project funded by DOT

Finance (₹ in crore)		
	Estimated budget outlay for the project	85.00
	Cumulative expenditure (*provisional upto Mar-2020*)	16.71
	Budget for FY 2020-2021	28.82

Project plan	**Deliverables and milestones**	**Target**	
		2019-2020	**2020-2021**
	5G RAN		
	Study complete	*NA (completed in 2017-18)*	
	Architecture evolved for various prototypes	*NA (completed in 2017-18)*	
	Basic lab infrastructure for 5G technology-based systems	3Q:19-20	3Q:20-21

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[39] **Memorandum-of-Understanding**

[40] **Centre of Excellence in Wireless Technology**

[41] **New Radio**

[42] **OpenAir Interface Software Alliance**

[43] **Radio Frequency**

[44] **Multiple Input Multiple Output**

	established		
	Cloud-RAN prototype	4Q:19-20	2Q:21-22
	NB-IoT prototype	2Q:19-20	4Q:20-21
	Massive MIMO prototype	3Q:19-20	3Q:21-22
	mmWave point-to-point prototype	4Q:19-20	4Q:21-22
	Cloud-RAN solution field trial	3Q:20-21	4Q:21-22
	NB-IoT solution field trial	1Q:20-21	1Q:21-22
	Massive MIMO field trial	3Q:20-21	1Q:22-23
	ToT of Cloud-RAN	4Q:20-21	1Q:22-23
	ToT of NB-IoT	3Q:20-21	2Q:21-22
	ToT of Massive MIMO	4Q:20-21	3Q:22-23
	5GNR gNB NSA-mode prototype (NSA: Non Standalone)	NA	4Q:20-21
	5GNR gNB NSA-mode solution field trial	NA	1Q:21-22
	ToT[45] of 5GNR gNB NSA-mode	NA	2Q:21-22
	5G Use Case Demonstrations and Technology Trials		
	Finalisation of Architecture for 5G Technology trials	4Q:19-20	*NA (completed)*
	Partnership in CeWIT and IIT Testbed	NA	1Q:20-21
	System Integration for IoT usecase	NA	2Q:20-21
	System Integration for Drone usecase	NA	2Q:20-21
	Inhouse testing of Usecases	NA	3Q:20-21
	Deployment of System at trial site	NA	4Q:20-21
	Initiation of trials	NA	4Q:20-21
	Observation and collection of Feedback	NA	1Q:21-22
	Reporting of outcome	NA	1Q:21-22
Projected physical outcome for FY 2020-2021	5G RAN • Basic lab infrastructure for 5G technology based systems establishment. • Prototype readiness for 5GNR NSA gNB, NB-IoT Base Station 5G Use Case Demonstrations and Technology Trials • 5G prototype and testing platform for C-DOT's LTE/5G products • 5G testbed infrastructure readiness for 5G usecases • Successful demonstration of usecases in 5G technology trials		
Reasons for revision of targets	• Basic lab infrastructure required for the development could not be established due to non-availability of necessary test equipment and other technology modules required for building prototypes. • Massive MIMO and mmWave developed stopped due to lack of sufficient demand in the market and lack of resources within C-DOT to pursue development. • Development of 5G ecosystem and operator interests have resulted in aligning C-DOT development to the needs of the industry.		

4.1.2 Development of 5G Standalone Core Network system and Data Plane Analytics

Objective	• To develop 5G standalone core network, and • To develop the nodes for 5G data plane acceleration and analysis • To provide integrated management and orchestration solution for C-DOT NGMN networks.
Brief Description	<u>5G Standalone Core Network system</u> LTE networks have been widely deployed and increasingly standardized. The typical scenarios that 5G is expected to address higher traffic in office and residential areas, higher densities in subways, malls, stadiums, high-speed mobility for highways, high-speed trains, etc. Key technology enablers for 5G: The 5G Standalone Core Network architecture is defined to support data connectivity and services enabling deployments to use techniques such as e.g. Network Function Virtualization and Software Defined Networking. It shall use service-based interactions between Control Plane (CP) Network Functions. Some key principles and concept are to: • Separate the User Plane (UP) functions from the Control Plane (CP) functions, allowing independent scalability, evolution and flexible deployments e.g. centralized location or distributed (remote) location. • Modularize the function design, e.g. to enable flexible and efficient network slicing. • Enable each Network Function and its Network Function Services to interact with other NF and its Network Function Services directly or indirectly via Service Communication Proxy, if required. The architecture does not preclude the use of another intermediate function to help route Control Plane messages (e.g. like a DRA). • Minimize dependencies between the Access Network (AN) and the Core Network (CN). The architecture is defined with a converged core network with a common AN - CN interface which integrates different Access Types e.g. 3GPP access and non-3GPP access. <u>5G Data Plane Analytics</u> • C-DOT has designed general purpose telco/carrier grade server nodes that use parallel processing techniques to handle large capacities of call processing & signaling Control Plane workloads. These server nodes are simultaneously able to offload the user Data Plane packet processing tasks to accelerators using intelligent NIC cards. • Under this program, C-DOT will develop applications for accelerating 5G data plane, its security and telemetry probes for data analysis <u>Management & Orchestration solution for Next Generation Mobile Networks</u> The study and POC for 5G testbed covered CDoT existing VNFs and PNFs

	orchestration and transport network slicing is also planned. The POC shall now be enhanced to provide integrated management and network orchestration framework for C-DoT NGMN solutions including access (RAN, Wifi), IMS/EPC/5GC, SDN enabled transport and application/services and shall be implemented in C-DoT 5G solutions.
Application Areas	5G Standalone Core Network system Following services can be demonstrated using 5G system: • Video Surveillance using Drone • Remote Healthcare Applications & IOT Agriculture • Augmented /Virtual Reality in Education,Healthcare, etc. 5G Data Plane Analytics • 5G solutions • Cloud Network Management & Orchestration solution for Next Generation Mobile Networks • Management and Orchestration of NGMN/5G networks
Key Deliverables	5G Standalone Core Network system • 5G SA core network architecture defined • 5G SA prototype for 5G test bed 5G Data Plane Analytics • Cloud based Next Generation Firewall • User Data Plane Accelerator • Media Plane Accelerator • Router telemetry probes Management & Orchestration solution for Next Generation Mobile Networks • CDOT PNF (Physical Network Function) Orchestrator/network slice creation for SDN and non-SDN enabled. • CDOT VNF (Virtual Network Function) Orchestrator • CDoT WiFi6 orchestrator and network slice creation framework • Study report for Zero touch network and service management and Cognitive orchestration in telecommunication
Status as on 31.03.2020	Proof-of-concept on MANO framework successfully demonstrated in C-DoT 5G testbed.

Finance (₹ in crore)		
	Estimated budget outlay for the project	85.00
	Cumulative expenditure (*provisional upto Mar-2020*)	NA
	Budget for FY 2020-2021	32.69

Project Plan	**Deliverables & Milestones**		**Target Date**	
			2019-20	**2020-21**
	5G Standalone Core Network system			
	Study of Cloud Based Databases		NA	1Q:20-21
	5G SA Architecture Development		NA	2Q:20-21
	DevOps Framework for 5G SA		NA	2Q:20-21
	Orchestrator Framework Development		NA	3Q:20-21
	5G SA Prototype Development for Test Bed		NA	3Q:20-21
	5G SA integration with simulated gNodeB		NA	4Q:20-21
	5G Data Plane Analytics			
	Cloud Based	Finalization of requirement	NA	1Q:20-21

	Firewall:	specification and architecture design		
		Detailed Design & Implementation	NA	2Q:20-21
		Integration Testing	NA	3Q:20-21
		Validation & Field Trial	NA	4Q:20-21
	User Data Plane Accelerator	Finalization of requirement specification and architecture design	NA	1Q:20-21
		Detailed Design & Implementation	NA	2Q:20-21
		Integration Testing	NA	4Q:20-21
	Media Plane Accelerator	Finalization of requirement specification and architecture design	NA	1Q:21-22
		Detailed Design & Implementation	NA	2Q:21-22
		Integration Testing	NA	2Q:21-22
		Validation	NA	3Q:21-22
		Field Trial	NA	4Q:21-22
	Router Telemetry Probes	Finalization of requirement specification and architecture design	NA	1Q:21-22
		Detailed Design & Implementation	NA	2Q:21-22
		Integration Testing	NA	2Q:21-22
		Validation	NA	3Q:21-22
		Field Trial	NA	4Q:21-22
Integrated Management & Network Orchestration Solution				
CDOT PNF orchestrator (C-PNFO):				
Framework for Non-SDN devices	Requirement and design		NA	2Q:20-21
	Implementation and testing with existing devices		NA	3Q:20-21
Framework for SDN enabled devices	Requirements and design		NA	1Q:21-22
	Implementation and testing with CDOT devices		NA	4Q:21-22
CDOT VNF orchestrator C-VNFO:				
Requirement, design, development			NA	2Q:20-21
Testing, Implementations in CDoT VNFs (EPC/5GC/applications)			NA	3Q:20-21
Framework/architecture for WiFi6 orchestration/Netwo slicing				
Study & Requirements			NA	1Q:20-21
Architecture and Design			NA	2Q:20-21
Study & Requirements			NA	4Q:20-21

Projected Physical Outcome of FY 2020-21	• 5G SA based Test Bed setup • Field Trial of cloud based next generation firewall • Integration Testing of user data plane accelerator with 5G nodes • Framework / architecture for WiFi6 orchestration / network slicing.
Reasons for revision of targets	NA

4.2   Carrier networks transport technologies for transport and access networks

Major portion of the traffic in the communication service providers' network is dominated by the video and data, besides traditional voice. In today's scenario, applications are data-centric demanding high bandwidth and large data rate for flow of information.

To keep pace with emerging trends like interactive HD[46]-video-based services, broadband data centre, cloud, 3D-video, etc, the network at transport/backhaul and access has to have a new generation Terabit capacity backhaul and needs to evolve along with upcoming technology trends.

R&D focus under the program is to build systems, sub-systems and gain expertise, in the technology for access, transport/backhaul, and metro/aggregation networks to indigenously build systems and sub-systems and gain expertise.

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[46] **High Definition**

4.2.1 Packet Optical Transport Platform

DWDM technology is the de-facto choice for TSPs at the core network to address the demands for high bandwidth. Augmenting the DWDM-based system with OTN switching and evolving into a POTP[47] lays the foundation for transparent, multi-wavelength manageable networks achieving maximum utilisation, manageability and wide client signal support for future DWDM networks.

OTN provides a flexible multiplexing hierarchy, transparent transport of client signals with backward compatibility for existing protocols. OTN as a transport combined with electronic switching technology makes an useful core network element.

Software Defined Networking (SDN) is a concept for the separation of the forwarding and the control plane of a network. It has already become a highly adopted technology in packet networks in the last years and made its way from early research activities to commercial use in operator environments.

Network operators are facing the challenges of growing traffic, new applications, like data center, and changing traffic patterns. This comes together with an increasing number of technologies, layers and protocols and the old problem of multi-vendor environments. Equipment vendors on the other hand are under extreme competition and price pressure. They need to provide distinguishing hardware functionalities and innovative features and limit the cost for protocol developments.

This is the environment where SDN has been identified as an approach for a solution to many of these challenges. One of the biggest challenges were separate domains per vendor due to lack of interoperability. Many operators like to work with a multi-vendor strategy to avoid dependence and maintain competitive cost levels from their vendors. Sometimes multivendor situations also come from acquisition of other networks.

Therefore, SDN is now also conquering the Transport Networks to simplify and automate the network operations. Programmable SDN platforms like ONOS, OpenDaylight, allow to easily create new applications and generate new revenues for the operators.

Because of intrinsic behavior like openness, flexibility and adapting nature of SDN platforms, it is seen an enabler of 5G ecosystem. Transport systems which are part of large networking infrastructure will play significant role in building KPIs based 5G applications. Hence it is important to carry out the study project to evaluate the requirements from a deployable system perspective.

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[47] **Packet Optical Transport Platform**

Objective	To develop of OTN switch platform for DWDM networks and enable C-DOT's DWDM and POTP products with SDN functions.
Brief description	Client ports are statically-mapped to a single line port in traditional WDM approach and there is no provision to remotely switch client traffic to a different line port or switch traffic from one line interface to another. An OTN switch enables ODUs[48] to be switched between interfaces. The main benefit of OTN multiplexing structure is that lower-order ODUs that are mapped into higher-order ODUs remain individually switchable. OTN switch can ensure very efficient utilisation of high-speed wavelengths with faster service provisioning and reduced overall CapEx[49] and OpEx[50]. The result is a greater improvement in fault restoration time, enabling robust carrier-grade networks with significant improvement in QoS. Software-defined networking (SDN) solution for C-DOT's POTP & DWDM system is a new model used to design, build, and manage networks. In SDN, the network's control and forwarding planes are separated, thus preparing the control plane and the forwarding plane for maximizing the utilization of networks. SDN architecture centralizes network control and moves the control logic to an off-device computer resource called the SDN controller. The technology gives options to the network operator to write a dozen of application useful for themselves. It gives network operator the power to deal with complexity, improve policy control, improve scalability, and remove vendor dependencies.C-DOTs routers program has accepted the SDN philosophy. In 5G testbed the philosophy is being tested in its preliminary stage. To ensure success of SDN philosophy, POTP/DWDM line of products should also be enabled with standard SDN interface.
Application areas	Optical backbone networks SDN enabled POTP & DWDM nodes with 3rd party controller application
Key deliverables	OTN switch with cross connect capacity ~1.6 Tbps[51], ~4 Tbps, ~10 Tbps • Prototype of an SDN enabled system with list of future activities • Prototype of Drivers (south bound interface) for SDN controllers. • Prototype of North bound interface at SDN controller for Controller/Management entities.
Status as on 31.03.2020	• System specifications, architecture and system engineering finalised for 1.6 Tbps POTP system. • HW and SW development completed for 1.6 Tbps POTP system. • System integration and testing of 1.6 Tbps POTP system completed and offered for internal validation • Design of hardware modules completed for 4T POTP system • Development of GMPLS-based control plane completed for 1.6T POTP • EMS development and testing completed for 1.6 Tbps POTP system. • Design of hardware modules completed for 4T POTP system

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[48] **Optical Data Unit**
[49] **Capital Expenditure**
[50] **Operating Expense**
[51] **Terabits per second**

Finance (₹ in crore)	Sanctioned budget outlay for the project			95.00
	Cumulative expenditure (*provisional upto Mar-2020*)			43.44
	Budget for FY 2020-21			25.30
Project plan	**Deliverables and milestones**		**Target**	
			2019-2020	**2020-2021**
	System requirements specification		*NA (completed in 2017-18)*	
	Architecture design finalisation		*NA (completed in 2017-18)*	
	System engineering finalisation		*NA (completed in 2017-18)*	
	Identification and specification optimisation of major components (modules, silicon, etc)		*NA (completed in 2017-18)*	
	HW and SW development completion (1.6 Tbps POTP system)		*NA (completed in 2018-19)*	
	System integration and testing of 1.6 Tbps POTP system and offer for internal validation		3Q:19-20	*NA (completed)*
	Validation and testing of 1.6 Tbps POTP system		4Q:19-20	1Q:20-21
	Offer for TEC validation/pilot/field trial for 1.6 Tbps POTP system		2Q:20-21	2Q:20-21 *(note)[1,3]*
	Development of network planner for POTP		3Q:19-20	*NA (Completed) (note)[4]*
	Development of GMPLS-based control plane for POTP		3Q:19-20	*NA (Completed) (note)[4]*
	Development completion for ~4 Tbps POTP system	Hardware	4Q:19-20	*NA (completed)*
		Software	1Q:20-21	3Q:20-21 *(note)[5]*
	Fabrication of multiple~4 Tbps POTP system in full configuration progressively		2Q:20-21	4Q:20-21 *(note)[6,7]*
	System integration and testing of ~4 Tbps POTP system and offer for internal validation	System integration and testing	4Q:20-21	2Q:21-22 *(note)[8]*
		Offer for internal validation	1Q:21-22	*(note)[9]*
	Validation and testing of ~4 Tbps POTP system		3Q:19-20	*(note)[9]*
	Pilot/field trial for ~4 Tbps POTP system		4Q:19-20	*(note)[9]*
	Offer for TEC validation of ~4 Tbps POTP system		4Q:19-20	*(note)[9]*
	Completion of HW and SW development for ~10 Tbps POTP system		*On hold (note)[2]*	*On hold (note)[2]*
	Fabrication of multiple ~10 Tbps POTP systems in full configuration progressively		*On hold (note)[2]*	*On hold (note)[2]*
	System integration and testing of ~10 Tbps POTP system and offer for internal validation		*On hold (note)[2]*	*On hold (note)[2]*
	Validation of ~10 Tbps POTP system		*On hold (note)[2]*	*On hold (note)[2]*
	Offer for TEC validation and pilot/field trial for ~10 Tbps POTP		*On hold (note)[2]*	*On hold (note)[2]*

	EMS development for POTP (1.6 Tbps POTP system)		
	EMS study and system requirements specification	*NA(completed in 2017-18)*	
	EMS architecture design	*NA(completed in 2017-18)*	
	EMS development and testing	3Q:19-20	*NA (completed)*
	EMS V1.0.0 Release for 1.6 Tbps POTP system for internal validation	3Q:19-20	*NA (completed)*
	NMS[52] V1.0.0 Release for 1.6 Tbps POTP system for internal validation	4Q:19-20	*NA (completed)*
	EMS development for POTP (~4 Tbps POTP system)		
	EMS study and system requirements specification	*NA(completed in 2018-19)*	
	EMS architecture design	1Q:19-20	*NA (completed)*
	EMS development and testing	4Q:20-21	2Q: 21-22
	EMS Release V2.0.0 for ~4 Tbps POTP system for internal validation	4Q: 21-22	4Q: 21-22
	NMS[53] Release V1.0.0 for ~4 Tbps POTP system for internal validation	4Q: 21-22	4Q: 21-22
	EMS development for POTP (~10 Tbps POTP system)		
	EMS study and system requirements specification	*NA(completed in 2018-19)*	
	EMS architecture design	*On hold (note)[2]*	*On hold (note)[2]*
	EMS development and testing	*On hold (note)[2]*	*On hold (note)[2]*
	EMS V3.0.0 Release for ~10 Tbps POTP system for internal validation	*On hold (note)[2]*	*On hold (note)[2]*
	Transport SDN solution for C-DOT's POTP & DWDM system		
	Assessment of the requirements to be met through SDN implementations for Transport products	NA	1Q: 20-21
	Identification of available enabling technologies in hardware and software for SDN implementation for Transport products	NA	2Q: 20-21
	Evaluation of design approaches for provisioning SDN support in transport products.	NA	3Q: 20-21
	Architecture Design with a prototyping system	NA	4Q: 20-21
Projected physical outcome for FY 2020-2021	• Offer for TEC validation and pilot/field trial for 1.6 Tbps POTP system. • Five Nodes of 1.6T to be prepared for POC in Telecom Service Provider • Three Nodes of 4.8T to be prepared for system Integration and Testing. • Architecture design of SDN solution with a prototyping system		
Reasons for revision of targets	Due to non-availability of sufficient funds, procurements could not be completed during the year.		

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[52] **Network Management System**

Note:

1. *Fabrication of multiple complete nodes in full configuration of ~4 Tbps POTP system required for system integration, internal validation and field trial, to be taken up gradually. Total of 3 nodes are planned to develop for this financial year due to budgetary constraints.*

2. *Development for ~10 Tbps POTP system presently put on hold due to budgetary constraints . Also, 1.6 T and 4T system perfpormance would be ascertained in due course for taking up 10 T activities.*

3. *CDOT's DWDM Equipment has been deployed in the field for trials, in three different networks. It is assumed that DWDM set-up in CDOT will be retained at CDOT for the TEC Certification of CDOT's OCN and POTP products.*

4. *Development has been completed for 1.6T system, however the development shall continue for higher systems.*

5. *The activity planned this FY is development of Board Support package of Hardware modules. Final Completion of development and integration activity will be subsequent to Hardware availability.*

6. *The milestone would be achieved in progressive manner. This depend upon availability of components etc. The milestone is marked as initiation of the activity.*

7. *This milestone is defined as initiation of the activity. As the procurements has been put on hold, because of budgetary constraints, targets have been defined assuming procurement process gets re-initiated by Q2 2020.*

8. *Fabrication of three partial nodes of ~4T system is planned for this FY2020-2021. The milestone shall be achieved progressively and is marked as initiation of the activity.*

9. *This activity will be taken up in subsequent financial year(s)*

4.2.2 TWDM PON system

In the PON technology, the maximum distance a single fibre covers is upto the splitter, which is kept near the customer premises. The PON architecture, therefore, has an advantage when compared to point-to-point carrier ethernet because of the low cost of ODN[54] required. C-DOT has indigenously designed and developed GPON[55], a TDM[56]-based access technology, and facilitated in setting up the manufacturing eco-system for GPON technology in the country through ToT to the manufacturers. At present, GPON technology is undergoing field deployment for connecting 250,000 grampanchayats through NOFN under BharatNet program.

With the widespread deployment of broadband optical access based on GPON technology and emergence of more and more bandwidth hungry services (like, 4K TV[57], video-on-demand, tele-medicine with real time transfer of video and image rich content, generating heavy traffic) as well as deployment of 4G technologies, broadband wireless access requires fibre-based backhaul.

To meet the increasing bandwidth requirements both at access and backhaul, it is desirable to build the fibre optical network based on symmetrical PON technology. The upcoming technology options are XGS-PON[58], TDM/TDMA-based NGPON2[59], TWDM[60]-based hybrid technology, etc.

Objective	To develop high capacity futuristic PON technology based on TDM/TDMA for symmetrical PON (i.e., XGS-PON) and hybrid technology based on TWDM for NGPON2, supporting tunable wavelength and flexible bit-rate configuration.
Brief description	C-DOT's TDM/TDMA-based PON technology (and its multiple variants as per field requirements) has made an impressive breakthrough as pivotal optical access technology and catalyst in the deployment of NOFN under BharatNet program to connect 250,000 grampanchayats in the country. As a natural progression to the technology and to further complement the PON family, symmetrical (TDM/TDMA-based) and hybrid (TWDM-based, a combination of both TDM and WDM[61]) PON technologies are the upcoming trends in the PON family to address the ever-increasing bandwidth needs in the access and backhaul. ITU-T has finalised the standards for these future generation PON systems: • **XGS-PON**: ○ The latest standard, XGS-PON (ITU-T G.9807 series) delivers 10 Gbps in both directions but also supports dual rate transmission. This allows 10/10 Gbps XGS-PON ONUs[62] and 10/2.5 Gbps XG-PON ONUs to be connected to the same OLT port through a native dual rate TDMA scheme in the upstream and TDM scheme in the downstream.

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[54] **Optical Distribution Network**
[55] **Gigabit Passive Optical Network**
[56] **Time Division Multiplexing**
[57] **Television**
[58] **10-Gbps Symmetrical Passive Optical Network (TDM/TDMA-based)**
[59] **Next Generation Passive Optical Network (TWDM-based hybrid PON)**
[60] **Time and Wavelength Division Multiplexing**
[61] **Wavelength Division Multiplexing**
[62] **Optical Network Unit**

- XGS-PON operates at upstream wavelength 1260-1280nm and downstream wavelength 1575-1580nm.
- Systems to be developed for this technology are OLT line card at central office OLT system, ONT system at customer premises and small box-type standalone Mini-OLT system.

- **NGPON2**:
  - Will combine the benefits of both TDM/TDMA and WDM technologies to achieve still higher bandwidth, i.e., 40 Gbps.
  - NGPON2 is the most advanced and sophisticated of all NG-PON technologies. It adds more wavelengths on the fibre (initially 4 in upstream and 4 in downstream, with more possible in the future). The system will support flexible bit-rate configurations (2.5/2.5 Gbps, 10/2.5 Gbps, and 10/10 Gbps) and use tunable lasers that allow operators to dynamically assign and change the wavelength on which a customer is connected.
  - Upstream wavelengths are in range of 1524-1544nm and downstream wavelengths are in range of 1596-1603nm.
  - NGPON2 system development is to include development of NGPON2 OLT line card at central office OLT system and NGPON2 ONT system at customer premises.

XGS-PON and NGPON2 can co-exist with current GPON/XG-PON networks and can be used to provide mobile backhaul. XGS-PON and NGPON2 are contemporary programs, suitable for both greenfield applications as well as for upgradation and expansion of the existing GPON network with new PON system, which can co-exist with current network.

- **TWDM PON**

This technology is combination of WDM and TDM technologies in a PON network. TWDM PON system is co-existence of GPON, XGS-PON and NGPON2.
All these PONs will have OLT as central office and ONTs as customer premises equipment.

Envisaged TWDM PON OLT will house line cards of GPON, XGS-PON and NGPON2 which can coexist on same PON link towards ODN. Any or combination of these PON systems can be used to provide mobile backhaul also. These systems can also be of great importance for strategic sectors as well.

Though ITU-T standards are there for these technologies, TEC specifications are not available at present for NGPON2. Hence, the next generation PON systems will be designed and developed as per C-DOT's defined specifications drawn from ITU-T standards.

- **5G Front Haul System**

The 5G promise of ultra-fast speed and higher responsiveness (lower latency) are conspiring to potentially overwhelm the front-haul network—one of the links between the phone and the internet. Operators cannot meet these expectations by building the 5G-RAN in isolation from other network domains, including the transport layer.

	Besides the upgrades to the RAN – which include cell densification, more antennas (i.e. massive MIMO) and the use of existing and new operating frequencies – operators need more fiber and new packet transport technologies that address the diverse applications and corresponding network requirements. Where possible, the 5G plans should leverage existing packet networks and optical transmission technologies to save on cost and speed of deployment.
Application areas	• Upgradation and expansion of existing GPON network. • Highly resilient PON deployments for Defence networks, mobile backhaul, etc. • Building segment, campuses, offices, Defence establishments, NKN[63], NOFN, etc. • TSP[64] and ISP[65] networks: deployment in access and backhaul. • Mobile backhaul in case of 4G or WiFi deployments. • Front-haul access network in case of 5G deployments
Key deliverables	**XGS-PON**: • XGS-PON OLT (chassis-based): catering to maximum 6000 ONTs. • XGS-PON Line Cards • XGS-PON Mini-OLT (4-port) :catering to maximum 128 ONTs, • XGS-PON ONT, **NGPON2**: • NGPON2 OLT line card (chassis-based) • NGPON2 ONTs **TWDM PON:** • TWDM OLTs • TWDM PON ONTs – ONTs same as XGS PON, NGPON2, GPON (in any combination) **5G Front Haul system:** • 5G Front Haul OLT o 5G Front Haul ONT
Status as on 31.03.2020	• EMS release done for XGS-PON (chassis based) • System Integration, offer for internal Validation and EMS release for XGS-PON (Mini-OLT) • System Integration, offer for internal Validation and EMS release for NGPON2 (Chassis based) • HW development, SW development, System Integration & testing of TWDM-PON integrated OLT chassis

Finance (₹ in crore)	Sanctioned budget outlay for the project	85.00
	Cumulative expenditure (*provisional upto Mar-2020*)	46.85
	Budget for FY 2020-2021	17.44

Project plan	Deliverables and milestones		Target	
			2019-2020	**2020-2021**
	XGS-PON *(Note)[1]*	System specifications, architecture design and engineering finalisation	*NA(completed in 2017-18)*	

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[63] **National Knowledge Network**
[64] **Telecom Service Provider**
[65] **Internet Service Provider**

	XGS-PON (chassis-based)	ONT HW	*NA(completed in 2017-18)*	
		ONT SW	*NA(completed in 2017-18)*	
		OLT SW	*NA(completed in 2017-18)*	
		OLT SW	*NA (completed in 2018-19)*	
		System integration, testing	*NA (completed in 2018-19)*	
		Offer for internal validation	*NA (completed in 2018-19)*	
		EMS release	1Q: 19-20	Completed
	XGS-PON (Mini-OLT)	OLT HW	*NA (completed in 2018-19)*	
		OLT SW	*NA (completed in 2018-19)*	
		System integration, testing	1Q : 19-20	*NA (completed)*
		Internal validation	2Q : 19-20	*NA (completed)*
		EMS release	4Q:19-20	*NA (completed)*
		EMS validation	NA	1Q: 20-21
		Offer for ToT	NA	2Q: 20-21
	Pilot production and assembly of XGS-PON (chassis-based) and Mini-OLT		2Q : 19-20	*NA (completed)*
	Commencement of pilot/field trial for XGS-PON (chassis-based) and Mini-OLT		Q3:19-20	3Q :20-21 (Note)[1]
	NGPON2 *(Note)[2]* (chassis-based)	System specifications, architecture design and engineering	*NA (completed in 2018-19)*	
		NGPON2 ONT HW	*NA (completed in 2018-19)*	
		NGPON2 ONT SW	*NA (completed in 2018-19)*	
		NGPON2 OLT HW	*NA (completed in 2018-19))*	
		NGPON2 OLT SW	*NA (completed in 2018-19)*	
		System integration, testing	2Q : 19-20	*NA (completed)*
		Offer for internal validation	3Q: 19-20	*NA (completed)*
		EMS release	4Q: 19-20	*NA (completed)*
		Pilot production and assembly of NGPON2	4Q: 19-20	3Q :20-21 (Note)[1]
		Pilot/field trial commencement for NGPON2	1Q: 20-21	4Q: 20-21
	TWDM-PON integrated OLT chassis	HW development	2Q :19-20	*NA (completed)*
		SW development	3Q : 2020-21	*NA (completed)*
		System integration, testing	4Q:19-20	*NA (completed)*
		Offer for internal validation	NA	1Q: 20-21
		EMS release	NA	2Q :20-21
		EMS validation	NA	3Q :20-21
	XGS-Ring ONT	HW Development	NA	1Q: 20-21

		SW Development	NA	2Q :20-21
		System integration, testing	NA	2Q :20-21
		Offer for internal valiation	NA	3Q :20-21
		EMS release and validation	NA	4Q :20-21
	5G Front Haul	OLT HW Development	NA	4Q :20-21 (note)[2]
		ONT HW Development	NA	4Q: 20-21
		OLT SW Development	NA	1Q :21-22
		ONT SW Development	NA	1Q: 21-22
		System integration, testing	NA	2Q: 21-22
		Offer for internal validation	NA	3Q: 21-22
		EMS release	NA	3Q: 21-22
		EMS validation	NA	4Q: 21-22
		Pilot production	NA	4Q: 21-22
		Commencement of Pilot/Field trial	NA	1Q: 22-23
		Offer for ToT	NA	2Q: 22-23
Projected physical outcome for FY 2020-2021	• XGS-PON (Mini OLT) EMS validation and offer for Transfer of Technology. • Assembly of more numbers of NGPON2 Line Cards and NGPON2 ONTs • Pilot/field trial commencement for NGPON2 (chassis-based). • EMS release and validation of TWDM-PON integrated OLT chassis. • System integration and EMS release of XGS-Ring ONT • Offer for internal validation of XGS-Ring ONT. • Hardware development of 5G FH OLTs and 5G FH ONTs			
Reasons for revision of targets	• Proposal was given to BBNL for commercial trial, response awaited. TEC testing in progress and field trial will be done as part of TEC process. • Non-availability of necessary components due to procurement delays.			

Note:

1. *Assuming all POs will be placed by 1st week of July so that components are received by first week of November 2020.*

2. *Assuming all POs will be placed by 1st week of July so that components are received by last week of December 2020.*

4.3   Next generation switching and routing systems

The penetration of broadband services in India is poised for a huge growth primarily due to the Government initiative on increasing broadband connections, as part of the 'Digital India' program.

Major portion of the traffic in the communication service providers' network is dominated by the video and data, besides traditional voice. In today's scenario, applications are data-centric demanding high bandwidth and large data-rate for flow of information.

IP network is becoming the core network for all data, voice and video communications. With the deployment of 3G and 4G mobile networks and standardisation activities of 5G mobile network, IP network is being used in the core and the edge. Hence the evolutionary trend in telecommunication networks is towards converging all existing telecommunication networks into a single all-IP-based packet switched optical internet.

The next generation IP network is viewed as an integrated platform for voice, video and data services capable of high-speed and differentiated services. Concurrently, standards for allowing differentiated services are being implemented in IP routers, thus setting the foundation for high quality voice traffic (or other multimedia traffic) over IP networks. These developments, together with the popularity of the IP protocol, have led the new as well as legacy Telcos[66] to select IP as the future infrastructure protocol. Thus the bandwidth requirement for the core network has increased manifolds. Few hundred Gbps speed towards the edge network has become insufficient for the multi-service all-IP-based packet switched optical internet.

The next generation switching and routing systems will address the requirement of very high bandwidth at the core network. This requires development of very high-speed routing systems providing interfaces for 100 Gbps towards the edge network for carrying traffic from core network to edge network and vice-versa, and supporting SDN and NFV features. Moreover, there is a significant requirement for enterprise router, L2/L3 (Layer-2/Layer-3) switch/router for LAN[67], MAN[68] and data centre switches.

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[66] **Telecommunication Company**
[67] **Local Area Network**
[68] **Metropolitan Area Network**

4.3.1 Next generation high-speed routing system

Modern communication networks are changing very fast - they are not only becoming very high-speed packet-based networks, but also becoming more and more SW-based. The use of NFV technology to run network services in SW enables SDNs to create a large distributed SW-based network. To achieve the vision of a high-performance SW-based network that is flexible, low-cost and agile, the traditional routing technology needs to be comprehensively enhanced with NFV and SDN functionalities to support a comprehensive SDN control plane in a virtualised environment.

It is desired that the next generation high-speed router ensures the high-bandwidth network functions operate at near line-speed, while taking advantage of the flexibility and customisation of low-cost commodity servers required for control plane processing. Moreover, the router with high-speed interfaces (of the order of 100 Gbps and more) is also required to minimise the overheads for packet processing, and to provide high-throughput, low-latency networking environments. The routing technology with SDN and NFV functionalities will also make the present EPC[69] technology more flexible. The EPC will provide a platform for IoT[70] communications, for large scale deployment of 4G/5G cellular networks.

In view of above, there is definite need to undertake indigenous developments for next generation high-speed routing systems.

Objective	To develop a next generation high-speed routing system with SDN and NFV functions
Brief description	In the next generation high-speed routing, it is envisaged that a router should act as a dynamic and flexible network component, having smarter data plane than just performing simple layer-3 functions.
	The next generation high-speed router should support a network architecture for complex stateful routing for data-flows, where packet processing by network functions can dynamically modify the path taken by data-flows, without unduly putting the load onto the centralised SDN controller. As part of SDN and NFV standards, the next generation high-speed router will have dynamic placement of network functions and routing of data-flows through a SW-based network, exploiting a combination of centralised SDN control and NFV capabilities in the network. This will also meet the growing communication needs for IoT. With smart sensing devices becoming ubiquitous, there is a need to support IoT communication at large scale, especially over cellular networks.
	The proposed next generation high-speed routing system will incorporate support for high-speed network interfaces like converged transport 100 Gbps interfaces and 100 Gbps ethernet interfaces be scalable, and will have modern networking features complying with SDN and NFV requirements. These features will make the product versatile and futuristic for use in public and private networks.
	A multi-Terabit routing platform has been developed for routing packets in large public networks. This platform serves as a building block for constructing large

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[69] **Evolved Packet Core**
[70] **Internet-of-Things**

	packet-routing systems that will be required within the next few years by service providers to carry huge volumes of the fast growing IP and internet traffic. Customised versions of the routing system will be created for use in the strategic networks. Scope of the project has been enhanced to develop additional compute node and intelligent network interface to address the requirement of large number of such nodes for implementing an SDN/NFV-based next generation network as well as for building core network supporting 5G technology requirements.
Application areas	The routing system will serve as a core node in the next generation IP switching networks.
Key deliverables	• Router with high-speed 100 Gbps transport interfaces by carrying out HW-SW integration of Suteevra WDM system with MTBR (Multi Tera Bit Router) system. • High-speed routing system with 100 Gpbs ethernet interfaces and SDN, NFV features. • Compute node and intelligent network interface for SDN/NFV routing.

Status as on 31.03.2020	• In-house designed and developed basic blocks, required for development of high-speed routing system
	
	• 100 Gbps transport interface integrated with MTBR and the system has been tested for point-to-point 100 Gbps transport. Components for additional transport interfaces ordered for field trial and procurement for the same is in progress.
	
	• Assessment and identification of key technologies for NFV and SDN implementation in the routing platform, completed.
	
	• Evaluation has been done for design approaches for networking technologies for provisioning NFV and SDN support in routing products.
	
	• MTBR SW enhancement for SDN/NFV functionalities has been done.
	
	• Selection of key components completed and further interactions in progress with key silicon vendors for the detailed information required for the actual design of high speed routing system.
	
	• System architectural design completed
	
	• HW and SW design with 100 Gbps ethernet interface has been completed. Components & PCB procurement are in progress
	
	• For Compute Node
	
	• Requirements specifications and system architecture design has been completed
	
	• The development of hardware and software as well as components procurement are in progress
	
	• For Intelligent NIC card
	   ➢ Requirements specifications and system architecture design has been completed
	   ➢ The development of hardware and software as well as components procurement are in progress

Finance (₹ **in crore**)	**Sanctioned budget outlay for the project**		65.00
	Cumulative expenditure (*provisional upto Mar-2020*)		29.97
	Budget for FY 2020-2021		24.07
Project plan	**Deliverables and milestones**	**Target**	
		2019-2020	**2020-2021**

	100Gbps transport interface in MTBR platform and evaluation of SDN and NFV		
	System requirements specification finalisation for transport interfaces in Router	*NA(completed in 2017-18)*	
	Procurement and production of 100 Gbps transport interface boards of C-DOT *Suteevra*	2Q:19-20	2Q:20-21
	Integration of 100Gbps transport interface with MTBR	*NA(completed in 2017-18)*	
	Validation of router with 100 Gbps transport interface	2Q:19-20	2Q:20-21
	Assessment of the requirements to be met for NFV and SDN implementations for routing products	*NA(completed in 2017-18)*	
	Pilot trial of high-speed routing system with 100 Gbps transport interface	3Q:19-20	3Q:20-21
	Identification of available enabling technologies in HW and SW for NFV and SDN implementation	*NA(completed in 2017-18)*	
	Evaluation of design approaches for networking technologies for provisioning NFV and SDN support in routing products	*NA(completed in 2017-18)*	
	High-speed routing system with 100Gbps ethernet interface, SDN and NFV features		
	Requirements specification of next generation router with SDN and NFV support and 100 Gbps ethernet interfaces	*NA(completed in 2018-19)*	
	Selection of key components	*NA(completed in 2018-19)*	
	Architecture design	*NA(completed in 2018-19)*	
	SW development on reference HW	1Q:19-20	*NA (completed)*
	SW testing on reference HW	3Q:19-20	*NA (completed)*
High-speed router	HW and SW development with 100 Gbps ethernet interface	4Q:19-20	2Q:20-21
	HW-SW integration and testing	4Q:19-20	2Q:20-21
	Validation and pilot trial of high-speed routing system	4Q:19-20	2Q:20-21
Compute node for SDN/NFV routing	Requirements specifications	1Q:19-20	*NA (completed)*
	System architecture design	2Q:19-20	*NA (completed)*
	HW development	4Q:19-20	2Q:20-21
	SW development	4Q:19-20	2Q:20-21
	HW-SW integration and testing	1Q:20-21	2Q:20-21
Intelligent NIC[71]	Requirements specifications	1Q:19-20	*NA (completed)*
	System architecture design	2Q:19-20	*NA (completed)*
	HW development	3Q:19-20	2Q:20-21
	SW development	4Q:19-20	2Q:20-21
	HW-SW integration and testing	1Q:20-21	3Q:20-21
	Integration of compute node and intelligent NIC	2Q:20-21	4Q:20-21
	Application testing on compute node with intelligent NIC	2Q:20-21	4Q:20-21

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[71] **Network Interface Control**

	Validation of compute node with intelligent NIC	3Q:20-21	4Q:20-21
	Pilot trial of compute node with intelligent NIC	4Q:20-21	4Q:20-21
	Development of EMS for HSRS nodes	*NA*	3Q:20-21
	Integration of EMS for HSRS with C-DOT NMS	*NA*	4Q:20-21
Projected physical outcome for FY 2020-2021	• Pilot trial of MTBR with 100 Gbps transport interface. • Pilot trial of high-speed router with 100G ethernet interface. • Pilot trial of compute node with intelligent NIC		
Reasons for revision of targets	• Pilot trial of router with 100G transport interface card got further delayed due to component sourcing because of certain difficulties being faced in release of POs. • For High-speed routing system with 100G ethernet interfaces, Compute Node for SDN/NFV routing and intelligent NIC, there were delays in procuring the desired components due to certain difficulties being faced in release of POs and due to the significantly extended component supply delivery times being experienced for some components in view of the global supply chain disruptions owing to Covid19 pandemic. Thus, the assembly of hardware could not be done as per plan. This resulted in delay in the development milestone.		

4.3.2 Switching and routing solution for LAN, MAN enterprise and data centre segment

C-DOT has already developed a 1 Tbps capacity STBR[72], high-capacity MTBR of 6 Tbps capacity, and a compact router providing throughput of upto 100 Mbps and 24-port layer-2 switch. STBR and layer-2 switch have undergone successful field trials and are under field deployment, and the technology has been transferred to multiple manufacturers for production. Technology for compact MTBR is in the process of pilot trial. Router and switch are strategic product lines and the development of these technologies have given significant technological breakthrough and steps towards achieving self-reliance in the IP-routing and switching technology in the country. These routers address the needs of the core as well as the edge networks.

The routers and switches are required in large numbers to set up LANs, MANs, WANs[73] and large size data centres, due to the increased thrust in penetration of broadband network in the country to realise the 'Digital India' program.

Deployment of indigenously developed routers and switches in the strategic sectors and public networks has given tremendous encouragement to address the large requirements of LANs, MANs, and enterprise and data centres, through development of indigenous solutions for switching and routing, in achieving self-reliance in this area of strategic importance, and in setting up a requisite manufacturing eco-system in the country.

This technology for routers and switches also has good potential in other developing countries.

Objective	To develop switching and routing solutions for LAN, MAN, enterprise and data centre requirements.
Brief description	There is a significant growth in the data centre and enterprise market and the requirement for switching and routing solutions, optimised for these requirements, is significant. The key motivation of this project is to develop indigenous solution for this segment. • **L2/L3 switch**: Layer-3 functionality will be added onto existing 24-port layer-2 switch to make it an integrated L2/L3 switch. A higher capacity version having 48 ports is also planned as part of this development to cater to market opportunities requiring higher port counts and MPLS transport protocol feature. • **Data centre switch**: This involves development of switches to cater to ToR[74] and Spine switches required in data centre network. The project will initially target medium capacity ToR and Spine switches with 10 Gbps and 40 Gbps links and finally result in delivery of higher capacity ToR switches of 48x10 Gbps, with 25/40/100 Gbps uplinks and higher capacity Spine switches of multiple 100 Gbps links, with options for 10/25/40 Gbps ports. • **HPC switch:** C-DOT has participated in a tender for designing and building a high speed switching fabric for High Performance superComputers (HPC) being developed indigenously. C-DOT has capability and experience of building such equipment. The scope of the project is being enhanced to include development of a new high speed switch, subject to award of contract to C-DOT.

[72] **Stackable Terabit Router**
[73] **Wide Area Network**
[74] **Top-of-Rack**

Application areas	LAN, MAN, enterprise networks, data centre networks in strategic, Government and enterprise market.		
Key deliverables	• Integrated L2/L3 switch: 24-port and 48-port. • Data centre switches: ○ Medium capacity ToR and Spine switches with 10 Gbps and 40 Gbps links, ○ Higher capacity ToR switches of 48x10 Gbps, with 25/40/100 Gbps uplinks, ○ Higher capacity Spine switches with multiple 100 Gbps links, with options for 10/25/40 Gbps ports. ○ Enhancement of higher capacity ToR and Spine switches to support 200G interfaces.		
Status as on 31.03.2020	• L3 switch implementation for 24-port and architecture design for 48-port L2/L3 integrated switch have been completed. • Product requirement, NFV, SDN requirement assessment and assessment of available technology for provisioning of NFV, SDN support in data centre switches have been completed. • 24-port L2/L3 switch has been pilot tried and delivered to SPIC. • 48-port integrated L2/L3 switch development has been completed and offered for validation. • Architecture design and implementation of High capacity ToR and Spine switches has been completed.		
Finance (₹ in crore)	**Sanctioned budget outlay for the project**		85.00
	Cumulative expenditure (*provisional upto Mar-2019*)		36.61
	Budget for FY 20202021		15.84

Project plan	Deliverables and milestones	Target	
		2019-2020	**2020-2021**
	L2/L3 switching platform		
	Implementation of L3 switching for 24-port switch	*NA (completed in 2017-18)*	
	Validation of 24-port L2/L3 switch	*NA (completed in 2018-19)*	
	Development of 48-port integrated L2/L3 switch and system engineering	*NA (completed in 2018-19)*	
	Validation of 48-port L2/L3 switch	3Q:2019-20	*1Q:2020-21*
	Data centre switches		
	Study of data centre technologies	*NA (completed in 2017-18)*	
	Product requirements specifications	*NA (completed in 2017-18)*	
	Medium-capacity ToR switch — Design and development	*NA (completed in 2018-19)*	
	Medium-capacity ToR switch — Validation	1Q:19-20	*1Q:20-21*
	SRS[75] for medium-capacity Spine switch	*NA (completed in 2018-19)*	
	Assessment of the requirements to be met for NFV and SDN implementations for data centre switching products	*NA (completed in 2017-18)*	

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[75] **Software Requirements Specification**

	Evaluation of design approaches for networking technologies for provisioning NFV and SDN support in data centre switching products		*NA (completed in 2017-18)*	
	High-capacity ToR switch	Requirements specifications	*NA (completed in 2018-19)*	
		Architecture design	*NA (completed in 2018-19)*	
		Design and development	*NA (completed in 2019-20)*	
		Integration	4Q:19-20	1Q:20 -21
	High-capacity Spine switch	Requirements specifications	*NA (completed in 2018-19)*	
		Architecture design	*NA (completed in 2018-19)*	
		Design and development	*NA (completed in 2019-20)*	
		Integration	4Q:19-20	1Q: 20-21
	Enhancement of high-capacity ToR and Spine switches with upto 200G interfaces		*NA*	2Q: 20-21
	High-capacity switches	Production	NA	2Q:20-21
		Validation	NA	3Q:20-21
		Field trial	NA	4Q:20-21
	HPC Switch	Requirement Analysis	NA	2Q:20-21
		Hardware realization: CAD/CAM Implementation	NA	3Q:20-21
		Board Assembly & PCBA Testing	NA	4Q:20-21
		Supply of the Systems	NA	4Q:20-21
Projected physical outcome for FY 2020-2021	• Pilot trial for 48-port L2/L3 switch, medium-capacity ToR switch. • System integration and testing of high capacity ToR and Spine switches.			
Reasons for revision of targets	Though Hardware designs have been completed for ToR and Spine switches but production did not happen on account of paucity of funds for procuring components.			

4.4   Satellite-based technologies

C-DOT has been working on development of secure communication network. Products and technologies for secure terrestrial fixed-line and mobile networks have been developed and deployed. Satellite communication is a crucial communication mechanism for remote and inaccessible areas as well as communication during emergency situations like disasters in strategic and Defence areas. Thus secured satellite communication is a challenge that needs to be addressed indigenously. In addition to its existing secured solutions for the terrestrial networks, it is proposed to develop satellite hub subsystem for secure satellite communication. This project is proposed to be taken up jointly with other Government R&D institutions having expertise in development of system/subsystem for satellite communication.

Satellite-based technologies program has undertaken to develop satellite hub baseband system, as client's requirements.

4.4.1 DVB-S2 hub baseband system

Objective	To realise a hub baseband system based on DVB-S2[76] standards that includes development of DVB-S2 (Digital Video Broadcasting- Satellite 2nd generation) modulator and MF-TDMA (Multi-Frequency Time Division Multiple Access) demodulator units.
Brief description	Requirement has been projected by DEAL for the above system to partner with C-DOT. Similar requirement has been given by BEL[77] for DVB-S2-based system for a different application. DVB-S2 is the successor of the popular DVB-S[78] system. Development of DVB-S2-based hub baseband system requires the development of multiple demodulators and modulators with multichannel capability supporting different selectable modulation schemes and configurable channel coding. It also requires the development of IF units. The hub baseband system is to be designed to integrate with off-the-shelf RF front end. The hub has to be integrated with satellite to provide digital video broadcasting services to satellite terminals.
Application areas	• Digital video broadcasting applications using satellite. • The system also finds suitability for north-eastern regions.
Key deliverables	Prototype hub baseband system consisting of DVB-S2 modulator units, MF-TDMA demodulator units along with test jig.
Status as on 31.03.2020	• System requirements and architecture finalized. Customer concurrence awaited • Algorithms simulations completed for DVB-S2 modulator and MF-TDMA demodulator. • Prototype Testing for Modulator and Demodulator in-progress. Development ongoing for Enhanced boards with ATCA (Advanced Telecommunications Computing Architecture) form factor.

Finance (₹ **in crore**)		
Sanctioned budget outlay for the project		8.00
Estimated revised budget outlay for the project deliverable		20.00
Cumulative expenditure (*provisional upto Mar-2020*)		7.07
Budget for FY 2020-21		7.43

Project plan	**Deliverables and milestones**	**Target dates**	
		2019-2020	**2020-2021**
	Requirements analysis, system architecture design and interfaces finalisation	Q1:19-20	*NA (completed)*
	DVB-S2 modulator, MF-TDMA demodulator architecture finalisation	Q1:19-20	*NA (completed)*
	Algorithms selection and simulation	1Q:19-20	*NA (completed)*
	Component procurement	1Q:19-20	*NA (completed)*
	Modulator, demodulator cards CAD activity	2Q:19-20	*NA (completed)*
	SW algorithm development	2Q:19-20	*NA*

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[76] **Digital Video Broadcasting (using) Satellite - 2nd generation**
[77] **Bharat Electronics Limited**
[78] **Digital Video Broadcasting (using) Satellite**

			(completed)
	HW cards fabrication, assembly and testing	3Q:19-20	*NA (completed)*
	Algorithm porting and testing	3Q:19-20	*NA (completed)*
	Integration and testing of prototype system	4Q:19-20	*NA (completed)*
	Completion of prototype DVB-S2 based hub baseband system	4Q:19-20	1Q:20-21
	Enhanced DVB-S2 hub system - requirements analysis and architecture design	1Q:20-21	1Q:20-21
	Design of modulator and demodulator cards with enhanced features.	2Q:20-21	2Q:20-21
	Simulation of algorithms for added features of modulation schemes and coding	2Q:20-21	2Q:20-21
	CAD for all the cards of hub baseband system, and algorithm development	3Q:20-21	3Q:20-21
	PCB[79] fabrication, assembly and testing	4Q:20-21	4Q:20-21
	Integration and testing of the baseband system	4Q:20-21	4Q:20-21
	Enhanced DVB-S2-based hub baseband system	4Q:20-21	4Q:20-21
Projected physical outcome for FY 2020-2021	Integrated and tested enhanced DVB Hub Baseband System consisting of DVB-S2 modulator, MFTDMA demodulator units and IF units.		
Reasons for revision of targets	System specification and architecture clearance is pending from the customer.		

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[79] **Printed Circuit Board**

4.4.2 Satellite based broadband solution (C-Sat-Fi)

Satellite Communication can play a big role in India's ambition to transform itself into a country empowered by digital technologies. In India, Satellite technology is especially suited for far flung and difficult terrain areas like North Eastern States, Leh, Ladakh, Andaman & Nicobar Islands, Lakshadweep, etc. It would be extremely useful in areas where laying optical fibre cables or installing mobile towers are difficult and next to impossible.

Recent development of High-Throughput Satellite (HTS) technology in Ku & Ka band, the bandwidth available for communication needs has increased many folds and cost of bandwidth has reduced tremendously. ISRO has already launched GSAT-19, GSAT-29, GSAT-11 and GSAT-20 satellites in Ku & Ka band which has augmented hundreds of Gbps of total bandwidth for our communication needs. ISRO is also planning to launch more satellites to increase the bandwidth capacity in the coming years. The new development of Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellite constellation and its opening-up in Indian space in near future for high speed broadband will enhance satellite infrastructure of our country.

Universal Service Obligation Fund (USOF) through BBNL has already funded connectivity in more than 6 thousand Villages through Satellite infrastructure. The service delivery of Voice, Video and Data using satellite backhaul to the villages is the most important requirement today.

Wi-Fi is a proven and cost-effective technology to provide last mile broadband connectivity and will help in proliferation of digital connectivity in least time and investment. Due to its operation in free spectrum (ISM band) and a very well-developed ecosystem of hardware/software and user equipment (Mobile/Laptops/Tables etc.), Wi-Fi is the most suited technology to provide connectivity in rural and unconnected areas.

Currently available satellite phones are proprietary, expensive and require line of sight to the satellite all the time and provide basic voice service and not designed for data services.

With this background, efficient integration of Wi-Fi for access and Satellite technology for backhaul makes most sense to provide digital connectivity in our country.

Application Area of Satellite based Broadband
- Connectivity in Rural and difficult terrain such as North & North East Region of India
- Connectivity in Disaster conditions
- Video distribution

Immediate Applications
- Enabling approx. 1500 DSPT (Digital Satellite Phone Terminal) locations with basic Voice connectivity with option of Data after turning off of NSS 6 satellite transponder
- Creating Digital Infrastructure in an Aspiration Villages and provide complete Voice, Data and Video services

Satellite based broadband solution (C-Sat-Fi)

Objectve	To develop a complete solution and service delivery to end users which can leverage the satellite bandwidth to provide triple play services (voice, video and data) in difficult and remote areas such as North & North East Region of India.

Brief Description	During the FY 2019-20, C-DOT has successfully conducted the PoC of the C-Sat-fi solution by integrating the already available products such as Service Switch, High Speed Access Point, Widhwan, miniPDO and MANORANJAN powered by Green Power Supply Unit (GPSU) platform with Satellite connectivity from BSNL, Hughes, Planet cast and Nelco (Tata Net).
	 Focus is now:
	 ● To make the solution cost competitive, in-a-single-box, build a management system which is optimized for satellite backhaul and integrated with VSAT operator network and ISP/TSP network
	 ● To create multiple variants of the solution, so that the end user can choose the solution based on their need. Services offered by multiple variants are as follows
	    o Providing voice services only
	    o Providing triple play services
	 ● To provide Plain Old Telephone System (POTS) connection and Wi-Fi access at every home
	 ● To create a single APP(Application) platform for user to access services
	 ● Content Acquisition and Delivery from Satellite link
	 ● Common Alert Protocol (CAP) based Emergency Alert notification services
	 ● Powering the entire system with solar based system.

Application areas	● Connectivity in Rural, unconnected and difficult terrain (Aspiration Village) ● Early Emergency Alert services ● Connectivity in Disaster conditions ● Machine to Machine (M2M) and Internet of Things (IoT) connectivity ● Video distribution
Key Deliverables	● C-Sat-Fi Box ● C-Sat-Fi Customer Premise Equipment (CPE) for Voice and Data services ● Content server for C-Sat-Fi solution ● Management System for C-Sat-Fi Solution ● Single APP for C-Sat-Fi solution ● PoCs and trials of C-Sat-Fi Solution at various locations. ● Pilot implementation, Progressive Rollout and technology support for C-Sat-Fi solution

Finance (₹in crores)	**Budget for FY 2020-2021**		5.80
Project Plan	**Deliverables and milestones**	**Target**	
		2019-2020	**2020-2021**
	C-Sat-fi v1.0 (with existing Wi-Fi AP, PDO, Service Switch, Widhwan & GPSU products)		
	Architecture design for Content Server for C-Sat-fi	N.A.	1Q:20-21
	Architecture design for Element Management System (EMS) for C-Sat-fi	N.A.	1Q:20-21
	Development of Content Server for C-Sat-Fi Solution	N.A.	2Q:20-21

	Development of Management System for C-Sat-Fi Solution	N.A.	2Q:20-21
	Integration testing of C-Sat-Fi with Management System	N.A.	3Q:20-21
	Offer to Internal Validation of C-Sat-Fi with Management system	N.A.	3Q:20-21
	PoC, Trial, Deployment of C-Sat-Fi v1.0	N.A.	1Q-4Q: 20-21
	Offer to ToT of C-Sat-Fi solution v1.0	N.A.	4Q:20-21
	C-Sat-fi v2.0 (C-Sat-Fi box, CPE, Widhwan & GPSU product) H/W Development		
	C-Sat-Fi box (CAP)	N.A.	3Q:20-21
	CPE (CCP)	N.A.	3Q:20-21
	S/W Development (CAP & CCP)	N.A.	3Q:20-21
	Integration and Testing of CAP & CCP	N.A.	4Q:20-21
	Integration of Emergency Alert platform with C-Sat-Fi v2.0	N.A.	4Q:20-21
	Single APP for C-Sat-Fi v2.0 Solution	N.A.	4Q:20-21
	Enhancement of Management System for C-Sat-Fi v2.0	N.A.	4Q:20-21
	Integration Testing of C-Sat-Fi v2.0	N.A.	4Q:20-21
	Offer to Internal Validation of C-Sat-Fi v2.0	N.A.	4Q:20-21
Projected physical outcome for FY 2020-2021	● C-Sat-Fi Access Point Box (CAP) ● C-Sat-Fi Customer Premise Equipment (CCP)		
Reasons for revision of targets	NA		

4.5   Power-efficient and green telecom technologies

Power being a major constraint in the country, it has been planned to undertake programs to put in R&D efforts to explore alternative sources of energy, and do design optimisations to enhance system power efficiency in the existing developed and deployed technologies as well as in the new technology programs. This will leverage on solar, wind and hybrid technologies to do a climate responsive technology design for the GRIHA[80] compliance. As part of design optimisation to enhance a product's power efficiency, more efficient linearisation techniques will be developed for the power amplifiers being used in C-DOT's GSM[81] products and also for products to be developed under 'Next generation mobile technologies' program. Trials will be conducted for C-DOT's SG-RAN[82] system in rural areas to assess the reduction in power consumption by non-air-conditioned BTS[83].

The scope of the program has been expanded to undertake commercial operations, new applications and technology developments. A project under this program, named 'High Efficiency RF Amplifier' has been completed.

Development focus under the program is on building a range of power supply systems with rated solar input powers of 75W, 250W, 2000W and 5000W, and other higher range rated solar input power to cater to the requirements of various C-DOT products and emerging field requirements.

Project deliverables under this scheme, namely, 'High Efficiency RF Amplifier' and Green Power Supply System, have been completed. During the FY 2020-21, the scheme will remain active, although no new project has being taken up.

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[80] **Green Rating for Integrated Habitat Assessment**
[81] **Global System for Mobile communications (*originally* Groupe Special Mobile)**
[82] **Shared GSM Radio Access Network**
[83] **Base Transceiver Station**

4.6   Centre of Excellence for lawful interception

Communication technologies are continuously evolving for enabling better user experience, providing more bandwidth, enhancing network and radio efficiency and reducing the cost of calls and data. Moreover, any new communication network architecture generally involves modifications of the corresponding interception equipment and tools.

Thus, with the ever changing communications technologies and services, the interception scenario continues to remain grim and challenging. Not only does it require continuous upgradation of the interception systems to cater to the new challenges of technology, it also requires a holistic approach from the perspective of technological R&D, finding and using available solutions, making policies and developing skills to provide a complete and useful interception environment for the LEAs[84] of the entire country. Moreover, new requirements of the LEAs and gaps and problems faced in current interception mechanisms have also to be addressed promptly.

It is with this point of view, that the CoE[85] for lawful interception has been proposed. CoE under its umbrella will bring together State and Central law enforcement agencies, policy makers, research organisations, academic institutions and indigenous solution providers and developers as well as telecom, internet and application service providers on a single platform with the aim to provide the right interception environment in the country. It will establish a research, training and policy framing facility to benefit all the stakeholders.

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[84] **Law Enforcement Agency**
[85] **Centre of Excellence**

4.6.1 Image and video analytics – face recognition

Objective	To perform image analytics such as face recognition on images, in collaboration with IIT Delhi.
Brief description	One of the state-of-the-art requirements of lawful interception planned to be taken up for development under this area is face recognition (image matching). This involves matching and recognising images from various angles, scenes, disguise, cloths etc. Face recognition has also been mentioned as a mandatory requirement in the Global Surveillance Report, Jul-2016, by Privacy International. LEAs also expressed similar requirements to C-DOT for recognising individuals through their images over internet. This requires handling of images through various angles, scenes, disguise, cloths, etc. In the initial phase of CoE preparation, C-DOT had worked in the development for the above requirements, and had been able to recognise only the frontal face under restricted environmental conditions. Therefore the accuracy of the above recognition needs to be improved. The project 'Image and video analytics', planned with primary development focus on 'Human face detection and recognition'. It is envisaged that the expertise available in IIT Delhi will help the project in detecting and recognising human faces in more diverse environments and will speed up the overall developmental process. In view of the above, the project is planned as collaborative R&D with IIT Delhi to develop a face detection and recognition engine based on the latest deep learning algorithm, namely, CNN[86].
Application areas	These applications will facilitate to generate metadata for LEAs' use and other applications for gathering intelligence.
Key deliverables	• Face recognition/detection engine based on CNN.
Status as on 31.03.2020	• Algorithm for face detection and face recognition in controlled and uncontrolled environment have been completed. • Algorithm for orientation detection in controlled and uncontrolled environment have been completed. • Validation has also been completed. • PoC for object detection and classifications, tower video analytics have also been developed / customised for IB based on face detection algorithm and demonstrated same to IB and other LEAs. • Algorithm implementation of ML serving for face recognition done. • Modeling of 40 Disguises in 128 dimensional facenet space for face recognition completed. • Completed algorithm development for object detection from tower and for detecting & classifying objects from normal height. • Pilot of FRT conduction at Information Bureau

Finance	Estimated budget outlay for the project	8.00
(₹ in crore)	Cumulative expenditure (*provisional upto Mar-2020*)	3.54

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[86] **Convolutional Neural Network**

Budget for FY 2020-2021				1.57
Project plan	**Deliverables and milestones**		**Target**	
			2019-2020	**2020-2021**
	Face detection	Training data-set preparation	*NA(completed in 2017-18)*	
		Algorithm study and implementation for controlled environment	*NA(completed in 2017-18)*	
		Orientation detection algorithm study and implementation for controlled environment	*NA (completed in 2018-19)*	
	Face recognition	Algorithm study and implementation for controlled environment	*NA(completed in 2017-18)*	
		Algorithm study and implementation for uncontrolled environment	*NA (completed in 2018-19)*	
		Algorithm study and design for various orientations	*NA (completed in 2018-19)*	
		Algorithm implementation for various orientations	1Q:19-20	*NA (completed)*
		Algorithm study and design for various disguises	*NA (completed in 2018-19)*	
		Algorithm implementation for various disguises	2Q:19-20	*NA (completed)*
	Face detection and recognition engine: validation, piloting, demo	for controlled environment	*NA (completed in 2018-19)*	
		for uncontrolled environment	*NA (completed in 2018-19)*	
		for various angles, clothes, disguises, etc.	4Q:19-20	*NA (completed)*
	Object detection	Algorithm development for object detection from tower	2Q:19-20	*NA (completed)*
	Object detection and classification	Algorithm development for detecting and classifying objects from normal height	3Q:19-20	*NA (completed)*
	Colour classification	Algorithm development for identifying objects of different colours	4Q:19-20	*NA (completed)*
	Face recognitions	Bug Fixes and Enhancements	NA	2Q:20-21
Projected physical outcome for FY 2020-2021	Pilot trial of face detection and recognition engine in controlled and uncontrolled environment for various angles, clothes, disguise, etc., is planned.			
Reasons for revision of targets	*NA*			

4.6.2 Short text message analytics

Objective	To perform text analytics such as SESH[87] on short text message in English and Hindi, in collaboration with IIT Patna
Brief description	One of the state-of-the-art requirements of lawful interception planned to be taken up for development under this area is short text analysis – identifying the sentiment, emotion, sarcasm and presence of hate speech.
	Short text message comprises tweets, posts, blogs, etc.
	Sentiment analysis itself has become quite advanced and includes emotion recognition, sarcasm detection, ABSA[88], thwarting, etc. Emotion recognition involves categorising documents into classes such as happy, sad, anger, disgust, fear, surprise, neutral or more. In Sarcasm detection documents that may sound positive are categorised as sarcastic based on some algorithms which look for contradictions. Hate speech classification includes finding out texts which spread hate, are offensive or toxic. This also requires development of a huge training dataset in English and Hindi for the specific domain of LEAs, i.e., crime, terrorism, etc, to improve the accuracy of results.
	In the initial phase of CoE preparation, C-DOT had worked in the development for the above requirements, and had been able to identify sentiment with 80% accuracy. Therefore the accuracy of the above needs to be improved. In addition, preparation of the National Security domain specific datasets needs to be done to get better accuracy.
	It is envisaged that the expertise available in IIT Patna will help the project in detecting and recognising sentiment, emotion etc with higher accuracy and will speed up the overall developmental process.
	In view of the above, the project is planned as collaborative R&D with IIT Patna to develop SESH tool based on the latest deep learning algorithms applicable for text, namely GRU[89], LSTM[90], CNN[91].
Application areas	These applications will facilitate to generate metadata for LEAs' use and other applications for gathering intelligence.
Key deliverables	• SESH tool based on deep learning.
Status as on 31.03.2020	• Project signed with IIT Patna and they have recruited the manpower for the same. • Algorithm development for sentiment in English is in progress. • Algorithm development for emotion in English is in progress. • Dataset creation is in progress.

Finance (₹ in crore)	**Estimated budget outlay for the project**	3.00
	Cumulative expenditure (*provisional upto Mar-2020*)	0.39
	Budget for FY 2020-2021	1.67

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[87] **Sentiment, Emotion, Sarcasm and Hate Speech**
[88] **Aspect-based Sentiment Analysis**
[89] **Gated Recurrent Unit**
[90] **Long Short-Term Memory**
[91] **Convolutional Neural Network**

Project plan	Deliverables and milestones		Target	
			2019-2020	2020-2021
	Training data-set preparation	for English language	4Q:19-20	*NA (completed)*
		for Hindi and other languages	4Q:19-20	*NA (completed)*
	Emotion	Algorithm development for various languages, *viz*, English, Hindi, etc.	2Q:19-20	1Q:20-21
		Design, Implementation and integration	3Q:19-20	2Q:20-21
		Validation	4Q:19-20	3Q:20-21
	Sentiment	Algorithm development for various languages *viz*, English, Hindi, etc.	3Q:19-20	*NA (completed)*
		Design and implementation and integration	1Q:20-21	1Q:20-21
		Validation	2Q:20-21	2Q:20-21
	Hate speech	Algorithm development for English language	4Q:19-20	*NA (completed)*
		Design , implementation and integration	2Q:20-21	2Q:20-21
		Validation	3Q:20-21	3Q:20-21
	Sarcasm	Algorithm development for English language	1Q:20-21	1Q:20-21
		Design , implementation and integration	3Q:20-21	3Q:20-21
		Validation	4Q:20-21	4Q:20-21
Projected physical outcome for FY 2020-2021	• Data-set preparation for sentiment and emotion – in English and Hindi. • Algorithm development for sentiment and emotion.			
Reasons for revision of targets	*NA*			

4.6.3 UN Navigation App (Wayfinder)

Objective	The UN navigation app is an in building navigation solution. It will enable users to find their way from point to point within the UN buildings and across floors. This will be especially useful for conference attendees. This is being developed as a gift for UN 75 tears completion by Govt. of India.
Brief description	There are 8 buildings to be covered under the project. The project duration will be 2019-2023 with 5 years support thereafter. Currently, the UN has 6 (A,B,C,D,E,S) buildings, with another building (H) coming up by May 2020. A temporary building with 3 conference rooms will be created during this period to facilitate conferences. All buildings will undergo renovation one by one up to 2023. Initially, a proof of concept will be given covering four floors of the "E building" in the UN campus, by April, 2020. Subsequently, as and when the buildings are ready, the app will work in these buildings. It is planned to give the proof of concept without any additional hardware i.e using Wi-fi on Android phones, with 2D maps and in English language. In addition Augmented Reality was also used to display 3D routes. Subsequently, to improve accuracy, beacons will be deployed. The beacons will be given to UN as a donation.
Application areas	• In building navigation
Key deliverables	• Wayfinder mobile app for *Android* and *iOS* devices. • Wayfinder web client • Wayfinder Backend Solution. • Hosting of Wayfinder solution
Status as on 31.03.2020	• A proof of concept of the Internal Navigation app was given by C-DOT successfully in its building in July, 2019, in the presence of Secretary(T), Member(T), DDG(IR) and Dir (IR). • Solution was hosted in UN • Android and iOS Apps were tested in E building & one floor of A building • Solution handed over to UN team for testing

Finance (₹ in crore)	Estimated budget outlay for the project		8.00
	Cumulative expenditure (*provisional upto Mar-2020*)		2.40
	Budget for FY 2020-2021		2.06

Project Plan	Deliverables & milestones	Target	
		2019-20	**2020-21**
	Proof of Concept – CDOT Delhi	2Q:19-20	*NA (completed)*
	Proof of Concept – E building , UN Geneva	4Q:19-20	*NA (completed)*
	Implementation and testing of 2D routes for A, B, C, D, S building	NA	3Q-20-21
	Study and prototyping using beacons	NA	3Q-21-23
	Testing & Enhancements in UN buildings, Geneva	NA	4Q:20-21

Projected physical outcome for FY 2020-2021	Android and iOS app showing 2D routes in UN buildings in Geneva.
Reasons for revision of targets	NA

4.6.4 C-DOT Video Conferencing Solution

Objective	C-DOT Video Conferencing Solution is being developed with a view to cater to the futuristic working mechanisms like work from home , virtual meetings and remote audio and video conferencing
Brief description	The Solution will provide a hosted solution for audio and video conferencing. It will include facilities like making Presentation, Collaborative whiteboard, Screen sharing, Private and Public Chat, Collaborative documentation. It will be scalable to meet increasing users.
Application areas	• Schools • Government Meetings • use by General public
Key deliverables	• Hosted VC solution
Status as on 31.03.2020	New Project

Finance (₹ in crore)	**Budget for FY 2020-2021**		4.61
Project Plan	**Deliverables & milestones**	**Target**	
		2019-20	**2020-21**
	Design, Development, testing of Browser based User Interface – Web client and Android, iOS phones	NA	2Q:20-21
	Load testing and Bench Marking of simultaneous conferences on different types of VMs	NA	1Q:20-21
	Load balancing and Solution Scaling	NA	3Q:20-21
Projected physical outcome for FY 2020-2021	Deployment of Video Conferencing in Govt. offices		
Reasons for revision of targets	NA		

4.6.5 Capacity enhancement

Objective	To set up the infrastructure for CoE for lawful interception.		
Brief description	Capacity building and enhancement is one of major objectives for setting up of CoE for lawful interception. The capacity building will require infrastructure creation and development, upgradation of the existing infrastructure, facilities, technology and tools. The infrastructure will include space set-up for workplace, laboratory, training rooms, furniture, lab equipment, training equipment, SW tools, etc.		
Application areas	Skill and knowledge development and dissemination in interception technology.		
Key deliverables	• Training infrastructure. • Data centre. • Seating area. • Lab set-up.		
Status as on 31.03.2020	• 2 training courses on CMS conducted in-house for DoT officers and LEAs. • 2 Training courses conducted on Grey market analysis for DoT officers. • 1 training course conducted on CMS-IM for LEAs. • 1 training course conducted on IMS for DoT officers.		
Finance (₹ in crore)	Sanctioned budget outlay for the project		15.00
	Cumulative expenditure (*provisional upto Mar-2020*)		0.53
	Budget for FY 2020-2021		0.10

Project plan	Deliverables and milestones		Target	
			2019-2020	**2020-2021**
	Training course planning and development	Skill requirement assessment, course planning	*NA (completed in 2017-18)*	
		Identifying research/academic institutions working in the relevant cyber technology areas and exploring for collaborative knowledge development and dissemination	*NA (completed in 2017-18)*	
		Course development on advanced interception techniques and related technologies	*NA (completed in 2017-18)*	
	Capacity enhancement for CoE	Training infrastructure	3Q:19-20	*(Note)[1]*
		Data centre	3Q:19-20	*(Note)[1]*
	Conducting training programs	3 training courses on CMS, IMS, CERT-Telecom, IPDR92, etc.	*NA (completed in 2018-19)*	

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[92] Internet Protocol Detail Record

Projected physical outcome for FY 2020-2021	• Infrastructure set-up for training and lab.
Reasons for revision of targets	•As the budget allocated for CoE Infrastructure creation was only 3.0 crores against 15.0 crores, hence tender could not be published.

Note:

1. ***In the Financial year 2020-21, the project is planned to put on hold due to reduction in budget (BE) allocated to C-DOT.***

4.6.6 Quantum-safe cryptography

C-DOT started work in this area with a study project under which study-cum-feasibility analysis of Quantum-safe cryptography was done. Thereafter, C-DOT developed an indigenous processor-based IP Encryptor, which apart from classical encryption & key exchange algorithms also supports Quantum-safe key exchange algorithms. This product is named as 'Compact Encryption Module (CEM)'. In order to enhance throughput and security, C-DOT also started working on implementation of Quantum-safe-algorithms in FPGA. From FY 2020-21, FPGA based activities have been shifted under PINE (Post-Quantum Inline Network Encryptor) project sanctioned by NSCS

Objective	• Support and enhancements in CEM as per feedback received from various prospective customers of Classical as well as Quantum-safe Encryptor • To get the security evaluation & certification done for CEM by a third-party certification agency • Development of IPsec-based Quantum-safe VPN (Virtual Private Network) using CEM • Integrate CEM in diverse networks in Lab scenarios such as 5G,WiFi and Satellite networks
Brief description	With the advent of quantum computers, the classical encryption mechanisms are no longer safe as the mathematical problems on which these crypto functions are based can be quickly solved by these new types of computers. The strength of classical key exchange mechanisms gets reduced to zero in this new quantum computing paradigm. Moreover, the strength of symmetrical encryption like AES also get reduced significantly in this scenario. NIST (USA) and other standardization organizations have started evaluating key exchange and encryption schemes capable of resisting quantum computer-based attacks. Some of the schemes looks promising and may likely be announced as the most efficient quantum safe key exchange algorithms by NIST. **CEM** In the last 2 years of the project (FY2018-2019 & FY2019-20), C-DOT has developed a Quantum-safe IP encryptor (named it as Compact Encryption Module i.e. CEM) with support of one Lattice-based (NewHope) and one Code-based (LEDACrypt) Quantum-safe algorithms. As per the migration path suggested by ETSI, CEM also supports hybrid implementation of public key cryptography (combination of one classical and one Quantum-safe key exchange algorithm). During demos, POC trials and presentations of Quantum-safe IP encryptor i.e. CEM to various prospective customers, C-DOT has received a lot of feedback to increase its usefulness. C-DOT plans to incorporate the feedback in CEM by taking up following activities in FY2020-21: • Development of mechanisms for key generation & transfer, CEM authentication using Quantum-safe signature algorithm etc. • Security evaluation & certification of CEM by a third-party certification agency. • Development of a framework to integrate a third-party custom encryption algorithm

	and Trials for a prototype custom encryption algorithm in CEM
Application areas	• Secure communication products in strategic, Government and enterprise market.
Key deliverables	• Enhancements in CEM which includes development of a mechanism for key generation & transfer, authentication using Quantum-safe signature algorithm etc. • Development of IPsec-based Quantum-safe VPN (Virtual Private Network) using CEM • Third-party security evaluation and certification of CEM. • Integration of Quantum-safe Encryptor (CEM) in diverse network scenarios such as 5G test bed, WiFi network (using C-DOT BBWT product) and Satellite network scenario.
Status as on 31.03.2020	• Developed a Quantum-safe IP encryptor called CEM with software implementation of selected lattice-based and code-based PQC algorithm. • Int egration of Quantum-safe IP encryptor with QKD server for key exchange. • Demos, POC trials and presentations given to various prospective customers, Successful POC trial of CEM completed in some use-case scenarios with Cabinet Secretariat • Successful POC of CEM done in NSCS for secure data transfer facility to be used by cyber security agencies of Govt. of India • Showcasing of CEM in multiple exhibitions such as SES'2019 (Strategic Electronic Summit), IMC'2019 (Indian Mobile Congress) & C-DOT Annual function. • Prototype implementation of Layer 2 IP payload encryption successfully done on two FPGA reference boards

Finance (₹ in crore)		
	Sanctioned budget outlay for the project	10.00
	Cumulative expenditure (*provisional upto Mar-2020*)	5.64
	Budget for FY 2020-2021	3.45

Project plan	**Deliverables and milestones**	**Target dates** *(Note)*[2]	
		2019-2020	**2020-2021**
	Setting up and readiness of basic lab set-up	*NA (completed)*	
	Signing up collaboration with a leading institute/researcher involved in the research on post-quantum cryptography	*NA (completed)*	
	SW implementation of a selected lattice-based PQC algorithm for VoIP phone and IP encryptor	*NA (completed)*	
	SW implementation of a selected code-based PQC algorithm for VoIP phone and IP encryptor	*NA (completed)*	
	Lab testing of SW-based implementation of lattice-based PQC algorithm for VoIP phone and IP encryptor	*NA (completed)*	
	Lab testing of SW-based implementation of code-based PQC algorithm for VoIP phone and IP encryptor	*NA (completed)*	
	FPGA-based reference or prototype implementation of a selected lattice-based PQC algorithm	*NA (completed)*	
	Enhancement of the basic PQC lab set-up with additional equipment, reference boards etc. for testing	1Q:19-20	*NA (completed)*
	Enhancements in ⟨ Study and design	1Q:19-20	*NA*

				(completed)
compact encryptor to make it ready for interfacing with QKD system for key distribution	Implementation		2Q:19-20	*NA (completed)*
	Validation		3Q:19-20	*NA (completed)*
System architecture design of FPGA-based PQC encryptor	Product requirements specifications		1Q:19-20	*NA (completed)*
	System design trials on processor-based FPGA reference boards		2Q:19-20	*NA (completed)*
	Lattice-based PQC algorithm and AES[93]-256 on a reference platform having multi-processing SoC with programmable HW logic	Prototype implementation	3Q:19-20	*NA (completed)*
		Validation	4Q:19-20	1Q:20-21 *(note)[1]*
	Readiness of system architecture design of FPGA-based PQC encryptor		4Q:19-20	1Q:20-21 *(note)[1]*
Exploring need of quantum-safe security in different domains (PKI, blockchain, 5G systems)	Study of need of PQC in PKI and prototype implementation		4Q:19-20	2Q:20-21
	Study of need of PQC in blockchain and prototype implementation		4Q:19-20	NA
	Study of need of PQC in 5G systems and make contribution to standards		4Q:19-20	4Q:20-21 *Note2*
Support and Enhancement in Compact Encryption Module (CEM)				
Integration of Quantum-safe Encryptor (CEM) in WiFi network (using BBWT)			NA	1Q:20-21
Development of key generation and transfer mechanism for CEM			NA	1Q:20-21
Validation of feature "key generation and transfer mechanism" of CEM			NA	2Q:20-21
CEM authentication using Quantum-safe signature algorithm			NA	2Q:20-21
Development of IPsec-based Quantum-safe VPN using CEM			NA	2Q:20-21
Validation of feature "CEM authentication using Quantum-safe signature algorithm" of CEM			NA	3Q:20-21
Validation of IPsec-based Quantum-safe VPN using CEM			NA	3Q:20-21

[93] **Advanced Encryption Standard**

	Integration of Quantum-safe Encryptor (CEM) in Satellite network	NA	3Q:20-21
	Integration of Quantum-safe Encryptor (CEM) in 5G test bed	NA	4Q:20-21
	Third party security evaluation and certification of CEM		
	Documentation as required for third party security evaluation of CEM	NA	2Q:20-21
	Security hardening of CEM, as required for third party security evaluation	NA	3Q:20-21
	Support and enhancement in CEM software as per the outcomes of security evaluation by third party agency	NA	4Q:20-21
Projected physical outcome for FY 2020-2021	• Security certification of CEM by a third-party security certification agency. • Implementation of a mechanism for CEM authentication using Quantum-safe signature algorithm. • Implementation of an offline key generation & transfer mechanism for CEM for data encryption. • Development of IPsec-based Quantum-safe VPN using CEM • Integration of Quantum-safe Encryptor (CEM) in 5G test bed, WiFi network (using C-DOT BBWT) and satellite network scenario.		
Reasons for revision of targets	• Field trials of C-DOT CEM for certain use-case scenarios of Cabinet Secretariat, which were unplanned, had to be prioritized in FY19-20. • There were some unforeseen delays by IIT Ropar Consultancy team for some FPGA-based activities		

Note:

1. *This activity is now shifted from QSC project to PINE project and merged with other activities in PINE project.*
2. *Study Completed. Contribution to Standards delayed with revised targets.*

4.6.7 Development of Quantum Key Distribution (QKD)

QKD is in nascent stage right now but its deployment is expected to pick up as Quantum Computers mature, which makes the current method of securing communication links prone to eavesdropping.

Objective	To design and develop "Quantum Key Distribution (QKD)" for securing communication links, carrying critical and sensitive information, from eavesdropping by an adversary, even if the same possesses infinite computational power.
Brief description	The QKD system provide Information Theoretic security to existing communication links by providing identical keys on two distant locations. These keys can then be used by the application entity to encrypt the data before it is launched in the medium. Any attempt by an adversary to eavesdrop on the key will be detected by the QKD system itself, which can then stop the generation of key to prevent sensitive data from being leaked to the adversary. With the rapid advancement in quantum computing and in the area of quantum algorithms (which can run over quantum computers), the traditional methods of securing the communication, widely in use now, are no longer secure from an adversary having access to quantum computers. This is primarily because of the fact that the algorithms employed in present day methods (like Diffie Hellman Key Exchange) are based on assumptions that it is virtually impossible, even for the most advanced classical computers, to carry out certain mathematical functions (like prime factorization of a very large integer) in a reasonable amount of time. However, this assumption is no longer valid with quantum computers, which can potentially carry out these operations very quickly (like Shor's algorithm for prime factorization).
Application areas	The equipment which makes use of the Keys generated by Alice and Bob for carrying out Encryption of the data being exchanged amongst them
Key deliverables	"Alice" and "Bob" nodes (which are connected to each other through a Quantum Channel and Classical Channel, both implemented using Single Mode Optical Fibers).
Status as on 31.03.2020	• Feasibility study completed. • Developed QKD Lab Prototype model.

Finance (₹ **in crore**)	**Estimated budget outlay for the project**	45.00
	Cumulative expenditure (*provisional upto Mar-2020*)	N.A.
	Budget for FY 2020-2021	9.35

Project plan	**Deliverables and milestones**	**Target**	
		2019-2020	**2020-2021**
	Requirement definition, architecting the solution	N.A.	1Q:20-21
	Hardware & software design for Alice & Bob	N.A.	2Q:20-21
	PCB-CAD development and software design	N.A.	4Q:20-21
	System integration	N.A.	1Q-2Q: 21-22
	System testing	N.A.	3Q-4Q:21-22
	System Validation	N.A.	1Q:22-23
	Comencement of field trial of the QKD solution	N.A.	2Q:22-23

Projected physical outcome for FY 2020-2021	• Hardware and Software Design and Development.
Reasons for revision of targets	N. A.

4.7 Telecom services and applications

This program focuses on the SW-intensive services and applications catering to the emerging trends, customer-specific developments, etc.

The program is continuing with projects 'Machine-to-Machine communication system' and 'C-DOT interoperable Set-Top Box'. It is expected that M2M communication will play an important role as the infrastructure for a ubiquitous society in near future. The M2M architecture comprises of sensors, gateways, networks (private as well as public), cloud infrastructure, services and security.

Convergence of broadcast and broadband is going to be the distinguishing feature and USP for the operators in present and future scenarios; bringing together media and data coherently to the consumer. Convergence can happen at different points/planes in the overall network, starting from core network through distribution network, access network or at the end service reception/consumption entity.

4.7.1 Machine-to-Machine communication

Objective	To design and develop oneM2M-standards-based M2M communication platform nodes.
Brief description	M2M communication involves end-devices like sensors and actuators (for temperature, humidity, etc), smart metering devices, which capture events like temperature reading, humidity reading, electricity meter reading, etc. These devices are data producers. This data is then transmitted over a wired/wireless network to application, which uses data to produce useful information or actuators which perform certain actions, back on the machines like switching off the air-conditioner, or cutting off the electricity if the load exceeds a threshold, etc. M2M communication is a form of data communication that involves one or more entities that do not necessarily require human interaction or intervention in the process of communication. It is a very crucial requirement that the M2M industry goes in a standardised way, so that various challenges of M2M communication are addressed properly. These include authentication of devices, confidentiality and integrity of data, access to data, service subscription, and above all, interoperability. OneM2M is the partnership project which is laying down the standards for the M2M communication. M2M communication platform nodes, according to oneM2M standards, are: • ASN[94], • ADN[95], • MN[96], • IN[97].
Application areas	• Smart cities, automobiles • Energy and utilities • Water management • Health care • Agriculture • Safety and surveillance, etc.
Key deliverables	• oneM2M based CCSP platform for IN, MN and ASN nodes with 11 CSFs and ADN • Contribution in National and International Forums for standardization of M2M communication. • Development of oneM2M solution comprising of CCSP and oneM2M applications.
Status as on 31.03.2020	• CCSP developed with 11 CSFs comprising of registration, data management and repository, security, subscription and notification, location, discovery, group management , device management, service charging and accounting, Transaction Management and Application and Service Layer Management as per oneM2M Release 3 implemented.

[94] **Application Service Node**
[95] **Application Dedicated Node**
[96] **Middle Node**
[97] **Infrastructure Node**

- ADN and ASN application-specific (tower monitoring) HW and corresponding AE[98] SW completed
- Interoperability testing of IN-CSE[99] from C-DOT successfully carried out at oneM2M interoperability event held at South Korea, Japan with ADNs, MNs and ASNs from various companies, namely, NTT DoCoMo, LAAS-CNRS, Interdigital, HPE, etc.
- Conformance testing of IN-CSE with ETSI successfully carried out.
- C-DOT participated in oneM2M interop event 4 , 5 and 6 performed interoperability and conformance testing of MN and IN.
- Extended lab trial of M2M network comprising of only two nodes, namely, ADN and IN at C-DOT campus completed.
- Pilot Trial has been completed with the field deployment of applications comprising of Smart Living , smart street light, canteen feedback system Developed in-house.
- Developed oneM2M based solutions with CDAC.
- Fire Detection and Healthiness Monitoring application deployed in ITU office in C-DOT Campus.
- Enhancement of CCSP to support information recording element, CoAP protocol with Security , MQTT protocol , Flex Container and Time Series Data , Certificate Based Security completed.
- M2M portal for service provider developed.
- Implementation of Device Management with TR069 and LWM2M Server and Client and NAE completed for four management objects.

Finance (₹ in crore)	Sanctioned budget outlay for the project		85.00
	Cumulative expenditure (*provisional upto Mar-2020*)		45.84
	Budget for FY 2020-2021		12.33
Project plan	**Deliverables and milestones**		**Target**
			2019-2020	**2020-2021**

	Deliverables and milestones		2019-2020	2020-2021
	Phase-1: IN, MN and ASN nodes with 4 CSFs			
	System requirements specification finalisation based on rel-1		*NA(completed in 2016-17)*	
	System architecture, engineering design		*NA(completed in 2016-17)*	
	CSE platform SW: design and development	Platform SW architecture finalisation for IN and ASN nodes	*NA(completed in 2016-17)*	
		SRS finalisation for 4 CSFs	*NA(completed in 2016-17)*	
		Design and development of IN (4 CSFs) with HTTP[100] protocol binding	*NA(completed in 2016-17)*	
		Design and development of ASN (4 CSFs) with HTTP protocol binding	*NA(completed in 2016-17)*	
		Enhancements in ASN, IN for non-blocking operation mode	*NA (completed in 2017-18)*	
		Design and development of MN (4 CSFs) with HTTP protocol binding	*NA (completed in 2017-18)*	
		SRS finalisation, design and development of 3 additional CSFs in IN	*NA (completed in 2017-18)*	
		SW development manual version-1 for	*NA (completed in 2017-18)*	

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98 Application Entity

99 **Infrastructure Node – Common Service Entity**
100 **Hyper text Transfer Protocol**

	oneM2M based application	
	Prototype for Management Adapter for Device Management CSF using Management Server	*NA (completed in 2017-18)*
	SRS finalisation, design and development of 3 additional CSFs in MN and ASN	*NA (completed in 2017-18)*
ADN1, ASN1 and AE: specific to tower monitoring application (Note)[2]		
AE platform SW: design and develop-ment	SW architecture finalisation for ADN-AE[101], IN-AE[102], ASN-AE[103]	*NA (completed in 2016-17)*
	Design and development of ADN-AE (4 CSFs) with HTTP protocol binding	*NA (completed in 2016-17)*
	Design and development of IN-AE (4 CSFs) with HTTP protocol binding	*NA (completed in 2016-17)*
	Design and development of ASN-AE (4 CSFs) with HTTP protocol binding	*NA (completed in 2016-17)*
	Design and development of MN-AE[104]	*On hold (Note)[1]*
	Enhancement in ADN-AE, ASN-AE, IN-AE for non-blocking mode of operation	*On hold (Note)[1]*
	SRS finalisation, design and development of 3 additional CSFs in MN	*On hold (Note)[1]*
ADN1 (ver.1) and ASN1	HRS[105] and architecture design	*NA (completed in 2016-17)*
	HW implementation	*NA (completed in 2016-17)*
	Board support package and application SW implementation	*NA (completed in 2016-17)*
	HW and SW integration and testing	*NA (completed in 2016-17)*
Integration and testing of ADN, ASN and IN with M2M application		*NA (completed in 2016-17)*
Commencement of validation and lab trial of M2M system nodes (ADN, ASN and IN)		*NA (completed in 2018-19)*
Study of telecom application on EMF estimation		*NA (completed in 2017-18)*
Commencement of extended lab trial of M2M network with applications		*NA (completed in 2017-18)*
ADN2 and ASN2: Generic HW with combination of any two interfaces: LoRA[106] and WiFi/GPRS[107]/ethernet		
ADN2	HW requirements specification and architecture design: 2 PAN[108] interfaces	*NA (completed in 2017-18)*
	HW design implementation	*NA (completed in 2017-18)*
	Board support package and application SW design implementation	*NA (completed in 2017-18)*

[101] **Application Dedicated Node – Application Entity**
[102] **Infrastructure Node – Application Entity**
[103] **Application Service Node – Application Entity**
[104] **Middle Node – Application Entity**
[105] **Hardware Requirements Specification**
[106] **Long Range**
[107] **General Packet Radio Service**
[108] **Personal Area Network**

		HW and SW integration and testing		*NA (completed in 2017-18)*	
	ASN2	HRS and architecture design: 2 PAN interfaces		*NA (completed in 2017-18)*	
		HW design implementation		*NA (completed in 2017-18)*	
		Board support package and application SW design implementation		*NA (completed in 2017-18)*	
		HW and SW integration and testing		*NA (completed in 2017-18)*	
	HW design and develop-ment of MN with ethernet	HRS finalisation for MN		*NA (completed in 2017-18)*	
		HW design and development for MN processing board for PoC		*NA (completed in 2017-18)*	
		MN processing board HW for PoC related SW support		*NA (completed in 2017-18)*	
		M2M infrastructure lab set-up		*NA (completed in 2017-18)*	
		HW and SW integration and testing		*NA (completed in 2017-18)*	
	AE for rural applica-tions (sample)	SW architecture finalisation for AE		*NA (completed in 2017-18)*	
		Design and development of ADN-AE		*NA (completed in 2017-18)*	
		Design and development of IN-AE		*NA (completed in 2017-18)*	
	AE for smart living (sample)	SW architecture finalisation for AE		*NA (completed in 2017-18)*	
		Design and development of ADN-AE		*NA (completed in 2017-18)*	
		Design and development of IN-AE		*NA (completed in 2017-18)*	
	Integration and testing of MN, ADN, ASN (with generic HW) and IN			*NA (completed in 2017-18)*	

Phase-2: IN, MN and ASN nodes with 12 CSFs and ADN based on oneM2M specifications release-2 (2019-2020 and beyond) (Note)[3]

	CSE platform SW: design and develop-ment	CoAP[109] and MQTT[110] protocol support over Mca[111] interface.	CoAP	*NA (completed in 2018-19)*	
			MQTT	2Q:19-20	*NA (completed)*
		CoAP with Security		2Q:19-20	*NA (completed)*
		Information Recording Element		*NA (completed in 2018-19)*	
		Enhancements in 7 CSF technical enhancements and maintenance in specifications for release-2		*NA (completed in 2018-19)*	
		Study of new technical reports released		*NA (completed in 2018-19)*	
		Implementation of enhanced release-2 feature Flex Container and Time Series Data		2Q:19-20	*NA (completed)*
		Design and development of 2 more CSFs in IN		*NA (completed in 2018-19)*	
		Enhancements in SDK[112] for new CSFs		*(Note)[4]*	
		M2M portal for service provider		*NA (completed in 2018-19)*	
		Study of new oneM2M technical reports released		3Q:19-20	Completed

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[109] **Constrained Application Protocol**
[110] **Message Queueing Telemetry Transport**
[111] **oneM2M defined reference point interfacing CSE and AE**
[112] **Software Development Kit**

		M2M service components (2)		*(Note)[5]*	
		Enhancement in M2M portal for M2M service components	3Q: 19-20	*(Note)[5]*
		Design and implementation of 2 CSFs	4Q: 19-20	*NA (completed)*
		Enhancements in CSFs	4Q: 19-20	*NA (completed)*
		Enhancements in SDK to support new CSFs and features		*(Note)[4]*
		M2M service components (4)		*(Note)[5]*
		Semantic interoperability	3Q: 20-21	3Q: 20-21
		oneM2M release-3 features	4Q: 20-21	4Q: 20-21
	Management of devices (CDOT-M2M EMS)	Functional requirements study and analysis, identification of modules and architecture design	*NA (completed in 2017-18)*	
		Development and integration of NAE[113], i.e., NBI[114] and its integration with CSE and enhancements for handling additional management objects	*NA (completed in 2018-19))*	
		Development of Management Server and integration with devices and enhancements for handling additional TR069 management objects	TR069	*NA (completed in 2018-19)*	
			LWM2[115]	3Q: 19-20	*NA (completed)*
		Development of Management Client	TR069	*NA (completed in 2018-19)*	
			LWM2M	2Q: 19-20	*NA (completed)*
		Enhancements in Management Server TR069, NAE for additional management objects	2Q: 19-20	*NA (completed)*
		Integration testing of management server with management clients (TR069 enhancements and LWM2M)	2Q: 19-20	*NA (completed)*
	MN HW with WiFi and LoRA	HW requirements specification and architecture design	*NA (completed in 2018-19)*	
		HW implementation	*NA (completed in 2018-19)*	
		Board support package and application SW implementation	*NA (completed in 2018-19)*	
		HW and SW integration and testing	*NA (completed in 2018-19)*	
	Validation of M2M system nodes (ADN, ASN, IN and MN) with additional CSF – progressively		3Q:19-20	*NA (completed)*
	M2M network pilot trial in the field with applications		4Q:19-20	*NA (completed)*

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[113] **Network Application Entity**
[114] **North-Bound Interface**
[115] **LightWeight Machine-to-Machine**

	MN HW with 6LoWPAN[116] and ethernet	HRS and architecture design	(Note)[6]	
		HW implementation		
		Board support package and application SW implementation		
		HW and SW integration and testing		
	Asset Tracking Application	SW architecture finalisation for AE	NA	1Q:20-21
		Design and development of ADN-AE	NA	2Q:20-21
		Design and development of IN-AE	NA	2Q:20-21
		S/W integration and testing	NA	3Q:20-21
	Smart Street Light Application	SW architecture finalisation for AE	NA	2Q:20-21
		Design and development of ADN-AE	NA	3Q:20-21
		Design and development of IN-AE	NA	3Q:20-21
		S/W integration and testing	NA	4Q:20-21
Projected physical outcome for FY 2020-2021	• CCSP enhanced for scalability and with semantics support and • A complete solution comprising of IoT applications and CCSP platform ready for deployment.			
Reasons for revision of targets	NA			

Note:

1. *Tower monitoring system field requirements did not get finalised. Hence the development of AE for MN and enhancements in ADN-AE, ASN-AE and IN-AE for non-blocking mode of operation has been put on hold.*
2. *ADN1 and ASN1 (ver. 1) development have been specific to Tower Monitoring function, which was planned to be propagated in the telecom network. Since, Tower Monitoring could get propagated in the field, thus validation activity for ADN1 and ASN1 (ver.1) were not taken-up.*
3. *Phase-2: The M2M CSF and feature-set are being evolved. Hence the time-line for subsequent development and enhancements of M2M network nodes will be worked out after finalisation of future releases and new features as per oneM2M standards, as well as the experience gained through the pilot trial of oneM2M network. The capacity and performance enhancement will also be addressed during the phase-2 development depending upon the field requirements. Moreover, HW platform for ADN and ASN will be finalised depending on the field requirements at that time.*
4. *The activity 'Enhancement in SDK' has been abandoned as the interfaces of oneM2M are open and defining an SDK will lead interface access in a proprietory way. If a requirement emerges from client/field the activity will be re-scheduled accordingly.*
5. *The activity 'M2M service components (2) and (4)' has not been initiated as the corresponding oneM2M specification TS-0007 service components has not evolved in oneM2M Release-2 and has also not been made part of oneM2M latest draft Release-3 technical specifications.*
6. *Development of 'MN HW with 6LowPAN and ethernet' has been put on hold, as present business scenario does not have requirement for this product.*

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[116] IPv6 over Low-power Wireless Personal Area Network

4.7.2 C-DOT Converged Service Delivery Platform (C-CSDP)

Convergence of broadcast and broadband is going to be the distinguishing feature and USP for the operators in present and future scenarios; bringing together media and data coherently to the consumer. Convergence can happen at different points/planes in the overall network, starting from core network through distribution network, access network or at the end service reception/consumption entity. Traditional broadcast networks have some of the inherent advantages, such as low latency distribution of broadcast contents with relatively simpler electronics at both transmitter and receiver ends. Also there are broadcast contents already available freely (free of cost) from various distribution platforms of National Broadcaster. These advantages and existing isolated network scenarios can be leveraged upon to develop more meaningful products and solutions suitable for converging technology landscape and meeting the consumer expectations. Broadcast offload for a broadband (specifically Wi-Fi as access network) is envisaged and can be incorporated at different planes; viz. at the Wi-Fi access point and at the end user reception entity such as STB, Mobile Handsets. A new converged service delivery platform is needed to bring in the enormous possibilities of infotainment from internet, along with broadcast contents on the same platform to experience many new innovative services. These innovative services will enable more user engagement with the content. Automatic and reliable TRP collection will be possible. Data analytics will become more prevalent to provide user centric advertisements and contents. As contents are becoming the driving force for the future converged networks, DRM (Digital Rights Management) plays a very crucial role in the value chain. At present DRMs are available from few developed countries with lot of restrictions on usage and imposes vendor locking of network elements. Hence a National DRM with ease of integration and open integration paradigm is also envisaged. A combination of linear and non-linear contents with appropriately enabled by open DRM will propel the future generations of converged networks and solutions. Hence, development focus is now on to build a converged service delivery platform along with a digital rights and access management system.

Objective	To design and develop converged service delivery platform consisting of linear content receivers with IP streaming capability and an appropriate Digital Rights and Access Management system for secure content delivery for converged network.
Brief description	Convergence of broadcast and broadband is going to be the distinguishing feature and a very important requirement for the operators in present and future scenarios; bringing together media and data coherently to the consumer in a cost effective manner. Convergence can happen at different points/planes in the overall network, starting from core network through distribution network, access network or at the end service reception/consumption entity. Broadcast offload for a broadband (specifically Wi-Fi as access network) is envisaged and can be incorporated at different planes; viz. at the Wi-Fi access point and at the end user reception entity such as STB, Mobile Handsets. A new converged service delivery platform that is able to receive the linear contents and provides necessary input to broadband networks is needed today to offer many new innovative services and advantages to the end consumers. As contents are becoming the driving force for the future converged networks, DRM (Digital Rights Management) plays a very crucial role in the value chain. At present DRMs are available from few developed countries with lot of restrictions on usage and imposes vendor locking of network elements. A combination of linear and non-linear contents with appropriately enabled by open DRM and access control system is very much required in near future by the service

	providers/operators/content aggregators.
Application areas	Linear Contents on IP networks and converged networks.
Key deliverables	C-CSDP project consists of three main deliverables: • STB with local IP Streaming (SIS) • Linear Content Aggregation System with IP streaming (LCAS) • C-DOT Digital Rights and Access Management (CDRAM)
Status as on 31.03.2020	N.A. (New Project)

Finance (₹ in crore)	Sanctioned budget outlay for the project	16.00
	Cumulative expenditure *(provisional upto Mar-2019)*	N.A.
	Budget for FY 2020-2021	4.44

Project plan	Deliverables and milestones	Target	
		2019-2020	**2020-21**
	STB with Local IP streaming (SIS) [Single TP Receiver]		
	Requirement and Architecture finalization of SIS	N.A.	1Q:20-21
	Design and Development of SIS	N.A.	2Q:20-21
	Integration and validation of SIS	N.A.	3Q:20-21
	Trial and ToT of SIS	N.A.	4Q:20-21
	Linear Content Aggregation System with IP streaming (LCAS)		
	Requirement Specifications	N.A.	1Q:20-21
	Architecture Finalisation	N.A.	2Q:20-21
	Design and Development	N.A.	3Q:20-21
	Integration and Validation	N.A.	4Q:20-21
	Trial and Integration support	N.A.	1Q:21-22
	Documentation and Integration support	N.A.	2Q:21-22
	C-DOT Digital Rights and Access Management (CDRAM)		
	Requirement Specification	N.A.	1Q:20-21
	Architecture Finalization	N.A.	2Q:20-21
	Design	N.A.	3Q:20-21
	Development (Implementation)	N.A.	4Q:20-21 to 1Q:21-22
	Integration	N.A.	2Q:21-22
	Testing and Validation	N.A.	3Q:21-22
	Trial & Rollout	N.A.	4Q:21-22

Projected physical outcome for FY 2020-2021	Tested STB with IP streaming, Linear Content Aggregation System
Reasons for revision of targets	N.A.

4.8 DoT projects

DoT, under the Ministry of Communications and Information Technology, Government of India, is responsible for coordinating with all ISPs[117] and service providers with respect to cyber security incidents and response actions as deemed necessary by CERT-In[118] and other Government agencies. Telcos are expected to share information on attacks on their networks, intrusion and frauds with Government agencies, including the telecom sectoral CERT[119] (CERT-Telecom), the national CERT and the National Cyber Coordination Centre.

Consequently, DoT has mandated C-DOT to undertake development of requisite technology to implement cyber-security monitoring for CERT-Telecom to protect the national critical infrastructure which can be attacked by adversaries through national internet infrastructure.

The mobile handset, over the years with host of applications, has also become smarter and is being used for storing valuable personal information and financial transactions, besides voice call and internet access, and is now vulnerable to cyber-attacks. Issues like increasing theft cases of mobile handsets, cloning of IMEI[120], illegal and non-genuine mobile phones have also cropped up, giving impetus to cyber threat. National Telecom Policy 2012 (sec 6.5) indicates the establishment of a national mobile property registry for addressing security, theft and other concerns like re-programming of mobile handsets.

The project CEIR[121] has been identified by DoT to build central database of all IMEIs used in India so that IMEIs of all stolen, lost or cloned mobile handsets can be blocked from accessing the network and eventually to control theft and counterfeiting of mobile handsets.

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[117] **Internet Service Provider**
[118] **Computer Emergency Response Team - India**
[119] **Computer Emergency Response Team**
[120] **International Mobile Equipment Identity**
[121] **Central Equipment Identity Register**

4.8.1 Cyber-security for CERT-Telecom

Objective	To carry out feasibility study and PoC for design, development and implementation of cyber security monitoring centre for CERT-Telecom, DoT, for proactive monitoring of country's internet traffic of the order of 3-4 Tbps, with respect to security analysis and threat detection to protect the critical national infrastructure involving telecom infrastructure as its backbone.
Brief description	The rise of cyber-crime and attacks from State and non-State actors has created a permanent threat landscape. Despite the sophistication and proliferation of today's highly advanced network security solutions at enterprise or corporate level, breaches and attacks continue unabated. In response, requiring complete visibility of the entire traffic at national level for proactive monitoring, the country needs to build a national infrastructure covering all the gateways of the major ISPs. Thus, proactive security measures can be taken to detect and block malicious traffic flowing through telecom infrastructure and targetted towards the national infrastructure. Government of India, in line with National Cyber Security Policy 2013, has created sectoral CERTs to mitigate cyber security threats to critical national infrastructure sectors, defined by the Ministries of Defence, Finance, Energy, Transportation and Telecommunications. The sectoral CERT under DoT is responsible for information security in the telecom domain as a licensor for all telecom services in the country. Telecom being the backbone of digital revolution in the country and also a requirement for all other critical infrastructure sectors under various Ministries, it is imperative to set up a national-level infrastructure by CERT-Telecom for proactive monitoring of massive security attacks like DoS[122], DDoS[123], malware outage, etc, so that suitable prompt actions towards issuing alerts to concerned stakeholders or taking up of mitigation actions can be taken to safeguard the infrastructure.
Application areas	• **DoS detection**: Traffic floods that may go unnoticed on bandwidth usage graphs may be more visible on the graph of flows than on a packet graph, as the spike produced by the flood is a much larger percentage of total flows than it is of total packets. • **Detection of malicious/suspicious traffic**: By applying the threat intelligence collected from external sources, it is possible to identify the flows with malicious or spurious connections this can be enhanced and supported with behavior based analysis withour requiring the content or payload. • **Scans detection**: A scan can be detected using a thresholding function. A host scan will appear as a source IP contacting more than a selected number of ports on a single host, and a network scan will appear as a host contacting more than a selected number of destination hosts.

Key deliverables	• **Phase-1:**
	  ○ Carrying out PoC: Implementation of the basic solution at few ISP gateways.
	  ○ PoC scope augmentation: Covering 4 more gateways using bought-out 3rd-party HW and SW solutions, and a lab set-up for SW development and testing.
	• **Phase-2:**

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[122] Denial-of-Service
[123] Distributed Denial-of-Service

	o Design of complete solution covering all major ISP gateways, based on the PoC outcome. o DPR[124] on setting up of cyber security monitoring centre for CERT-Telecom comprising the infrastructure, development of scalable application SW and features, planning for data center with NOC[125] and SOC[126], review and approvals of DPR by the competent authority. • **Phase-3:** o Progressive implementation of the project in the subsequent years, based on approved DPR.
Status as on 31.03.2020	• Computing statistics detected for vulnerable hosts (IP addresses, event counts, country, ISP/Organizations) completed. • Detection of TCP port scans completed using adjustable threshold for number of flows • DNS statistics & Compromised DNS Servers being exploited activity completed. • Detection of DoS and DDoS attacks completed based on evaluation of incoming and outgoing packet volume. • DPR based on the PoC outcome prepared and submitted to DOT for undertaking full-fledged project development, and progressive implementation nation-wide. • Validation completed for IPFIX probe and its pilot trial in the field at one ISP gateway • PoC for basic solution (as defined in phase-1) at one ISP gateway completed with 3rd-party evaluation system - IPFIX[127] 200 Gbps flow generator and basic security analytics solution. • Specifications to augment the scope of PoC (as per phase-1) with bought-out 3rd-party HW and SW solutions at 4 ISP gateways, and a lab set-up for SW development and testing, have been completed. • Procurement and implementation of bought-out HW to augment the scope of PoC at 4 ISP gateways, have been completed. • Lab set-up at Delhi completed for the development of o multistage, multinode, scalable analytic framework, o 100 Gbps IPFIX probe.

Finance (₹ in crore)	Budget for FY 2020-2021	For R &D activity only	8.61
		Data center build and IT deployment	110.00 (Note)[2]

Project plan	Deliverables and milestones		Target	
			2019-2020	**2020-21**
	Phase-1(a)			
	Study of few gateways with respect to total internet traffic up to 200 Gbps for PoC and availability of required number of 10G/40G ports on existing load balancer		*NA* *(Completed in FY 2017-18)*	
	Implementation of flow generator capable of supporting 160 to 200 Gbps raw data and supporting IPFIX along with other protocols		*NA* *(Completed in FY 2017-18)*	

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[124] **Detailed Project Report**
[125] **Network Operation Centre**
[126] **Security Operation Centre**
[127] **Internet Protocol Flow Information Export**

	IPFIX flow generation comprising L4 to L7 metadata 1:1 sampling by taking the copy of raw traffic as input		*NA* *(Completed in FY 2017-18)*
	Implementation of Collector server application at each of the PoC location.		*NA* *(Completed in FY 2017-18)*
	Sending L4 and L7 metadata (DNS[128], BGP[129], URL[130], etc), based on preconfigured template for flows, to IPFIX collector		*NA* *(Completed in FY 2017-18)*
	Installation of a flow analytic server at some central location capable of receiving the flows from few collectors for security analysis		*NA* *(Completed in FY 2017-18)*
	Providing remote access to designated stakeholders for security analysi s and testing		*NA* *(Completed in FY 2017-18)*
	Phase-1(b)		
	Preparation of specifications and tendering for 3rd-party HW and SW to augment the scope of PoC to cover few more gateways		*NA* *(Completed in FY 2017-18)*
	Procurement and implementation of bought-out HW to augment the scope of PoC at 4 ISP gateways		*NA* *(Completed in FY 2018-19)*
	Phase-2		
	Study of various Big Data frameworks suitable for real-time analysis of large volume of data.		*NA* *(Completed in FY 2018-19)*
	Lab set-up for development of multistage, multinode, scalable analytic framework		*NA* *(Completed in FY 2018-19)*
	Lab set-up for development of 100 Gbps IPFIX probe		*NA* *(Completed in FY 2018-19)*
	Analytic scenario development using live traffic as part of PoC from 4 ISP gateways	Computing statistics for a vulnerable host (Ip addresses, event counts, country, ISP/Organization)	1Q:19-20	*NA* *(completed)*
		Detection of TCP port scans using adjustable threshold for number of flows	2Q:19-20	*NA* *(completed)*
		DNS statistics	1Q:19-20	*NA* *(completed)*
		Detection of DoS and DDoS attacks based on evaludation of incoming and outgoing packet volume	4Q:19-20	*NA* *(completed*
	DPR based on the PoC outcome for undertaking full-fledged project development, and progressive implementation nation-wide		1Q:19-20	*NA* *(completed)*
	Phase-3		
	IPFIX probe 100-200 Gbps development and testing		1Q:19-20	*NA* *(completed)*
	Validation of IPFIX probe and its pilot trial in the field at		2Q:19-20	*NA*

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[128] **Domain Name Registration**
[129] **Border Gateway Protocol**
[130] **Uniform Resource Locator**

one ISP gateway			*(completed)*
Tender for procurement of HW for IPFIX probe for 10 sites		1Q:19-20	*NA (completed*
Field trial for in-house-developed 100-200 Gbps IPFIX probe at 10 ISP gateways		4Q:19-20	*NA (completed*
Enhancements and upgradation of IPFIX probe		4Q:19-20	1Q:20-21
IPFIX probe deployment nation-wide across all ISP gateways		*(Note)[1]*	*(Note)[1]*
Deployment of PFIX probe at 24 ISP Gateways.	Delivery of Hardware	*NA*	2Q:20-21
	Procurement of MPLS links for T-CERT VPN	*NA*	2Q:20-21
	Installation of Hardware, C-DOT Router and MPLS links at all the locations.	*NA*	3Q:20-21
	Integration and testing with IPFIX application and Internet traffic collected from ISP Gateway.	*NA*	4Q:20-21
Augmenting the Big-Data Platform at C-DOT (CERT Lab.) to handle the sampled traffic from 28 ISP Gateways.	Procurement of high-end servers.	*NA*	2Q:20-21
	Augmenting the MPLS link at HUB location of TCERT VPN	*NA*	2Q:20-21
	Installation & integration of various modules of Big-Data Platform in CERT Lab. (e.g Kafka, SPARK, Elasticsearch)	*NA*	3Q:20-21
	Development of Security Analytics for high-scale Big-Data Platform	*NA*	2Q:20-21
	Deployment of scaled-up version of Security Analytics (CCSM) on Bigdata platform	*NA*	3Q:20-21
User Interface for Multi-stake holders with	Role-based access control	*NA*	2Q:20-21
	Configurable Dashboards	*NA*	2Q:20-21
	Configurable report generation and advanced analysis	*NA*	2Q:20-21
	Advanced analysis Integrated with 3rd party feeds.	*NA*	2Q:20-21
	Customization of Analysis Reports	*NA*	3Q:20-21
CERT Data Center Build	Space Allocation for CERT-T Main Data Center	*NA*	2Q:20-21 (Note)[2]
	Study the Requirements & Design of CERT-T Data Center Build	*NA*	3Q:20-21 (Note)[2]
	Setup of Data Centre for CERT Telecom Tender	*NA*	3Q:20-21 (Note)[2]
	Tender Evaluation & PO placement for DC Build	*NA*	4Q:20-21 (Note)[2]
	Equipment deployment of DC Build	*NA*	1Q:21-22 (Note)[2]
CERT Data	Design of TCERT Main	*NA*	3Q:20-21 (Note)[2]

	Center IT	Setup of Data Centre IT Tender preparation & release	*NA*	3Q:20-21 (Note)[2]
		Tender Evaluation & PO placement	*NA*	4Q:20-21 (Note)[2]
		Equipment deployment of IT.	*NA*	2Q:21-22 (Note)[2]
Projected physical outcome for FY 2020-21	• To enable the traffic Collection at ISP gateways and generation of IPFIX flows without any involvement of ISP equipment. • To connect and access web-based CERT application a bare minimum infrastructure at user end will serve purpose. • Expansion of Big-Data platform from CERT-lab at C-DOT to full fledge deployment required to cater the full traffic from all ISP gateways. • Facilitation of cyber forensics, NOC/SOC monitoring and capacity building center as central facility.			
Reasons for revision of targets	• There has been delay in the procurement requisite HW, required for lab set-up and to undertake development activities.			

Note:

1. *Nation-wide deployment activity of IPFIX probe across all gatways, is tentatively planned for 2 years, starting from 1Q:2020-2021, which is however subject to revision based on availability of resources.*
2. *CERT Data Centre Build activity will depend on DPR approval and space allocation by DOT*

4.8.2 CEIR development

The project has been conceptualised in FY 2017-2018 in two phases, namely:

Phase-1:
- Design and development of application for publication of stolen or lost mobile handsets, and synchronising the database with all TSPs of India.
- Field implementation of phase-1(a) and enhancements.

Phase-2:
- Design and development of identification and publication of cloned or illegal IMEI database and interface with local EIRs[131] of all TSPs of India.
- Field implementation for phase-2(a) and enhancements.

During FY 2017-2018, design and development activities of both phase-1 and phase-2 had been completed for stolen device reporting system and publication of cloned/illegal IMEI. However, synchronisation with databases of all TSPs, field implementations, enhancements, etc., as defined above, were not taken up, since DoT desired to have pilot implementation of CEIR solution capabilities (limited) covering all aspects for CEIR with all major TSPs of one LSA[132]. C-DOT completed the pilot implementation of its proposed EIR solution in Maharashtra LSA, as directed by DoT.

In view of above, definition of phase-1 and phase-2 of the project now stands revised from FY 2018-2019 onwards and details are given below:

1. **Phase-1 (offline):** To send off-line subscriber device information, i.e., IMEI, IMSI[133], and MSISDN[134] to CEIR to all the 21 LSAs, similar to solution implemented in Maharashtra LSA, for roll-out of CEIR pan-India in off-line mode.

2. **Phase-2 (real-time):** To upgrade phase-1 implementation to real-time/near real-time mode in all 22 LSAs.

Objective	To develop CEIR to facilitate integration of all the EIRs of all the TSPs of the country to address the issue of stolen or lost mobile handsets and cloned IMEIs across the country.
Brief description	CEIR is a database of the IMEI numbers of blacklisted mobile handsets, whitelisted numbers including genuine IMEI shipped by vendors or OEMs[135], and suspect list including IMEI numbers reported in theft cases. It interfaces with the IMEI database of all mobile network operators and acts as a central system for all the network operators to share the blacklisted mobile terminals so that devices blacklisted in one network will not work on other networks even if the SIM[136] in the device is changed. The CEIR will be operated and maintained by DoT and will be accessible to all the stakeholders including citizens, to check whether a purchased mobile device is a genuine one, and it will be maintained at national level with disaster recovery site.

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[131] Equipment Identity Register
[132] Licensed Service Area
[133] International Mobile Subscriber Identity
[134] Mobile Station International Subscriber Directory Number
[135] Original Equipment Manufacturer
[136] Subscriber Identity Module

	C-DOT's EIR solution will provide the following functions: • Centralised database to store MSISDN-IMEI-IMSI triplets of all Indian subscribers, • Interface with local EIRs of all telecom service providers across India, • Triplet data collection through real-time/near-real-time through secure interface, • Interface with GSMA[137] for validating IMEI numbers, • Device registry for Indian mobile manufacturers, individual imports and long-term in-roamers, • Device pairing, • IMEI verification – web portal, mobile app and SMS[138]-based, • Stolen device reporting system – eKYC[139] integration and customisation as per requirement from State police and policy from DoT, • Stolen mobile localisation for local police to trace stolen mobiles, • Device authentication mechanism for cloned handsets, • SIM change mechanism for blacklist-overriding subscribers, • Query interface with Government, LEAs and citizens, • Several types of offline and online report generation.
Application areas	• Blocking of lost or stolen mobiles, localisation of lost or stolen handsets, leading to reduction of thefts, • Localisation of stolen mobile handsets for investigation by State police, • Detection of cloned IMEI, leading to check on spurious and cloning and improving the network health, • Reduction in counterfeiting and health hazards, • Reduction of tax evasion.
Key deliverables	**Deliverables planned for 2018-2019:** 1. CEIR lab preparation for application SW development, testing, load simulation and validation, 2. Application for real-time/near-real-time data collection from TSPs, 3. Device registry, 4. IMEI verification web portal, mobile app, 5. Device pairing through mobile app, web portal and SMS, 6. eKYC complied stolen device reporting system. **Deliverables planned for 2019-2020:** 1. Field deployment of CEIR – all LSAs and all TSPs, 2. DR[140] implementation, 3. Customs import and verification – web-portal and mobile app. 4. Help-desk system for fault management **Deliverables planned for 2020-2021:** 1. Field Deployment of Phase-1 2. Device pairing through- mobile app (Android and iPhone), web portal and SMS. 3. Online interface testing through simulator. 4. Development of online interface

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[137] **Groupe Special Mobile Association**
[138] **Short Message Service**
[139] **Electronic (based) Know Your Customer**
[140] **Disaster Recovery**

Status as on 31.03.2020	• As per requirement from DoT, Stolen Device Reporting System (SDRS), a functional module of CEIR was implemented on priority. SDRS would be used for reporting and tracing of stolen mobile phones. • CEIR pilot project was launched Maharashtra for reporting and tracing of stolen mobile phones on 13th September 2019 by Hon'ble Minister of Communications in presence of Hon'ble Minister of State for Communications. • As asked by DoT, Indian Counterfeited Device Restriction (ICDR) was implemented on priority. ICDR is used for importing mobile devices to India through customs. • ICDR was made operational in January 2020 and running successfully. • DPR feedback received from DoT and after rework modified DRP has been submitted again to DoT for approval. • SDRS Mobile app is prepared.

Finance (₹ in crore)	**Budget for FY 2020-2021**		17.02

Project plan	**Deliverables and milestones**		**Target**	
			2019-2020	**2020-2021**
	PoC and piloting for CEIR in one LSA (Maharashtra)			
	Study and requirements specifications		*NA (Completed in FY 2017-18)*	
	Architecture design		*NA (Completed in FY 2017-18)*	
	Design implementation		*NA (Completed in FY 2017-18)*	
	Integration testing and start of internal validation		*NA (Completed in FY 2017-18)*	
	Lab demonstration and pilot trial		*NA (Completed in FY 2017-18)*	
	Phase-1 (offline mode)			
	Requirements specification, architecture and design finalisation		*NA (Completed in FY 2018-19)*	
	Lab infrastructure set-up for development		*NA (Completed in FY 2018-19)*	
	Device pairing implementation	through mobile app (Android)	*NA (Completed in FY 2018-19)*	
		through web portal	*NA (Completed in FY 2018-19)*	
		through SMS	*NA (Completed in FY 2018-19)*	
		through mobile (iPhone)	*NA (Completed in FY 2018-19)*	
	IMEI verification	SMS	*NA (Completed in FY 2018-19)*	
		Web Portal	*NA (Completed in FY 2018-19)*	
		mobile app (iPhone)	*NA (Completed in FY 2018-19)*	
	Device Registry	for Indian manufacturers	*NA (Completed in FY 2018-19)*	

	for individual import	*NA* *(Completed in FY 2018-19)*	
	for long-term in-roamers	*NA* *(Completed in FY 2018-19)*	
Device authentication	through competent authority	*NA* *(Completed in FY 2018-19)*	
	through mobile manufacturers	*NA* *(Completed in FY 2018-19)*	
Stolen/lost device reporting system enhancement for eKYC-based authentication		2Q:19-20	*On hold (note)[1]*
Error reporting and alarm display		*NA* *(Completed in FY 2018-19)*	
Interface with State police for blacklist data		*NA* *(Completed in FY 2018-19)*	
Validation of phase-1 system and readiness for deployment with lab servers		2Q:19-20	*NA (completed)*
Field infrastructure planning and deployment (Note)[2]	Site preparation and equipment planning	2Q:19-20	*NA (completed)*
	Tender preparation and release	2Q:19-20	(Note)[2]
	PO placement	3Q:19-20	(Note)[2]
	PR site equipment procurement	3Q:19-20	(Note)[2]
	Equipment deployment in field	4Q:19-20	(Note)[2]
Field Deployment of Phase-1		*NA*	(Note)[2]
Phase-2 (real-time mode)			
Online interface testing through simulator		*NA*	1Q : 20-21
Device pairing	Through mobile app (Android)	*NA*	3Q : 20-21
	Web portal	*NA*	3Q : 20-21
	Through SMS	*NA*	3Q : 20-21
	Through mobile app (iPhone)	*NA*	3Q : 20-21
Device Registry for Indian Manufacturers and Imports		*NA*	2Q : 20-21
Device authentication		*NA*	2Q : 20-21
Device authentication through mobile manufacturers		*NA*	3Q : 20-21
Interface finalisation for online triplet collection		1Q:19-20	2Q : 20-21
Development of online interface		3Q:19-20	4Q : 20-21
Validation and readiness for field deployment (without DR)		1Q:20-21	2Q : 21-22
Customs import and verification - web-portal and mobile app		3Q:19-20	*NA (completed)*
CEIR Disaster Recovery Software implementation		2Q:20-21	3Q : 21-22
Validation of CEIR Disaster Recovery (DR)		*NA*	4Q : 21-22
DR field infrastructure planning and deployment	Release of Technical spec of DR equipment	1Q:20-21	1Q : 21-22
	Tender preparation and release	4Q:19-20	(Note)[2]
	PO placement	1Q:20-21	2Q :21-22
	Equipment deployment in field	2Q:21-22	3Q :21-22
Field deployment of phase-2 with DR		4Q:20-21	4Q :21-22

Projected physical outcome for FY 2020-2021	• Roll-out of CEIR pan-India in offline mode. • Development of online interface (Phase-2).
Reasons for revision of targets	• Delay in the procument of lab equipments leads delay in validation of phase-1. • SDRS and ICDR modules were prioritized, as a result few other modules were delayed. • DRP still under approval and this let to shift in the timelines of the remaining planned activity of phase-1 and phase-2.

Note:

1. *Stolen or lost device reporting system enhancement for eKYC-based authentication, implemented but further activities for integration and testing, etc, have been put on hold, as Supreme Court has declared eKYC-based authentication is not mandatory.*

2. *DOT dependent activity. Equipment specification is already done, waiting for confirmation from DOT to place the tender. As per the last meeting with DOT with ED, C-DOT, a committee is yet to be formed to finalize whether it will be deployed on Cloud or on Data centre with procured servers.*

3. *Field infrastructure, site planning and deployment information are awaited from DoT.*

4.8.3 C-DOT interception request and approval system (CIRAS)

Law Enforcement Agencies (LEAs) need to get interception request approved from Secretary, Ministry of Home affairs or an officer designated by him, before provisioning target for interception. Therefore, there is a need of an electronic system to get interception approved from MHA. Currently, this process of Interception request and approval is manual process and not within the scope of CMS.

C-DOT interception request and approval system (CIRAS) aims at automating the process of interception request and approval currently for the Central LEAs only.

Objective	This system will enable end to end electronic system for intercept request and approval.
Brief description	As per the interception law of India, any Central LEA needs interception requirement to get approved from MHA before provisioning a Target for lawful interception in Telecom / ISP network. Currently interception request approval procedure is not in scope of the CMS system. Central LEAs get interception requirement of any target approved from MHA offline manually. LEAs have to initiate intercept request in physical form to MHA for interception of targets. The interception request is approved by competent authority in Union MHA and transmitted to LEA in physical form only. LEA can do provisioning of the target in CMS system only after MHA approval, the.
	This system is being developed with the objective in center to provide end to end web-based electronic interface for processing of interception request generated by LEAs and its approval by competent authority in MHA. This system will be installed at MHA who will also act its administrator and from that system web interface will be provided to all Central LEAs for generating interception request and MHA for approval/rejection and also for generating interception order. After successful acquisition of approvals LEA users will use existing CMS system for provisioning the target in CMS system and interception activation of the target.
	There will be separate web-based applications for LEAs and MHAs in the CIRAS system, for LEAs to initiate interception request (LEA-CIRAS) and for MHA approving/ rejecting interception requests (MHA-CIRAS).
Application areas	• LEA-CIRAS and MHA-CIRAS will run on servers hosted at MHA premises.
	• LEA-CIRAS: There will be hierarchy of users in LEAs with different privileges who will generate interception request and forward request to MHA. Thus, first level of approval will be within LEA before forwarding request to MHA. Top level users will assign the approving and forward privilege to LEA users of lower level. Top level user will approve request from lower level user.
	• MHA-CIRAS: There will be provision for hierarchy of users for approving or rejecting interception request from LEAs. There will be 4 levels of approving authorities within MHA. This is the maximum limit of user levels in MHA, it is up to MHA that they define users up to 4 levels. MHA will have authority to approve target in all INDIA basis. Request from LEAs will be received by first level user and then forwarded to next level for further action. Interception request can be rejected

	at any level, but it will be approved at last level only.
Key deliverables	**Deliverables planned for 2020-21:** • Requirement finalization with MHA. • Implementation of the application • Lab setup procurement and make the lab operational • Application validation • Field setup preparation • Field deployment
Status as on 31.03.2020	Detailed Project Report has been submitted to MHA and waiting for the approval along with desired funding.

Finance (₹ in crore)	**Budget for FY 2020-2021**		1.30

Project plan	Deliverables and milestones	Target	
		2019-20	**2020-2021**
	Requirements Freezing	NA	1Q:20-21
	Architecture design	NA	1Q:20-21
	Design implementation	NA	2Q:20-21
	Lab equipment procurement	NA	2Q:20-21
	Lab setup preparation	NA	2Q:20-21
	Integration testing	NA	2Q:20-21
	Validation testing	NA	2Q:20-21
	Readiness for deployment	NA	3Q:20-21
	Field setup procurement	NA	2Q:20-21
	Field setup preparation	NA	3Q:20-21
	Field Deployment	NA	4Q:20-21

Projected physical outcome for FY 2020-2021	Field Deployment C-DOT interception request and approval system
Reasons for revision of targets	NA

Note:
This project is presently under consideration for approval. Project development will continue after formal award of work.

4.9   National Security Council Secretariat (NSCS)

National Security Council Secretariat (NSCS), a Gov.t of India agency has granted administrative approval and funding to C-DOT for following two Cyber Security Research & Development projects that will lead to development of network security products that can be potentially used by Strategic Government agencies.

The Projects are:
1.   PINE: Post-Quantum Inline Network Encryptor
2.   Quantum-secure Smart Video IP Phone

The project proposals for these projects were submitted by C-DOT to NSCS in December 2019 under the category of projects that involve Research, Development & Engineering leading to production capability. Subsequently in January 2020, C-DOT team also gave presentations on these projects to NSCS Project Evaluation Committee. The Projects got approved by NSCS's High Powered Committee (HPC) on Cyber-Security R&D in March 2020. These projects will be periodically reviewed by a Project Review & Monitoring Committee (PRMC) that shall be formed by NSCS. The funds utilized in these projects shall also be audited by NSCS.

4.9.1 Post-Quantum Inline Network Encryptor (PINE)

This is a new project sanctioned to C-DOT by NSCS. C-DOT started working on implementation of Quantum-safe-algorithms in FPGA under Quantum Safe Cryptography Project in FY2019-20. Based on the experience gained through those activities, a project proposal was submitted to NSCS for development of an FPGA based IP Encryptor product. This resulted in sanction of PINE Project. Overall, PINE Project sanctioned by NSCS to C-DOT is of 2 years duration. Activities of FY2020-21 are listed here.

Objective	The objective is to develop a tamper-resistant Post-quantum In-line Network Encryptor (PINE) product capable of providing Post Quantum key exchange mechanism and symmetric encryption (AES256) of Ethernet frame (L2) and IP packet (L3) payload at 1Gbps encrypted throughput
Brief description	FPGA-based Post-quantum In-line Network Encryptor (PINE) project entails development of a high data throughput in-line IP network encryptor which shall support quantum safe key exchange algorithms along with classical key-exchange algorithms along with hardened symmetrical data encryption at 1 Gbps line rate. The product shall also be made tamper resistant and rugged. In FY2020-21, it is planned to develop a custom hardware board; port the system software & FPGA software onto the board to support L2 and L3 encryption and post-quantum key exchange and house the board in a tamper resistant enclosure. IN FY2021-22, product shall be made more robust through load-testing & security-testing. Product shall also be offered for security evaluation.
Application areas	Secure communication products in strategic, Government and enterprise market.
Key deliverables	• System architecture design of FPGA-based post quantum in-line network encryptor (PINE). • FPGA SoC based Custom board with Tamper resistant enclosure • Layer 2 and Layer 3 payload encryption implementation in FPGA • Post quantum and classical key exchange along with USB/serial port-based key-input mechanism
Status as on 31.03.2020	Prototype implementation of Layer 2 IP payload encryption successfully done on two FPGA reference boards

Finance (₹ in crore)		
Sanctioned budget outlay for the project		12.10
Cumulative expenditure (*provisional up-to Mar-2020*)		N.A.
Budget for FY 2020-2021		9.32

Project plan	Deliverables and milestones	Target dates	
		2019-2020	**2020-2021**
	Detailing of Product Requirement Specifications and Hardware Requirement Specifications	NA	1Q:20-21
	Enhancement in encryptor FPGA logic design for handling Layer 2 packets encryption (on reference	NA	1Q:20-21

	board)		
	System architecture Design	NA	1Q:20-21
	Design of Custom board, CAD, PI and SI	NA	2Q:20-21
	Enhancement in encryptor FPGA logic design for handling Layer 3 packets encryption (on reference board)	NA	2Q:20-21
	Tamper Resistant enclosure design and manufacture	NA	2Q:20-21
	PCB manufacture of custom board	NA	3Q:20-21
	FPGA logic and software porting on custom board	NA	3Q:20-21
	System Integration & Testing	NA	4Q:20-21
Projected physical outcome for FY 2020-2021	Tamper Resistant in-line network encryptor (dual 1G ports) with PQC key exchange and AES 256 cryptography functions		
Reasons for revision of targets	N.A.		

4.9.2 Development of Quantum Secure Smart Video IP Phone (QSSIPP)

This is a new project sanctioned to C-DOT by NSCS. C-DOT has a prior experience in development of a Secure Voice over IP Phone product. C-DOT also has experience in the area of Post-Quantum cryptography algorithms under Quantum-safe-cryptography project. Additionally, in FY2019-20, C-DOT worked on a product 'Sleek Video IP Phone' under the Project "Secure Network Solutions: Enhancements & Trials". Combining the experience gained in these past projects, C-DOT submitted a project proposal to NSCS for "Development of Quantum Secure Smart Video IP Phone". The proposal got approved resulting in this project sanctioned for one year duration.

OBJECTIVE	To develop a Quantum secure customer premise equipment (CPE) with VoIP based Video and Voice calling Features		
BRIEF DESCRIPTION	Besides voice and video calling over IP (Internet Protocol) over Ethernet, this product shall have security features such as: • Biometric Authentication • Facial Authentication • Secured Call establishment using Post-Quantum-cryptography protocols • Voice-based commands		
APPLICATION AREAS	Secure communication products in strategic, Government and enterprise market Secure communication		
KEY DELIVERABLES	• C-DOT Custom hardware for Video IP Phone in plastic packaging • Software for call processing, user and security features		
Status as on 31.03.2020	• New Project		
FINANCE (₹. in Crores)	Sanctioned Budget outlay of the scheme		10.00
	Cumulative expenditure (provisional up-to Mar-2020)		N.A
	Budget for FY 2020-21		8.31
PROJECT PLAN	**Deliverables / Milestones**	**Target Dates**	
		2019-20	**2020-2021**
	Basic IP Phone product readiness with custom hardware boards, plastic packaging and software for voice-only calls	NA	2Q:20-21
	Enhancements in Basic IP Phone product to enable Video Calls	NA	3Q:20-21
	Further Enhancements to support Quantum Security, Biometric security, Voice-based commands, Facial authentication	NA	4Q:20-21
PROJECTED PHYSICAL OUTCOME FOR THE FY 2020-2021	Quantum secure Smart Video IP Phone Product (with custom Hardware boards, Plastic Packaging and necessary software)		

4.10 Enabling technologies and telecom networks

The program comprises of the following:

- PoCs and piloting trials to gain operational insights.
- Applications of technologies and related issues.

4.10.1 Study of Quantum Key Distribution

Objective	To carry out feasibility for developing lab prototype of QKD system
Brief description	QKD makes it possible to randomly generate and distribute a secret key over an open communication channel (which may comprise of an optical fibre or free space), something which is not possible in the classical domain. The laws of physics, as are known today, guarantee that any attempt of eavesdropping on this open channel will introduce errors into the key, and thus eavesdropping is going to be surely detected. The security of a QKD protocol is based on the impossibility to observe a quantum mechanical system without changing it. An adversary (usually referred as Eve) trying to wiretap the quantum communication would thus inevitably leave traces (in the form of higher bit error rate) which can be detected by the two legitimate parties trying to set up the QKD link amongst themselves (usually referred as Alice and Bob). QKD cannot securely transmit a predetermined information - it can only securely generate and distribute a truly random key. Once generated, this random key can be subsequently used in conjunction with standard encryption algorithms, like AES, to securely transmit data over a classical communication channel. A continuously operating QKD system will steadily generate and distribute a new secret key, thus ensuring that the standard encryption algorithm can periodically change the key making the communication robust against the eavesdropping (who may have been able to decrypt the information if the same key is continuously used over a long period). Thus, QKD solves the most difficult problem in modern cryptography - that of key distribution.
Application areas	Secured key generation over optical fibre.
Key deliverables	QKD lab prototype model.
Status as on 31.03.2020	• Error estimation and error correction for QKD simulator implemented. • Specifications generated and raised indents for procurement for capital items. • Majority of components required for design of QKD lab prototype indented
Finance (₹ in crore)	**Budget for FY 2020-2021** 0.39

Project plan	Deliverables and milestones	Target	
		2019-2020	**2020-2021**
	Simulator for error estimation, error correction and privacy amplification	3Q:19-20	Completed
	Setting up quantum photonics lab for conducting experiments related to QKD	4Q:19-20	Note
	Design of QKD lab prototype model	1Q:20-21	1Q:20-21

Projected physical outcome for FY 2020-2021	Prototype model of QKD lab.
Reasons for revision of targets	*NA*

Note:

This activity could not be completed due delay in procurement. it is planned be taken up under the development program.

4.11 Enhancements, upgradations, adaptations and technical support for developed technologies

Under this program, every year C-DOT identifies and provides for its developed and deployed technologies, value addition, upgrades and other support services like SW bug-fixes, alternate solutions against component obsolescence and field support. Field/pilot trials are also conducted at multiple locations, to prove the viability of the developed technologies.

4.11.1 Design support for developed technologies

Objective	To provide enhancements, upgradations, bug-fixes, solutions for component obsolescence and field support for the technologies developed and deployed in the network with new set of features or migration, scalability, and trials of newly developed technologies.
Brief description	Support will be provided for: • MAX, MAX-NG and IN services, • Optical technologies (GPON, NOFN),Optical Core Networks • SDCN – Support activities and SDCN enhancements in DRDO & MHA • Network steganography and network steganalysis. • Green Power Supply Unit
Application areas	Product enhancements, support against obsolescence, and field support.
Key deliverables	• 24x7 support on the existing MAX systems, upgradation to MAX-NG systems in BSNL network, and support for IN services and NGN technology deployed in the MTNL network. • On-site and off-site field support for NOFN implementation with C-DOT GPON technology. • Field support for deployment, PoC, demonstration, etc, for other technologies. • Value engineering and design enhancements to address field and manufacturing issues. • SDCN support in NCR[141], and provisioning of secure data services. • Technology engineering support for ATM switch and NIU[142] deployments. • Optical technologies (GPON, NOFN): Development and integration of NOFN EMS Migration to Angular2+ platform, NOFN EMS validation and Intallation at the customer site, Installation at customer sites, customer feedback incorporation • Support and enhance the network steganography solution implemented in C-DoT VoIP phone. • Under green power supply, TOT support for 2KW and 5KW systems and ield deployment and support for provisioning of Solar power supply for C-SAT-FI system are planned .
Status as on 31.03.2020	It is an ongoing technology support program to address various field issues, component obsolescence, upgradation, etc, for the deployed systems.
Finance (₹ in crore)	**Budget for FY 2020**-2021 24.52
Project plan	Activities are planned for every year, depending on customer request, field deployment requirements, market demands, etc.

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[141] **National Capital Region**
[142] **Network Interface Unit**

4.11.2 Technology field implementations and roll-outs

Objective	To roll out technologies that have been successfully field tried and accepted in telecom network.
Brief description	During the 12th Plan period, many of the technologies have been developed, field tried, piloted and technologies have also been transferred to the manufacturers for production. Besides, there are customised developments, solution architecting and field implementations for some of the network elements. Some of the technology roll-outs, field implementations planned during the year are: • ISP monitoring: Implementation of requisite solution for lawful interception and monitoring of internet traffic by LEAs, • Customised development of router HW, • Customisation of router SW stack, • LTE-A: Enhancements and trials for RAN[143] and EPC, • CMS: Support, • NMS: Enhancements and trials, • WiFi: Technology enhancementsand trials, • NMS trials and enhancements for BBNL[144] – phase-1 and phase-2, • Satellite hub baseband support for phase-1 and phase-2, • *Samvad*: Enhancements, trials and field implementation, • Secured network solutions: Enhancements and trials, • NDMA project: CAP-compliant EWP, • TEC project on MTCTE[145] portal, • Optical core networks – trials and enhancements, • PCR solution for NDMA, • CiSTB support, • MTCTE (Mandatory Testing and Certification Scheme)
Application areas	Technologies planned for roll-out and implementation cater to the requirements of BSNL, MTNL, BBNL, Defence, etc.
Key deliverables	• Major deliverables of the technology roll-outs and field implementations program are: • Customised development and field implementation: NOFN-NMS[146], , router HW, etc. • Optical core networks – trials and enhancements. • PCR solution for NDMA. • GIS-based monitor for telecom infrastructure and services. Satellite hub baseband support for phase-1 and phase-2.
Status as on 31.03.2020	• Technologies for MAX-NG, IMS, Voice-over-FTTH, BBWT, NMS, router, etc, proven in field and are operational in the network.
Finance (₹ in crore)	**Budget for FY 2020-21** 212.56
Project plan	Following sub-sections provide the broad plans for roll-outs and field implementations for major technologies.

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[143] **Radio Access Network**
[144] **Bharat Broadband Nigam Limited**
[145] **Mandatory Testing and Certification of Telecom Equipments**
[146] **Network Management System for National Optical Fibre Network**

4.11.2.1 ISP monitoring field implementation

Objective	To study the network of each ISP, prepare solution document for each ISP, implement and support.
Brief description	DoT, MHA and all major LEAs have defined the C-DOT's role in the SOP[147] to study the network of all ISPs in the country, prepare the complete monitoring solution and implement to cover the total internet traffic.
Application areas	• Lawful interception and monitoring of internet traffic by LEAs. • This project will meet the requirement of the data monitoring part of CMS project.
Key deliverables	• A low cost scalable solution (upto 600 Gbps), as per the requirement of each individual ISP location (gateway/PoP[148]) covering all ISPs. • Implementation of solution provided by C-DOT at gateways/PoPs wherever HW is procured and handed over by the ISP to C-DOT.
Status as on 31.03.2020	• ISP solution implemented at 8 additional ISP gateways (Verizone Hyderabad, BSNL Ernakulaum, VNIPL Mohali, Power Grid Shillong, Vodafone Idea Chennai, Tata Sky Delhi, AT&T Delhi and Verizone Noida), including upgradations during the year and cumulative total ISP gateway monitoring solutions pan-India installed at 108 locations. Hands-on trainings conducted for LEAs, and SOP for handing-over of IMS infrastructure completed and SOP released by DoT. • DoT officers of Security wing have been given due trainings for taking over IMS for PCI[149] operations as per SOP. • The handing-over of IMS LSA-wise to DoT has commenced. 8 ISP Monitoring sites have been handed over to PCI (DOT) for Delhi LSA. • IMS infrastructure access given to 5 central LEAs and 6 regional LEAs.

Finance (₹ in crore)	**Budget for FY 2020-2021**			0.69

Project plan	**Deliverables and milestones**[2]		**Target**	
			2019-2020	**2020-2021**
	Implementation at 10 ISP gateways		NA(completed in 2013-14)	
	Implementation at 10 more ISP gateways		NA(completed in 2013-14)	
	Set-up of lab and monitoring centre		NA(completed in 2013-14)	
	Implementation at 10 more ISP gateways		NA(completed in 2015-16)	
	IMS training program for LEAs	Training infrastructure set-up	NA(completed in 2016-17)	
		Training course offer for LEAs	NA(completed in 2017-18)	
		Training course offer for LEAs	NA(completed in 2018-19)	
		Training course offer for LEAs	NA(completed in 2019-20)	
		Training course offer for LEAs (2020-21)	NA	3Q to 4Q: 20-21
	Implementation at ISP gateway solution at	20 locations (2017-18)	*NA (Completed) (Note)*[1]	
		11 locations (2018-19)	NA(completed in 2018-19)	
		6 locations (2019-20)	4Q: 19-20	*NA (Completed)*

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[147] **Standard Operating Procedure**
[148] **Point-of-Presence**
[149] **Prime Custodian of Interception**

		6 locations (2020-21)	NA	4Q: 20-21
	Handing over IMS infrastructure to PCI, i.e., DoT, for all operations and support, as per the technical SOP	Training program for DoT officers of Security wing	*NA (Completed)*	
		Handing over IMS infrastructure to PCI	4Q:19-20	1Q-4Q:20-21 (progressively)
Projected physical outcome for FY 2020-2021	• Handing over of IMS infrastructure to PCI. • Implementation at 6 additional ISP gateways. • Conducting 2 IMS training courses for LEAs and DOT.			
Reasons for revision of targets	NA			

Note:

1. *Completed for 15 locations handed over by ISPs.*

4.11.2.2 Customised development of routing HW platform

Objective	To develop a router hardware platform with its platform software.
Brief description	This technology program has been introduced as a sponsored project to develop a router HW against publically issued RFP[150]. The key motivation is to develop a router HW using off-the-shelf multicore processor and subsequently using the indigenous multicore processor designed by DRDO. The necessary platform SW will also be developed.
Application areas	Switching and routing in strategic networks.
Key deliverables	• Router HW based on off-the-shelf multicore processor. • Platform SW for the router HW based on the off-the-shelf multicore processor. • Router HW based on indigenous multi-core processor of DRDO. • Platform SW for the router HW based on the indigenous multi-core processor of DRDO.
Status as on 31.03.2020	• Requirements specifications, architecture design, acceptance testing plan completed. • For off-the-shelf multicore-processor-based customised router (phase-1), boards' schematics, CAD layout and routing, SI, PI and thermal analysis, CAM[151], QA[152] and PCB fabrication have been completed. • In Platform SW, high-level design, detailed design and implementation have been completed. • Assembly of phase-1 routing platform proto cards using off-the-shelf multicore processor completed. • Bringing up the board, OS[153] porting, testing and Integration with platform SW completed for phase-1 routing platform cards using off-the-shelf multicore processor. • Assembly of multiple cards, integration of multiple systems and testing have been completed for Phase-1. Acceptance Testing by DRDO and EMI/EMC/ESS testing have been completed. • For indigenous multicore-processor-based customised Router (Phase-2), DRDO has completed the fabrication of the processor chip and provided the physical details of the chip. Preliminary architecture of the indigenous multicore processor based router has been completed and functional specifications are in progress for the boards. • For phase-2 development, received additional inputs and required clarifications on indigenous multicore processor, which is now tested by DRDO. The phase-2 board designs have been updated as per the changes/inputs from DRDO • Phase-2 boards' CAD implementation & Board Analysis (SI/PI/thermal) and CAM have been completed; platform SW high level design and detailed design have been completed • Ordering of components for the Phase -2 boards has been initiated and the PO releases to be done after release of payment from DRDO for the completed Phase-1 milestone

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[150] **Request For Proposal**
[151] **Computer-Aided Manufacturing**
[152] **Quality Assurance**
[153] **Operating System**

Finance (₹ in crore)	Budget for FY 2020-2021		2.87
Project plan	Deliverables and milestones	Target	
		2019-2020	2020-2021
	Phase-1		
	Requirements specifications of HW platform	*NA (Completed in FY 2016-17)*	
	Architecture design of HW platform	*NA (Completed in FY 2016-17)*	
	Architecture design of Platform SW	*NA (Completed in FY 2016-17)*	
	Acceptance testing plan	*NA (Completed in FY 2016-17)*	
	Detailed schematic design of router HW platform	*NA (Completed in FY 2017-18)*	
	High level design of platform SW	*NA (Completed in FY 2017-18)*	
	Realisation of HW: CAD implementation of boards	*NA (Completed in FY 2017-18)*	
	Detailed design of platform SW	*NA (Completed in FY 2017-18)*	
	Boards analysis, CAM and PCB fabrication	*NA (Completed in FY 2017-18)*	
	Assembly of boards and bringing up the HW board	*NA (Completed in FY 2018-19)*	
	OS porting on boards	*NA (Completed in FY 2018-19)*	
	Platform SW integration and testing on boards	*NA (Completed in FY 2018-19)*	
	Production, testing of multiple boards and systems	1Q:19-20	*NA (Completed)*
	Supply of Phase-1 systems and AT	1Q:19-20	*NA (Completed)*
	Phase-2		
	Requirement specifications of Phase-2 HW platform	*NA (Completed in FY 2018-19)*	
	Architecture design of HW and SW platform	*NA (Completed in FY 2018-19)*	
	Detailed schematic design of router HW platform	*NA (Completed in FY 2018-19)*	
	High level design of platform SW	1Q:19-20	*NA (Completed)*
	Realisation of HW: CAD implementation of boards	1Q:19-20	*NA (Completed)*
	Detailed design of platform SW	1Q:19-20	*NA (Completed)*
	Boards analysis and CAM	1Q:19-20	*NA (Completed)*

	Proto PCBs fabrication	1Q:19-20	1Q:20-21
	Assembly of boards and bringing up the HW boards	2Q:19-20	2Q:20-21
	OS porting on boards	2Q:19-20	3Q:20-21
	Platform SW integration and testing on boards	3Q:19-20	3Q:20-21
	Production, testing of multiple boards and systems	3Q:19-20	4Q:20-21
	Supply of Phase-2 systems and AT	3Q:19-20	4Q:20-21
Projected physical outcome for FY 2020-2021	• Production, testing and supply of Phase-2 RHP systems • Acceptance Testing of Phase2 RHP Systems		
Reasons for revision of targets	• The project was awarded in Mar-2016 and subsequently after multiple interactions with DRDO, additional security requirements emerged, making it necessary to enhance the architecture and design, and embed the security requirements in the design itself to make the system high-grade security compliant. This iterative adaptation of the product architecture resulted in delays in commencing the detailed design • Phase-1: Since large number of board designs were required to be done in CAD, inspected and assembled, it took more time to complete phase-1 development, QA and proto assembly. Some of the components and PCBs required for assembly were also supplied late due to vendor side delays and shipping export control issues. • Phase-2 indigenous multicore processor-based customised router has been added as a second deliverable in this FY, since DRDO has been able to complete the fabrication of this processor chip and could provide the chip related physical and electrical details that are required to start the development. • Further progress on Phase-2 Router platform development was dependent on getting the required additional details of the indigenous multicore processor (which is the key device) and necessary support from DRDO, based on the progress in characterization and testing of the various functions of the processor by DRDO. Since indigenous multicore processor chip testing by DRDO got delayed, there were delays in getting the required functional and packaging related inputs and clarifications from DRDO about the indigenous multicore processor. Additionally, DRDO had asked for certain new design changes and enhancements to be done after initial testing of their chip. All necessary changes in board design and platform SW architecture could be finalized with DRDO by Jan-2019, and the board-level schematic design changes and CAD implementation of the boards, and the associated platform SW design, could start only after that. • While CAD implementation of the Phase 2 boards, analysis and CAM have been completed for the Phase-2 router development, POs release for components & PCBs have been on hold due to delays in receipt of payments from DRDO for the completed Phase -1 milestone, there by affecting the subsequent activities of assembly, testing, integration and Acceptance Testing		

Note:

1. *Project on hold till project contract extension done and routing stack support from vendors are started by ANURAG.*
2. *Presently, the project is on hold till receipt of payments from ANURAG for completed milestones.*

4.11.2.3 Customisation of routing SW stack

Objective	To customise, port and integrate router stack on router HW platform for Defence.
Brief description	This technology program has been introduced as a sponsored project to develop a router stack against publically issued RFP. The key motivation is to develop a routing solution based on the indigenous router HW platform. This involves customisation, porting and integration of the control plane, the data plane and the management plane SW from third party and testing the solution on router HW platforms based on off-the-shelf multicore processor and indigenous multicore processor (RHP[154]-1 and RHP-2). After the integration, the functional conformance and performance testing will be carried out.
Application areas	Switching and routing in strategic networks.
Key deliverables	**Phase-1:** • Customisation, porting and integration of SW stack on the standard multicore processor reference hardware platform. **Phase-2:** • Customisation, porting and integration of SW stack on indigenous router HW platform-1 , based on commercial multicore processor (RHP-1). • Customisation, porting and integration of SW stack on indigenous router HW platform-2 , based on indigenous multicore processor (RHP-2).
Status as on 31.03.2020	Phase-1: • Customisation, porting and integration testing, functional testing completed on the standard multicore processor reference platform. Phase-2: • Functional, conformance and performance testing done and issues reported to ANURAG, DRDO for resolution. Support from stack vendors need to e activated by ANURAG. • Architecture design has been completed for RHP-2. Detailed design is in progress.

Finance (₹ in crore)	**Budget for FY 2020-2021**		0.39

Project plan	**Deliverables and milestones**		**Target**	
			2019-2020	**2020-2021**
	Study of router SW		*NA (completed)*	
	Requirements specifications and release of SW stack by client		*NA (completed)*	
	Architecture design of SW	Phase-1	*NA (completed)*	
		Phase-2	*NA (completed)*	
	Detailed design	Phase-1	*NA (completed)*	
		Phase-1	*NA (completed)*	
		Phase-2	2Q:19-20	3Q:20-21 (Note)[1]
	Implementation, customisation, porting and integration of SW stack on the standard multicore processor reference platform (phase-1)		*NA (completed)*	

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[154] **Reconfigurable Hardware Processor**

	Customisation, porting and integration of SW stack on router HW platform	Phase-2 on RHP-1	1Q:19-20	*Completed*
		Phase-2 on RHP-2	3Q:19-20	4Q:20-21 (Note-2)
	Functional, conformance and performance testing	Phase-2 on RHP-1	1Q:19-20	3Q:20-21 (Note-4)
		Phase-2 on RHP-2	3Q:19-20	4Q:20-21 (Note-3)
Projected physical outcome for FY 2020-2021	• Router SW stack Functional, conformance and performance tested on (RHP-1). • Router SW stack ported and integrated on router HW platform using indigenous multicore-processor (RHP-2).			
Reasons for revision of targets	• Integration with RHP-1 was delayed due to the delays in availability of the full featured routing stacks from the customer and the HW platform for integration. • Delivery schedule of phase-2 using the indigenous multicore processor, was dependent on the availability of tested indigenous multicore processor, which has got delayed. Hence, new dates have been indicated based on the availability of tested routing HW platform based on customer's indigenous multicore processor.			

Note:

1. *Assuming that Support from all software stack vendors and hardware vendors for porting, integration and testing is available for RSP-Phase-2. The support was not available for in 2019-20 and till May 2020. It is assumed that support from stack vendors will be reactivated by ANURAG, DRDO in Q2:2020-21.*

2. *The milestone has dependency on availability of validated indigenous router HW under development (RHP-2). It is assumed that from 1st january 2021 validated hardware platform is available for RSP (Phase-2) Porting.*

3. *The milestone has dependency on availability of validated indigenous router HW under development (RHP-2), and test equipment from customer's lab. It is assumed that three number of validated RHP-2 platform is available in Q4:2020-21.*

4. *The milestone has dependency on availability of support from routing stack vendors for resolving reported issues for RSP-1. The routing stacks support is not available for RSP-1 issues since September 2019. It is assumed that the support will be activated by ANURAG, DRDO in 2Q: 2020-21.*

5. *Project on hold till project contract extension done and routing stack support from vendors are started by ANURAG.*

6. *Presently, the project is on hold till receipt of payments from ANURAG for completed milestones.*

4.11.2.4 Support for Switches and Routers

C-DOT has developed advanced switches and routers, which are already deployed in various networks. This product line comprises of Aggregator, secure L2/L3 switch (CSX-100), STBR (CRAT-100), SAVAAR and Secure Router (CRTR-210). Some of add-on units like v.35 adapter (CADV3501/3502) were also developed. Some of these products have been deployed in the Defence, MTNL, BSNL, SDCN, NKN, CERT etc. These routing and switching technologies have been transferred to multiple indigenous manufacturers. Indigenously developed switch and router technology has been well received in the field for building LAN, edge and core networks.

Envisaging a good prospect for switching and routing technology deployment in the country, the program has been planned to comprehensively address the requirements from field and necessary support for enhancements.

Objective	To carry out technology enhancements, and customization to support roll-out of the indigenous switches and router technology in the current/ prospective clients' networks.
Brief description	The requirement for indigenous switches and routers in core and edge segment of various networks of the Government and strategic sectors, is significant. Some of the prospective clients' networks requiring these switches and routers are Defence, SDCN, BSNL, MTNL, BharatNet, RailTel, secure network, etc. Thus, considering the prospective demand, the switching and router product line needs constant enhancements, customization and upgradation in features. Moreover, technology support to C-DOT licensees as well as obtaining third party certifications for the product is required, as per the customer needs.
Application areas	➢ Switching and routing solutions in IP networks. ➢ Defence and strategic networks
Key deliverables	1. Integration of Switch EMS with C-DOT NMS 2. Integration of secure router EMS with C-DOT NMS 3. Integration of compact router EMS with C-DOT NMS 4. Enhancement of switch and router features for EAL certification. 5. Enhancement of switches and Routers as per the additional requirements received from the strategic networks (Note)[1]
Status as on 31.03.2020	NA

Finance (₹ in crore)	**Budget for FY 2020-2021**		12.23

Project plan	**Deliverables and milestones**	**Target**	
		2019-2020	**2020-2021**
	Integration of L2/L3 switch (CSX-100) EMS with C-DOT NMS	NA	2Q: 20-21
	Integration of secure router EMS with C-DOT NMS	NA	2Q: 20-21
	Development of EMS for compact router	NA	2Q: 20-21
	Integration of compact router EMS with C-DOT NMS	NA	3Q: 20-21
	Enhancement of L2/L3 switch and secure router features for EAL certification.	NA	3Q:20-21

	EAL-3 Testing of L2/L3 switch and secure router	NA	4Q:20-21
Projected physical outcome for FY 2020-2021	1. Support, enhancements of C-DOT switches and routers, as per the needs of various networks. 2. ToT of C-DOT switching and routing technology to additional manufacturers. 3. Integration of EMS of C-DOT switches and router with in-house NMS. 4. Enhancements of switches and routers as required for EAL certification		
Reasons for revision of targets	*NA*		

4.11.2.5 WiFi technology enhancements

C-DOT's WiFi technology has been deployed in the NOFN[155] under *BharatNet* program for providing horizontal connectivity beyond *panchayat*. The technology is also being deployed in CSC[156], in Defence network. A MoU has been signed with CSC SPV[157] for extending broadband services beyond *panchayat* using C-DOT's WiFi technology. The technology is gaining significant momentum and the focus on its large-scale deployment by the Centre and State administration to create a requisite broadband wireless infrastructure to provide good e-governance, will enable the service providers to provide affordable e-services. Moreover, the Defence applications also are embarking on WiFi technology to improve the existing communication infrastructure, where terrains are tough and possibilities of laying physical infrastructure are difficult and remote.

Envisaging a good prospect for WiFi technology deployment in the country, the program has been planned to comprehensively address the field requirements.

Objective	To carry out enhancements in the existing Wi-Fi product, and to develop additional components and variants to complement the existing C-DOT Wi-Fi product line to provide a comprehensive indigenous Wi-Fi solution for creating requisite broadband wireless infrastructure.
Brief description	C-DOT has designed Wi-Fi systems complied with IEEE[158] 802.11a/b/g/n/AC[159] standards with different variants as per the network requirement which are as below: • **Solar Wi-Fi** (v1 and v2) is a versatile Wi-Fi system, which works on solar power and can be used for both indoor and outdoor applications with IP65[160] and IP67[161] standards. • **Long-range Wi-Fi** is a solution to establish point-to-point and multipoint Wi-Fi link of Wi-Fi for horizontal extension of network. • **High-speed access point (v1)** is Wi-Fi base station, designed to comply with 802.11ac standards with backward compatible to a/b/g/n standards offering data speeds beyond 1 Gbps. • **PDO**[162] **(v1)** is the value addition in Wi-Fi services to support the increasing demand of internet service and its delivery through local shop owner. • **IGW**[163] **card** is designed to meet growing demand of IoT over Wi-Fi access technology and mini-PDO (mPDO[164]). • **WAC**[165] **and EMS**[166] for control, configure and monitoring of C-DOT BBWT[167] systems.

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[155] **National Optical Fibre Network**

[156] **Citizen Service Centre**

[157] **Special Purpose Vehicle**

[158] **Institute of Electrical and Electronics Engineers**

[159] **WiFi/WLAN Technology a/b/g/n/AC standard**

[160] **Ingress Protection class 65**

[161] **Ingress Protection class 67**

[162] **Public Data Office**

[163] **Internet of Things (IoT) Gate Way**

[164] **Mini Public Data Office**

- **Mini PDO** has been developed to meet the requirement of PDO functionality with Ethernet backhaul, applicable in locations such as Post Office, Shopping Malls where Ethernet backhaul is already available.
- **EFW**[168] is a card based on IGW H/w whose form factor has been reduced to meet Bamboo Wi-Fi deployment.
- **Pocket-PDO** is designed to provide the retailing of Wi-Fi over 4G backhaul.
- **WAP**[169] is designed to make the access point cost competitive, making it suitable for rural hotspot deployments.
- **AAA**[170] for User Authentication, Authorisation and Accounting functionality.

C-DOT WiFi technology product-line has been successfully field tried in CSC (leveraging *BharatNet* infrastructure), Defence, India Post, etc.

Further, C-DOT has developed the following solutions for emerging field requirements for deployment, which are as follows:

- **Satellite based WiFi backhaul**: Objective of satellite WiFi is to offer internet and other IP-based services using Ku/Ka[171] band VSAT[172] or smart LNB[173] and C-DOT WiFi to areas not connected using cable or fibre.

- **Balloon WiFi**: The Balloon WiFi aims to bring internet access to remote and rural area poorly served by the existing provisions. It helps to provide communication during natural disasters to affected regions. The balloon uses patch and sector antennas which are directional antenna to provide coverage to wider targeted areas. Backhaul and power can be provided using direct power over fibre from *grampanchayat* or through satellite backhaul in case of natural disaster conditions.

- **Bamboo WiFi:** C-DOT has developed WiFi system using the natural bamboo to work as Omni antenna along with integrated WiFi system with a coverage of 100 meters (approx) in 360 degrees. This type of system is suitable for forest ranges and can be camouflaged into nature. These systems are suitable for outdoor installation in all weather conditions.

- **Ruggedized BBWT System** to meet the Defence requirements.

In view of the successful completion of trial, and the emerging field requirements, the existing product-line needs enhancements, which are briefly summarised as follows, for proliferation of C-DOT's WiFi product-line in the prospective client networks:

- Develop access points for following needs
  - Cost competitive for the enterprise hotspot requirements.
  - Mesh router with 4G Backhaul,

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[165] **Wireless Access Controller**

[166] **Element Management System**

[167] **Broad Band Access Terminal (Wi-Fi Terminal)**

[168] **Eco Friendly WiFi (Bamboo WiFi Card)**

[169] **Wireless Access Point card**

[170] **Authentication, Authorization & Accounting**

[171] **Frequency Spectrum Band (K under/K above)**

[172] **Very Small Aperture Terminal**

[173] **Low Noise Block downconverter**

	o Complied to the latest Wi-Fi 6 (802.11ax) standards
	• Integrate the Wi-Fi Access Point with cellular core Network
	• Prototype of Product based on V & E Band
	• **WAP**[174] is designed to make the access point cost competitive, making it suitable for rural hotspot deployments.
	• **AAA**[175] for User Authentication, Authorisation and Accounting functionality.
	
	C-DOT Wi-Fi technology product-line has been successfully field tried in CSC (leveraging *BharatNet* infrastructure), Defense, India Post, etc.
	
	Further, C-DOT has developed the following solutions for emerging field requirements for deployment, which are as follows:
	
	Satellite based WiFi backhaul: Objective of satellite WiFi is to offer internet and other IP-based services using Ku/Ka[176] band VSAT[177] or smart LNB[178] and C-DOT WiFi to areas not connected using cable or fibre.
	Balloon WiFi: The Balloon WiFi aims to bring internet access to remote and rural area poorly served by the existing provisions. It helps to provide communication during natural disasters to affected regions. The balloon uses patch and sector antennas which are directional antenna to provide coverage to wider targeted areas. Backhaul and power can be provided using direct power over fibre from *grampanchayat* or through satellite backhaul in case of natural disaster conditions.
	Bamboo WiFi: C-DOT has developed WiFi system using the natural bamboo to work as Omni antenna along with integrated WiFi system with a coverage of 100 meters (approx) in 360 degrees. This type of system is suitable for forest ranges and can be camouflaged into nature. These systems are suitable for outdoor installation in all weather conditions.
	Ruggedized BBWT System to meet the Defence requirements.
	
	In view of the successful completion of trial, and the emerging field requirements, the existing product-line needs enhancements, which are briefly summarised as follows, for proliferation of C-DOT's WiFi product-line in the prospective client networks:
	• Develop access points for following needs
	   o Cost competitive for the enterprise hotspot requirements.
	   o Mesh router with 4G Backhaul
	   o Complied to the latest Wi-Fi 6 (802.11ax) standards
	• Integrate the Wi-Fi Access Point with cellular core Network
	• Prototype of Product based on V & E Band

Application areas	• WiFi deployment to extend horizontal connectivity from last mile and providing WiFi hot-spot functionality. • Employment creation and encouraging village level entrepreneurship through

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174 **Wireless Access Point card**

175 **Authentication, Authorization & Accounting**

176 **Frequency Spectrum Band (K under/K above)**

177 **Very Small Aperture Terminal**

178 **Low Noise Block downconverter**

	PDO deployment. • Providing point to point and point-to-multipoint connectivity to connect nearby villages to *grampanchayat*s (with backhaul PoP[179]). • Providing connectivity to remote, difficult and tough terrains and unconnected areas using satellite-based WiFi broadband. • Provision of WiFi in case of disaster using high altitude balloon and setting up of emergency network. • Development of WiFi for terrorist-bound areas using camouflaged WiFi with Bamboo antenna. • Providing most secure connectivity to Defence using sub-GHz-band WiFi.*(Note-5)* • Connectivity requirement of NE[180] Region, Aspiration Villages, universities, organization etc. through Wi-Fi Hotspot • Robust and easy to deploy network for surveillance devices in Smart Cities etc. • Enterprise hotspot for densely populated areas such as Railway stations, Fair, Public Events etc. • Public WiFi installations complied to WANI[181] framework to meet NDCP-2018[182] requirements • Wi-Fi Offload • 5G[183] use cases (Surveillance, AR[184]/VR[185] Indoor, Dense Environment and other evolving use cases) • 4G/5G Front haul, High Throughput P2P[186]/P2MP[187] Link, Air Fiber
Key deliverables	• Satellite-based WiFi broadband - *C-SAT-Fi*. (Note)[10] Ruggedised BBWT for Defence, as per Defence JSS Penta 5[188] standard. (Note)[12] • Sub-GHz-band (450 MHz, 650 MHz, and 900 MHz) WiFi radio for Defence and other applications. (Note)[5] • Mini-PDO. • WiFi core (WAC, EMS and AAA) for large public WiFi network and enterprise network with redundant functionalities. • SHW[189], HAP[190] and, PDO and other variants. • Balloon and Bamboo WiFi. • WiFi alliance HS (Hot Spot) 2.0 certification.

[179] **Point of Presence**
[180] **North East**
[181] **Wireless Access Network Interface**
[182] **National Digital communication Policy**
[183] **5th Generation Mobile Network Technology**
[184] **Augmented Reality**
[185] **Virtual Reality**
[186] **Point-To-Point Communication**
[187] **Point-to-MultiPoint Communication**
[188] **Mil Grade Environmental Tests Standard**
[189] **Solar Hotspot Wifi (Solar WiFi version 2)**
[190] **High speed Access Point**

	• ToT of Solar WiFi (v2), high-speed access point, WAP, and PDO.
	• Low-cost 802.11 ac 4X4 – MU-MIMO[191] Wave-2 variant of access point.
	• Eco-friendly access point: Small form-factor for Bamboo WiFi deployments.
	• Access point with satellite backhaul based on smart LNB[322] subject to agreement of SoW[192] with smart LNB vendor and ISRO[193] towards hub development. (Note)[7]
	• Access point based on 802.11ax standard (primarily for WiFi connectivity in Crowded places, like, events in a stadium, exhibitions, fairs, large religious places,etc).
	• Solution for secure communication for defence requirement: Integration of
	• Solution for NDMA[194]: Enhancement of *Sajag* app for disaster information.
	• Feasibility report on WiFi *EasyConnect* for supporting IoT[195] devices.
	• Wi-Fi Mesh router with 4G Backhaul
	● XAP[196] (Wi-Fi6 Access Point based on Qualcomm SoC)
	● EAP[197] (Enterprise Access Point based on Qualcomm SoC)
	● Proto of 60 GHz V Band Radio
	● WiFi PDO (PPDO[198]) with 4G(LTE[199]) and Ethernet backhaul
	● Wi-Fi Integration with LTE/5G Core Network
Status as on 31.03.2020	• Solar WiFi (v1): TEC certification completed and PoC[200] trials completed in Navy sites at Vizag and Andaman, and in HSCC[201]-Noida.
	• Solar WiFi (v2): Design, development and validation completed and offered for TEC certification, PoC trials completed in Navy sites at Karvar and Mumbai, and ToT[202] completed.
	• TEC certification awarded for Solar WiFi (v1) and Solar WiFi (v2)
	• Solar WiFi in sub-GHz band: PoC trials completed at high altitudes of Leh and Ladakh for the Indian Army.
	• WiFi in CSC network: Roll-out completed at Tigaon and Rohtak block in Meerut districts.
	• Balloon and Bamboo WiFi: Design and development completed.
	• WAC for small scale requirements: Design, development, installation and commissioning completed at TEC building.
	• High-speed access point (v1): Validation completed and TEC Certification completed.

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[191] **Multi User Multiple Input Multiple Output**

[192] **Scope of Work**

[193] **Indian Space Research Organization**

[194] **National Disaster Management Authority**

[195] **Internet of Things**

[196] **802.11aX based Access Point**

[197] **Enterprise Access Point**

[198] **Pocket PDO**

[199] **Long Term Evolution**

[200] **Proof of Concept**

[201] **Hospital Services Consultancy Corporation Limited**

[202] **Transfer of Technology**

	• High-speed access point (v2): Design and development completed. (Note)[9] • IGW card: Design and development completed. • PDO (v1): Design, development and validation completed, and PoC trials completed at Bengaluru post office and CSC Meerut. • PDO (v2): Design and development completed. PoC completed at Bengaluru post office and CSC Meerut. Following field trials have been conducted successfully: • **Balloon WiFi**: The Balloon WiFi helps to provide communication during natural disasters to affected regions. • **Bamboo WiFi:** C-DOT has developed WiFi system using the natural bamboo to work as Omni antenna along with integrated WiFi system with a coverage of approx. 100 meters in 360 degrees. This type of system is suitable for forest ranges and heritage sites. • **Satellite-based WiFi backhaul**: Objective of Satellite WiFi is to offer internet and other IP-based services using Ku/Ka band VSAT[203] or smart LNB[204] and C-DOT WiFi to areas not connected using cable or fibre. • Integration testing of C-DOT BBWT system with *Ayecka* smart LNB at Planetcast NOIDA alongwith ISRO: Voice testing using optimum codec for more number of simultaneous voice calls have been completed successfully. • Integration testing of C-DOT BBWT system with NELCO[205] VSAT (on C-band) done at C-DOT Bengaluru. •WAP[206]: Design, Development and Testing completed. Integrated with EMS. •Solar Wi-Fi(v2): Enhanced for active PoE and optical interface of 1G+ •HAP[207] (v1): Enhanced for dying gasp. •Pocket PDO: Design and Development completed. •EFW[208]: Design and Development completed. •FAP[209]: Hardware Design, Development and Assembly completed. •Design, Development and Testing of EMS for AAA is completed. •TEC Validation for voice call testing using C-DOT BBWT Wi-Fi AP completed. •Quantum Safe cryptography solution integrated with Wi-Fi for providing secure P2P communication. •Wi-Fi solution integrated with low bit rate codec gateway to provide support for more no. of simultaneous calls over satellite bandwidth.

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[203] **Very Small Aperture Terminal**

[204] **Low Noise Block downconverter**

[205] **VSAT Service provider**

[206] **Wireless Access Point**

[207] **High speed Access Point**

[208] **Eco Friendly Wifi**

[209] **Four x four (4x4) Access Point**

	• WAC V2.0 Development, Testing and integration with SHW, HAP and WAP completed.	
	• Testing on COTS[210] WiFi6 AP and Use Case Trial with WBA[211] Completed	
	• HDK[212] & SDK[213] shared by Qualcomm for Wi-Fi 5 & Wi-Fi 6 AP Development on Qualcomm SoC[214]	
	• PoCs /and trials of WiFi-technology-based product-line	
	• Pilot implementation and technology support for roll-out of WiFi technology	

Finance (₹ in crore)	**Budget for FY 2020-2021**	22.69

Project plan	**Deliverables and milestones**	**Target**	
		2019-20	**2020-21**
	Design, development and validation of WAC	*NA (completed in 2019-19)*	
	Design of high-speed access point (v1)	*NA (completed in 2018-19)*	
	WiFi certification of high-speed access point (v1)	*NA (completed in 2019-20)*	
	TEC certification of Solar WiFi (v1)	*NA (completed in 2018-19)*	
	Design of Solar WiFi (v1)	*NA (completed in 2018-19)*	
	Design of high-speed access point (v2)	*NA (completed in 2018-19)*	
	Design of Solar WiFi (v2)	*NA (completed in 2018-19)*	
	Design of PDO (v2)	*NA (completed in 2018-19)*	
	Development and validation of high-speed access point (v2)	*NA (completed in 2018-19)*	
	Development and validation of Solar WiFi (v2)	*NA (completed in 2018-19)*	
	Development and validation of PDO (v2)	*NA (completed in 2019-20)*	
	TEC certification of Solar WiFi (v2)	*NA (completed in 2019-20)*	
	Development and integration testing of WAC on BBWT access points	*NA (completed in 2019-20)*	
	Development of WANI[215] framework	*NA (completed in 2019-20)*	
	Development of PDO (v2) and mini-PDO	*NA (completed in 2019-20)*	
	PoC trial of Balloon WiFi	*NA (completed in 2019-20)*	
	Study of Li-Fi technology, its co-existence with WiFi	*NA (completed in 2019-20)*	
	TEC certification of HAP (v1) and GR[216] preparation for PDO	*NA (completed in 2019-20)*	
	Validation of EMS, WAC and mini-PDO	*NA (completed in 2019-20)*	
	PoC trial of Bamboo WiFi	*NA (completed in 2019-20)*	
	PoC of early emergency alert through public WiFi infrastructure	*NA (completed in 2019-20)*	
	Migrating BBWT access points on WANI framework	*NA (completed in 2019-20)*	
	Design and development of PDO variant	*NA (completed in 2019-20)*	

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[210] **Commercial Off-The-Shelf**

[211] **Wireless Broadband Alliance**

[212] **Hardware Development Kit**

[213] **Software Development Kit**

[214] **System on Chip**

[215] **WiFi Access Network Interface**
[216] **Generic Requirements**

Study of smart home WiFi	*NA (completed in 2019-20)*	
TEC certification of C-DOT PDO	*NA (completed in 2019-20)*	
Design and development Wave-2 access point	*NA (completed in 2019-20)*	
Scalability testing of WAC and AAA	*NA (completed in 2019-20)*	
PoC trial of satellite-based WiFi broadband	*NA (completed in 2019-20)*	
Study of WiFi in 5G	*NA (completed in 2019-20)*	
Validation and TEC certification of Wave-2 access point	3Q-4Q: (19-20) (Note)[3]	(Note)[8]
Offer to TEC for certification of WAC	3Q:19-20	4Q: 20-21 (Note)[13]
Design of access point based on new standards(802.11ax) subject to availability of chip-sets	4Q:19-20	1Q: 20-21
PoC trial of WiFi in the Railways	NA(Note)[4]	
PoC trial of ruggedised and sub-GHz WiFi in Defence	NA (Note)[5]	
ToT of PDO and variants, SHW, HAP and sub-GHz band WiFi	*NA (completed) (Note)[5] for sub-GHz band*	
TEC validation for voice call testing using WiFi	*NA (completed in 2019-20)*	
Enhancement of Solar WiFi (v2) for active PoE	*NA (completed in 2019-20)*	
Enhancement of HAP (v1) for 'dying gasp'	*NA (completed in 2019-20)*	
Redundancy for WiFi core network	*NA (completed in 2019-20)*	
Enhancement of Solar WiFi (v2) for optical interface of 1G+	*NA (completed in 2019-20)*	
Design and development of eco-friendly access point	*NA (completed in 2019-20)*	
Design and development of EMS for AAA	*NA (completed in 2019-20)*	
Design and development of EMS for WAC	*NA (completed in 2019-20)*	
Design and development of NMS for WiFi network	2Q:19-20	(Note)[11]
Validation of EMS for AAA, WAC	2Q:19-20	1Q:20-21
Study on feasibility of integration of AP with quantum-safe cryptography solution	*NA (completed in 2019-20)*	
WiFi solution integrated with low bit-rate codec gateway	*NA (completed in 2019-20)*	
Enhancement of *Sajag* app for disaster information as per NDMA requirements	*NA (completed in 2019-20)*	
Offer to Validation of Pocket PDO	3Q:19-20	2Q: 20-21 (Note)[14]
Validation of NMS for WiFi network	3Q:19-20	(Note)[11]
Design and development of access point with satellite backhaul based on smart LNB	3Q:19-20	(Note)[7]
Development, testing and validation of low-cost variant of Wave-2 access point	*NA (completed in 2019-20)*	
Study of WiFi *EasyConnect* for supporting IoT devices	*NA (completed in 2019-20)*	
Enhancement of AP for support of synchronisation for P2P/P2MP	*NA (completed in 2019-20)*	
WAC v2.0 development and testing (for large-scale deployments)	*NA (completed in 2019-20)*	

	Integration of WAC v2.0 with variants of AP		*NA (completed in 2019-20)*	
	Four x four (4x4) Access Point	S/W Development	NA	2Q:20-21
		System Integration and Testing	NA	2Q: 20-21
		Offer to Internal Validation	NA	2Q: 20-21
		Integration with WAC	NA	3Q: 20-21
		Offer to Internal Validation for WAC Integrated system	NA	3Q:20-21
		Integration with EMS	NA	3Q:20-21
		Offer to Internal Validation for EMS[217] Integrated system	NA	3Q:20-21
	Enterprise Access Point	H/W Development	NA	2Q:20-21
		S/W Development	NA	2Q:20-21
		System Integration and Testing	NA	3Q: 20-21
		Offer to Internal Validation	NA	3Q: 20-21
		Integration with WAC	NA	4Q: 20-21
		Offer to Internal Validation for WAC[218] Integrated system	NA	4Q:20-21
		Integration with EMS	NA	4Q:20-21
	802.11aX based Access Point	H/W Development	NA	2Q:20-21
		S/W Development	NA	2Q:20-21
		System Integration and Testing	NA	3Q: 20-21
		Offer to Internal Validation	NA	3Q: 20-21
	Wi-Fi Mesh Router with 4G backhaul[15]	S/W Development	NA	4Q:20-21
		System Integration and Testing	NA	1Q: 21-22
		Offer to Internal Validation	NA	1Q:21-22
	WAP-SE1	Offer to Internal Validation	NA	2Q:20-21
		Offer to TEC Certification for WAP	NA	3Q: 20-21 (Note)[13]
		Enhancement of WTP[219] and WAC for MESH feature	NA	2Q: 20-21
		Integration of WAC for Mesh feature	NA	2Q: 20-21
		Offer to Internal Validation with WAC integrated system	NA	2Q:20-21
		Offer to ToT	NA	4Q:20-21
	Integration of Wi-Fi with cellular core		NA	2Q:20-21
	Prototype of 60 GHz V Band		NA	4Q:20-21
	Support, PoC ,trials and progressive rollouts for Wi-Fi Technology product line.		NA	1Q-4Q: 20-21
	WANI Central Registry and App Development along with Infrastructure Setup for Pan-India Public Wi-Fi Scheme		NA	2Q-4Q: 20-21 (Note)[17]

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[217] **Element Management System**

[218] **Wireless Access Controller**

[219] **Wireless Termination Point**

Projected physical outcome for FY 2020-2021	• Wi-Fi Mesh Router with 4G backhaul • XAP (Wi-Fi6 Access Point) • EAP(Enterprise Access Point) • Proto of 60 GHz V Band Radio
Reasons for revision of targets	• Limited manpower available for the EMS development • Delay in assembly of pocketPDO • Delay in Agreement with Qualcomm for 802.11ax design support

Note:

1. *GR preparation of PDO is deferred due to non-approval of WANI framework of TRAI by DOT.*
2. *As GR preparation of PDO itself is suspended, TEC certification cannot be taken up.*
3. *Test tool for Wave-2 certification is not available.*
4. *Trial of Wi-Fi in the railways is not being pursued, as requirements from the prospective client did not emerge.*
5. *Sub-GHz WiFi is not being pursued, as after initial PoC and discussion, requirements from the prospective client did not emerge.*
6. *Development is subject to agreement of SoW with smart LNB vendor.*
7. *ISRO has not shown interest in developing a hub compatible with smart LNB.*
8. *Completed.*
9. *Test environment and test tools required for Wi-Fi Alliance certification not available. Also Focus now is on the low-cost variant; hence Wi-Fi certification of High-Speed Access Point is not being pursued.*
10. *Satellite backhaul related deliverables will now be moved to Satellite based broadband technologies programme.*
11. *As there are no tender requirements wrt NMS, activities related to NMS are not being taken up.*
12. *BEL would be taking care of the ruggedization as per JSS Penta5 standard.*
13. *Instead of TEC Certification, reworded as Offer to TEC certification.*
14. *Instead of Validation, reworded as Offer to Internal Validation.*
15. *Hardware development for Mesh Router will happen as part of C-Sat-fi programme. Same hardware will be updated with 4G backhaul.*
16. *Design, Development and Testing will be finished by the timeline committed. Validation deliverable will be tracked through the WAP-SE1 deliverable identified in the forthcoming ABP.*
17. *Discussion undergoing at DOT for the development of Central Registry and App. For WANI for the PAN-India Public Wi-Fi Scheme by C-DOT and cabinet note already put for the same.*

4.11.2.6 GPON technology enhancements, customisation and roll-out

C-DOT has developed products like ONTs and OLTs alongwith several variants, based on the GPON technology, to address field requirements and their cost-effective deployment. This technology is being deployed in the NOFN under *BharatNet* program to provide broadband pipes to *grampanchayat*s to fulfill the Government's plan to provide the requisite broadband infrastructure across the country. This will help to connect rural India and cost-effectively extend all the e-services, like education, telemedicine, internets, entertainment, etc, as available in main cities and provide good e-governance to the nation, thus contributing to the 'Digital India' program.

The experience gained during technology deployment and field trials indicate that there is still much more scope to address the specific needs of public networks like BSNL and MTNL, to extend FTTH services beyond *grampanchayat*s, to connect Government institutions, to serve individual houses through *BharatNet* as well as to meet the requirements of Defence networks. This program has been initiated to fulfill those requirements.

Objective	To carry out enhancements, customisation of the existing GPON network elements, and development of new variants through incremental efforts to complement the existing family of C-DOT GPON network elements, to address the different networks' requirements for GPON technology deployments.

Brief description	C-DOT has developed various products based on GPON technology to be used in FTTH scenarios. C-DOT's indigenously developed GPON OLTs and ONTs are being deployed in NOFN network and more than 1,00,000 *grampanchayat*s are already connected through these network elements. GPON product line has been further complemented with the following products:
	
	 • **Mini-OLT**: Mini-OLT has been TEC certified and the technology has been transferred to manufacturers. The product has been deployed in networks of MTNL, Navy and the NOFN.
	
	 • ONT-R[220]: ONT-R has been developed with two PON ports to enhance reliability against fibre-cut in field. The ONT also supports Ring architecture for GPON network. Field trial for ONT-R has been completed and TEC certification done.
	
	 • OTDR controller card: OTDR controller card has been developed to become part of FFLS[221] system which diagnoses and pin-points the fibre-fault in the field. Field trial for the controller has been completed in the NOFN. The FFLS system is planned for ToT and deployment in the field.
	
	 • **Next generation PON**:
	
	    o **WDAN** (WDM-based): WDAN system comprising OLT and ONT has been developed to extend 1 Gbps bidirectional dedicated bandwidth to high-end users. Pilot trial has been completed.
	
	    o **XG-PON** (TDM/TDMA-based): XG-PON OLT prototype development has been completed and validated. Pilot trial has been completed.
	
	 • It is a box-type small OLT system having 4 PON ports. Small size and low-power requirements provide flexibility of deployment in various segments. The OLT

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[220] **Optical Network Termination – Ring (architecture)**
[221] **Fibre-Fault Localisation System**

fulfills the requirements of small offices with not more than 500 desks and residential apartments with up-to 500 individual house units. Product is developed and validated and its Transfer of technology has been done.

- **ONT with RF support:** It has RF video output in addition to the existing features in the current ONTs. This was requirement of Indian Navy. Product is developed and validated and its Transfer of technology has been done to BEL. It is being deployed in Indian Navy Ships.

- **Titli ONT with 'dying gasp':** Titli ONT is a small size low-power ONT with 2 ethernet and 2 POTS ports. This is required to extend FTTH services beyond grampanchayats for connecting Government institutions and also to serve individual houses through the NOFN. Product is developed and validated and its Transfer of technology has been done.

- **8-port GPON line card:** This is a GPON OLT PIC[222] with 8 PON ports. This has increased the total number of customers to 12000 from 6000 per OLT. It co-exists with existing 4-PON-port line card without any change in OLT chassis, in the NOFN. Product is developed and validated and its Transfer of technology has been done.

- **Small ONT with WiFi:** There was demand for having an ONT similar to Titli ONT but with WiFi. So this small ONT with WIFi was designed and developed. Product is developed and validated and its Transfer of technology has been done.

- **Modified SCM-1 (base switch):** SCM (Switch and Control Module) card used in GPON OLT was redesigned to take care of obsolescence of one of its major component i.e, base switch. Product is developed and validated and its Transfer of technology has been done.

During development, trials and deployment of above-mentioned products, need was also felt to design and develop products like 16 port OLT Line card, 16 port GPON MiniOLT, Service Switch (modified ONT17A) integration with C-SAT-FI, Low cost small ONT, Low Cost Office OLT.

Development of all these products under the proposed project will complement the existing GPON product line to address various requirements. The volume for the proposed products is expected to be large considering the future expansion of BharartNet and expansion of network beyond *gram-panchayats* through bodies like CSC etc.

Application areas	To be used in networks (like NOFN) with current products requiring enhancements or to cater for new requirements.
Key deliverables	• 16 port Line Card • Service Switch integration with C-SAT-FI • 16 port GPON MiniOLT • Low cost ONT (ONT26) • Low cost Office OLT
Status as on 31.03.2020	• System integration, internalvalidation and field trial completed for the following: ○ 4-port Office OLT,

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[222] **PON Interface Card**

o ONT with RF support,
o *Titli* ONT with 'dying gasp',
o Small ONT with WiFi,
o Modified SCM-1 (base switch).

- Field trial completed for the following:
  o 4-port Office OLT,
  o ONT with RF support,
  o *Titli* ONT with 'dying gasp'.
- ToT completed for the following:
  o 4-port Office OLT,
  o ONT with RF support,
  o *Titli* ONT with 'dying gasp',
  o 8-port GPON OLT line card.
- System integration and Validation complete and ToT done for 8-port GPON Line Card
- EMS release for 4-port Office OLT, ONT with RF support, Titli ONT with 'dying gasp' done
- Internal Validation, EMS release and ToT done for Small ONT with WiFi
- Internal Validation and ToT done for Modified SCM-1 (base switch)
- Hardware development, Software development, System Integration & testing, EMS release and offer to Internal validation done for 16-port OLT Line Card

Finance (₹ in crore)	Budget for FY 2020-2021		7.50	
Project plan	**Deliverables and milestones**		**Target**	
			2019-2020	**2020-2021**
	HW development	4-port Office OLT	*NA (completed in 2017-18)*	
		ONT with RF support		
		Titli ONT with 'dying gasp'		
		8-port GPON OLT line card		
	SW development	4-port Office OLT	*NA (completed in 2017-18)*	
		ONT with RF support		
		Titli ONT with 'dying gasp'		
		8-port GPON OLT line card		
	System integration, testing and validation	4-port Office OLT, ONT with RF support, *Titli* ONT with 'dying gasp'	*NA (completed in 2018-19)*	
		8-port GPON OLT line card	1Q: 19-20	*NA (completed)*
	EMS release	4-port Office OLT, ONT with RF support, *Titli* ONT with 'dying gasp'	1Q: 19-20	*NA (completed)*
	Pilot/field trial	4-port Office OLT	*NA (completed in 2018-19)*	
		ONT with RF support	*NA (completed in 2018-19)*	
		Titli ONT with 'dying gasp'	*NA (completed in 2018-19)*	

		8-port GPON OLT line card	1Q:19-20	*NA (completed)*
	ToT	4-port Office OLT	*NA (completed in 2018-19)*	
		ONT with RF support	*NA (completed in 2018-19)*	
		Titli ONT with 'dying gasp'	*NA (completed in 2018-19)*	
		8-port GPON OLT line card	*NA (completed in 2018-19)*	
	Small ONT with WiFi	HW development	*NA (completed in 2018-19)*	
		SW development	*NA (completed in 2018-19)*	
		System integration, testing	*NA (completed in 2018-19)*	
		Internal validation	1Q: 19-20	*NA (completed)*
		EMS release	2Q: 19-20	*NA (completed)*
		Pilot trial	3Q: 19-20	2Q: 20-21
		ToT	1Q: 19-20	*NA (completed)*
	Modified SCM-1 (base switch)	HW development	*NA (completed in 2018-19)*	
		SW development	*NA (completed in 2018-19)*	
		System integration, testing	*NA (completed in 2018-19)*	
		Internal validation	4Q: 19-20	*NA (completed)*
		EMS release	*NA (completed)*	
		Pilot trial	1Q: 19-20	*NA (completed)*
		ToT	1Q: 19-20	*NA (completed)*
	16-port OLT line card	HW development	1Q: 19-20	*NA (completed)*
		SW development	2Q: 19-20	*NA (completed)*
		System integration, testing	3Q: 19-20	*NA (completed)*
		Internal validation	4Q: 19-20	*NA (completed)*
		EMS release	4Q: 19-20	*NA (completed)*
		EMS validation	NA	1Q: 20-21
		Offer for ToT	NA	2Q: 20-21

	16-Port Mini OLT	HW Development	NA	2Q : 20-21
		SW Development	NA	3Q: 20-21
		System integration testing	NA	3Q: 20-21
		Internal validation	NA	4Q: 20-21
		EMS release	NA	4Q: 20-21
		EMS validation	NA	1Q: 21-22
		Offer for ToT	NA	1Q: 21-22
	Low Cost ONT (ONT 26)	HW Development	NA	3Q: 20-21 (note)[1]
		SW Development	NA	4Q: 20-21
		System integration testing	NA	4Q: 20-21
		Internal validation	NA	1Q: 21-22
		EMS release and validation	NA	1Q: 21-22
		Offer for ToT	NA	1Q: 21-22
	Low Cost Office OLT	HW Development	NA	3Q: 20-21 (note)[1]
		SW Development	NA	4Q: 20-21
		System integration testing	NA	1Q: 21-22
		Internal validation	NA	2Q: 21-22
		EMS release	NA	2Q: 21-22
		EMS validation	NA	2Q: 21-22
		Offer for ToT	NA	3Q: 21-22
	Service switch (modified ONT17A)	Service switch integration with C-SAT-FI	NA	2Q: 20-21
Projected physical outcome for FY 2020-2021	• Pilot Trial of Small ONT with WiFi • EMS Validation and Offer for ToT of 16-port OLT line card EMS release of HW & SW Development of Low Cost Office OLT. • Service switch integration with C-SAT-FI. • Internal Validation and EMS Release of 16-port MiniOLT. • HW & SW Development and System Integration testing of Low Cost ONT (ONT26). • HW & SW Development of Low Cost Office OLT			
Reasons for revision of targets	ToT has been done to ITI and Cyient, it was decided that pilot trial will be done by ToT partner as part of TSEC process, already in progress by ITI			

Note:

1. *Assuming all POs will be placed by 1st week of july so that componets are received by first week of November 2020*

4.11.2.7 LTE enhancements, trial and customisation

There have been significant changes in the LTE markets across the world and in India due to massive increase in use of data. Increased use of smart phones, social networking through internet, and media consumption, like videos, music, etc, via OTT services, have led to establishing high-speed wireless networks. Therefore, LTE, which at one point of time happened to be viewed to fulfill the requirements of large-size corporate houses, now becomes the need for common man and this technology is being widely deployed. Most of the operators worldwide have stopped deploying 3G and have straightaway shifted to deploying 4G-based (LTE/LTE-A) systems. In India too, most of the operators have stopped investing in 3G and have started channeling their resources to 4G technology deployment.

Introduction of the large operators' 4G-only and IP-only networks along with a disruptive business model has brought in significant changes in the dynamics of the market in the country. All these factors have led to significant uptake of 4G network equipment in the field.

Envisaging a good prospect for LTE technology deployment in the country, the indigenously developed LTE technology needs to enhance, customise and build the base platform for undertaking next generation 5G program, and accordingly, this program has been planned.

4.11.2.7.1 Radio Access Network

Objective	• To carry out enhancements, customisations and trial for enhanced LTE technology to meet the field requirements as well as to evolve the LTE platform towards 'LTE Advanced Pro' (higher releases), the base platform for 5G technology. • To customise the technology for Defence and public safety networking needs.
Brief description	**LTE enhancements to develop new variants to meet the civilian market**: • Since there has been a significant uptake of 4G network equipments in the market, a large number of eNodeB and RRH variants catering to multiple capacities (ranging from 10 to 1000 users), multiple frequency bands, multiple bandwidths (1.4, 3, 5, 10, 20 MHz) and power capacities (100 mW, 250 mW, 1W, 5W, 20W, 30W) are being built to fulfill various field requirements, like residential, SOHO[223], large campus, rural, and urban cell. • The previous product line completed under this program comprises of low-capacity (less than 64 users) femto eNodeB coupled with 10W RRH in TDD[224] band 40 (2300 MHz), FDD[225] band 3 (1710-1880 MHz), both in 10 MHz bandwidth. This product line will cater to the requirements of residential, large campus and rural. • The TSPs have started installing large capacity eNodeB systems (20 MHz, 20W, more than 256 users) in band 40. BSNL has now been allocated 5MHz in 2100 MHz (Band 1) and 20 MHz in 2500 MHz band (Band 41) for 4G deployment in the network. • In view of the above field deployment scenarios, the present LTE enhancement program plans to build higher capacity eNodeB system, which will also address the component obsolescence. • C-DOT is also exploring newer markets in the African and South-East Asian countries as there has been significant interest in these countries for working with C-DOT. The requirements of these countries are for higher capacity macro systems and long range cells (more than 256 active subscribers and 20-30W or higher power requirement). This LTE enhancements program will also try to address the requirements of African and South-East Asian countries. **LTE enhancements catering to newer 3GPP releases**: • The current deployments in the network are for 3GPP Release-10. The current C-DOT LTE technology caters to Release-8 and Release-9 and very few features of Release-10. • 'LTE-Advanced' addressed in 3GPP Release-10 is now having newer releases known as 'LTE-Advanced Pro' and is detailed in 3GPP Releases-11, 12 and 13. These provide features like carrier aggregation enhancements, CoMP[226], MDT[227], battery saving techniques, MTC[228], better integration with WiFi and support for public safety needs. • This LTE enhancement program will also incorporate features of the above-mentioned newer 3GPP releases depending on field requirements.

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[223] **Small Office Home Office**
[224] **Time-Division Duplexing**
[225] **Frequency-Division Duplexing**
[226] **Coordinated Multi-Point**
[227] **Minimisation of Drive Test**
[228] **Machine-Type Communication**

	Evolving the LTE platform to 5G base platform:

	• While 4G deployment is progressing at a fast pace - multiple countries, operators and chip-set and technology module vendors have already started working on 5G technology. 5G is expected to provide:
	  ○ higher speeds: 10 Gbps peak throughput with a user experience of 0.1 to 1 Gbps,
	  ○ higher density of devices: more than a million devices per square km,
	  ○ lower end-to-end latency: millisecond-level latency,
	  ○ higher speeds of end devices: 500 kmph – e.g., bullet trains,
	  ○ larger volume of data: in Terabit per square km.
	• Even though all the use cases of 5G are not clear and there are many unresolved issues in 5G development, it is evident that the core technology will be based on LTE. 3GPP Release-14, 15 and 16 are expected to cater to 5G requirements with Release-16 to be finalised around 2020.
	• The LTE enhancement program will therefore, orient the development towards realising the base platform required for 5G technology development.
	
	Customisation of LTE systems for Defence and PPDR[229] requirements:
	• The Defence forces worldwide have been trying to build a TCS[230] using TETRA[231]-based or other proprietary technologies. These experiments failed after massive investments by US DoD[232]. They are now shifting towards all-IP and LTE as the base technology around which the Defence and public safety networks will be built. The armed forces and military establishments are moving away from proprietary technologies as LTE provides them with a more mature, standards-based, multi-vendor, proven, reliable and lower cost solutions. It also takes less time to build these solutions. The public safety networks, used by firefighters, police, railways, forest department, emergency services, etc., have also started shifting away from TETRA/proprietary networks towards LTE.
	• 'LTE enhancements' program will upgrade the existing LTE system to develop new variants to cater to the new requirements in civilian networks, to do feature enhancements as per newer 3GPP releases (Release-11, 12, 13), to evolve the LTE platform to 5G base platform, and to do customisation and ruggedisation to meet the Defence and public safety network requirements.

Application areas	• LTE civilian markets. • Base platform for future 5G technology based systems. • LTE-based Defence communication systems. • LTE-based PPDR communication systems (for public safety).
Key deliverables	• LTE Macro eNodeB compliant to Release-10+ and higher capacity.
Status as on 31.03.2020	• Development completed for C-DOT LTE system comprising of eNodeB and EPC. • Single sector (1-sector) macro eNodeB lab trial completed. Over-The-Air (OTA) testing conducted inside C-DOT Campus at Delhi and Bangalore. • Completed Pilot Trials with a Satellite backhaul with an external party. • Macro eNodeB (1-sector) integrated with C-DOT EPC.

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[229] **Public Protection and Disaster Relief**
[230] **Tactical wireless Communication System**
[231] **Terrestrial Trunked Radio**
[232] **Department of Defence**

	• Phase-2: 3-sector baseband HW completed, and HW prototype available for SW porting and testing.		
Finance (₹ in crore)	**Budget for FY 2020-2021**		46.52

Project plan	Deliverables and milestones	Target	
		2019-2020	**2020-2021**
	eNodeB		
	Phase-1: Technology module procurement: PO placement	Completed	
	Phase-1: Enhanced Macro eNodeB lab trial (for 1-sector)	Completed	
	Phase-2: 3-sector Macro eNodeB architecture design	Completed	
	Phase-1: Enhanced Macro eNodeB pilot trial (for 1-sector)	Completed	
	Phase-2: 3-sector baseband HW available	Completed	
	RRH 10W available	1Q:19-20	(Note)[1]
	RRH 20W available (Band-3, Band 40, Band-41), 4T4R	3Q:19-20	2Q:20-21
	Phase-2: 3-sector baseband HW and eNodeB SW integration — (20W RRH, Band-3, Band-40, Band-41)	3Q:19-20	3Q:20-21
	RRH Band-1 (2100MHz), 40W, 4T4R	NA	3Q:20-21
	RRH Band-41 (2500MHz), 40W, 4T4R	NA	3Q:20-21
	RRH Band-3 (1800MHz), 40W, 4T4R	NA	4Q:20-21
	RRH Band-5 (850MHz), 40W, 4T4R	NA	4Q:20-21
	RRH Band-8 (900MHz), 40W, 4T4R	NA	1Q:21-22
	3-sector enhanced Macro eNodeB and RRH (Band-1 & Band 41, both 40W) integration	NA	4Q:20-21
	3-sector enhanced Macro eNodeB and RRH offer to validation	3Q:19-20	4Q:20-21
	3-sector enhanced Macro eNodeB field trial	4Q:19-20	1Q:21-22
	Initiation of ToT of RAN solution (eNodeB consisting of 3-sector BBU and RRH for Band-1, Band-3, Band-5, Band-8, Band-41) RRH: 40W, 4T4R each.	NA	4Q:20-21
	Select features from Rel-11 onwards	NA	1Q:21-22
	RRH Dual Band (B1 + B3, 2100MHz + 1800MHz), 40W, 2T2R each	NA	2Q:21-22
	Dual Band RRH offer to validation	NA	2Q:21-22
	Field Trial of Dual Band RRH	NA	2Q:21-22
	Field Trial of Rel-11+ feature set	NA	1Q:21-22
	Initiation of ToT of Rel-10 RAN solution with Dual Band RRH (Band-1 and Band-3)	NA	2Q:21-22
	EMS for LTE-A RAN		
	Enhancement, development, testing and release of LTE-EMS (RAN) for phase-2	2Q:19-20	1Q:20-21
	Enhancement of RAN EMS for Rel-10	NA	2Q:20-21
	Enhancement of RAN EMS Field Trial Ready Version	NA	3Q:20-21
	Development, testing and release of LTE-NMS (RAN) for	4Q:19-20	1Q:20-21

	indigenous RAN		
	Enhancement of LTE-NMS(RAN) for Rel-10	NA	2Q:20-21
	Enhancement of LTE-NMS(RAN) Field trial ready version	NA	3Q:20-21
Projected physical outcome for FY 2020-2021	• RRH 20W in three variants: (Band-3, Band-40, Band-41) • RRH 40W in five variants: (Band-1, Band-3, Band-5, Band-8, Band-41) • Phase-2: 3-sector eNodeB comprising of RRH, Baseband HW and SW ready for ToT. (Rel-10), 20W • Phase-2: 3-sector eNodeB solution comprising of RRH, Baseband HW and SW, field trial • 3-Sector eNodeB comprising of 40W RRH, Baseband HW, and SW ready for ToT (Rel-10) • RRH Dual Band variant-B1+B3 (Design complete) • Release of LTE-EMS (RAN) • Release of LTE-NMS (RAN)		
Reasons for revision of targets	• Complex technology development: required redesign in multiple modules: RRH PA-LNA, thermal/heat related cabinet/chassis redesign • Significant delay in the procurement process for technology modules, required for development and enhancements. • Delay in getting Export License clearance of key chipsets from US used in eNodeB. • Xilinx/ADI IP Integration issues and poor ODM support (Due to cost cutting in ODMs and low volume orders from C-DOT for chipsets) • Delay in getting WPC clearance for procurement of radio technology module, required for development and testing. • New models of RRH and features added to cater to BSNL/MTNL 4G tender requirements.		

Note:

1. *Xilinx stopped supporting the chip leading to component obsolescence and subsequent redesigning of card with upgraded chip (10W RRH milestone change).*

4.11.2.7.2 Core network

Objective	To carry out enhancements and trial for enhanced LTE technology to meet the field requirements as well as to evolve the LTE platform towards 'LTE Advanced Pro' (higher releases), the base platform for 5G technology.
Brief description	The present LTE technology comprising of eNodeB and EPC, is planned to be taken for pilot trial and the site is being identified for the same. **LTE enhancements catering to newer 3GPP releases**: The current deployments in the network are for 3GPP Release-10. The current C-DOT LTE technology caters to Release-8 and Release-9 and very few features of Release-10. 'LTE-Advanced' addressed in 3GPP Release-10 is now having newer releases known as 'LTE-Advanced Pro' and is detailed in 3GPP Releases-11, 12 and 13. **Evolving the LTE platform to 5G base platform**: While 4G deployment is progressing at a fast pace - multiple countries, operators and vendors have already started working on 5G technology. 5G is expected to provide: • all IP network, • higher speeds: 10 Gbps peak throughput with a user experience of 0.1 to 1 Gbps, • higher density of devices: more than a million devices per square km, • lower end-to-end latency: millisecond level latency, • larger volume of data: in Terabit per square km. Even though all the use cases of 5G are not clear and there are many unresolved issues in 5G development, it is evident that the core technology will be based on LTE. 3GPP Release-14, 15 and 16 are expected to cater to 5G requirements with Release-16 to be finalised around 2020. To meet the 5G requirements, there is a need to enhance network architecture technologies based on SDN, NFV and Cloud. The LTE enhancement program will, therefore, orient the development towards realising the base platform required for 5G technology development. The program will upgrade the existing LTE system to develop new variants to cater to do feature enhancements as per newer 3GPP releases (Release-11, 12, 13), to evolve the LTE platform to 5G base platform, and to do customisation and ruggedisation.
Application areas	• Base platform for future 5G technology based systems.
Key deliverables	• Core network compliant to Release-10+ and base core platform for 5G.
Status as on 31.03.2020	• Development completed for C-DOT LTE system comprising of eNodeB and EPC. • EPC integration with CMS for lawful interception completed. • Subscriber provisioning system completed. • AAA functionality in HSS[233] completed. • Integration of payment gateway with 3rd party gateway completed. • Integration with phase-1 1-sector Macro eNodeB completed • Lawful interception and integration with CMS

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[233] **Home Subscriber Server**

	• Charging GUI[234] and Sy interface in charging • Virtualised EPC and IMS Rel-1. • Trusted wireless access gateway. • Trusted/Untrusted Wireless Access Gateway integrated with LTE/IMS		
Finance **(₹ in crore)**	**Budget for FY 2020-2021**		26.80
Project plan	**Deliverables and milestones**	**Target**	
		2019-2020	**2020-21**
	EPC		
	Lawful interception and integration with CMS (including validation)	*NA (completed in FY 2018-19)*	
	Integration with phase-1 1-sector Macro eNodeB	*NA (completed in FY 2018-19)*	
	Service provisioning system	*NA(completed in FY 2017-18)*	
	Validation with multiple handsets	*NA(completed in FY 2017-18)*	
	AAA functionality in HSS	*NA(completed in FY 2017-18)*	
	Charging GUI[235] and Sy interface in charging (including validation)	*NA (completed in FY 2018-19)*	
	Planning and specifications for cEPC[236]/cIMS[237] implementation	*NA(completed in FY 2017-18)*	
	Payment Gateway interface: API integration (including validation)	*NA(completed in FY 2017-18)*	
	Virtualised EPC: Rel-1	*NA (completed in FY 2018-19)*	
	Virtualised IMS: Rel-1	*NA (completed in FY 2018-19)*	
	Validation of EPC and IMS Rel-1	*NA (completed in FY 2018-19)*	
	TWAG[238]	*NA (completed in FY 2018-19)*	
	Integrated EPC-IMS core with TWAG	*NA (completed in FY 2018-19)*	
	Validation of integrated EPC-IMS core with TWAG	1Q:19-20	1Q:20-21
	Untrusted Voice-over-WiFi	1Q:19-20	*NA (completed)*
	Release-11, 12, 13 features: identification, implementation planning	On hold *(Note)[1]*	
	Study of 5G core architecture	1Q:19-20	*NA (completed)*
	Strategy for migration of 4G core to 5G core	2Q:19-20	*NA (completed)*
	Release-11, 12, 13 features: delivery	On hold *(Note)[1]*	
	Virtualised EPC: Rel-2 delivery	2Q:19-20	*NA (completed)*
	Virtualised IMS: Rel-2 delivery	2Q:19-20	*NA (completed)*
	Release-14, 15, 16 features: identification, implementation planning	2Q:19-20	*(Note)[2]*
	Feature enhancement, development, testing and release	4Q:19-20	4Q:20-21

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[234] **Graphical User Interface**
[235] **Graphical User Interface**
[236] **Cloud-based Evolved Packet Core**
[237] **Cloud-based IP Multimedia System**
[238] **Trusted WiFi Access Gateway/ Trusted Wireless Access Gateway**

	for incorporation of access nodes with LTE-NMS (EPC)	*(progressively)*	*(progressively)*
	Integrated EPC-IMS core (Rel-2) with trusted and untrusted Voice-over-WiFi	3Q:19-20	*NA (completed)*
	Development of 5G core network prototype for test-bed	4Q:19-20	*(Note)*[3]
	Validation of integrated EPC-IMS core (Rel-2) with trusted and untrusted Voice-over-WiFi	4Q:19-20	1Q:20-21
	Pilot trial of EPC-IMS core (Rel.-2) with trusted and untrusted Voice-over-WiFi	4Q:19-20	1Q:20-21
	Interoperability Testing and Trials	NA	2Q:20-21
	Data Plane Acceleration	NA	2Q:20-21
	Operational Interface Enhancements	NA	3Q:20-21
	Enhancements for 5G Non Stand Alone(NSA)	NA	3Q:20-21
	Services Integration	NA	4Q:20-21
Projected physical outcome for FY 2020-2021	1. Validation of integrated EPC-IMS core (Rel-2) with trusted and untrusted Voice-over-WiFi 2. Interoperability Testing with different vendor's RAN solution 3. Enhancements in operational interface for LTE-IMS converged core solution		
Reasons for revision of targets	Delayed due to priority of other projects.		

Note:

1. *The major features planned for 'LTE Advanced Pro' and subsequently 5G, have been identified for implementation as WiFi integration and Cloud-based core network solution. However, identification of additional features of Releases–11, 12, 13, and 14, 15, 16, and their implementation will be taken up as per the field requirements, if emerges.*

2. *Identification of features for Releases – 15 for 5G core and implementation thereof, is presently being focused to directly migrate present architecture of EPC core (complied with LTE – advanced) to 5G core architecture. The Release 16 implementation will be planned over 5G core architecture as per the field requirements, if emerges.*

3. *Activity has been shifted to 5G Core Project.*

4.11.2.8 CMS support

Objective	To provide requisite technology support and enhancements for CMS required in the field, LEMF[239] functionality integration, testing, acceptance and support at various LEAs.
Brief description	The central monitoring infrastructure has been installed and put in operation in the field, which comprises of CMC[240] at Delhi, its DR at Bengaluru, 21 RMCs[241] located at each LSA connected through secure MPLS network to all TSPs, ILD[242] switches and ISPs.
Application areas	• Lawful interception and analysis for LEAs.
Key deliverables	• Enhancements through new SW releases and technical support for CMS (CMC, CMC-DR, RMC, ISF[243] and LEMF) and Intelligence Manager[244].
Status as on 31.03.2020	• Tier-III-certified CMC DC build along with IT[245] infrastructure at Delhi and CMC DR DC build along with IT infrastructure at Bengaluru are operational. • ISF equipment installed at all 21 LSAs. • Installation, AT and commissioning of RMC completed in all 21 LSAs. • 62 LEAs onboard CMS and operations commenced: • State LEAs – Uttaranchal police, Kerala police, Uttar Pradesh police, Madhya Pradesh police, Punjab police, Jammu and Kashmir police, Chhattisgarh Police, Himachal Pradesh Police, Haryana Police, Nagaland Police and Meghalaya police. • Central LEAs – CBI[246] at 4 locations (Delhi, Mumbai, Chennai, and Kolkata), NIA[247] at Delhi, NCB[248] at 14 locations, DoE11 at 16 locations, CBDT[220] at 12 locations, Signaling intelligence (SI) at 3 Locations, Cabsec (RAW)15 at Delhi. • 51 LEAs in the process of onboarding CMS: • CBDT[249]: at 2 locations, • IB: at 35 locations, • State police: at 6 locations. • DRI at 8 locations • Some LEAs have started using CMS in terminal mode. • IRI analysis is in operation at 6 LEA locations – Jammu and Kashmir police, NCB (at Assam), NCB (at Chandigarh), Signaling Intelligence at 3 locations. • IM for LEAs comprising of various functionalities, namely, CDR analytics for LEAs, Request Response for CDR data collection, ETL[250], is also deployed at 3 locations of Signaling Intelligence.

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[239] **Law Enforcement Monitoring Facility**
[240] **CMC Data Centre**
[241] **Regional Monitoring Centre**
[242] **International Long Distance**
[243] **Interception Store-and-Forward**
[244] **Intelligence Manager**
[245] **Information Technology**
[246] **Central Bureau of Investigation**
[247] **National Investigation Academy**
[248] **Narcotics Control Bureau**
[249] **Central Board of Direct Taxation**
[250] **Extract Transform and Load**
[15] **Cabinet Secretariat (Research & Analysis Wing)**

Finance (₹ in crore)	Budget for FY 2020-2021		20.12
Project plan	Deliverables and milestones	Target	
		2019-2020	2020-2021
	CMC DR IT infrastructure	1Q:19-20	NA(Completed)
	Technology support for CMS infrastructure installed in field	FY 2020-21 and beyond (*progressively*).	
Projected physical outcome for FY 2020-2021	• On-boarding of LEAs. • New SW upgrades for all nodes of CMS.		
Reasons for revision of targets	NA		

4.11.2.9 Satellite hub baseband system: Customer support for phase-1 and phase-2

Objective	• To provide support for satellite hub phase-1 system already supplied to the customer (DEAL). • To provide customer support for carrier-grade hub Phase-2 system already supplied to the customer (DEAL). • To provide additional system and spare cards to support satellite hub phase-2 system. Supply orders expected from the Customer.
Brief description	Satellite hub provides voice and data communication among different types of satellite terminals, and also, act as a gateway between satellite terminals and ground-based communication networks. C-DOT has developed the carrier-grade hub baseband as per customer's (DEAL) specifications and has delivered to the customer. The system has been integrated with satellite and DEAL terminals and is operational in the field.
Application areas	• Communication services using satellite. • Extending communication in remote and inaccessible areas.
Key deliverables	• Field support for satellite hub baseband system delivered under phase-1 and phase-2. • Supply of spare cards and additional system for phase-2 as per expected supply orders from Customer.
Status as on 31.03.2020	• Carrier-grade hub baseband system installed in DEAL, Dehradun. • Integration and testing of the system with customer's module completed at DEAL, Dehradun. • The integrated system shifted to field site (Army headquarter, Meerut). System installed and working in simplex mode. • Field support for carrier-grade hub baseband system ongoing.

Finance (₹ in crore)	Budget for FY 2020-2021		16.23

Project plan	Deliverables and milestones	Target	
		2019-2020	**2020-2021**
	Planning for execution of the order, purchase of components and PCBs, release of Gerber, etc.	*Completed in 2018-19*	
	Cards assembly, HW testing, SW porting and testing	*Completed in 2018-19*	
	System integration and testing	*Completed in 2018-19*	
	Delivery of carrier-grade hub baseband to the customer	*Completed in 2018-19*	
	Integration and testing with customer's modules	1Q:19-20	*NA (completed)*
	Field trial and testing with satellite	2Q:19-20	*NA (completed)*
	Field support for carrier-grade hub baseband system	4Q:19-20	1Q: 20-21
	Customer interaction & finalization of detailed deliverables as per the expected supply orders from customer for Phase-2 spares and additional system.	*NA*	2Q: 20-21
	Procurement of components, PCBs and other units as per expected orders	*NA*	3Q: 20-21
	Cards assembly, HW testing, SW porting & testing	*NA*	4Q: 20-21

	System integration & testing (additional System)	NA	4Q: 20-21
	Development and supply of multiple system of carrier-grade hub to the customer	4Q:19-20 *(note)[1]*	4Q: 20-21 *(note)[1]*
	Field Support for already supplied Carrier Grade Hub Baseband	NA	4Q: 20-21
Projected physical outcome for FY 2020-2021	• Field tested Carrier Grade Satellite Hub Baseband system • Development of additional system and spare cards of Phase-2 (based on the expected supply orders from the customer).		
Reasons for revision of targets	• Delay in the integration testing of the carrier hub baseband as customer's modules are in development phase and are not available for testing		

Note:

1. Supply order for the multiple systems of carrier grade hub baseband system is expected from the customer.

4.11.2.10 Samvad: Enhancements, trials and field implementation

Objective	To deploy enterprise version of *Samvad* app for *Android* and *iOS* in select enterprises to fulfill their secure communication requirements and also to carry out enhancements of *Samvad* app for public use.
Brief description	This is the next generation messaging solution to provide secure multimedia communication among users. The *Samvad* app has undergone pilot trial in various prospective Government user segments, namely, State police, Central LEAs, Defence, etc. There has been significant encouraging response for using *Samvad* for secure internal voice and data communication. The app is user friendly, with a robust GUI and provides state-of-the-art features and functionalities, as available in any of modern day messaging system.
Application areas	• Secure call and chat app. • App for general public use.
Key deliverables	• Enterprise version of *Samvad* mobile app for *Android* and *iOS* devices. • Public version of *Samvad* mobile app for *Android* and *iOS* devices.
Status as on 31.03.2020	• Samvad iOS-based mobile app development has been completed. • Samvad mobile app: pilot trial for android-based mobile app for voice call and chat applications, completed for Madhya Pradesh police, Intelligence Bureau, Indian Air Force, CSC, Power Grid, Karnatka police, Hyderabad police, NDMA, NIC[251]. • Samvad is being deployed for CMS users. • Samvad pilot trial is going on in DoT[252], MHA. • Commercial proposal has also been submitted to Madhya Pradesh police, Karnatka police, IB and Power grid, has been submitted for its deployment in their network. • Commercial order executed for IB • A number of fixes and enhancements given for IB

Finance (₹ in crore)	**Budget for FY 2020-2021**		5.85

Project plan	**Deliverables and milestones**		**Target**	
			2019-2020	**2020-2021**
	Mobile apps design, development and testing	Disaster recovery validation	1Q:19-20	3Q:20-21
		Validation for *iOS*-based mobile app	*NA (completed in 2018-19)*	
		Intrusion study	*NA (completed in 2018-19)*	
		Security audit	*NA (completed in 2018-19)*	
		Traffic reports	*NA (completed in 2018-19)*	
		Pilot trial for *iOS*-based mobile app	*NA (completed in 2018-19)*	
		Intrusion implementation	*NA (completed in 2018-19)*	
		Backup and restoration - client and server side	*NA (completed in 2018-19)*	
		Video call	*NA (completed in 2018-19)*	
		Streams	*NA (completed in 2018-19)*	

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[251] **National Informatics Centre**
[252] **Departmrnt of Telecommunications**

		Customisations in mobile apps for *Android* and *iOS*		*NA (completed in 2018-19)*	
	Mobile apps infra-structure scaling	Requirements generation		*NA (completed in 2018-19)*	
		Design, development and testing for customised client	Android	*NA (completed in 2018-19)*	
			iOS	*NA (completed in 2018-19)*	
		Enhancements as per customer requirements		NA	2Q:20-21
		Deployment in Government Offices		NA	2Q:20-21
		Design, development and testing at application server and database for handling large loads		4Q:19-20	3Q:20-21
		Load testing and security audit		1Q:20-21	4Q:20-21
		Offer for validation		2Q:19-20	1Q:21-22
Projected physical outcome for FY 2020-2021	Deployment of enterprise *Samvad* in select enterprises.				
Reasons for revision of targets	Every feature requires development in both *iOS* and *Android* apps, which has taken significant development time				

4.11.2.11 NMS trials and enhancements

Objective	To provide end-to-end Network Management System products/OSSs to TSPs, PSUs and Govt Agencies, *viz*, BBNL, MTNL Defence, BSNL, Airport Authority of India (AAI), RailTel, PGCL etc.
Brief description	Under this project, enhancements of BharatNet NMS phase-1 and phase-2 products, development of Customised Applications/solutions for BharatNet, customisation of CDR (Subscriber management applications) and converged NMS solutions for Software Defined Network(SDN)-compliance Network Elements/Devices(NEs) of TSPs, *viz*, BBNL, BSNL, Airport Authority(AAI) of India Kolkata and PAN India AAIs etc, are planned to be taken up. Tasks envisaged under each of these objectives: • **C-DOT SM[253] applications:** o C-DOT SM solution currently operational on 4 data centres which need to be consolidated into 2 data centres as per BSNL requirements. C-DOT provides C-DOT SM solutions through TCSL which is providing the total solution for BSNL network. C-DOT as an OEM offers a subscriber management SW (CDOT-SM) applications which allow subscriber facilities to be managed from a centralised location. o Customisation of CDOT-SM applications, porting of existing applications to new HW and SW platforms, configuration, load testing and deployment at BSNL sites. • **BharatNet NMS for BBNL Phase I and Phase II projects :** o Customised applications and management systems shall be developed, tailored and enhanced to evolve to the new, additional and changing requirements of customer project phases, technologies, networks, services and network solution providers, and existing applications be upgraded and enhanced to handle changes, new features, interfaces, vendors, platforms, standards and higher capacity. o Solutions developed for industry challenges pertaining to dynamism, virtualisation, security aspects of networks and management. o Customised solutions developed for targeted customers for specific domains of operation, like, availability, SLA and expansion requirements. o Analytics and projection of solutions to higher management. • **Converged NMS framework: Enhancements for SDN, Non SDN:** o NMS for monitoring the SDN – the emerging new technology-based telecom networks. ➢ Piloting/PoC of NMS solution designed for new technologies, domains and networks to potential customers of Govt/PSU sectors ➢ Development of Converged NMS with management applications/features to manage C-DOT internal products and multi-technology telecom networks in phased manner
Application	End-to-end network management solutions at element, network and service layers

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253

Subscriber Management

areas	for multi-technology networks (applicable to multiple vendors)

Key deliverables	• **CDOT-SM Solutions for CDOT Technology switches**
	  • Customization, deployment and roll-out on new platform as per customer requirements (Subject to issuance of PO by SI/Customer)
	• **BhartNet NMS BBNL Phase I and Phase II :**
	  • Enhancement releases for BharatNet NMS
	  • Bug-fix and patch releases for BharatNet NMS
	  • Integration with Tejas and ITI EMSs
	  • Enhancements and bug-fix releases to Alphion, Tejas, UTL and ITI[254]-specific EMS as per EMS releases, enhancements and customer requirements
	  • Business Exchange Gateway software (subject to approval of techno-commercial proposal by BBNL)
	  • Integration with state led NOCs of BharatNet Phase 2 state led model
	  • BharatNet Dashboard development, enhancements as per BBNL, DoT/USOF requirements
	  • Customization of Location Management System for phase-2 BBNL projects
	  • Enhancement and integration of CDOT EMS APIs with third party NMS Systems (GFGNL NMS)
	  • UNMS for BharatNet Phase 1 and state-led NMSs (phase 2) and Satellite NMS
	  • Mobile Application Enhancements as per field trial outcome subject to project approval from BBNL.
	• **Converged NMS framework: Enhancements for SDN, Non SDN:**
	  • Study of SDN NMS solutions, prototyping and external interfacing
	  • Design and development of Converged NMS for C-DOT Internal Products, Monitoring/managing multi technology systems (applicable to multiple vendors)
	  • Integration of C-DOT DWDM/POTP NMSs in to Converged NMS

Status as on 31.03.2020	1. **BharatNet NMS:**
	  • NOFN NMS Integrated with Alphion Technology and AT completed.
	  • NOFN-NMS integrated with Tejas EMS. Interoperability AT in progress.
	  • Mobile application developed and demonstrated as per BharatNet NMS requirements.
	  • BharatNet Dashboard and Reports developed based on DoT/BBNL requirements and deployed.
	2. **Business Exchange Gateway (BEG)**
	   NOFN NMS Integrated with CSC through BEG APIs and operational.
	  • BharatNet Phase 2 -Business Exchange Gateway -Requirements collected, analysed and prepared Software Requirements Specifications (SRS). SRS approval received from BBNL.
	  • BEG Commercials shared with BBNL for Approval
	3. **Converged SDN-compliant NMS:**
	  • Study and analysis of SDN technology with NMS perspective completed.
	  • Web service interfacing with standard ONOS Controller, Restful notification from ONOS Controller carried out.

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[254]

Indian Telephone Industry

Finance (₹ in crore)	Budget for FY 2020-2021		13.86
Project plan	Deliverables and milestones	Target	
		2019-2020	2020-2021
	CDR: Subscriber Management (SM)		
	Porting of CDOT-SM application, mediation, database modules to new HW and RHEL[255]-OS platform	1Q:19-20	1Q:20-21
	Integration testing of application, mediation, database modules porting and load testing of all SM modules, installation, configuration and testing at BSNL sites	2Q:19-20	2Q:20-21
	Installation, configuration and testing at BSNL sites and support	3Q:19-20	3Q:20-21
	Migration and go-live operational and support	4Q:19-20	4Q:20-21
	NOFN-NMS applications customisation, enhancements and customisation for last mile connectivity, PoC and field implementation		
	NOFN-NMS integration AT with Tejas technology and development of Tejas specific reports	1Q:19-20	*NA (completed)*
	Development and customisation of management dashboard and reports as per DoT	1Q:19-20	*NA (completed)*
	Bug-fixes, support and enhancements to NOFN-NMS	1Q:2019-20	*NA (completed)*
	NOFN-NMS integration AT with Alphion technology	2Q:19-20	*NA (completed)*
	SNMS development and release (provided BBNL signs agreement one quarter before and with separate commercials)	2Q:19-20	*NA (completed)* (Note)[1]
	Mobile application development for BharatNet (provided requirements are finalised by BBNL with separate commercials)	2Q:19-20	*NA (completed)*
	Integration with BharatNet phase-2 BBNL nodes	3Q:19-20	*NA (completed)*
	Bug-fixes, support and enhancements to NOFN-NMS	3Q:19-20	4Q:20-21
	Integration with BharatNet phase-2 NMS/EMS (state-led model) (provided NMS/EMS is available from BBNL for BharatNet phase-2)	4Q:19-20	(Note)[2]
	Bug-fixes, support and enhancements to BharatNet NMS	4Q:19-20	Q1-Q4:20-21 (progressively)
	Design, development of BEG and Integration with GFGNL NMS	NA	2Q:20-21
	ITI EMS Integration, customization and support (Interoperability testing to be done) (schedule	NA	2Q:20-21

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[255] **Red Hat Enterprise Linux**

depends on BBNL)		
BharatNet Dashboard development, Enhancements, support, DOT/USOF NMS requirements and releases	NA	1Q-4Q:20-21
UNMS release 1 development /deployment in NOFN Network (Subject to BBNL's approval)	NA	2Q:20-21
Mobile App development/Field trial	NA	2Q:20-21
Integration of BEG with state led VSAT NMS	NA	4Q:20-21
Integration of 8 state-led NOC NMSs with BEG	NA	3Q:20-21
NOFN NMS Support, Enhancements and bug fixes	NA	1Q-4Q:20-21
UNMS release 1 Support, Enhancements and bug fixes to BBNL	NA	3Q:20-21
Integration of BharatNet NMS with Phase-2 GPON Nodes	NA	*NA (completed)*
Integration of BEG with BharatNet UNMS release 1	NA	4Q:20-21
BharatNet Phase-1 Dashboard Development /deployment	NA	4Q:20-21
Converged NMS framework: Enhancements for SDN & Non SDN		
Explore the features of third-party NMS solutions for SDN	1Q:19-20	*NA (completed)*
Prototype virtual SDN set-up using Open Source tools in data plane, control plane and application plane[1].	1Q:19-20	*NA (completed)*
External interfacing with SDN Open Source tools and prototype virtual SDN (w.r.t NMS operations)	2Q:19-20	*NA (completed)*
NMS configuration application prototype development (for prototype virtual SDN)	3Q:19-20	*NA (completed)*
NMS reporting application prototype development for configuration feature (for prototype virtual SDN)	4Q:19-20	*NA (completed)*
Exploring 'Open Config' vendor neutral 'Data Models' for O&M operations using NMS /OSS Solutions to TSPs. Design and development of Generic Trouble Ticket System Integration with Fault Management (TT)	NA	1Q:20-21
Exploring newer Management Interfaces like gNMI, gNOI, Protobuf. Design and development of TMF Standard based Resource Management Framework (Inventory and Config Mgmt).	NA	2Q:20-21
Incorporating Domain Specific Data Models (DWDM, IP) in Converged NMS Framework. Design and development of TMF Standard based	NA	3Q:20-21

	Resource Management Framework (Fault and Performance Mgmt).		
	Incorporating newer 'Management Interfaces' like NetConf, RestConf in Converged NMS Framework. Integration of C-DOT DWDM/POTP NMSs in to Converged NMS and Filed Trial to BSNL/Rail Tel/TSPs	NA	4Q:20-21
	Customization and Roll out of IPNMS (DC NMS) for Airport Authority of India (AAI) Kolkata, PAN India AAI and ISTRAC		
	Collection of requirements, Study, Analyse, Development/Customisation of IPNMS as per the AAI Kolkata requirements to monitor/manage multi-vendor/multi technologies IP based NEs/Devices (Subject to PO is issued by AAI Kolkata to C-DOT)	NA	1Q:20-21
	Procurement of required O&M field Engineers and train them on C-DOT IPNMS solutions. Installation of RHEL OS, configuration and deployment of CDOT IPNMS and make operational/manage by out sourced O&M engineers	NA	2Q:20-21
	Enhancements implementation, bug fix releases to AAI Kolkata as per the customer feedback. Field Trial/Demo of C-DOT IPNMS to other AAI centres in India. Development and deployment of IP-NMS for ISTRAC (subject to PO confirmation from ISTRAC)	NA	3Q:20-21
	IPNMS – Warranty, AMC proposal and support	NA	4Q:20-21
Projected physical outcome for FY 2020-2021	- Integration testing of application, mediation, database modules porting and load testing of all SM modules, installation, configuration and testing at BSNL sites. - Integration with BharatNet phase-2 NMS/EMS (state-led model) (provided NMS/EMS is available from BBNL for BharatNet phase-2). - UNMS for BharatNet Phase1, Phase 2, State NoCs and Satellite NMS - NMS reporting application prototype development for configuration feature.		
Reasons for revision of targets	Delay in raising PO by customer/SI, additional/evolving requirements for network operations, Integration with additional systems/applications, technology advancements in domains etc. resulted in revision of targets		

Note:

1. SNMS V1.0.0 Release was developed and demonstrated to CSC and BBNL, howerver BBNL has not signed the agreement , hence this milestone is not applicable

2. Gujarat GFGNL NMS integration with BEG completed for Inventory Modules and CSC APIs. BEG development for Fault Management and Notifications are in-progress for GFGNL. BEG Integration for Maharastara NOC/NMS is in-progress for Inventory, Fault Management and Notificaitons modules. There are 6 more states NOC/NMSs planned to be integrated with BEG.

4.11.2.12 Optical Core Network: Trials and enhancements

Objective	• To carry out PoCs, pilot/field trials, • To implement 100G DWDM technology system in the prospective clients' networks, • To provide requisite support for technology roll-outs, and • To provide O&M[256] support in the field.
Brief description	• 100G DWDM system is already operational in BSNL network, Chennai with live traffic since last two years. BSNL has asked for some more Muxponder cards to cater to low bit rate customer requirements. • 100G DWDM system installed in RailTel network between Mangalore and Madgaon section at 12 sites to cover approx. 320 kms of fibre route. The desired network is expected to accommodate the growing demand for bandwidth and transport for all types of traffic, like, ethernet, SDH, OTN, etc. The system is working with live traffic. There might be a requirement of additional wavelengths on the existing route for which C-DOT has to supply extra hardware (Muxponder cards). It is also highly likely that after 6 months of error free traffic working on this route, RailTel might plan to extend the link upto Panvel to cover around 543 kms of fibre route with 18 more DWDM nodes and ask C-DOT to provide the required hardware. • 100G DWDM system installed in MTNL Network, Delhi at Kidwai Bhawan, Shakti Nagar and Karol Bagh in a ring configuration. The system is working with live traffic. There might be a requirement of additional wavelengths on the existing route for which C-DOT has to supply extra hardware (Muxponder cards). MTNL might also plan to connect 3 more core sights with DWDM nodes in future and ask C-DOT to provide the required hardware to connect those additional sites.
Application areas	Optical backbone networks.
Key deliverables	100G DWDM system (configurable as per field requirement) consisting of following elements: • TEs and ROADMs, • ILAs[257], • EMS.
Status as on 31.03.2020	• 100G DWDM system is already in operation in BSNL network, Chennai. • 100G DWDM equipment installed in the RailTel Network between Madgaon and Mangalore sections at 12 locations. • 100G DWDM equipment installed in the MTNL Delhi network at three locations.

Finance (₹ in crore)	**Budget for FY 2020-2021**		4.96
Project plan	**Deliverables and milestones**	**Target**	
		2019-2020	2020-21
	PoC with live traffic of 100G DWDM network at BSNL	1Q:19-20	*NA*

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[256] **Operation and Maintenance**
[257] **In-Line Amplifier**

	Chennai.		*(completed)*
	Installation and trial of C-DOT 100G DWDM system in RailTel network to establish optical fibre-based broadband telecom long-haul network	4Q: 19-20	*NA (completed)*
	Installation and trial of C-DOT 100G DWDM system in MTNL network at Delhi to connect the nodes and establish optical fibre-based broadband telecom ring network	3Q: 20-21	*NA (completed)*
	Supply and installation of additional cards to cater to low bit rate customers in BSNL Chennai.	NA	3Q: 20-21
	Supply and installation of additional wavelengths on the already deployed route from Madgaon to Mangalore. Extending the link from Madgaon to Panvel by installation of 18 more nodes.	NA	4Q: 20-21
	Supply and installation of additional wavelengths on the already deployed DWDM ring in MTNL Delhi network. Deployment at three additional sites in the network to cover 6 nodes in ring configuration.	NA	3Q: 20-21
Projected physical outcome for FY 2020-2021	• Support for already deployed DWDM system in BSNL, RailTel and MTNL networks. • Supply and installation of additional hardware to cater to new requirements.		
Reasons for revision of targets	NA		

Note:
1. *The project plan and its execution for phased-wise trial is subject to approval from RailTel and award of the work.*

4.11.2.13 MTCTE (Mandatory Testing and Certification Scheme)

Objective	To design and develop MTCTE portal for TEC
Brief description	This portal provides provision for online certification of telecom equipment by TEC. It also provides administration of Mandatory Testing and Certification of Telecom Equipment (MTCTE) process and process like Voluntary Testing, Certificate Modification Renewal. The testing is to be carried out by TEC designated labs and based upon their test / reports, certificate shall be issued by TEC.
Application areas	Testing and certification of Telecom equipment.

Key deliverables	**Phase-1**
	2018-2019
	1. Implementation of mandatory testing in Phase 1 of MTCTE.
	2. Bilingual Homepage & linked pages.
	3. CERT certification of MTCTE portal.
	4. Deployment of portal on Meghraj Cloud.
	2019-2020
	1. New Roles - Top Management, Pre-check Evaluator - login, dashboard etc.
	2. Implementation of Digital signatures on output certificate.
	3. Support for dynamic addition of various CAB users.
	4. Offered MTCTE portal to general public.
	5. CERT certification
	6. Phase 2 of MTCTE on C-DOT Test bed
	   • Voluntary Testing (TA, IA and COA).
	   • Certificate modification and Renewal.
	   • Configurator.
	   • Web Manager.
	   • Communication Dialog.

Status as on 31.03.2020	1. Phase 1 is completed. 2. Phase 2 features on C-DOT test bed with access to TEC. 3. CERT Certification of MTCTE.

Finance (₹ in crore)	**Budget for FY 2020-2021**		2.15

Project plan	Deliverables and milestones		Target	
			2019-2020	**2020-21**
	Implementation of New Feature	Implementation and validation of new features raised by TEC.	NA	1Q :20-21
		Incorporating modifications on existing features raised by customer.	NA	1Q :20-21
		Testing and Validation.	NA	1Q :20-21
		Generation for remaining products and subsequent mandatory flow process.	NA	2Q :20-21
		Subsequent release for all products.	NA	2Q :20-21
		Incorporating enhancements & feedbacks in release	NA	2Q :20-21
	Migration of MTCE Portal to	Implementation of MTCTE with NAS & Load Balancer	NA	3Q :20-21

	Linux	Architecture and validation on C-DOT test bench.	NA	3Q :20-21
		Implementation of CERT guideline for Linux based system	NA	3Q :20-21
		Apply for final CERT Certification	NA	3Q :20-21
		Installation of required software's and Configuration of VMs provided by NIC.	NA	4Q :20-21
		Enabling DR feature on cloud.	NA	4Q :20-21
		Final Testing & Validation on cloud	NA	4Q :20-21
		Migration of DB and filesystem from windows based VMs to Linux based VMs	NA	4Q :20-21
		Public Release of MTCTE	NA	4Q :20-21
Projected physical outcome for FY 2020-2021	• Implementation of new features incorporating enhancements & feedback in release. • Migration of DB and filesystem from Windows based VMs to Linux based VMs. • Public release of MTCTE.			
Reasons for revision of targets	*NA*			

4.11.2.14 NDMA projects: Projects related to disaster management

The pojects, which are presently under consideration and approval by the Government, are:

1. **ITU CAP EWS platform**

   NDMA[258] is envisaging to build a CAP[259]-compliant integrated EWP[260] with geo-intelligent functionalities for disaster management,

   - for warning the Indian public of emergencies and disasters;

   - for addressing the measures for the prevention of disaster;

   - for mitigation; and

   - for preparation and capacity building for dealing with threatening disaster situations or disasters.

   The primary objective of an integrated EWP is to modernise and integrate existing alerting and warning authorities as well as dissemination of the same through various types of media at the national, State, territorial, local levels in a single, cohesive interface in secured manner.

   The proposal is comprehensive involving multiple agencies for the development, implementation and operation of the facilities planned to be created under the program. At present, the proposal is awaiting approval. C-DOT will be involved in the development of requisite platform of to be used nation-wide for operations. Project development will continue subject to award of work.

2. **Priority Call Routing**

   Many disasters have happened in the past in various parts of the country. Whenever there is disaster, everybody panics and start calling their near and dear ones residing in the affected areas. The persons in the affected area start making calls to their near and dear ones to seek their help and thus congest the telecom network.

   In order that State administration, SDMA and NDMA remain in constant touch through mobile network, there is a definite need for giving ovedrriding priorities to their calls in the network.

   During this year, it is planned to have interaction with various TSPs and other stakeholders regarding finalisation of data specification and data collection, API interfaces for periodic data collection and initiate development for a PCR[261] portal or centralised application which is accessible to all the stakeholders of PCR.

   These projects are under approval phase and separate budget will be planned for undertaking projects related to disaster management. While the approvals are awaited, suitable budget is provisioned for FY 2019-2020 out of the allocation provided to C-DOT, to carry out preliminary project activities, like field surveys, requirement assessment, initial development, etc. Project development will continue after formal award of work.

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[258] **National Disaster Management Authority**
[259] **Common Alerting Protocol**
[260] **Early Warning Platform**
[261] **Priority Call Routing**

4.11.2.14.1 CAP compliant Integrated Location based Early Warning Platform

Objective	To design, develop and implement a CAP-compliant geo-intelligence platform for integrating forecasting agencies, disseminating agencies and disaster management authorities for geo-targeted disaster early warning dissemination. The project will strengthen Disaster Risk Mitigation (DRM) capacity at Central, State and Local levels in order to enable mainstreaming of risk mitigation measures into the overall development agenda. The project will help to measure progress in achieving 7 Global targets like Mortality, People affected, Economic Loss, Critical Infrastructure & services, Disaster risk reduction strategies, International cooperation and Early Warning and Risk information as per Sendai Framework, 2015.
Brief description	NDMA is envisaging to build a CAP-compliant integrated early warning platform with geo-intelligent functionalities for disaster management to warn the people of emergencies and disasters and to address the measures for the prevention of disaster, or the mitigation, or preparedness and capacity building for dealing with threatening disaster situations or disasters. The primary objective of integrated EWP is to modernise and integrate existing alerting and warning authorities, as well as dissemination of the same through various types of media at the national, state, territorial, and local levels in a single, cohesive interface, in secured manner. Before roll out of the project pan India basis, NDMA has selected Tamil Nadu for implementation of pilot project. In pilot project IMD RMC Chennai and CWC HQ have been selected as forecasting agencies, Tamil Nadu SDMA as authorizing agencies for public alert dissemination and TSPs have been selected for dissemination of location-based SMS and Cell Broadcast message dissemination.
Application areas	• Centralized Early Warning Platform for different kind of disasters like Cyclone, Flood etc. • Geo-Intelligent functionalities for location based early warning generation and dissemination Map. • Dissemination of alerts, advisories in vernacular languages based on flexible geographic targeting. • Integration of multiple agencies responsible for generating, disseminate and management of disaster early warning into a centralized platform • Strengthening Disaster Risk Mitigation (DRM) capacity at Central, State and Local levels in order to enable mainstreaming of risk mitigation measures into the overall development agenda.

Key deliverables	• Hosting of CAP compliant Integrated Location based Early Warning Platform with following functionality:
	  o CAP complaint alert generation and management
	  o Geo-Intelligent functionalities
	  o Authentication and Authorization of alert dissemination from relevant authority.
	  o User and Configuration Management.
	• Procurement and Establishment of Test Bed infrastructure at C-DOT for Internal Testing and Validation of Platform before hosting in Cloud Infrastructure.
	• Standard Operating Procedures (SOP) for IMD, CWC, TN-SDMA, TSPs in

	coordination with National Disaster Management Authority (NDMA) and Department of Telematics (DoT). • Integration with Indian Metrological Department (IMD) RMC Chennai centre for Early Warning Message dissemination for issuing warnings for meteorological events like Cyclone. • Integration with Central Water Commission (CWC) head quarter for Early Warning Message dissemination for River wise Flood Forecasting in Tamil Nadu. • Integration with Airtel, BSNL, Reliance Jio and Vodafone-Idea for location based early warning SMS dissemination. • Proof of Concept of Cell Broadcast message dissemination with one TSP in Tamil Nadu. • CERT-IN certification to ensure security of the application. • Hosting of Platform at C-DOT testbed infrastructure and third-party Cloud Infrastructure and enable access to TNSDMA, IMD-Chennai, CWC, DoT, and respective TSPs. • Location specific SMS dissemination to masses in English Language. • Support for Hindi and Tamil languages for SMS dissemination. • Integration with Tamil Nadu SDMA as Controlling authority. • Training for IMD RMC Chennai, CWC-HQ, TN-SDMA officials.
Status as on 31.03.2020	• Common Alerting Protocol as per ITU.T X.1303 Standard has been implemented as a part of the platform. • Basic functionalities of Common Alerting Protocol (CAP) compliant Early Warning Platform have been developed • Specification for development of APIs for integrating TSPs with CAP Platform has been released and circulated to TSPs. • Basic requirements have been identified and further interaction with NDMA, TN-SDMA, IMD RMC Chennai, CWC-HQ is going on for finalization of requirements for interface design for respective agencies. • Interaction is ongoing with NDMA, DoT for finalizing SOPs, message dissemination QoS. • The platform has been demonstrated to the disaster management authorities of 12 states • Access of the platform has been provided to Kerala SDMA and round the clock support was given during Kerala flood 2018, 2019 when the platform was extensively used for public advisory dissemination. • Interaction with TEC and NDMA is in progress for standardization of CAP parameters and early warning message. Modification of ITU.T X.1303 standard as per Indian context.

Finance (₹ in crore)	Budget for FY 2020-2021		7.25

Project plan	Deliverables and milestones	Target	
		2019-2020	2020-2021
	Design and Development of CAP Early Warning Platform		
	CAP Generator, CAP Aggregator, CAP Validator and	NA	1Q:20-21

CAP Dispatcher Module of CAP-EWP platform		
Nowcast warning interface for IMD Chennai	NA	1Q:20-21
Flood Forecast interface for CWC	NA	1Q:20-21
Secured interface for TSPs for CAP XML dispatch	NA	1Q:20-21
Geo intelligence functionalities and High Priority Group SMS functionalities.	NA	2Q:20-21
Cyclone warning interface and mapping functionalities of Cyclone bulletin for IMD Chennai	NA	2Q:20-21
Create provision for processing of CWC flood forecast bulletin in CWC interface	NA	2Q:20-21
Design and development of APIs to receive SMS dissemination statistics from TSPs automatically	NA	2Q:20-21
Tamil Nadu SDMA interface for review alerts generated by forecasting agencies and issue public warnings through geo-targeted SMS	NA	2Q:20-21
User management, multi-tier authorization management and template management module of CAP-EWP	NA	3Q:20-21
Proof of Concept of Cell Broadcast message dissemination	NA	3Q:20-21
APIs for receiving Cell Broadcast dissemination statistic	NA	3Q:20-21
Support of Tamil and Hindi language in CAP-EWP	NA	3Q:20-21
Alert life cycle management	NA	4Q:20-21
Alert generation and dissemination statistics module, report management module for IMD, CWC and SDMA	NA	4Q:20-21
RBAC based interfaces for DoT HQ and DoT LSA wing user for monitoring alert status and SMS, Cell Broadcast dissemination statistics for all TSPs	NA	4Q:20-21
Design of Role based interfaces for respective TSPs to visualize alert status and message dissemination statistics	NA	4Q:20-21
Hosting of CAP-EWP Platform and Security Certification		
Hosting of CAP-EWP Platform in C-DOT Testbed and provision for giving access to relevant stakeholders	NA	1Q:20-21
Cloud Infrastructure Preparation for hosting of CAP-EWP and make provision for giving access to all stakeholders.	NA	2Q:20-21
CERT-IN security Certification of CAP-EWP	NA	3Q:20-21
Hosting of CERT-IN certified CAP-EWP in cloud environment	NA	4Q:20-21
Finalization of Standard Operating Procedure for IMD, CWC, TN-SDMA and TSPs for CAP-EWP Pilot Project implementation in Tamil Nadu	NA	2Q:20-21
Implementation of CAP-EWP project in the State of Kerala	NA	(Note)[1]
Pan India Project**		(Note)[2]
Preparation of Techno commercial project proposal for pan India implementation of CAP Early Warning	NA	(Note)[2]

	Platform		
	Requirement finalization for integration of early warning dissemination agencies All India Radio, Indian Railways, Doordarshan.	NA	(Note)[2]
	Requirement finalization for integration of early warning forecasting agencies INCOIS, GSI, SASE	NA	(Note)[2]
Projected physical outcome for FY 2020-2021	• CAP-compliant EWS core engine (ver.1) and interface for interworking with one alert generating agency. • Implementation plan for prospective alert generating agencies based on field surveys and requirements assessment (*subject to award of work*).		
Reasons for revision of targets	*NA*		

Note:

1. *Techno commercial proposal for Kerala has been submitted to Kerala SDMA and administrative approval has been received. At present financial negotiation is going on.*

2. *The project is presently under consideration and approval of the NDMA. Individual states are also in interaction with C-DOT through DoT for location-based mass alert system solution. Project development will continue after formal award of work.*

4.11.2.14.2 Priority Call Routing

Objective	To develop a PCR system which is accessible to all the stakeholders for defining priority call subscribers and initiating priorities for these subscribers in the TSP networks.
Brief description	Whenever there is disaster event, everybody panics and start calling their near and dear ones residing in the affected area. Besides, the persons in the affected area also start making panic calls to their near and dear ones to seek their help and thus congest the telecom network. Disaster relief numbers are broadcast by the Government during disasters in the affected areas but calls to these numbers do not mature as the telecom network is congested due to the artificial load generated. On TSP side, some pre-communicated subscriber numbers of high importance, like the District Collector, Chief Minister, Council of Ministers, police persons, NDRF[262] teams, etc, are accorded highest priority in their telecom networks, so that calls to and from these numbers have an overriding priority over other calls in that network. Therefore, to fufill the above requirements, a need for nationwide PCR system, have been envisaged, where the concerned disaster management authorities list down the PCR numbers alongwith their priority which can then be forwarded to the TSPs in near-real time. Disaster management authorities should also have an option to give commands to TSPs to activate/deactivate the PCR numbers in any district of the States and Union Territories.
Application areas	• Centralised PCR management by the NDMA. • Automatic information channel between disaster authorities and telecom service provider. • Nationwide database containing list of all PCR numbers - LSA, TSP, District and State-wise. • Trigger-based activation of PCR list in affected districts by TSPs.
Key deliverables	• A centralised PCR system accessible to all the stakeholders of PCR.
Status as on 31.03.2020	• C-DOT have demonstrated the PoC of the PCR system enabling TSPs to manually download the PCR list from the PCR system and further provision the PCR numbers in their network. • The PoC was successfully completed in Jammu and Kashmir and Kerala.

Finance (₹ **in crore**)	**Budget for FY 2020-2021**		0.89
Project plan	**Deliverables and milestones**	**Target**	
		2019-2020	**2020-2021**
	Requirements specifications and architecture design	1Q:19-20	1Q:20-21
	Interfacing with TSPs for the near-real time PCR list synchronisation (joint responsibility of TSPs, DoT, and C-DOT)	2Q:19-20	2Q:20-21

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[262] National Disaster Response Force

	SMS connectivity on SMPP (responsibility of DoT)	2Q:19-20	2Q:20-21
	Lab infrastructure set-up for development	2Q:19-20	2Q:20-21
	PCR system development of modules	2Q:19-20	2Q:20-21
	Lab validation of PCR system	3Q:19-20	3Q:20-21
	Testing and integration with TSPs (joint responsibility of TSPs, DoT and C-DOT)	3Q:19-20	3Q:20-21
	Validation testing of PCR application by DoT	3Q:19-20	3Q:20-21
	Acceptance testing and ready for deployment (joint responsibility of TSPs, DoT, NDMA and C-DOT)	3Q:19-20	3Q:20-21
	Pan India deployment of PCR system	3Q:19-20	3Q:20-21
Projected physical outcome for FY 2020-2021	PCR system - accessible to all the stakeholders of PCR.		
Reasons for revision of targets	*NA*		

Note:
1. *Detailed Project Report (DPR) submitted, approval awaited.*

4.11.2.15 CiSTB Support

Objective	To provide technical support to CiSTB project/products and complete the trials.
Brief description	C-DoT interoperable STB (CiSTB) project was initially envisaged towards design & developing of Interoperable STB solution Architecture as knowledge partner to TRAI. C-DoT has designed and developed Solution architecture for STB interoperability along with the network elements – Cable STB, DTH STB and Conditional Access System (CAS). Also C-DOT has designed and developed OTT (Over The Top) STB. C-DoT solution architecture is part of TRAI consultation papers on STB interoperability. TRAI pilot trial was also initiated by TRAI involving all industry stakeholders. C-DOT has signed MoU with BECIL on C-DOT CAS for business promotion and commercialization. C-DoT is presently in different stages of engagement with probable customers and partners. C-DoT has initiated trial of C-DoT CAS and STB in PrasarBharati (Door Darshan) network. Transfer of Technology (ToT) has been initiated for different STB varients. To complete the remaining activities wrt trials and to provide necessary technical support to the prospective customers/manufacturing partners, CiSTB Support for 2020-21 is planned.
Application areas	Broadcast and converged networks
Key deliverables	Support for the followings • Cable & DTH STB • C-DoT CAS • OTT STB
Status as on 31.03.2020	C-DoT interoperable STB development and testing for interoperable set top box for Cable and satellite and over the top set top box (OTT) has been completed. Field trial done for Cable STB and C-DOT interoperable Basic CAS for IMCL Mumbai. C-DoT CAS and DTH STB trial taken up in Doordarshan network.

Finance (₹ in crore)	**Budget for FY 2020-2021**		2.90

Project plan	**Deliverables and milestones**	**Target**	
		2019-2020	**2020-2021**
	Support for Cable & DTH STB	N.A.	1Q to 4Q : 20-21
	Support for CAS	N.A.	1Q to 4Q : 20-21
	Support for OTT STB	N.A.	1Q to 4Q : 20-21

Projected physical outcome for FY 2020-2021	Trial and Support to customers & manufacturing partners
Reasons for revision of targets	N.A.

4.12 Campus infrastructure

Objective	To construct part of a Housing & Hostels complex (Staff housing : 1 Block)		
Status as on 31.03.2020	• All statutory approvals, including environmental clearance, have been received. • C-DOT project board has approved ₹5 crore expenditure towards construction and related work. • Plan, cash-flow statement, location plan and other details prepared with the architect and approved by the project board. • Tender evaluation committees – technical and financial – formed to finalize the tender. TEC has given his recommendation on 2nd December, 2019 & tender document got modified accordingly. • Indent for the work was raised on 3rd February, 2020.		
Finance (₹ in crore)	Sanctioned budget outlay		60.00
	Cumulative expenditure (provisional upto Mar-2020)		0.28
	Budget for FY 2020-2021		3.00

Project plan	Deliverables and milestones	Target	
		2019-2020	**2020-2021**
	Initiation of tendering process for commencement of construction activity subject to approval by C-DOT Project Board	1Q:20-21	1Q:20-21
	Award of work and commencement of construction	2Q:20-21	2Q:20-21
	Foundation and construction upto plinth level	2Q:20-21	3Q:20-21
	Structure and brick work , plastering work	3Q:20-21	4Q:20-21
	Interior work	4Q:20-21	1Q:21-22
	Completion of proposed part of work	2Q:21-22	2Q:21-22

Projected physical outcome for FY 2020-2021	• Construction of residential complex (Staff Housing units, 1 Block) will commence and the following work will get completed: • Construction of the structure and brick work & plastering work.
Reasons for revision of targets	C-DOT project board's approval for the indent.

5   Annexures

Annexure-I	Cumulative expenditure on technology programs and executable projects as on 31.03.2020, proposed revisions with justifications, and budget for FY 2020-2021
Annexure-II	Projects completed during FY 2019-2020
Annexure-III	Projects being initiated during FY 2020-2021
Annexure-IV	Justifications for revised estimate
Annexure-V	Joint ventures and operative MoUs with strategic partners
Annexure-VI	Acronyms

5.1 Annexure-I: Cumulative expenditure of technology programs as on 31.03.2020, proposed revisions and budget for FY 2020-2021

Under the technology programs listed in the following table various projects are executed. The project executables on their completion are removed from the respective program. However, the expenditure incurred for these completed projects are included in the cumulative expenditure of the corresponding program. The projects listed below pertain to projects currently being executed.

5.1.1 Technology programs and executable projects

Table 5.1: Cumulative expenditure, proposed revisions, and budget for the technology programs for FY 2020-2021

Program and executable project	Sanctioned budget outlay for the program/ project	Proposed revision in sanctioned budget outlay	Cumulative expenditure upto 31.03.2020 (*provisional*)	Budget For FY 2020-2021
Next generation mobile technologies				
Development of 5G systems	85.00	NA	16.71	28.82
Development of 5G standalone core (SA) network system and Data Plane Analytics	85.00	NA	*New Project*	32.69
Carrier networks transport technologies for transport and access networks				
Packet Optical Transport Platform	95.00	NA	43.44	25.30
TWDM-PON system	85.00	NA	46.85	17.44
Next generation switching and routing systems				
Next generation high-speed routing system	65.00	NA	29.97	24.07
Switching and routing solution for LAN, MAN, enterprise and data centre segment	85.00	NA	36.61	15.84
Power-efficient and green telecom technologies				
Green power supply system	22.00	NA	19.05	Completed
Satellite-based technologies				
Digital Video Broadcasting – 2nd Generation	10.00	20.00	7.07	7.43
Satellite based Broadband solution (C-Sat-Fi)	6.00	NA	*New Project*	5.80
Enabling technologies and telecom networks				
Study of Quantum Key Distribution	3.33	NA	1.32	0.39
Telecom services and applications				
Machine-to-Machine communication	85.00	NA	45.84	12.33
C-DOT interoperable Set-Top Box	16.00	25.00	18.07	Completed
C-DOT Converged Service Delivery Platform (C-CSDP)	16.00	NA	*New Project*	4.44
Centre of Excellence (CoE) for lawful interception				
Open Source Intelligence	15.00	NA	12.05	Completed
Image and video analytics: face	8.00	NA	3.54	1.57

Program and executable project	Sanctioned budget outlay for the program/ project	Proposed revision in sanctioned budget outlay	Cumulative expenditure upto 31.03.2020 (*provisional*)	Budget For FY 2020-2021
recognition				
Capacity enhancement	15.00	NA	0.53	0.10
Quantum-safe cryptography	10.00	NA	5.64	3.45
Network steganography and network steganalysis	10.00	NA	1.86	Completed
Short text message analytics	3.00	NA	0.39	1.67
UN navigational application[1] (*under consideration for approval*)	8.00	NA	2.40	2.06
C-DOT Video Conferencing Solution	5.00	NA	*New Project*	4.61
Development of Quantum Key Distribution	45.00	NA	*New Project*	9.35
Post-Quantum Inline Network Encryptor (PINE)	12.10	NA	*New Project*	9.32
Development of Quantum Secure Smart Video IP Phone (QSSIPP)	10.00	NA	*New Project*	8.31
Campus infrastructure	60.00	NA	0.28	3.00
Total				**217.79**

5.1.2 Technology programs and executable projects

Table 5.2: Budget for the technology programs for the FY 2020-2021

(₹ *in crore*)

Technology program and project executables	Budget for FY 2020-2021
Enhancements, upgradations, adaptations and technical support for developed technologies	**237.08**
Product design support for: • SDCN • Optical products: GPON, NOFN • OCN • Network steganography and network steganalysis • Green power supply	24.52
Other activities: • MAX-NG: Support, • ISP monitoring: Implementation of requisite solution for lawful interception and monitoring of internet traffic by LEAs, • Customised development of router HW customisation of router SW stack, • LTE-A: Enhancements and trials for RAN and EPC, • CMS: Support, • NMS: Enhancements and trials, • SD: Network elements, • WiFi: Technology enhancements, trials and roll-outs, • *Samvad*: Enhancements, trials and field implementation, • Secured network solutions: Enhancements and trials, • TRAI project on call drop, • NDMA project CAP-compliant EWP, • NDMA project PCR solution, • TEC project on MTCTE portal, • OCN: Enhancements and trials,	212.56

5.1.3 DoT projects

Table 5.3: DoT projects

(₹ *in crore*)

Technology program and executable projects	Budget for FY 2020-2021
• Computer Emergency Response Team – Telecom	8.61
• Central Equipment Identity Registrar	17.02
• C-DOT interception request and approval system (*under consideration for approval*)	1.30

5.1.4 C-DOT solution roll-outs in Govt. Departments

Table 5.4: C-DOT solution roll-outs

Technology program and executable projects	Budget for FY 2020-2021
Video Conferencing solution roll-out in Govt. Departments	18.00
Samwad roll-out in Govt. Departments	13.00

5.2 Annexure-II: Projects completed during FY 2019-2020

5.2.1 Projects under program 'Power efficient and green telecom technologies'

Table 5.4: Closure of project 'Green power supply system'

(₹ *in crore*)

Program: Power efficient and green telecom technologies		
Executable project	Project: sanctioned budget outlay	Projected cumulative expenditure till closure (31.03.2020) (*provisional*)
Green power supply system	22.00	19.05

Brief closure report of the above mentioned project is given below:

5.2.1.1 Green Power supply system

Project has been started with the objective to develop an alternate power supply system based on green technologies specifically for mobile towers (BTS) and also to supply power to the current products, like BBWT, ONT, and DRAX, developed in C-DOT.

The development has been completed successfully as per the project scope planned and hence brought to closure.

The major accomplishments during the project development are :
- Design and implementation of 75W indoor Hybrid power system.
- Design and implementation of 125W outdoor Hybrid power system
- Design and implementation of 250W indoor Hybrid power system
- Design and implementation of 2KW Hybrid power module
- Design and implementation of 5KW system with 2KW power modules

5.2.2 Projects under program 'Telecom services and applications'

Table 5.5: Closure of project 'C-DOT Interoperable set-top box'

(₹ *in crore*)

Program: Telecom services and applications		
Executable project	Project: sanctioned budget outlay	Projected cumulative expenditure till closure (31.03.2020) (*provisional*)
C-DOT Interoperable set-top box	25.00	18.07

Brief closure report of the above mentioned project is given below:

5.2.2.1 C-DOT Interoperable Set-top box

Project has been started with the defined objective to develop C-DOT interoperable Set Top Box for Cable , Satellite and OTT segments and also C-DOT inter operable CAS .

The development has been completed successfully as per the project scope planned and hence brought to closure.

The major accomplishments during the project development are:
- Design and implementation of interoperable Set top box for Cable.
- Design and implementation of interoperable set top box for Satellite (DTH) .
- Design and implementation of over the top set top box (OTT)
- Design and implementation of interoperable Conditional access system (CAS).

5.2.3 Projects under program 'Technology field implementations and roll-outs'

Brief closure report of the closed project is given below:

5.2.3.1 NGN Roll out for MTNL

The activities associated with NGN Rollout project in MTNL network have either got completed and deliverable offered in field or some are in a state where they need to taken up in associated technology development and support projects. The detailed status of the targeted deliverable in the project is tabulated below:

Planned activities	Status
Roll-out of NGN and IN core network at Delhi and Mumbai	Completed
Acceptance Testing of C-DOT NGN core network	Completed
Migration of traditional IN services to NGN-IN services at MTNL Delhi and Mumbai	Completed
Integration of TAX functionality into NGN network	Completed
Completion of NGN core and copper access node in MTNL network	Completed
MTNL Toll-Free services migration on C-DOT NGN-IN platform	All developmental requirements have been completed but as the server hardware installed at MTNL sites has no support available from the vendor, required release upgrade has not taken place. This part can be done as a support activity when the availability of hardware by MTNL is ensured.
Trials of leased circuits over MPLS in MTNL	Completed
Replacement of existing 40,000 MTNL landline connections with C-	This activity is also held up primarily due to hardware obsolescence and as required release upgradation is

DOT NGN platform	dependent on the replacement of server hardware. MTNL is already apprised of the hardware support limitations. Further a commercial proposal is already submitted to MTNL for restoration of Bandra Exchange with C-DOT LTE-IMS Converged Core solution which will address both fixed line requirements (approx. 1 Lac lines proposal is there) and the server hardware support concerns. Depending on the proposal acceptance, activity can be taken up along with other LTE/IMS trial activities.
Trial of LTE in MTNL network	Basic integration testing completed. However, since similar activities are planned for trial with other access and core solution vendors in "LTE-A Customization Enhancement and Trial (R13)", it is decided to continue the trials and the subsequent migration in the network under this project.
Migration of IMS-compliant core to fully IMS core in MTNL	

5.2.3.2 Router trials and enhancements

This program was started to carry out trials for C-DOT routers in various networks and to progressively enhance the capability of indigenous router with new features to meet the requirements of the prospective networks. Consecutively, the additional routers were assembled and trials of this technology was carried out in the various networks of government and strategic sectors. It required fabrication of multiple routers/add on units, for PoCs in the networks of prospective clients, feature enhancements, customisation etc., to meet their current and future requirements. The EMS development and its integration with NMS for C-DOT routers have also been developed under this project.

Moreover, under this program, the C-DOT routers have been evaluated for IPv6 Ready Logo and EAL-3 certification. C-DOT router has already been certified by international body for IPv6 ready logo. The testing for EAL-3 certification has been completed by STQC.

So, the project has already met the desired objective.

5.2.3.3 Secured network solutions: Enhancements and trial (VoIP based secure network)

The objective of the project was to upgrade Army's ATM based RED NETWORK to VoIPbased secure network.

Project Schedule	Timeline
RFP/Tender Issued by ARMY	June 2014.
Supply Order Issued by ARMY	29 Sept 2015
Last Date of Delivery	25 Jan 2016 (Within 16 weeks)
Last Date of Installation	25 April 2016 (Within another 16 weeks)
Costing of Project	• Total Cost of the Project (3 years warranty) (excluding AMC) = Rs. 16.63 crores + Taxes

		• Total AMC Cost (7years) = Rs. 9.10 crores + Taxes	
Payment schedule	Complete Delivery	40%	
	Installation & Testing	40%	
	Acceptance Testing & Training	10%	
	60 days after expiry of warranty	10%	

Intimation of Fore Closure from ARMY and C-DOT's response

First Indication of Foreclosure seeking explanation	14 June 2017
Intimation of Formal Foreclosure	22 Aug 2017
C-DOT's formal request for revocation of foreclosure	15 Sep 2017
Meeting held between SO-in-C and ED, C-DOT	21 Sep 2017
Additional trials conducted by C-DOT in Army Network	Nov 2017 onwards
C-DOT's reminder for seeking Army's response towards request for revocation of foreclosure	24 July 2018
Letter for C-DOT's consent on Army's proposal for upgrade to high-capacity exchanges with no financial implications and utilizing the items already supplied by C-DOT	20 Mar 2019
C-DOT's response to Army's Letter for consent	01 April 2019
Meeting between C-DOT and ADG(T)	12 April 2019
Revised response by C-DOT to Army after the deliberations during the meeting (C-DOT and ADG(T)	16 May 2019
Letter for options by Indian Army towards the disposal of items supplied as part of the foreclosed project	24 July 2019
C-DOT's response to Army's letter (for options)	16 Sep 2019
C-DOT's reminder letter to Army seeking their response to letter (16 sept)	27 Dec 2019

Current status of the Project:

A formal intimation of "FORECLOSURE OF PROJECT" was received from ARMY on 22 Aug 2017. The Project Team since then have been in continuous touch with ARMY staff to convince it to use the supplied equipment with some customization and addition of modules like LMG, PRI etc. An official letter was received from ARMY on 24 July 2019 in this regard and was considered by the C-DOT Board. A reply letter from C-DOT dated 16 Sep 2019 was sent to ARMY. As per this letter by C-DOT marketing team & duly approved by C-DOT board, it is communicated to ARMY that C-DOT has accepted option 3 among the options given by ARMY. As per option 3, C-DOT shall configure and install the softswitches supplied against the said Supply Order as 2000 subscriber exchanges at the locations to be chosen by Army. Army shall consider the payment of INR 2.5 Crore towards the cost of additional hardware necessary for such configuration over and above the cost of hardware already supplied till 17 Aug 2017.

C-DOT, since 16 Sep 2019, is waiting for the response from ARMY to initiate the activities as per additional requirements of 16K POTs line of ARMY demands. C-DOT has also sent a reminder letter on 27 Dec 2019 seeking their response. The project has been put on hold in terms of installation and deliveries and its resources shifted to some other priorities projects . After getting written intimation from Army regarding revocation of foreclosure or acceptance of supplied items along with additional hardware, the project can be revived with new deliverables and timelines.

The project is currently put on hold.

5.2.3.4 Secured network solutions: Enhancements and trial (Sleek Video IP Phone)

Based upon activities done under the sub-project on sleek Video IP Phone in FY2019-20 and the experience gained through development of past projects, a project proposal was submitted to NSCS for development of Quantum-safe Smart Video IP Phone. The same has received approval. Activities under the new project are over and above the activities under the sub-project Sleek Video IP Phone.

Therefore, all further activities shall be done under the project "Quantum-safe Smart Video IP Phone." The activities that are already completed, the equipment and the components purchased in FY2019-20 and the Lab infrastructure utilized by Sleek Video IP Phone sub-project in FY2019-20 shall be utilized in the new project. All the manpower deployed in the sub-project "Sleek Video IP Phone" shall also be shifted to the project "Quantum-safe Smart Video IP Phone."

Hence, it is proposed that the sub-project "Sleek Video IP Phone" defined under the project "Secured network solutions: Enhancements and trial" be closed.

5.2.4 Projects under program 'Centre of excellence'

Table 5.6: Closure of project 'Network steganography and network steganalysis'

(₹ *in crore*)

Program: Centre of excellence		
Executable project	**Project: sanctioned budget outlay**	**Projected cumulative expenditure till closure (31.03.2020)** (*provisional*)
Network steganography and network steganalysis	10.00	1.86
Open Source intelligence	15.00	12.05

Brief closure report of the above mentioned project is given below:

5.2.4.1 Network steganography and network steganalysis

Network steganography and network steganalysis are two very important areas in advanced network security of future telecommunications networks. Its application is especially in the scenarios where encrypted traffic is not allowed/blocked, as per the policies of intermediate network.

In this project, C-DOT has implemented network steganography and network steganalysis in a particular model variant of C-DOT Secure VoIP phone. It can facilitate the potential customers using this variant of C-DOT's secure VoIP phone to send and receive secure information and data over the

networks especially in the scenarios where user agencies do not have control over the security & encryption policies of the intermediate network.

Network steganography in VoIP phone to potential users demonstrated successfully. Identification and planning for customizations for prospective customers completed.

Enhancements in network Steganography implementation to implement customizations required by prospective customers completed.

The objective of the project met and the project will be continued under product design support from FY 2020-21.

5.2.4.2 Open source intelligence

The project has been started with the objective to design and develop various tools for analysis of socially networked persons by information extraction virtualisation and analysis, using NLP and data mining techniques.

The objective of the project fulfilled as expected and all the planned activities under the project as – design and development of short-text analytic tool with data collection from multiple social-media sites say, twitter, you-tube, linked-in and online news sites id collected, twitter data analysis for general metrics, sentiment, gender based distribution, popular discussed entities, user-mentions, hashtags and topics has been developed and delivered.

The technology and expertise developed as part of this project shall form the key basis for SESH project that shall be targeted to take the resultant product to market.

5.2.5 Projects under program 'Enabling technologies and telecom networks'

Brief closure report of the closed project is given below:

5.2.5.1 Prototype development of 5G MANO framework

The dynamism in 5G services demand agile networks. This makes programmability of network functions and automation in network management and orchestration as an essential requirement of 5G solutions. Network programmability can be achieved by technologies like virtualization, cloud, NFV, SDN, microservice architecture, edge computing and network slicing. MANO frameworks allow automation in orchestrating the services running over networks functions (PNF, VNF, HNFs) designed using these complex 5G technologies thus providing end-to-end consistent but differentiated services across 5G access, core and transport networks.

- MANO framework activities started in 2019-20. The details of work accomplished are as follows:

1. Management, Orchestration and Network Slicing portal for 5G testbed – This portal provides single window to manage all components deployed in 5G testbed including functional management (ems for both VNF&PNFs), VNFI management and orchestration/network slicing.

2. POC of transport network slicing in 5G testbed Network slicing in 5G testbed for transport was aimed at creating 'Network Slices' that provide defined quality of service. The framework provides inventory of 'Resources' for 5G testbed devices and Network Slices. A 'Slice Type' can be defined that is characterized by QoS parameters for each network function that is traversed for providing the service. For example, Slice-lora1, Slice-LTe etc. can be defined with QoS parameters for GPON, routers and DWDM nodes in 5Gtestbed scenario. To create Network Slice of any of these Slice Types, all these nodes get consistently configured with the desired QoS parameters. The framework is ready to be implemented in actual devices in 5G Testbed.
    a. Framework for transport network slicing for existing CDOT nodes (GPON, Router, DWDM)
    b. POC of framework in 5G testbed topology

3. POC of service life cycle management for devices supporting VNF or that can be migrated to VNF framework

    LCM Framework provide on-boarding, initiation, configuration, scaling, fault and termination of VNFs and services. The scaling is policy based and can be done using triggers (eg SNMP alarms from the node) or polling of some performance parameters. The framework implemented are ready to implemented in actual devices in 5G Testbed.

    a. Framework for LCM for a test service (Apache server – initiation, scaling, termination)
    b. Framework for LCM for CDOT IMS nodes
    c. POC for LCM for CDOT IMS nodes

5.3 Annexure-III: Projects being initiated during FY 2020-2021

5.3.1 Projects under program 'Telecom Application and Services'

(₹ *in crore*)

Technology program	Program: status		Program: estimated budget outlay	Program: cumulative expenditure till closure (31.03.2020) (*provisional*)
Telecom Service and Applications	Continuing		**120.00**	**86.52**
Executable projects	**Projected**		**Estimated budget outlay**	**Project: cumulative expenditure (till 31.03.2020) (*provisional*)**
	Duration (months)	**Effort (man-months)**		
C-DOT Converged Service Delivery Platform (C-CSDP)	24	328	16.00	NA

5.3.1.1 C-DOT Converged Service Delivery Platform (C-CSDP)

The objective the opjective is to to design and develop converged service delivery platform consisting of linear content receivers with IP streaming capability and an appropriate Digital Rights and Access Management system for secure content delivery for converged network.

Convergence of broadcast and broadband is going to be the distinguishing feature and USP for the operators in present and future scenarios; bringing together media and data coherently to the consumer. Convergence can happen at different points/planes in the overall network, starting from core network through distribution network, access network or at the end service reception/consumption entity. Traditional broadcast networks have some of the inherent advantages, such as low latency distribution of broadcast contents with relatively simpler electronics at both transmitter and receiver ends. Also there are broadcast contents already available freely (free of cost) from various distribution platforms of National Broadcaster. These advantages and existing isolated network scenarios can be leveraged upon to develop more meaningful products and solutions suitable for converging technology landscape and meeting the consumer expectations. A new converged service delivery platform is needed to bring in the enormous possibilities of infotainment from internet, along with broadcast contents on the same platform to experience many new innovative services. These innovative services will enable more user engagement with the content. Automatic and reliable TRP collection will be possible. Data analytics will become more prevalent to provide user centric advertisements and contents. As contents are becoming the driving force for the future converged networks, DRM (Digital Rights Management) plays a very crucial role in the value chain. At present DRMs are available from few developed countries with lot of restrictions on usage and imposes vendor locking of network elements. Hence a National DRM with ease of integration and open integration paradigm is also envisaged. A combination of linear and non-linear contents with appropriately enabled by open DRM will propel the future generations of converged networks and solutions. In the view of above , the project is proposed to be initiated in FY 2020-21

5.3.2 Projects under program 'Centre of excellence'

(₹ *in crore*)

Technology program	Program: status		Program: estimated budget outlay	Program: cumulative expenditure till closure (31.03.2020) (*provisional*)
Centre of excellence	Continuing		**80.00**	**32.78**
Executable projects	**Projected**		**Estimated budget outlay**	**Project: cumulative expenditure (till 31.03.2020) (*provisional*)**
	Duration (months)	**Effort (man-months)**		
Quantum Key Distribution	36	360	45	NA

5.3.2.1 Quantum Key Distribution

During the FY 2020-21, it is planned to initiate the development of OKD (Quantum Key Distribution) .

With the rapid advancement in quantum computing and in the area of quantum algorithms (which can run over quantum computers), the traditional methods of securing the communication, widely in use now, are no longer secure from an adversary having access to quantum computers. This is primarily because of the fact that the algorithms employed in present day methods (like Diffie Hellman Key Exchange) are based on assumptions that it is virtually impossible, even for the most advanced classical computers, to carry out certain mathematical functions (like prime factorization of a very large integer) in a reasonable amount of time. However, this assumption is no longer valid with quantum computers, which can potentially carry out these operations very quickly (like Shor's algorithm for prime factorization)

The objective of the project is to design and develop "Quantum Key Distribution (QKD)" for securing communication links, carrying critical and sensitive information, from eavesdropping by an adversary, even if the same possesses infinite computational power. The QKD system proposed to be developed will, thus, provide Information Theoretic security to existing communication links by providing identical keys on two distant locations. These keys can then be used by the application entity to encrypt the data before it is launched in the medium. Any attempt by an adversary to eavesdrop on the key will be detected by the QKD system itself, which can then stop the generation of key to prevent sensitive data from being leaked to the adversary.

5.3.3 Project Under program 'Next generation mobile technology'

(₹ *in crore*)

Technology program	Program Status		Program estimated budget outlay	Program cumultive expenditure till closure (31.03.2020) *(provisional)*
Next generation mobile technology	Continuing		500.00	130.9
Executable projects	**Projects**		**Estimated budget outlay**	**Project cumulative expenditure (till 31.03.2020)** *(provisional)*
	Duration (months)	**Effort (manmonths)**		
Development of 5G standalone core network system and data Plane and Analytics	24	1800	85.00	NA

5.3.3.1 5G standalone core network (SA) system and data plane analytics

During the FY 2020-21, it is planned to initiate the development of 5G standalone core network system(SA) and data plane analytics under next generation mobile technology program.

LTE networks have been widely deployed and increasingly standardized new deployments are going on. Meanwhile, the telecom world has started exploring what 5G should be, mechanisms to implement it and the potential services.

The typical scenarios that 5G is expected to address higher traffic in office and residential areas, higher densities in subways, malls, stadiums, etc, high-speed mobility for highways, high-speed trains, etc. The services that are expected to be provided are mobile internet service for video streaming, cloud storage and usage services, virtual reality, augmented reality, IoT services like smart home, smart grid, ITS, surveillance, etc. The critical scenarios and the technology enablers that have been identified are:

Critical scenarios:

- eMBB, enhanced mobile broadband
- uRRLC ,Ultra-reliable, low latency connections
- mMTC ,massive to machine type communication

Key technology enablers for 5G: The 5G Standalone Core Network architecture is defined to support data connectivity and services enabling deployments to use techniques such as e.g. Network Function Virtualization and Software Defined Networking. It shall use service-based

interactions between Control Plane (CP) Network Functions. Some key principles and concept are to:

- Separate the User Plane (UP) functions from the Control Plane (CP) functions, allowing independent scalability, evolution and flexible deployments e.g. centralized location or distributed (remote) location.

- Modularize the function design, e.g. to enable flexible and efficient network slicing.

- Wherever applicable, define procedures (i.e. the set of interactions between network functions) as services, so that their re-use is possible.

- Enable each Network Function and its Network Function Services to interact with other NF and its Network Function Services directly or indirectly via a Service Communication Proxy if required. The architecture does not preclude the use of another intermediate function to help route Control Plane messages (e.g. like a DRA).

- Minimize dependencies between the Access Network (AN) and the Core Network (CN). The architecture is defined with a converged core network with a common AN – CN interface which integrates different Access Types e.g. 3GPP access and non-3GPP access.

C-DOT is working on incorporating parts of its packet processing technology used in the routers/switches program into the 5G solutions as pluggable Network Interface Card (NIC) based 'accelerators' in standard servers using the common standard called Peripheral Component Interconnect Express (PCIe) used widely in the IT world.

Additionally, with the advent of Software Defined Networking (SDN) and Network Function Virtualization (NFV) the traffic patterns in networks are becoming increasingly on-demand and dynamic. Predictability traffic patterns and therefore the reconfiguration of virtual network topologies at the network and transport levels will become too complex for manual reconfiguration. Alternate network resource optimization mechanisms based on optimization, not dependent on human intervention, need to be evolved for the contemporary and future communication networks. Embedding deep learning into the 5G mobile and wireless networks is one of the techniques to utilize the network efficiently. Knowledge of the past traffic pattern and volume and its variation with time and events can enable the service provider to dynamically reconfigure the network resources on demand without manual intervention. Historical analysis of the traffic pattern can also help early detection and mitigation of any suspicious network activity like Denial of Service (DoS) attacks.

In view of above, there is definite need for examining the network data to determine the detailed shape of the communication streams, the identities of the communicating end points, and what can be established about their location in the network. Simply knowing what typical communication patterns look like, can be used to infer information about a particular observed communication, undertake indigenous developments for network probes for telemetry data in next generation routing systems.

This project will focus on developing a high performance data plane software for the upcoming 5G Converged Core project. Under this program, C-DOT will develop applications for accelerating 5G data plane, its security and telemetry probes for data analysis.

With this technology developed, C-DOT will be able to handle both the Control Plane and Data Plane traffic using common server hardware. This would have two major advantages:

- It will provide low cost advantage of volume pricing leading to low CAPEX

- Communication networks will be able to use the same common set of tools and techniques as those used widely for managing IT services leading to a much lower OPEX.

5.3.4 Projects under program 'National security council secretariat (NSCS) Projects'

National Security Council Secretariat (NSCS), a Gov.t of India agency has granted administrative approval and funding to C-DOT for following two Cyber Security Research & Development projects that will lead to development of network security products that can be potentially used by Strategic Government agencies.
The Projects are:

1. PINE: Post-Quantum Inline Network Encryptor

2. Quantum-secure Smart Video IP Phone

The project proposals for these projects were submitted by C-DOT to NSCS in Dec 2019 under the category of projects that involve Research, Development & Engineering (R, D&E) leading to production capability. Subsequently in Jan 2020, C-DOT team also gave presentations on these projects to NSCS Project evaluation committee. The Projects got approved by NSCS's High powered committee (HPC) on Cyber-Security R&D in March 2020. These projects will be periodically reviewed by a Project Review & Monitoring Committee (PRMC) that shall be formed by NSCS. The funds utilized in these projects shall also be audited by NSCS.

5.3.4.1 Post-Quantum Inline Encryptor (PINE)

Under Quantum-safe-cryptography Project, C-DOT developed a product called Compact Encryption Module (CEM). This product is an IP-layer Encryptor, which apart from classical encryption & key exchange algorithms also supports Quantum-safe key exchange algorithms. In order to enhance throughput and security, C-DOT also started working on implementation of Quantum-safe-algorithms in FPGA. Based on the experience gained through those activities, a project proposal was submitted to NSCS for development of an FPGA based IP Encryptor product. This resulted in sanction of PINE Project for 2 years duration.

5.3.4.2 Quantum-secure smart Video IP Phone

C-DOT has a prior experience in development of a Secure Voice over IP Phone product. C-DOT also has experience in the area of Post-Quantum cryptography algorithms under Quantum-safe-cryptography project. Additionally, in FY2019-20, C-DOT worked on a product 'Sleek Video IP Phone' under the Project "Secure Network Solutions: Enhancements & Trials". Combining the experience gained in these past projects, C-DOT submitted a project proposal to NSCS for "Development of Quantum-Secure Smart Video IP Phone". The proposal got approved resulting in this project sanctioned for one year duration.

5.4 Annexure-IV: Justifications for revised estimates

5.4.1 Satellite Based Technologies

(*₹ in crore*)

Technology program	Status	Estimated budget outlay	Proposed revision in estimated budget outlay	Cumulative expenditure (till 31.03.2019) (*provisional*)
Satellite Based Technologies	Continuing	**60.00**	**90.00**	**67.55**
Executable projects	**Status**	**Sanctioned budget outlay**	**Proposed revision in sanctioned budget outlay**	**Cumulative expenditure (till 31.03.2019) (*provisional*)**
1. Digital Video Broadcasting (DVB)-S2	Continuing	10.00	20.00	7.07

Satellite hub baseband Satellite hub system (phase-1) development was initiated as a joint development project between CDOT and DEAL. The system was developed and delivered to DEAL, which was integrated with satellite and terminals.
Carrier-grade hub baseband system (phase-2) with redundancy has been developed and delivered to the customer.

During the FY 2018-19, another development program DVB-S2 has been initiated. DVBS-2 is a second generation satellite digital video broadcasting technology, a successor of the popular DVB-S system. A number of major satellite broadcasters and DTH operators use DVB-S2, in conjunction with MPEG-4 advanced video coding, for the delivery of HDTV462 services. Realisation of hub baseband system based on DVB-S2 standards requires the development of multiple DVB-S2 modulators and MF-TDMA de-modulator units with multichannel capability supporting different selectable modulation schemes and configurable channel coding. It also requires the development of IF units.
In DVBS-2, System requirements and architecture finalized. Customer concurrence awaited. Algorithms simulations completed for DVB-S2 modulator and MF-TDMA demodulator.
Prototype Testing for Modulator and Demodulator in-progress. Development ongoing for Enhanced boards with ATCA (Advanced Telecommunications Computing Architecture) form factor.

During the FY 2020-21, it is planned to carry out , integration and testing of enhanced DVB Hub baseband system consisting of DVB-S2 modulator, MF-TDMA demodulator units and IF units

Also, a new program 'Satellite based broadband solution (C-Sat-Fi) has been initiated under Satellite-based technologies. During the FY 2020-21, the efforts will on the PoC, Trials, deployment of C-Sat-Fi v1.0.

In view of the above activities planned in FY 2020-2021, the allocated budget for 'Satellite hub baseband' project needs to be appropriately enhanced from ₹60.00 crores to ₹90.00 crores. Subsequently, the budget of Digital Video Broadcasting (DVBS-2) is also proposed to be revised from ₹10.00 crores to ₹20.00 crores.

5.5 Annexure-V: Joint ventures and operative MoUs with strategic partners

A. Joint ventures

Table 5.6: Joint ventures

#	Program	Executable project	Organisation concerned	Country	Purpose
1	Wireless and mobile communications	Broadband wireless access global research centre	Alcatel-Lucent	France	Setting up of joint global research centre for development of mobile broadband wireless access system.

B. MoUs and project agreements

Table 5.7: Operative MoUs

#	Executable project	Organisation concerned	Purpose
A	**Next Generation Mobile Technology**		
1.	Academic Interaction on 4G and 5G technology		
1a	4G and 5G technology development	IIT Bombay, India	Joint collaborative research projects in the areas of 4G and 5G.
1b	4G and 5G technology development	MOU Ghana	Development of a reliable and cost effective world class communications infrastructure and services in Ghana.
1c	In the field of Visible Light Communication and Light Fidelity (Li-Fi)	MOU with the University Court - University of Edinburg, Scotland	• R&D on High Speed Access Points on Li-Fi technology for Access and Backhaul • R&D of Hybrid Network Architecture for Li-Fi and Wi-Fi Interoperability and co-existence with traditional cellular network. • R&D in the area of Handover management & load balancing techniques in Li-Fi network • R&D in the area of Modulation Techniques to increase the data rates of optical links for Li-Fi network. • R&D in the area of Channel modelling for Li-Fi network • R&D of Solar panel Li-Fi receiver architecture and design.
2	Development of 4G / 5G		
2a	Development of 5G	IIT Roorkee, India	5G technology and related communication system
2b	Development of 5G	NUICC	Manufacturing and delivery of innovative and advanced telecommunication products/services to customers and service providers
2c	Development of 5G	Federal Ministry of Comm. Nigeria	Synergizing Indian Research and development solutions and services to customers and service providers in Nigeria with the support from 'Telesuprecon FZE (and Associate Companies)'
2d	Development of 5G	IIT Madras	• High frequency RF modules • Air Interface layer 1 Algorithm and

#	Executable project	Organisation concerned	Purpose
			optimization • Massive MIMO baseband algorithm
2e	Development of 5G	MOU with CSIR CEERI, Pilani	• MmWave technologies • Last-mile connectivity • High data-rate communication • Augmentation and establishment of fabrication and testing facilities • 5G use-case-specific devices and component fabrication • Edge-automation platform • IoT-enabled smart sensors • M2M common service platform
2f	Development of 5G	IIT, Hyderabad, India	Joint collaborative research projects in the areas of 4G, 5G, WiFi, Wireless PHY, SDN, NFV.
2g	Development of 5G	Centre of Excellence in Wireless Technology (CEWiT), IIT Madras, ndia	Joint collaborative research projects in the areas of 4G/4G-Adv, 5G, WiFi, Wireless PHY (Physical layer of the OSI model), Wireless solutions in various domains
B	**Enhancements, upgradations, adaptations and technical support for developed technologies**		
1	Applicable to all relevant projects	Bharat Electronics Limited (BEL), India	Framework for R&D, manufacturing, creation, delivery of solutions, services and support.
2	Applicable to all relevant projects	Mahanagar Telephone Nigam Limited (MTNL), India	Co-operative framework for R&D, manufacturing, operation and delivery of equipments.
3	Applicable to all relevant projects	ITI Limited	Synergy between R&D efforts and expertise in manufacturing, creation and delivery of innovative telecommunication services and support activities of mutual interest.
4	Applicable to all relevant projects	Telecommunications Consultants India Limited (TCIL), India	Cooperation for delivery of telecom products.
5	Applicable to all relevant projects	Genesys Corporation, Japan	For exploring and working together on joint Information and Communication Technology projects.
6	Applicable to all relevant projects	TCIL and ITI Limited, India	Synergizing R&D, manufacturing and delivery of innovative and advanced telecommunication products and services to customers and service providers around the world with special focus towards developing countries.
7	BBWT, GPON	Intelligent Communication Systems India Limited (ICSIL), India	• Deployment of C-DOT BBWT in near vicinity of NCR/urban India for building smarter networks. • To monitor, configure and manage telecom network elements for optimal performance. • Use of C-DOT GPON variants for extending connectivity to urban and rural NCR/Delhi.
8	BBWT, GPON, GyanSetu	M-Tech Nigeria Limited, Nigeria	• Deployment of C-DOT BBWT variants, high-speed access points, WiDHWAN. • Deployment of C-DOT GyanSetu.

#	Executable project	Organisation concerned	Purpose
			• Use of C-DOT GPON variants, network management SW and network planning solutions in M-Tech network.
10	BBWT, WiDHWAN, LTE-A, GPON	Telesuprecon FZE, UAE	• Deployment of C-DOT BBWT variants, high-speed access points, WiDHWAN and LTE-A. • Use of C-DOT GPON variants, network management SW and network planning solutions in Telesuprecon network and projects.
11	C-DOT's wireless, optical products and SW solutions	MOU Telecon, Cambodia	Synergising Indian research and development efforts in telecommunication with delivery and implementation of C-DOT's innovative and advanced telecom solutions and services to customers and service providers in Cambodia.
12	Creation of advanced technologies for establishing secure high-speed communication network and services	Centre for Artificial Intelligence and Robotics (CAIR), Defence, India	For establishing secure high-speed communication network and services.
13	Design support for developed technologies – ATM	BEL and Integrated Head Quarters, Ministry of Defence (Indian Navy), India	Establishing a frame-work for co-operation in development, production and deployment activities relating to ATM technology products.
14	Geo-intelligence	Space Applications Centre, ISRO, Ahmedabad, India	pment of web-based GIS using high-resolution satellite data to monitor and intercept cellular mobile communications.
15	Geo-intelligence and technology planning for NOFN, NMS for NOFN	Bharat Broadband Network Limited (BBNL), India	Establishing a frame-work for cooperation in telecommunication R&D, creation and delivery of innovative telecommunication services and support activities relating to the telecommunication equipment management and services.
16	MAX-NG technology roll-out in BSNL network	BSNL, India	Implementing the migration of PSTN-based C-DOT's MAX and RAX systems to VoIP-based C-DOT's MAX-NG systems, in the BSNL network.
17	Engaging Consultant for OSINT Program	Centre of Excellence program, IIT, Delhi, India	Method and Apparatus for Multilingual and multi modal keyboard search in mixlingual speech corpus
18	LTE-A, WiFi 5G development,	MTNL and ITI Limited, India	Development, delivery and deployment of IoT and smart city vertical solutions, WiFi hotspot, FTTH, VAS to cater to the requirements of various smart cities.
19	MAX and RAX support	BSNL, India	Technical support for C-DOT DSS in BSNL network.

#	Executable project	Organisation concerned	Purpose
20	NGN roll-out in MTNL network	MTNL, India	• Delivery of converged voice, video, data and multimedia services to MTNL's landline and mobile broadband subscribers • Upgradation of IP/MPLS core network in MTNL Delhi and Mumbai
21	SDCN	MTNL, India	Roll-out of SDCN services in Delhi region.
22	Conditional Access System (CAS)	MOU with Broadcast Engineering Consultants India Limited (BECIL)	To work jointly and formalize an understanding between BECIL and C-DOT to work jointly on projects in the field of IT/ICT and communication systems for Conditional Access System (CAS)
C	**Communication and security research and monitoring**		
1	CMS	National Technical Research Organisation (NTRO), India	Joint R&D for shared interests and mutual benefits.
2	CMS national roll-out	BSNL, India	For infrastructural work of RMC DC.
3	CMS national roll-out	BSNL, India	Provision of MPLS services for CMS project.
4	CMS national roll-out	MTNL, India	For infrastructural work of RMC DC at Delhi and Mumbai.
5	R&D for security management for Law Enforcement Agencies : CMS	Centre for Artificial Intelligence & Robotics, (CAIR), Defence, India	• For IP multimedia system (IMS) • Integration with CMS
D	**Synergizing efforts of various public sector understanding and autonomous bodies under DOT for increasing operational efficiency.**		
1	In the field of IMS/EPC Converged Network Core; IP/MPLS Core Routers and 5G	Addendum to MOU dated 22.02.2018 with MTNL, India	• Delivery of converged voice, video data and multimedia services to MTNL's landline and mobile broadband subscribers • Upgradation of IP/MPLS Core Network in MTNL Delhi and Mumbai • To conduct 5G Trials as per guidelines and format issued by DOT.
E	**Synergizing Indian Research and Development efforts in telecommunication with delivery and implementation of C-DOT's innovative and advanced telecommunication solutions and services to manufacturers and customers**		
1	In the field of IT infrastructure for fibre and wireless networks, NMS, CDOT XPON variants, IoT, M2M, NGN	MOU with Burundi Backbone System, Burundi, Africa	• To establish ICT Industry base in Burundi Backbone System • Broadband delivery in Burundi Backbone System • To monitor, configure and manage the communication elements in Burundi Backbone System for optimal performance. • For extending connectivity in Burundi Backbone System. • Technology based planning of suited telecom network architecture for rural Burundi backbone system. • C-DOT will advise/assist as needed in providing Smart City Solutions for Burundi

#	Executable project	Organisation concerned	Purpose
			Backbone System. • Wi-Fi technology enhancement and roll outs, optical aggregation access system, NGN. • Consultancy Services, advice and assist as needed in selection of technologies and planning and implementation. • Advise/Assist as needed in establishment of Centre for Excellence at Burundi Backbone System.
F	**NMS technology for NOFN**		
1	National Optical Fiber Network (NOFN) also called BharatNet - NMS for PAN-India roll-out of the NOFN	Extension of MOU through project agreement with BBNL, India	C-DOT's customized Network Management Solutions (NMS) for PAN-India roll out of the National Optical Fiber Network (NOFN). However, the project is not yet complete and development and testing of the EMS-NMS integration with Non-CDOT GPON vendors is in progress.
2	NOFN – For providing broadband connectivity to the rural areas initially by laying incremental fiber cable from nearby blocks.	MOU with BBNL, India	• To monitor configure provision and manage BBNL Network as per signed agreement dated 22.04.2014 • To provide integrated tools for fault localization • Field trial of new GPON technologies in BharatNet and to provide the support for implementation of GPON based networking solutions • To provide software solutions for structured rule based transparent business interactions across stakeholders of BharatNet Project • To provide converged NMS solutions for integration of State lead NMSs/EMSs of Multi-vendor systems with centralized NMS Systems (UNMS) of BBNL • Extending the use of broadband delivery from ONT and Use for point to point and point to multipoint communication.
G	**Centre of excellence for Lawful interception**		
1	Open Souce Intelligence	IIT, Delhi, India	Collaborative project on multi-lingual and multi-modal keyword search in a mix-lingual speech corpus.
2	Post-Quantum Cryptography	IIT Ropar, India	Commercial Hybrid post-quantum SW implementation planned in VoIP, IP encryptor along with an FPGA based post-quantum implementation on an FPGA reference board.

C. ToT agreements signed with prospective manufacturers

Table 5.8: ToT agreements

#	Strategic partner	Purpose
1	Bharat Electronics Limited (BEL), Bangalore	Terabit Router
2	Bharat Electronics Limited (BEL), Bangalore	DSP platform for transcoding (NGSP)
3	Bharat Electronics Limited (BEL), Kotdwara	MAX-NG
4	Indian Telephone industries (ITI), Mankapur	MAX-NG
5	Instrumentation Limited (IL), Kota	MAX-NG
6	Himachal Futuristic Communications Limited (HFCL)	BBWT
7	System Controls Technology Solutions Pvt. Limited, Bangalore	BBWT
8	Advanced Numerical Research and Analysis Group (ANURAG), DRDO	• Router HW platform development • Router stack porting, customisation and validation
9	Department of IT and e-Governance, Govt of Jharkhand	Establishing a framework for cooperation in joint research, development, manufacturing, creation and delivery of innovative telecommunication services and support activities related to telecommunication equipment and services
10	CSC e-Governance Services India Limited	Joint execution of development and commercial deployment of projects of mutual interest
11	Telekom Kenya	Cooperation in delivery and implementation of C-DOT's telecom solutions and services in Kenya
12	Central Electronics Ltd	Supply, installation, testing and commissioning of roof-top on-grid solar power plant system on buildings at C-DOT Delhi and Bengaluru centres
13	Global IEEE Institute for Engineers, Bengaluru	To work jointly in the areas of common interest
14	Mahanagar Telephone Nigam Limited (MTNL)	Rollout of Secure Dedicated Communication Network in Delhi region
15	Foundation for Innovation and Technology Transfer (FITT), IIT Delhi	Development of SW tool for performing image analytics such as detection and recognition of faces in images and videos
16	Kaynes Technology India Private Ltd (12 September 2018)	ToT of C-DOT GPON
17	Kaynes Technology India Private Ltd (16 August 2018)	ToT of C-DOT BBWT (WiFi) family of systems and PDO.
18	Bharat Electronics Kotdwara (17 September 2018)	ToT for Solar WiFi technology (IP65), Solar WiFi technology (IP67), High Speed Access point, High Speed Access point (IP67) (Outdoor)
19	CSC Wi Fi Choupal Services India Pvt ltd (22 May 2018)	ToT for C-DOT Gigabit Passive Optical Network (G-PON) System

5.6   Annexure-VI: Acronyms

Acronym	Expansion
0-9	
3D	3-Dimensional
3G, 4G, 5G	3rd, 4th, 5th Generation (wireless communication technology)
3GPP	3rd Generation Partnership Project
6LoWPAN	IPv6 over Low-power Wireless Personal Area Network
A	
AAA	Authentication, Authorisation and Accounting
ABSA	Aspect-based Sentiment Analysis
ADN	Application Dedicated Node
ADN-AE	Application Dedicated Node – Application Entity
AE	Application Entity
AI	Artificial Intelligence
ANURAG	Advanced Numerical Research and Analysis Group
API	Application Program Interface
ASN	Application Service Node
ASN-AE	Application Service Node – Application Entity
AT	Acceptance Testing
ATM	Asynchronous Transfer Mode
B	
BBNL	Bharat Broadband Network Limited
BBWT	BroadBand Wireless Terminal
BE	Budget Estimate
BECIL	Broadcast Engineering Consultants India Limited
BEL	Bharat Electronics Limited
BGP	Border Gateway Protocol
BSNL	Bharat Sanchar Nigam Limited
BTS	Base Transceiver Station
C	
CACU	Centralised Access Control Unit
CAD	Computer-Aided Design
CAIR	Centre for Artificial Intelligence and Robotics
CAM	Computer-Aided Manufacturing
CAP	Common Alerting Protocol
CapEx	Capital Expenditure
CAS	Conditional Access System
CBDT	Central Board of Direct Taxation
CBI	Central Bureau of Investigation
CCSP	C-DOT Common Service Platform
CDC	Central Data Centre
C-DOT	Centre for Development of Telematics
CDR	Call Detail Record
CEIR	Central Equipment Identity Registrar
cEPC	Cloud-based Evolved Packet Core
CERT	Computer Emergency Response Team
CERT-In	Computer Emergency Response Team - India
CERT-Telecom	Computer Emergency Response Team – Telecom (sectoral)
CGRAN	Compact GSM Radio Access Network
cIMS	Cloud-based IP Multimedia System

Acronym	Expansion
CiSTB	C-DOT interoperable Set-Top Box
Cloud-RAN	Cloud-based Radio Access Network
CMC	Central Monitoring Centre
CMMI	Capability Maturity Model - Integrated
CMS	Centralised Monitoring System
CNN	Convolutional Neural Network
CoAP	Constrained Application Protocol
CoE	Centre of Excellence
CoMP	Coordinated Multi-Point
CPE	Customer Premises Equipment
Covid	Corona Virus Disease
CSC	Common Service Centre
CSE	Common Service Entity
CSF	Common Service Functions
CWC	Central Water Commission
D	
D2D	Device-to-Device
DC	Data Centre
DC	Direct Current
DDoS	Distributed Denial-of-Service
DEAL	Defence Electronics Application Laboratory
DG	Diesel Genset
DNS	Domain Name Registration
DoD	Department of Defence
DoE	Department of Electronics
DoS	Denial-of-Service
DoT	Department of Telecommunications
DPR	Detailed Project Report
DR	Disaster Recovery
DRAX	Data Rural Application Exchange
DRDO	Defence Research and Development Organisation
DRM	Digital Rights Management
DRM	Disaster Risk Mitigation
DST	Department of Science and Technology
DTH	Direct-To-Home
DVB-S	Digital Video Broadcasting (using) Satellite
DVB-S2	Digital Video Broadcasting (using) Satellite – 2nd generation
DWDM	Dense Wavelength Division Multiplexing
E	
EAL	Evaluation Assurance Level
EIR	Equipment Identity Register
eKYC	Electronic (based) Know Your Customer
EMF	Electro-Magnetic Field
eMMTC	Enhanced Massive Machine Type Communication
EMC	Electromagnetic Compatibility
EMS	Element Management System
eNodeB	Evolved Node B
EPC	Evolved Packet Core
ETL	Extract Transform and Load
ETSI	European Telecommunications Standards Institute

Acronym	Expansion
EWP	Early Warning Platform
EWS	Early Warning System
F	
FAT	Factory Acceptance Testing
FBMC	Filter Bank Multi-Carrier
FDD	Frequency-Division Duplexing
FFLS	Fibre-Fault Localisation System
FMCP	Fixed and Mobile Converged Platform
F-OFDM	Fiiltered Orthogonal Frequency Division Multiplexing
FPGA	Field-Programmable Gate Array
FTTH	Fibre-to-the-Home
FY	Financial Year
G	
Gbps	Gigabits per second
GBS	Gross Budgetary Support
GHz	Giga Hertz
GIS	Geographic Information System
GMPLS	Generalised Multi-Protocol Label Switching
GPON	Gigabit Passive Optical Network
GPRS	General Packet Radio Service
GR	Generic Requirements
GRIHA	Green Rating for Integrated Habitat Assessment
GRU	Gated Recurrent Unit
GSI	Geological Survey of India
GSM	Global System for Mobile communications (*originally* Groupe Speciale Mobile)
GSMA	Groupe Special Mobile Association
GUI	Graphical User Interface
H	
HAP	Home Access Point
HD	High Definition
HRS	Hardware Requirements Specification
HSCC	Hospital Services Consultancy Corporation Limited
HSS	Home Subscriber Server
HTTP	Hypertext Transfer Protocol
HW	Hardware
I	
IB	Intelligence Bureau
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
IF	Intermediate Frequency
IGW	Internet-of-Things Gateway (card)
IIT	Indian Institute of Technology
ILA	In-Line Amplifier
ILD	International Long Distance
IM	Intelligence Manager
IMCL	IndusInd Media and Communications Ltd
IMD	Indian Meterological Department
IMEI	International Mobile Equipment Identity
IMS	Internet Protocol (based) Multimedia Subsystem
IMSI	International Mobile Subscriber Identity

Acronym	Expansion
IMT-2020	International Mobile Telecommunications – vision for 2020 and beyond
IN	Infrastructure Node
IN	Intelligent Networks
IN-AE	Infrastructure Node - Application Entity
INCOIS	Indian National Centre for Ocean Information Services
IN-CSE	Infrastructure Node – Common Service Entity
IoT	Internet-of-Things
IP	Internet Protocol
IP65	Ingress Protection 65
IP67	Ingress Protection 67
IPDR	Internet Protocol Detail Record
IP-DSLAM	Internet Protocol Digital Subscriber Line Access Multiplexer
IPFIX	Internet Protocol Flow Information Export
IPR	Intellectual Property Right
IPTV	Internet Protocol based Television
IPv6	Internet Protocol version 6
IRI	Interception-Related Information
ISF	Interception Store-and-Forward
ISP	Internet Service Provider
ISRO	Indian Space Research Organisation
IT	Information Technology
ITI	Indian Telephone Industries
ITS	Intelligent Transport System
ITU-R	International Telecommunication Union – Radiocommunication
ITU-T	International Telecommunication Union – Telecommunication
J	
JSS	Joint Services Specifications
K	
KSWAN	Karnataka State Wide Area Network
L	
L2/L3	Layer-2/Layer-3
LAG	Line Access Gateway
LAGU	Line Access Gateway Unit
LAN	Local Area Network
LCT	Local Terminal
LDPC	Low Density Parity Check
LEA	Law Enforcement Agency
LEMF	Law Enforcement Monitoring Facility
LoRA	Long Range
LNB	Low Noise Buck
LSA	Licensed Service Area
LSTM	Long Short-Term Memory
LTE	Long Term Evolution (of universal terrestrial radio access network)
LTE-A	Long Term Evolution – Advanced
LTE-Femto	Long Term Evolution – Femto (cell)
LWM2M	Lightweight Machine-to-Machine
M	
M2M	Machine-to-Machine
MAN	Metropolitan Area Network
MANO	Management and Network Orchestration

Acronym	Expansion
Massive MIMO	Massive Multiple Input Multiple Output
MAX	Main Automatic Exchange
MAX-NG	Main Automatic Exchange - Next Generation
Mca	oneM2M defined reference point interfacing CSE and AE
MDT	Minimisation of Drive Test
MEA	Ministry of External Affairs
MHA	Ministry of Home Affairs
MF-TDMA	Multi-Frequency Time Division Multiple Access
mmWave	Millimeter Wave
MIB	Ministry of Information and Broadcasting
MIMO	Multiple Input Multiple Output
MN	Middle Node
MN-AE	Middle Node - Application Entity
MoU	Memorandum-of-Understanding
MPLS	Multi-Protocol Label Switching
MQTT	Message Queuing Telemetry Transport
MSISDN	Mobile Station International Subscriber Directory Number
MSO	Multiple System Operator
MTBR	Multi-Terabit Router
MTC	Machine-Type Communication
MTCTE	Mandatory Testing and Certification of Telecom Equipments
MTNL	Mahanagar Telephone Nigam Limited
MU-MIMO	Multi-User Multiple-Input Multiple-Output
MUSA	Multi-User Shared Access
N	
NAE	Network Application Entity
NB-IoT	Narrowband Internet-of-Things
NAIR	National Academy of Indian Railways
NBI	North-Bound Interface
NCB	Narcotics Control Bureau
NCR	National Capital Region
NDA	Non-Disclosure Agreement
NDMA	National Disaster Management Authority
NDRF	National Disaster Response Force
NE	Network Element
NELCO	National Radio and Electronics Company
NFV	Network Function Virtualisation
NGN	Next Generation Networks
NGN-IN	Intelligent Networks (services) in Next Generation Networks (platform)
NGPON2	Next Generation Passive Optical Network (TWDM-based hybrid PON)
NIA	National IB Academy
NIC	National Informatics Centre
NIC	Network Interface Control
NIST	National Institute of Standards and Technology
NIU	Network Interface Unit
NKN	National Knowledge Network
NLP	Natural Language Processing
NMS	Network Management System
NOC	Network Operation Centre
NOFN	National Optical Fibre Network

Acronym	Expansion
NOFN-NMS	Network Management System for National Optical Fibre Network
NOMA	Non-Orthogonal Multiple Access
NR	New Radio
O	
O&M	Operation and Maintenance
OCN	Optical Core Network
ODN	Optical Distribution Network
ODU	Optical Data Unit
OEM	Original Equipment Manufacturer
OFC	Optical Fibre Cable
OLT	Optical Line Termination
ONT	Optical Network Termination
ONT-R	Optical Network Termination – Ring (architecture)
ONU	Optical Network Unit
OpEx	Operating Expense
OS	Operating System
OSA	OpenAir Interface Software Alliance
OSINT	Open Source Intelligence
OTDR	Optical Time-Domain Reflectometer
OTN	Optical Trunk Network
OTT	Over-the-Top
P	
PAN	Personal Area Network
PCB	Printed Circuit Board
PCI	Prime Custodian of Interception
P-CMM	People Capability Maturity Model
PCR	Priority Call Routing
PCT	Patent Cooperation Treaty
PDMA	Pattern Division Multiple Access
PDO	Public Data Office
PHY	Physical layer (of the OSI (Open System Interconnection) model)
PI	Power Integrity
PI	Product Integration
PIC	PON Interface Card
PIN	Personal Identification Number
PO	Purchase Order
PoC	Proof-of-Concept
PON	Passive Optical Network
PoP	Point-of-Presence
POTP	Packet Optical Transport Platform
PPDR	Public Protection and Disaster Relief
PQC	Post-Quantum Cryptography
PSTN	Public Switched Telephone Network
PSU	Public Sector Undertaking
PVDG	Photo-Voltaic DC Generator
Q	
QA	Quality Assurance
QKD	Quantum Key Distribution
QoS	Quality-of-Service
R	

Acronym	Expansion
R&D	Research and Development
RAN	Radio Access Network
RAX	Rural Automatic Exchange
RE	Revised Estimate
RF	Radio Frequency
RFP	Request for Purchase
RHEL	Red Hat Enterprise Linux
RHP	Reconfigurable Hardware Processor
RLAN	Radio Local Area Network
RMC	Regional Monitoring Centre
ROADM	Reconfigurable Optical Add-Drop Multiplexer
RRH	Remote Radio Head
RSVP-TE	Resource Reservation Protocol – Traffic Engineering
RTS	Roof-Top Solution
S	
SAU	Service Access Unit
SAVAAR	Specialised Architecture for Value-Added Application of Router
SCAMPI-A	Standard CMMI Appraisal Method for Process Improvement – Class A
SCMA	Sparse Code Multiple Access
SDCN	Secure and Dedicated Communication Network
SDH	Synchronous Digital Hierarchy
SDK	Software Development Kit
SDN	Software Defined Networking
SESH	Sentiment, Emotion, Sarcasm, Hate-speech
SG-RAN™	Shared GSM Radio Access Network
SI	Signal Integrity
SI	System Integration
SPIC	System Planning and Implementation Centre
SIM	Subscriber Identity Module
SITC	Supply, Installation, Testing and Commissioning
SM	Subscriber Management
SMS	Short Message Service
SOC	Security Operation Centre
SOHO	Small Office Home Office
SOP	Standard Operating Procedure
SoW	Scope-of-Work
SPV	Special Purpose Vehicle
SRS	Software Requirements Specification
STB	Set-Top Box
STBR	Stackable Terabit Router
STR	Simultaneous Transmission and Reception
STQC	Standardisation Testing and Quality Certification
SW	Software
T	
TAX	Trunk Automatic Exchange
Tbps	Terabits per second
TBR	Terabit Router
TCIL	Telecommunication Consultants India Limited
TCP	Transfer Control Protocol
TCS	Tactical wireless Communication System

Acronym	Expansion
TDD	Time-Division Duplexing
TDM	Time Division Multiplexing
TDMA	Time Division Multiple Access
TEC	Telecommunications Engineering Centre
Telco	Telecommunication Company
TETRA	Terrestrial Trunked Radio
TIFR	Tata Institute of Fundamental Research
TLF	Toll-Free
ToR	Top-of-Rack
ToT	Transfer-of-Technology
TRAI	Telecom Regulatory Authority of India
TRP	Target Rating Point
TSDSI	Telecommunications Standards Development Society, India
TSP	Telecom Service Provider
TV	Television
TWAG	Trusted WiFi Access Gateway/ Trusted Wireless Access Gateway
TWDM	Time and Wavelength Division Multiplexing
TWDM-PON	TWDM-based Passive Optical Network
U	
UAN	Universal Access Number
URL	Uniform Resource Locator
URLLC	Ultra-Reliable and Low Latency Communication
USOF	Universal Service Obligation Fund
USP	Unique Selling Point
V	
VAS	Value-Added Service
VCC	Virtual Calling Card
VoIP	Voice over Internet Protocol
VSAT	Very Small Aperture Terminal
W	
WAC	WiFi Access Controller
WAN	Wide Area Network
WANI	WiFi Access Network Interface
WDAN	Wavelength-based Distribution and Aggregation Network
WDM	Wavelength Division Multiplexing
WiDHWAN	Wireless Data connectivity at Home using Wireline Access Network
WiFi	Wireless Fidelity
WiPS	Wireless Phone Secure
X	
XGS-PON	10 Gbps Symmetrical Passive Optical Network (TDM/TDMA-based)
XG-PON	10 Gbps Passive Optical Network (TDM/TDMA-based)
Y	
Z	

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