Bhutan Telecom

Gross National Happiness Commission

Royal Government of Bhutan

Project Completion Report
On
The Project for Optical Fiber Techniques in Telecommunications Engineering

February 2017

Bhutan Telecom Limited

AND

Japan International Cooperation Agency

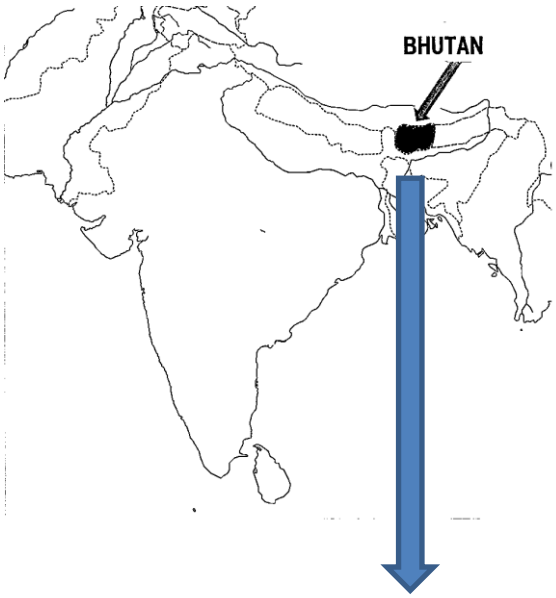
JAPAN RECOM Ltd.

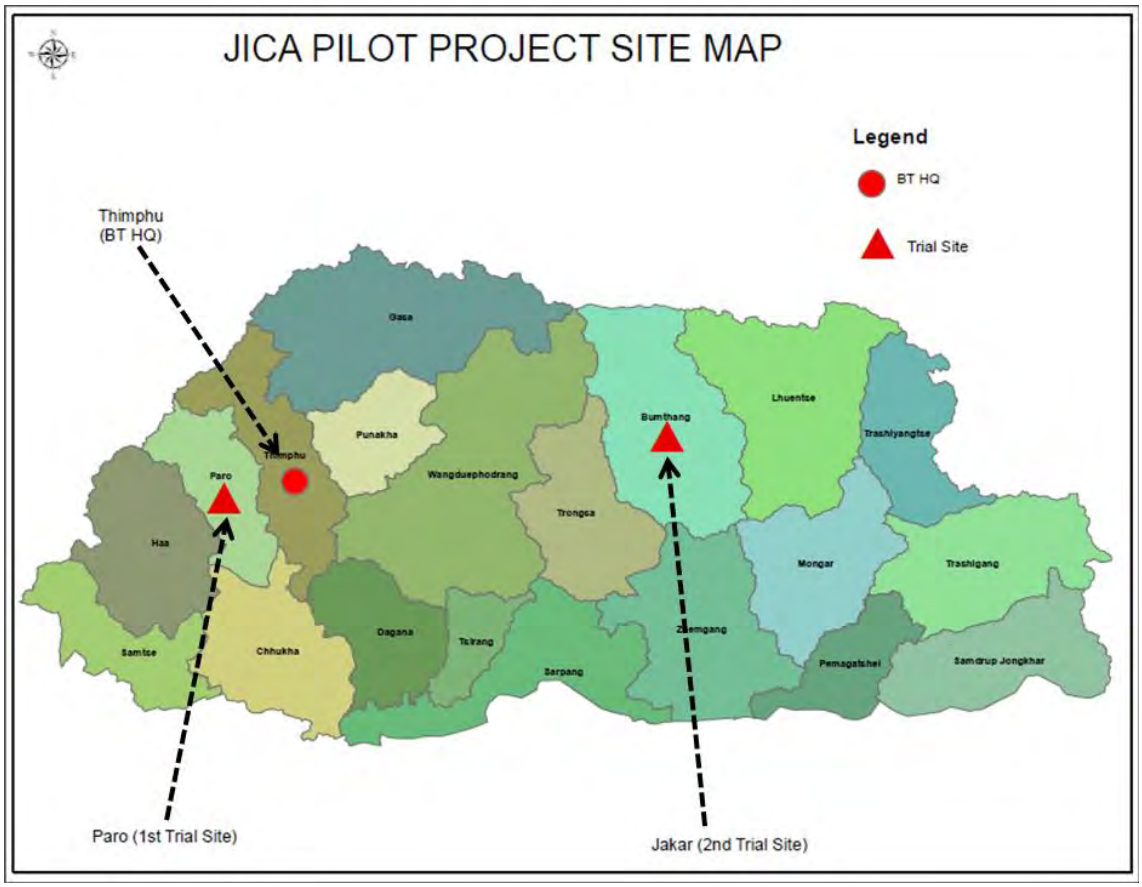
PANTEL INTERNATIONAL CO., LTD.

MIRAIT Technologies Corporation

EI
JR
17-017

Project Location





Abbreviations

BT	Bhutan Telecom Ltd
C/P	Counterpart
CA	Chief Advisor
CEO	Chief Executive Officer
FTTB	Fiber To The Building
FTTC	Fiber To The Curb
FTTH	Fiber To The Home
FTTX	Generic term optic fiver access technology
GE-PON	Gigabit Ethernet-Passive Optical Network
GIS	Geographical Information System
GNHC	Gross National Happiness Commission
G-PON	Gigabit-Passive Optical Network
GPS	Global Pointing System
ICT	Information and Communication Technology
IT	Information Technology
JCC	Joint Coordinating Committee
JICA	Japanese International Cooperation Agency
MM	Minutes of Meeting
MoIC	Ministry of Information and Communication
NGN	New Generation Network
O&M	Operation and Maintenance
OPGW	OPtical fiber composite Overhead Ground wire
PDM	Project Design Matrix
RD	Record of Discussion
SDH	Synchronous Digital Hierarchy

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I. Basic Information of the Project

1.1 Country

The Kingdom of Bhutan is a landlocked country of 38,000 sq.km in area with about 700,000 inhabitants, located in the easterrn end of the Himalayas. About half of the territory runs over a steep terrain above 3000 m above sea level. 70% of the country is covered with forest containing virgin forests. Its pristine environment has vegetation varying from subtropical to coniferous forest, to alpine vegetation zone as the altitude increases.

Bhutan is known well among the world as the country of GNH (Gross National Happiness), and aiming to realize a society driven by no economy development but people's happiness.

Bhutan has maintained very good relation with Japan through exchanges between the royal families and other economic cooperation.

Cities and towns in Bhutan are located in valleys between steep mountains and isolated from each other. The development of telecommunications network is important for these communities to be unified each other and realize the social inclusion. The project aims to strengthen the engineering capability in Optic Fiber Network in order to enhance the e-government service over the country, which is now being implemented by the Government.

1.2 Title of the Project

The project was named as "PROJECT FOR OPTICAL FIBER TECHNIQUES IN TELECOMMUNICATIONS ENGINEERING" based on R/D signed in October 2013.

1.3 Duration of the Project (Planned and Actual)

The Period of implementation was 3 years based on the R/D.

Plan: April 2014 to February 2017.

Actual: April 2014 to March 2017

1.4 Background (from Record of Discussions(R/D))

The Domestic Long-distance Communications Transmission Network (City to City) was completed by installing the Digital Microwave System initially through Grant Aid by Government of Japan in the year 1991-1998. With ever-growing penetration of Internet and technology innovation in the world, demand for broadband services such as multimedia communications, which requires high-speed connectivity between users, began to grow even in a small country like Bhutan. Foreseeing that this demand for high-speed data will continue growing and given the fact that the legacy copper networks will not be able to cater to such demands, BT started to introduce the Optical fiber cable (OPGW) links & NGN-SDH System in late 1990s. BT now has OPGW fiber connecting all the

Dzongkhags (districts) in Bhutan.

With the establishment of OPGW fiber links to all Dzongkhags, transmission capacity on the national backbone is no more a challenge. BT has been however facing challenges in delivering high-speed/broadband in the Local/Access Network (intra city) since majority of BT's access networks are still on the legacy copper networks. In keeping with the government policies to promote use of ICT in the country and ever-increasing growth in the consumption of data, it was felt imperative that BT would need to deploy fiber in the access network. BT however does not have adequate experience in developing optical fiber access network in intra city.

Nonetheless, to be able to meet the demands from both government and private agencies, BT had to introduce optic fiber technology such as Fiber-to-The Cabinet, Fiber-to-The Building, Fiber-to-The Home (FTTC/FTTB/FTTH). In order to materialize the introduction, existing BT engineers needed to obtain skills on planning, designing & implementing fiber networks.

1.5 Overall Goal and Project Purpose (from Record of Discussions(R/D))

The project was implemented based on the Project Design Matrix (herein after referred to as PDM).

Prior to the start of the project, the Chief Advisor (CA) notified its commencement to BT executives, related officers of Ministry of Information and Communication, followed by discussions with major BT members over the draft of the Work Plans. The initial Work Plan was prepared based on the result of "Detail Planning

Survey on the Project for the Optical Fiber Techniques in Telecommunication

Engineering" conducted in Sep. 2013. The business environment of BT changed and the initial Work Plan was necessary to modify to meet the BT's business plan before Project started in April 2014.With the change of BT's business, the Work Plan, PDM, handover materials and machines and equipment were reviewed and modified or altered, and then those revised documents were accepted at the 1st JCC meeting, and then the project started. Refer ANNEX 1-4 gives JCC MM.

1.5.1 Overall Goal

Unified ICT network is provided in Bhutan.

1.5.2 Project Purpose

Capacity of BT's engineering in optical fiber access network design, construction, and maintenance will be developed.

1.6 Implementing Agency

Bhutan Telecom Limited

Refer ANNEX 1-6 gives Project implementation framework.

2 Results of the Project

2.1 Results of the Project

2.1.1 Input by the Japanese side (Planned and Actual)

2.1.1.1 Amount of input by the Japanese side:

Inputs from the Japanese side among others included the following for which the total cost is estimated at 200 million Japanese Yen. In terms of planned inputs versus actual, there were no major deviations

2.1.1.2 Dispatch of Experts (Total short-term experts including CA may be only 6)

6 persons: No change for Planned and Actual.

- One Long term Expert (Chief Advisor/FTTX Technology, Safety work), and
- Five short term Expert (FTTX design, FTTX construction, GIS/GPS operation FTTX R&D, Broadband Application).

Refer ANNEX 1-1 gives each Dispatched Experts

2.1.1.3 Short-term Training in Japan

A total of 12 BT employees attended training in Japan in two separate batches during the month of April 2015 and 2016 respectively. Number of participants was increased from 5 to 7 in the second training because it was felt important that BT's executives got exposure to Japanese broadband service features, business models, operation and maintenance framework to aid BT's future business. Refer ANNEX 1-3 gives List of training.

(1)First training course in Japan

The first batch of 5 participants attended training in Japan in the month of April 2015 for 10 days from 6-17 April 2015.

In November 2014, the CA prepared the curriculum for the 1st training course in Japan incorporating the feedbacks of BT executives and taking into account the skill levels of the C/Ps. Home support team in Japan arranged the companies and lecturers participating in the training along with the curriculum. Table 2 gives an outline of the training course.

Table 1 Outline of 1st Training Course

Name of Course	Training on Strengthening Capacity of Optical Fiber Engineering for Bhutan Telecom
Duration	Apr. 6, 2015 – Apr. 17, 2015
No. of trainees	5 persons in charge of outside plant engineering and operation and maintenance
Objective	To understand Japanese FTTX access network engineering and operation & maintenance methods

After returning to Bhutan, the trainees presented the result of training to the BT executives and managers. In the presentation, it was highlighted that BT needed opportunities to grasp the approach for FTTX access broadband services through the presentations, and therefore this requirement was taken into account in the 2nd training course.

(2) Second training course in Japan

The 2nd training for 7 participants was done in Apr. 2016 for 8 days. The main objective of the 2nd training was to familiarize BT's management members on the various Japanese broadband services, supporting technology, operation and maintenance system, research and development works, etc. The learning from this training would help BT in the formulation of its FTTX access network development strategy as well as other measures pertaining to broadband services.

Table 2 Outline of 2nd Training Course

Name of Course	Training on Strengthening Management Capacity on Optical Fiber Technology for Bhutan Telecom
Duration	Apr. 6, 2016 – Apr. 15, 2016
No. of trainees	7 persons from Management level of Bhutan Telecom
Objective	To understand FTTX facility management and movement of FTTX broadband service and technology innovation

After returning home, the participants commented that the training was very useful for Bhutan Telecom to cope up with the developing trend in the broadband access network as well as services.

Photo 1 Scene of 2nd training in Japan

2.1.1.4 Equipment Provision

One of the major components of the project constituted of equipment and machineries for experiment

works for which the total cost including the in-house training was JPY27 million. The lists of machines provided are given in the table 4 and more details on each is furnished in ANNEX 1-4.

Table 3 Major Machines and Equipment procured

No.	Item	Qty	Specification	Recipient	Cost (Yen Million)
1	Construction Vehicle (Splicing-VAN)	1	TOYOTA Hi-Ace Super VAN	BTL	5.7
2	Small excavator	1	JCB Back Loader	BTL	3.9
3	Fiber welding machine	2	Fujikura 12R	BTL	2.2
4	Machines and devices related to GIS/GPS system	1 Set	GIS Pathfinder, Hybrid Computer	BTL	2.4
5	Materials for Experiment Work (optical cable, construction tool, safety equipment etc.)	1 set	UG fiber cable, Closure, OTDR	BTL	13.2
	Total				27.4

2.1.1.5 Overseas Activity Cost

Overseas activity cost includes mainly consumable goods, printing materials, communication expense etc. Detail breakdown on the costs are as seen in Table 5.

Table 4 Overseas activity Cost

No.	Item	Cost (JPY thousand)	Remarks
1	Vehicle related expenses	190	Vehicle rent for short-term expert
2	Consumable goods	180	Paper for Printing, photocopy, etc.
3	Communication expense	25	Mailing, mobile phone for experts
4	Printing cost	65	Materials for JCC meeting, etc. Biding manuals
5	Other expense	430	Materials for experiment works, Rent fee for workshop, etc.
	Total	890	

2.1.2 Input by the Bhutan side (Planned and Actual)

2.1.2.1 Counterpart assignment

At the Kickoff meeting in May 2014, BT assigned 7 counterparts for the Project and JCC members

accepted the assignment. These counterparts were in the capacities of Project Director (Director Technical), Project Manager (Manager, Operation Div.) and the rest 5 staffs from access network sections of the Operations Division. During the project period, 3 counterparts were changed due to retirement or promotion. Table 6 gives the list of counterparts and engagement period.

Refer ANNEX 1-2 gives each List of counterparts

2.1.2.2 Provision of office:

Office space for the project was allocated in the Western Region, Thimphu with necessary furniture and equipment including a mobile device as well as Internet connection.

2.1.2.3 Other items borne by BT:

- Support for obtaining on-site permission for Japanese experts, tax exemption certificate for vehicle/equipment were provided/
- Some running expenses for project implementation such as utility payment and some consumable items were provided
- Provide transportation vehicle to project site when visiting local offices.

2.1.3 Activities (Planned and Actual)

Actual Activities are given the following Table 5 and Refer ANNEX 1-5 gives WorkPaln/Activity.

Table 5 Actual Activities

Output	Description of activities
Output 1 <Three technical manuals (*1) are developed.>	Activity 1-1: To collect information regarding actual technical standards and design guidelines of optical fiber in Bhutan, Activity 1-2:To develop solution guideline, clarifying problems inwork procedure and identifying solutions for each problem, Activity 1-3: To conduct experiment work according to the guideline, Activity 1-4: To review and evaluate the experiment work, Activity 1-5: To elaborate manuals reflecting the result of experiment work.
Output 2 <O&M system is developed>	Activity 2-1:To verify existing equipment including GIS/GPS system and check their conditions of deterioration, Activity 2-2:To identify problems in operation and maintenance system related to the fiber optical network in Bhutan, Activity 2-3:To develop guideline of equipment substitution and calculate annual budget to keep good condition of it, Activity 2-4: To conduct technical guidance through local training for engineers working at BT headquarters office and local telephone exchange station.

Output 3 <Experiment work in trial sites (two areas) is completed>	Activity 3-1: To conduct site survey as a preparation for the experiment work. Activity 3-2:To design and plan the experiment work including identification of necessary equipment and budget Activity 3-3:To carry out the first experiment work in the Paro (*2) following the plan, Activity 3-4: To review and evaluate the first experiment in order to plan the second experiment work, Activity 3-5:To carry out the second experiment work in Jakar(*2), Activity 3-6:To review and evaluate the second experiment.

*Remarks (*1): 1.FTTX design/construction manual, 2.Quality inspection and FTTX specification manual, 3. Safety work management manual*

*(*2): Sites of experimental works in the actual phase were changed from Phuentsholing to Paro and from Mongar to Jakar with JCC's approval*

2.1.3.1 Activities for Output 1

(1) Development of Guideline for Specification, inspection and safety work (Activity 1-1)

According to an interview from May to June in 2014 with the C/P, BT did not have instruction manual on technical standards of fiber optic cables, safety management guidelines, etc. For example, BT usually procured machines, materials, equipment, or equivalent items every time after examining proposals from venders.

After explaining to related staffs through the C/P that, to ensure quality telecom service it is very important to adopt and maintain standard technical specifications for materials to be procured, fundamental specifications and pertinent know-hows have been incorporated in the technical manuals.

(2) Developing Technical Manuals for Design, Inspection, and Safety Work (Activity1-2, 3)

In June 2014, CA assigned the persons for developing the technical manuals, prepared developing schedule, and formed the Progress Meeting on developing the manuals in order to manage the progress.

On July 25, 2014 CA delivered the lecture and exercises on the outline of FTTX technology to the related engineers based on the result of pre-assessment. (Refer to ANNEX 2-3 for the visual aids)

Photo 2 Scene of FTTX lecture

C/Ps successfully develop the draft version of the Manual taking into account experience and learning from the 2 trial sites of Paro and Jakar, in particular, on the construction and safety management fronts. Further, lessons learned from the two training courses in Japan on the FTTX R&D movement, latest operation methods, Quality Control, etc. helped the C/Ps in the development of the technical manuals. To track the progress, several meetings were held on the development of manuals through which comments and feedbacks on further improvements were gathered. Final drafts of the manuals were circulated to the Regional Managers of BT's exchanges and the feedbacks received from them have been incorporated. (Refer ANNEX 2-3)

In Nov. 2016, 3 manuals were developed and combined into Technical Manual consisting of Design (37 pages), Construction (35 pages), Safety Work (8 pages), and Specification and Quality Control (19 pages). The manual has been already delivered to the working level at each telephone office and is being used by the technical staffs. The manual is submitted to JICA as one of the outputs of the project. Refer ANNEX 2-9 gives FTTX manual.

2.1.3.2 Activities for Output 2

(1) To verify existing equipment including GIS/GPS system and check their conditions of deterioration (Activity 2-1)

BT has been managed and administrated cupper cable access network on paper basis. In coming FTTX access network phase, those works are inevitable to digitalize by using GIS/GPS information when considering accurate and effective facility management. So, CA instructs BL to cope with migrating from paper-based management to computer-based one.

(2) FTTX Facility management by GIS/GPS sys (Activity 2-1, 2-2)

The CA conducted a lecture on the purpose of FTTX access network system management and how having it would improve operational efficiency. Through this lecture, it was highlighted that the FTTX management system is generally used for managing the network efficiently and effectively by digitizing the installed FTTX access facilities including topology, number of cores, used cores,

history of failures etc. Therefore BT has to digitize and store existing facility information, and this work started from May 2015. From Jun. 2016 to Jul.2016, BT started to add the geographical information as instructed by GIS/GPS short-term expert. Prior to the geographical data input exercise, the expert assessed the skill level(*3) of two BT staffs in charge of data base, and shared knowledge and techniques on how to operate GPS devices, store collected data in to a server through a practical work. The expert also left behind guidelines for BT to follow in future.. Refer ANNEX 2-1 gives GIS O&M Guidelines.

After this practical work, the expert re-assessed the skill level of BT the staffs. The result of assessment is given in the table.

Table 6 Skill level assessment Pre- and Post- instruction

Staff (Period of GIS experience)	Readiness (Jun.10,2016)	Improved level (Jul.21,2016)
Staff in 10 year experience	9/10	10/10
Staff in 0.5 year experience	6/10	9/10

*Remarks (*3): Basic knowledges of staffs on GIS were assessed with a question-answer sheet before and after the lecture/OJT training*

(3) To develop guideline of equipment substitution and calculate annual budget to keep good condition of it (Activity 2-3)

GIS expert presented Outline of GIS for BTL's executives to understand the importance of GIS/GPS system in O&M works over the optical fiber access network and make those works more efficient and effective in July 2016, and then BT secured the budget as well as staffs. As result, BT decided to keep 2 staffs for GIS section, and was recruiting new staffs.

Photo 3 Scene of the Presentation on GIS

(4)Training on Operation and Maintenance System (Activity 2-4)

Since completion of 1st experimental work in Oct. 2015, BT has been expending FTTX access

network in the various exchanges across the country. However, BT staff had no experience in how to find out failures and cope up with those failures. Given this shortfall, the C/Ps guided by the CA started to develop the guidebook on how to cope with failures or troubles on the FTTX access network. The guidebook also provides ways and methods on how to examine/monitor and test the FTTX network components. The guidebook was used in the presentation mentioned in FTTX training (July.2016) above, and was delivered to all BT telephone office. Refer ANNEX 2-2 gives guidelines for Testing and Troubleshooting.

(5) In-house FTTX training course (Activity 2-4)

FTTX training course aimed to improve engineering skills of BT staff related to the outside plant section was scheduled from Jun. 2015 to Aug. 2015. But due to a delay in the delivery of training aids and tools, the training had to be deferred until the 2nd experimental work implementation was complete. With the consensus at the 2nd JCC meeting, the training was postponed to be implemented in Jul. 2016.

From Jul 18, 2016 to Jul. 22 2016, 17 engineers from various telephone offices of BT participated in the training at the BT headquarter. The C/P and BT staff who participated in the 2nd experiment work and GIS short term expert gave lectures on FTTX technology and engineering. Refer ANNEX 2-8 gives Result of in-house training.


Photo 4 Scene of FTTX Training

Further, the Chief Representative of JICA Bhutan Office gave a special lecture on “Leveraging Development Cooperation by Applying ICT”. The executives of BT who participated in the special lecture session made positive comment as “the lecture gave such clues as to how ICT technology can be applied in leveraging development works, and said it was very interesting” Refer ANNEX 2-8 gives Result of in-house training.

2.1.3.3 Activities for Output 3

(1)Preparation of JICA procurement list (Activity 3-1,3-2)

From May to October 2014, the CA and the short-term expert visited the 2nd trial site at Jakar. The

main objective of this visit was to carry out a field survey in order to grasp and prepare the list of necessary materials and machines for the 2nd trial site. Through this survey, necessary details on length of fiber cables, number of closures and other related materials were identified. Based on this compilation of bill of materials, procurement process was carried out from February to May 2015, and the consignments were shipped to Bhutan subsequently. Those materials were handed over to BT in Aug. 2015 after custom clearance in Jul. 2015.

Phot 5 Handover Ceremony (left) and Materials (right)

(2)1st Experiment Work (Activity 3-2, 3-3)

From Aug. to Nov. 2014, 1st experiment work was demonstrated in Paro with participation of FTTX short-term expert. The main purpose of the works carried out at the 1st trail site was to demonstrate to BT's technical team on how to improve BT's traditional engineering practice through monitoring, discussion, and recommendations. Through these discussions and onsite instructions on the best engineering practices such as estimating and designing network component capacities and quantities based on the forecasted demand from detailed surveys, the-then BT's engineering practices became more accurate and economical. Refer ANNEX 2-4 gives Construction Check point.

(Needs of protection from CATV cable) (Instructing how to protect from dust)

Photo 6 Improper cable lying and Instruction scene

(3) 2nd Experiment Work (Activity3-4, 3-5)

From Sep. to Oct. 2014, the CA and the Construction Expert instructed BT FTTX project staff how to measure and design the cabling work in Jakar. Based on the experience in 1st experiment work, BT staff conducted a basic design including demand survey, laying route, locations of cabinet placement, laying route of underground duct, and a detail design and construction plan (working plan and quantity of materials). The staff identified necessary quantities of optic fiber cables, closures, construction tools, etc.

From May to July 2015, BT staff under the guidance of the CA conducted a survey over the project area prior to the start of works of 2nd trial in order to lay cables smoothly and safely. The following preliminary works were also carried out to ensure smooth implementation of the works for 2nd trial site. Refer ANNEX 2-5 gives Preliminary site survey for the trial work.

- Checking the pass of underground ducts
- Removing mud and sand etc. in manholes
- Improving, repairing and protecting cabling facilities
- Instructing CATV companies to improve their cables on BT telephone poles, etc.

The materials and machines handed over to BT were transported to Jakar in late August 2015.

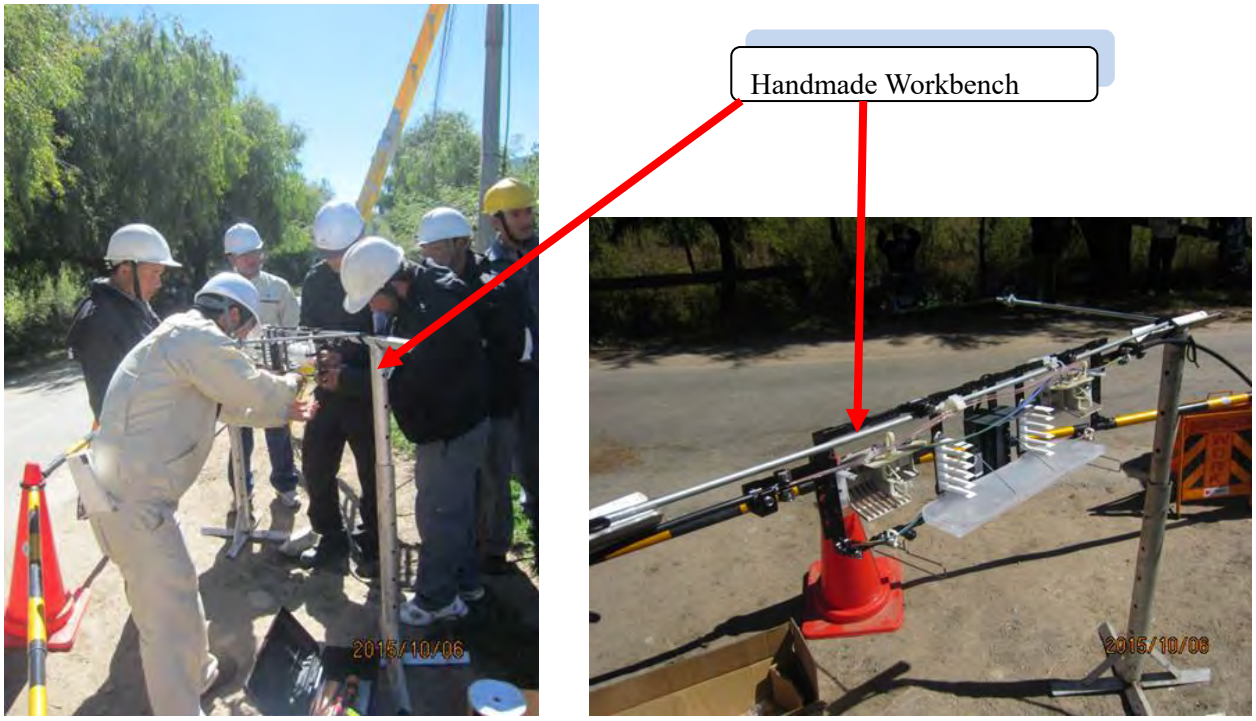
In Sep. 2015, the CA and the short-term expert gave 10 BT staffs a practical training at the site office on how to install new types of optic fiber cables, closures and other accessories. The actual installation works of the 2nd trial at Jakar started in Sep. 2015 and was completed on Oct. 20, 2015 well before the schedule. This was made possible with the support extended by the Manager of Jakar Telephone Office despite having to change cable laying route due to some road widening works. As soon as the trial fiber network was completed, BT started to provide broadband service on the installed optic fiber cable.

The CA, the short-term expert and BT staffs reviewed the works done and discussed items to be improved with the Work Completion Report prepared by the C/P

.Refer ANNEX 2-6, 7 gives Completion report and Feedback/comment report.

Phot 7 Scene of a practical training (left: Safety Belt, right: Ladder)

Phot 8 Scene of the Work (left: Morning Meeting, right: Cabling Work)



Phot 9 Scene of Optic Fiber Connection Work on Handmade Workbench

2.1.3.4 Overall Activities throughout project period

(1)JCC Meeting

For reasons of updating the progress of the project and getting endorsement on the changes in the activities, if any, 5 JCC meetings were convened during the entire project period. The JCC meetings were scheduled and held every 6 months the last and final of which was held on the 20th of January 2017. The meetings were coordinated and led by the counterparts. The progress reports including

issues and solutions if any, were presented to the JCC members by the project team led by the CA, Project Director and the Project Manager. .

Refer ANNEX 4 gives each JCC memo.

Major agenda at each JCC meeting is given in following table

Table 7 Agenda of JCC meeting

Meeting	Date	Agenda	No. of attendees	
			Bhutan Side	Japanese
1st	Jul. 2014	Approval on modified, Work Plan, handover items, experiment work sites （*1）, C/P responsible for GIS / GPS engineer(*2)	6	4
2nd	Jan. 2015	- developing method of manuals - confirming 1st training in Japan	5	4
3rd (*3)	Dec. 2015	- reporting 1st experiment work - progress of manual development	6	4
4th	Aug. 2016	- Results of 2nd training in Japan and in-house training - Outline of Workshop	8	3
5th	Jan. 2017	- Achievement of Project - Result of Monitoring Project	11	7

Remarks (1) Phuntsholing (Southern are of Bhutan) and Mongar (Eastern area of Bhutan) were scheduled for experiment works, but changing the locations to Palo and Jakar was accepted at 1st JCC meeting because of safety and public awareness. Experiment works actually were implemented in Palo and Jakar.

(2) C / P responsible for GIS / GPS had scheduled 3 people, but changed from BT current situation to 2 persons

. (3) Although 3rd JCC meeting was scheduled in Jul 2015, it was postponed to Dec. 2015 with consent of all JCC members due to the overlap with2nd Experiment work .

Phot 10 Scene of the JCC (left: 1st JCC, right: 2nd JCC)

(2) In-country tour FTTX training (4 Regional Telephone offices)

Each BT's telephone office has been so far developing FTTX access network at its responsible area in the countryside. The CA and one of the C/Ps carried out the training tour for complementing related staffs those who could not attend the FTTX course in Jul. 2016. The training included economical design, efficient and effective construction technique, safety work, etc. and was held at following Regional Telephone offices.

Refer ANNEX 2-9 gives each FTTX tour training Curriculum. .

- Western Regional office in Oct. 2016, 8 staffs participated in
- South-Western Regional office in Dec. 2016, 15 staffs participated in
- Central Regional office in Dec. 2016, 15 staffs participated in
- East Regional office in Dec. 2016, 19 staffs participated in

Phot 11 Scene of the In-country tour FTTX training

(3)Workshop in 2016

Workshop (IT seminar) was held on Nov. 30, 2016 in Thimphu with participants from Ministries, academic society, Bhutan Telecom, foreign telecommunications operators, and private companies in Bhutan. The purpose of the workshop was to introduce the JICA funded FTTX Project, and deepen

mutual understanding over ICT technologies and services, and promote cooperation between Japan and public and organizations in Bhutan such as Ministry Information and Telecommunications, telecommunications operators, universities, healthcare and medical institutions, etc. Refer ANNEX 2-10 gives Workshop agenda.

About 100 participants attended including Minister of Information and Communications, Chief Executive Officer of Druk Holding and Investments, ICT officers of Cabinet Secretariat, IT officers of Ministry of Health, Director of Disaster Prevention Bureau, Director of Department of Road, Chief Executive Officer of IT Park, an associate professor and a researcher of University of Medical Sciences of Bhutan, Executive Secretary of Thimphu City Office, Executive Researchers of NTT Laboratory, Senior Managers of International Relations, NTT East, Executives and managers of Bhutan Telecom, General Manager and staffs of JICA Bhutan Office and JICA experts to Bhutan, etc.

Major topics were;

- Case Study of e-Government by ICT officer of Cabinet Secretariat,
- Case Study of e-Education by Bhutan Royal University,
- IT Techno-park by a private sector,
- Outline of Fab Lab by JICA representative,
- Trend of FTTX R&D by NTT Laboratory,
- Applications on broadband network by NTT East, etc.

Each presentation was very much useful for Bhutan to promote and develop IT strategies for future, and there were active exchanges of opinions among attendants.

Refer ANNEX 1-7 gives IT workshop.

Media coverage of the workshop was taken up largely by the national broadcasting company, BBS and Kuensel, the national newspaper.

Phot 12 Scene of the Workshop (left: MoIC Minister, right: Participant)

2.2 Reaching level after Project

2.2.1 Outputs and reaching levels / Indicators

Achieved outputs and attained levels / indicators of the project are shown in Table 9.

Table 8 Reaching level at the completion of Project

Outputs	Index at Planning phase	Reaching Level
Output 1: Three technical manuals are developed.	Developed, printed 30 copies, delivered to each telephone office	December 2016: 30 copies were distributed to the head office and each local telephone office.
Output 2: O&M system is developed	1. 2(two) GIS/GPS operation engineers are trained. 2. 20(twenty) O&M operator of regional staff are trained.	June 2016: 2 GIS staffs were trained July 2016: Training was conducted to maintenance engineers of 17 telephone station. December2016: Complimentary training tours were conducted.
Output 3: Experiment work in trial sites (two areas) is completed.	FTTX is completed in two trial sites.	Work completion reports were submitted after trial work

Refer PDM in ANNEX 3 gives details.

2.2.1.1 Reaching level of Output 1

During the project period, the CA and the short term experts gave counterparts lectures on outline of FTTX technology time to time, instructions on implementing experiment works, and these counterparts also experienced trainings in Japan and during the experiment works. Discussions during regular project meetings helped gain knowhow and techniques which were incorporated in the following manuals:

- FTTX design of 37pages, FTTX construction manual of 35 pages
- Safety work management manual of 8pages
- Quality inspection and FTTX specification manual of 19 pages.

For reasons of easy transportation and convenient usage, the 3 technical manuals were compiled and combined into one volume named “Technical Manual”. 30 copies have been printed and distributed to all telephone offices of BT. Refer ANNEX 2-9 gives FTTX manual.

The technical manual was used as a textbook both during the in-house training held at BT headquarter and supplementary training for those staff of local offices who could not attend the in-house training.

This means Output 1 was achieved.

2.2.1.2 Reaching level of Output 2

Before starting the operation and maintenance improvement phase, number of staff assigned for GIS section was only one although the section operated and managed all of GIS facilities. It appeared that the manpower in the GIS section was inadequate considering work volume of operation, maintenance and digitalization of existing paper-based data. The CA explained the importance of the task of the section, and BT allocated one more staff to the section.

In July 2016 GIS/GPS short-term expert transferred knowledge to 2 staffs of the section on how to collect data, store obtained data into a database system, and use those stored data. This sequential process was compiled in a manual, and the manual was left with the GPS/GIS management section for reference during the digitalization of existing paper-based information. Digitalization of the 2 experiment works has been done.

Besides, CA held the training for operation and maintenance staffs at local telephone office at BTL headquarter, and those trainees work at O&M section of each telephone offices after training. As the follow-up training, CA and C/P had a tour of complimenting the each regional telephone offices in December 2016. At that moment trainees who participated in the

Headquarters' training, it was witnesses that they work as a core engineer at the office, and gave necessary instructions to his staffs. In the demand aspect, the expansion of FTTX access network progressed and FTTX subscriptions increases in number.

Those two figures indicate that the Output 2 is achieved.

2.2.1.3 Attained level for output 3

The target of the Output 3 was to complete 2 experiment works perfectly.

(1) 1st Experiment work in Paro

In Oct. 2014, the CA and a short term expert monitored BT's conventional engineering work performed by BT staff from the point of view of economic efficiency, accuracy, and safety work, and pointed out the problems in conventional processes and works, and instructed solutions on the spot.

(2) 2nd experiment work in Jakar

Jakar is located at an altitude of more than 3000m above sea level. Considering severe condition in winter season, the work started in Sep. 2015 and was completed in Oct. 2015 well in advance of the schedule. Staffs engaged in the 2nd work performed their tasks keeping in mind the key economic factors like optimal cost, efficiency, accuracy, and safer engineering practice. This was an indication that the BT staff acquired the knowhow and techniques transferred to them by the experts.

Refer ANNEX 2-6,7 gives each Completion Report and Feedback comment.

Since then, BT has been developing FTTX access network by itself. Table 9 gives the growth trend of FTTX connections.

Table 9 Movement of number of FTTX connections

Year	2013	2014	2015	2016
Paro Office Area	35	182	261	443
Jakar Office Area	0	0	429	489
Total of BT	1573	2829	6135	7485

Comparing the number in 2014 (before the work) with that of 2015 (after the work), the number of connections jumped up after the work. BT staff engaged in the 2 trial site works could have possibly acted as the core driving force influencing other BT staff to construct and provide more connections through FTTX network. This figure means that the output 3 was perfectly achieved.

2.2.2 Project Purpose and indicators

(Target values and actual values achieved at completion)

According to the last PDM on July 17, 2014, the Purpose of the project is to develop BT's engineering capacity of FTTX access network design, construction, and maintenance, while the Verifiable Indicator in PDM sheet stipulates that BT's Access Network team is to design, construct and maintain FTTX access network by themselves.

During project implementation period, C/P understood the FTTX technology, know-how, etc. through participating in BTL's internal meeting and first and second the training course in Japan , Because the completion reports and work inspection sheets prepared developed by the participants in trial works shows their attaining level (refer to ANNEX2-6, 2-7). After that, C/P implemented the in-house training course by themselves referring with the manuals which they developed. In addition results of pre- and post- assessment tests as well as their feedback clearly presents their attaining level (refer to ANNEX2-8)

Further, BT staff applied their capability in FTTX engineering knowhow obtained during the project period on expanding FTTX access network in the country, contributing to the national project named "Safe-City". The Safe City fiber network was designed and constructed by BT staff using the knowhow and skills gained through the trial works of the JICA FTTX project. BT staffs are handling the operation and maintenance of the Safe City fiber network, which connects all the surveillance camera of the capital city.

In this context, the purpose of the project is achieved.

2.3 History of PDM Modification

PDM sheet version 1 was settled at the 1st JCC meeting in Jul.2014. Version 0 was developed in Sep. 2013 during JICA's Detail Survey on the project, and at that moment Objectively Verifiable Indication for Overall Goal in version 0 was not yet settled. 1st JCC meeting settled and confirmed the indicator and made other descriptions more accurate in the sheet and settled as Version 1. After version 1 was settled, there was no modification in the sheet. ANNEX 3 gives each version of PDM

sheet.

Table 10 History of PDM

Version	Timing	Modification items
Version 1	1st JCC meeting (Jul.17, 2014)	- Objectively Verifiable Indication ・for Overall Goal was set as “more than 90”) ・for Output 2.1:changed the number of GIS/GPS operation engineer from 3 to 2. - Clarifying means of verification ・Means of verification of overall goal: Pointing out of MIC’s or BT’s annual report ・Means of verification of Objective: Adding evaluation of skill level check before and after trainings ・Pointing out of MIC’s or BT’s annual report ・Means of verification of Output: Printed the technical manual, feedback report on the technical manual, training reports, Work completion reports on.
Version 2	2nd JCC (Jan. 9, 2015)	- No change to Version1 - 3rd Meeting in Jul. 2015 was postponed to Dec. 2015 because of overlapping on experimental work
Version3	3rd JCC (Dec. 14, 2015)	- No change in PDM
Version4	4th JCC (Aug. 11, 2016)	- No change in PDM
Version5	5th JCC (Jan.20, 2017)	- No change in PDM

ANNEX 3 gives each version of PDM by JCC meeting.

2.4 Others

2.4.1 Results of Environmental and Social Considerations (if applicable)

Nothing was identified.

2.4.2 Results of Considerations on Gender/Peace Building/Poverty Reduction (if

applicable)

Not relevant to Gender/Peace Building/Poverty Reduction.

3 Results of Joint Review

3.1 Results of Review based on DAC Evaluation Criteria

The result of project is evaluated from the point of view of DAC Five Evaluation Criteria of "Relevance", "Effectiveness", "Efficiency", "Impact" and "Sustainability".

Where "Relevance" means how much PJ Purpose is valid to the Overall Goal, "Effectiveness" of how much PJ output benefits to BT, "Efficiency" of how efficient the Inputs to the Output, Impact of how much PJ purpose effects Cross-Cutting Issue under Overall Goal, and Sustainability of how long PJ effects BT's various works related to FTTX access network.

C/P and CA examined the Project as the Interim evaluation before last JCC meeting, and confirmed all of indexes were being cleared.

3.1.1 Examination prior to Last JCC Meeting

In the examination, both C/P and CA confirmed the achievement, process, Activities, Input by Bhutan and Japan side, Outputs, Objectives, Overall Goal, as well as BT's ownership for handed over machines and materials. The examination was done based on the DAC's 5 evaluation Items and then Lessons learned and recommendations described later were conducted. .

(1) Confirming Results

Inputs were done on schedule mostly as planned by both Bhutan and Japan side, although dispatch periods of short term experts were modified for meeting the shifted period of experiment works. 3 out of 7 assigned counterparts of BT were changed during the period because of their retirements or study abroad. But there was no serious problem due to immediate assignment of successors by BT.

(2) Situation of Outputs after Project completion

As for output 1, a draft version of the technical manual was developed by reflecting discussions at a regular manual development meeting, experiences of experiment works, latest information obtained in trainings in Japan, etc. on it.

The draft version was delivered to managers of telephone offices for collecting advices or opinions, and those were reflected in, and then the technical manual was developed in October 2016. 30 copies of the manual was printed, and delivered to related section of headquarter and local telephone offices. It is expected that the manual will be used as a reference book on designing and constructing FTTX access network.

As for Output 2, BT allocated one staff to GIS section before O&M phase started, which was felt inadequate given the operation & maintenance workload of the section. After discussion with BT executives on importance of the section for managing and operating a database system, collecting information, BT allocated 2 staffs to the section. The GIS short-term expert after his arrival in BT, checked the skill level of C/P and gave necessary instructions. He also developed a guideline and conducted trainings for related BT staffs. Facility data of O&M should be updated every day,

therefore CA advised time to time that it was important that BT kept 2 staffs for the section.

As for Output 3, which includes 2 experiment works, those were completed almost on schedule. Inspection check sheets on works and participation reports on works were submitted. Further broadband services became available in the areas where the trial works were implemented.[1]

A local hotel owner posted praising articles on a local newspaper.

(3) Situation of reaching revel

Output 1 to 3 were almost achieved and reached over Indexes, while participants in the project led FTTX design, construction and operation for BT's nationwide FTTX expansion. In this context, the objective of the project is understood to have cleared the target.

The summary of examination is given in the table 11

Table 11 Summary of Examination

No	Criteria	Evaluation	Description
1	Relevancy	High	Overall Goal is that Unified ICT network is provided, while BT will cover 90% of Dzongkhags (prefectures) in the country with Fiber Access Network Services by 2019. The bench mark comes from BT's 2012-2017 Five Year development Plan along with the 11th Five Year National Development Plan. Before starting PJ, BT didn't have any organized experience in FTTX access engineering work. After completion of PJ, BT can develop the FTTX access network by itself, which is the PJ purpose. This is evaluated that PJ purpose is thoroughly valid the Overall Goals. BT already has developed FTTX access network in 17 out of 20 Dzongkhags in the country as of end of Oct. 2016, while the ratio of introducing FTTX access network reached 85%. BT intends to continuously introduce the network more aggressively to meet the demand, and therefore it is not difficult for BT to cover 90% of Dzongkhags with FTTX access network. This means that the benchmark set as the index will be cleared by the end of 2019.
2	Effectivenes	High	Effectiveness is evaluated by 80% or more in achievement.

[1] *Voice communications is available on traditional cupper cable, but high-speed signals such as video, etc. are not due to the circuit loss. Optical cable, because of its lower loss and broadband character, enables to cover more distance. A hotel 8 km away from a telephone office in the trial was provided broadband services after the trial works.*

	s		3 outputs of developing 3 kinds of manuals, O&M system for FTTX access network, and 2 experimental works are perfectly effective to transfer FTTX engineering technique and knowhow. Chief Advisor and JICA experts held time to time lectures and gave necessary instructions, and then they showed how to cope with through their practical works, finally instructed BT's staff to experience the real works. This step-by-step process is very much effective to transfer this kind of techniques and knowhow.
3	Efficiency	High	Efficiency is evaluated by the relation of the input to obtained output. The project required and expended as same 170 million yen as planned, while PJ was started in Apr. 2014 and completed in Feb. 2017 as scheduled. 3 outputs of manuals, O&M system and 2 experiment works as well as 2 training courses in Japan were developed and implemented as scheduled. In other words, expected outputs were conducted or implemented successfully with planned budget and period, while the inputs were efficiently placed for outputs.
4	Impact	High	Impact is examined as relation between PJ Purpose and Overall Goal. The former is "BT's FTTX access network engineering capability was developed, while the latter is "90% of Dzongkhag is covered with FTTX access network by 2019". PJ also provided the necessary facilities as well as machines for engineering work. In this context, BT has got the power of design, construction and maintenance by itself. If there are demands for FTTX access subscriptions as well as budget allocation for procuring construction materials, BT can immediately deploy the network before 2019. FTTX access network engineering technology transfer is most useful for BT to realize unified ICT network covering 90% or more of Dzongkhag. As ripple effects or outcomes from PJ, it is expected that BT capability supports the government in developing e-government programs (G2C Project, e-education, e-health, etc.) and accelerates private establishments coping with developing IT and software industry in IT Techno-Park, etc.

5	Sustainability	High	The demand has been moving from ordinary voice communication to multi-media information exchange for telecommunications services. Therefore the cables of access network have also been replaced with FTTX from metallic one, and FTTX price for procurement becomes more economical compared with traditional metal cables. The government also requires BT to deploy broadband infrastructure over the country. Apart from institutional and policy constraint, BT has no choice but to select FTTX development in its access network. Chief Advisor and JICA experts left the techniques and knowhow to BT's staff, while those techniques and knowhow are compiled into manuals and opened for BT's staff, considering higher turnover rate of BT employees. It is expected that transferred technology will remain inside, and updated manuals by the staff according to the progress of FTTX technology. In addition, huge demand will brush up the skill of BT staff. Although BT's business is tight, the price of FTTX comes down gradually and it can charge necessary amount on subscriptions for sustain the broadband services.

3.1.2 Concluding Evaluation

Last JCC meeting evaluated the project in same method as the examination and concluded. The summary of result is given in following table 12.

Table 12 Summary of concluded evaluation result

No	Criteria	Result	Explanation
1	Relevancy	High	The objective realized with Japanese technology, techniques and knowhow, meets the national development plan, Japans cooperation policy. The objective is realized with Japanese technology, techniques and knowhow, meets the national development plan, Japan's cooperation policy
2	Effectiveness	High	Developing the manual and implementing trial works by BT's 17 staff settled the engineering, operation and maintenance knowhow in BT.

			BT staff can now independently plan/design, construct, operate & maintain with improved confidence and quality
3	Efficiency	High	JPY 170 million was invested for this 3-year project: April 2014 to February 2017 3 main outputs of the project, development of manual, operation & maintenance system, trial works were completed within schedule without any major hindrance, and overall objectives achieved
4	impact	High	Japanese best practices and knowhow on fiber optics engineering transferred through in-house trainings as well as trial works will have long-term positive impacts on: - BT's FTTX network development - Royal government's ICT initiatives in making public service delivery efficient. Thus, the overall goal is surely being attained.
5	Sustainability	High	Outside plant section of BTL has been installing, maintaining, operating access network since BTL's establishment. BT besides the JICA project has been deploying fiber in the access network replacing the legacy copper pairs to meet the increasing demand for high speed broadband Fiber is the future, and therefore outputs of this Optical fiber engineering project are here to stay as part and parcel of BT's FTTX networks.

3.2 Key Factors Affecting Implementation and Outcomes

In order to avoid risk factors influencing on the progress, the project members shared the possibilities of risks etc. with the working plan, PDM sheet etc. at the internal regular meeting. Although the project met the 3 retirements in members, BTL immediately assigned successors. And the schedule was kept as planned

3.3 Evaluation on the results of the Project Risk Management

JICA Bhutan office supported a smooth implementation of the Project in the form of monitoring activities of Project Team, coordinating with related organizations in sharing project progress and problems, and solving problems.

BT also took necessary actions immediately before the problems became worse. For example, Manager of Jakar Telephone office gave an outside civil engineering company the necessary advice

immediately to keep on track the schedule of 2nd experimental work. The laying route of the underground optic fiber cable had to be changed due to the construction of a building on the route identified in preliminary survey a year before the 2nd work.

3.4 Lessons Learnt

(1) Improving operation management method on existing facilities (Numbering on telephone poles)

BTL does not attach identification signs or plates on existing outside facilities such as telephone poles etc. unlike Japan because BTL has not many those. BTL probably increases outside facilities which should be managed by as the number of users grows in near future. Introduction identifying or numbering method into management of outside facilities is useful for BTL to carry out efficient operation and maintenance works.

After discussion with the counterpart on that managing method, BTL decided to start attaching numbering plates on telephone poles and plan to widen this to whole county following the trial construction.

Introduction of attaching numbering plats on poles, etc. enables BTL workers to identify easily applicable or appropriate facilities on the spot, and is expected to make works more efficient.

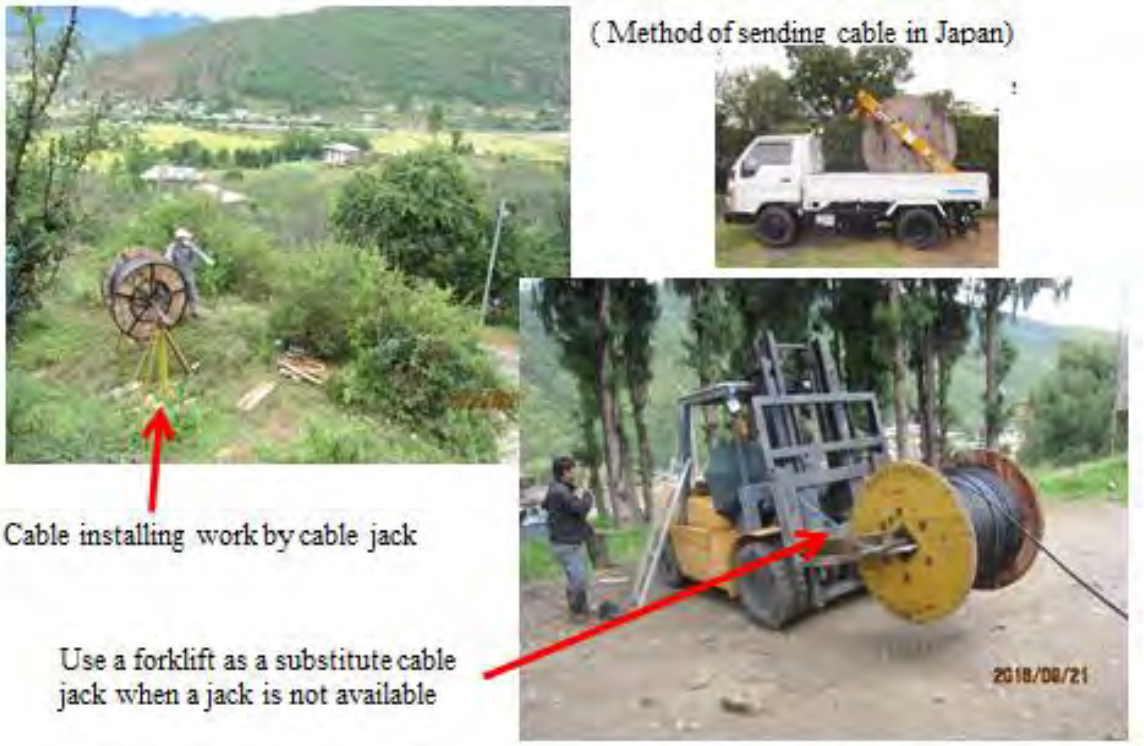
Those advices on operation and maintenance management method are also more useful and important in implementation of technical cooperation project additionally to technology transfer.

(2) Inventory and utilization of equipment and tools

It is difficult for telecommunication operators or construction companies in developing countries to arrange all of necessary construction machines, tools, etc. Usually a cable jack is used for installing aerial or underground cables if possible.

A lack of some necessary construction machines and tools moves the staff to use the available substitutes. For example a forklift, which was donated through a JICA project in 2003, was used to sending cables into pole to pole as the substitute of a cable sending machine (Refer Fig-1)

Fig-1 Case of using forklift (Aerial cable Installation)



(3) Promotion of broadband services through public relations activities

People rushed the telephone office for broadband service subscriptions just after that the completion of FTTX trial construction was aired by the local TV station.

Such promotion activities including use of mass-media, seminars or demonstrations, etc. for local communities are expected to increase BTL's revenues whenever BTL starts new services in the country. So, it is expected that the marketing section together with the operation and maintenance section of BTL should promote the new services.

4 For the Achievement of Overall Goals after the Project Completion

4.1 Prospects to achieve Overall Goal

Post completion of the FTTX Project, BT will use the Jakar trial site as an example network to refer to during its own fiber expansion works in the access networks. Most importantly, the technical manuals will be used as guiding documents when it comes to planning/designing, deploying and maintaining fiber access networks. The technical manuals will also be updated as and when required to do so to incorporate changes in the fiber technology.

To enhance data connectivity in light of the ever-growing demand for data both in the office and at home, BT will invest every year Nu. 40~50 million to expand fiber in the last mile/access networks. As projected in the Project Design Matrix, by 2019, BT should have fiber in the access network in 90% of the Dzongkhags.

BT installed FTTX access network in four Dzongkhags out of 20 ones (20% of FTTX covering ration) at the end of the year 2013 before starting the project, while in October 2016 the covering ratio of FTTX has reached to 85% (17 Dzongkhags).

BT intends to continuously introduce the network more aggressively to meet the demand, therefore it is not difficult for BT to cover 90% of Dzongkhags with FTTX access network. This means that the benchmark set as the index is cleared by the end of 2019.

Figure 1 gives a recent movement of number of traditional copper and FTTX access subscriptions compared with for the reference

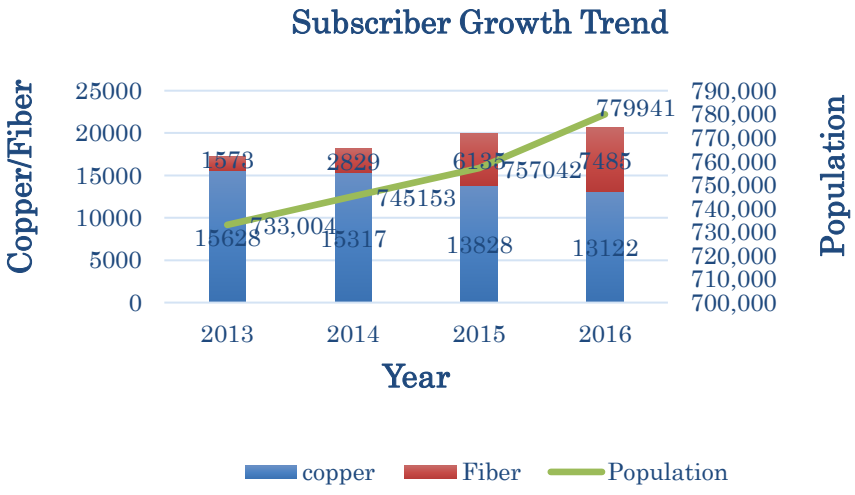


Fig. 1 Movement of number of copper and FTTX access subscription

4.2 Plan of Operation and Implementation Structure of the Bhutan side to achieve Overall Goal

Whilst the overall planning and designing of FTTX networks will be the responsibility of the Corporate Planning and Strategy Division, implementation and O&M of FTTX thereafter will be the sole responsibility of the respective Regions of the Operations Division. Besides the fiber network of trial site at Jakar, BT has fiber in the access networks deployed in 17 out of 20 Dzongkhags of the country the O&M of which are currently being taken care by the Regions and exchanges. Therefore, post completion of the FTTX project, the O&M of it should not be of any major concerns.

4.3 Recommendations for the Bhutan side

4.3.1 Expansion FTTH from FTTB/FTTC

The infrastructure for the current broadband service in BTL is FTTX has FTTB/FTTC/FTTH.

When providing broadband service

s, telecommunication operators usually employs FTTB/FTTC because of installation cost.[2] Passive devices are used for interconnecting trunk lines (optic fiber) with branch (copper cable) lines.

Disadvantage of using FTTB/FTTC are; failure rate is high, less connection speed, poor operability, poor responsibility, less stability in providing broadband services and vulnerability to natural disaster thereby increasing customer dissatisfaction.

Future is FTTH. I understand the budget and installation cost, but in the long run, business will prosper. If customer is happy, business will be a flow.

Demanding internet speed with change in technology, I would urge BTL to think upon using and promoting FTTH in coming days/future.

4.3.2 Holding practical GIS/GPS training for other BT's staff

Method of applying GIS system on plant record management was introduced during the project, while two staff obtained the GPS data, stored into a computer, got trained on how to process and use the stored data through practical training. The information in the system are useful to not only manage and administrate existing facilities including outside plants, transmission links, mobile communication services for maintenance purpose, but also to analyze market conditions.

For the time being 2 staffs are engaged in managing, developing and maintaining the system, and it *looks weak when considering employees' turnover. JICA short term expert left the Guide Book for this purpose, and BT is*

[2] *FTTB/FTTC technology consists of optic fiber cables for trunk routes and metallic cables for branch or delivery circuits. This configuration enables operators to save initial investment cost because the operator can use existing metallic cables in service for the FTTX/FTTB branch or delivery circuits. On the contrary the cost of installing FTTH becomes higher than that of FTTB/FTTC because the operator has to laying optic fiber on all sections between a telephone offices to user's premises.*

recommended to hold practical GIS/GPS training afterwards.

4.3.3. Examining Possibility of collaboration with other project

National Land Commission Secretariat of Bhutan and JICA are implementing "Project on Development of National Geo-Spatial Data" and it will be completed Sep. 2017. This project uses the base map of 25000 and BT's facility management need 1000 or 2500. This kind of base map will be used by other authority of water and road management in urban areas.

BT is recommended to examine the possibility of collaboration with National Land Commission Secretariat to extend GIS usage to other telecommunications facility management.

4.3.4 Forming system updating plant data related to FTTX access after installation of facilities and failure information by optic cable, cabinet, and user

Designing FTTX access network considering future demand enables BT to use installed cables efficiently and economically. If there is a well-managed facility record database including length of cables, date accommodating in cabinets, numbering poles, unused lines, unused terminals, and failure history by each, BT can quickly respond soon after receiving complaints from customer.

BT is recommended to form the system of the plant record in manner of installation –record, amending failure- record, subscription-record, etc., even in paper basis.

4.3.5 Provision of safety tools and equipment for safer construction works

As FTTX cabling works are usually done at height on power/telephone poles or underground in a manhole, accidents such as falling from height, electric shock, oxygen shortage are the major concerns. So, it is desirable to prepare such safety tools and machines such as safety belt for poles, helmet, ladders, earth leakage detectors etc.

ANNEX 1: Results of the Project

(List of Dispatched Experts, List of Counterparts, List of Trainings, etc.)

ANNEX 2: List of Products (Report, Manuals, Handbooks, etc.) Produced by the Project

ANNEX 3: PDM (All versions of PDM)

ANNEX 4: R/D, M/M, Minutes of JCC (copy)

ANNEX 5: Monitoring Sheet (copy)

(Remarks: ANNEX 4 and 5 are internal reference only.)

ANNEX 1: Result of the project

ANNEX 1-1

List of Dispatched Experts

Name	Charge	2014												2015												2016											
		4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
Mr. Junya YAMAGUCHI	Chief Advisor / FTTX Technology / Quality Control, Safety work management		5/2								1/23				5/1								1/27				4/28									2/15	
Mr. Tomoaki TAKASE	FTTX design engineering					8/28		10/25																													
Mr. Takashi MATSUDA	FTTX construction engineering							10/11		11/29									9/5			11/15																
Mr. Kouichi KAMIMURA	GIS/GPS operation engineering																											6/3		7/29							
Mr.Toshiyuki YUZUKI	FTTX R&D engineering																																11/28	12/4			
Mr.Nobuo KAMBA	Broadband applied technology																																11/28	12/4			

Remarks: Planning

Actual

List of Counterparts

	Planned			Actual		
	Name	Official position	Period	Name	Official position	Period
Project Director	Mr.Karma Tshewang	General Manger Operation Div	2014.5~2017.1	Mr.Karma Tshewang	Director Technical	2014.5~2017.1
Project Manager	Mr.Sonam Rinchen	Project Manager, Druknet Div	2014.5~2017.1	Mr.Sonam Rinchen	Project Manager Druknet Div	2014.5~2015.12
				Mr.Sonam Phuntsho	DyGeneral Manager /Operation Div	2015.12~2017.1
Counter part1 (Design/GIS)	Mr.Ugyen Dorji	GIS officer /Operation Div	2014.5~2017.1	Mr.Ugyen Dorji	GIS officer /Operation Div	2014.5~2016.10
				Ms.Kinley Wangmo	Engineer / Operation Div	2016.10~2017.1
Counter part2 (Construction)	Mr. Rinzen Dorji	Technical officer Operation Div	2014.5~2017.1	Mr. Rinzen Dorji	Technical officer / Operation Div	2014.5~2017.1
Counter part3 (Safety manage /Specification)	Mr.Dorji Yeshey	Technical officer	2014.5~2017.1	Mr.Dorji Yeshey	Technical officer	2014.5~2015.8
				Mr.Pemba Sherpa	Assistant Engineer /Operation Div	2015.8~2017.1
Counter part4 (FTTX R&D)	Mr.Sonam Phuntsho	DyGeneralManager/Operation Div	2016.11~2017.1	Mr.Sonam Phuntsho	DyGeneral Manager /Operation Div	2016.11~2017.1
Counter part5 (Advance BB)	Mr.Sangay Wangchk	IT Engineer / Operation Div	2016.11~2017.1	Ms.Kinley Wangmo	IT Engineer / Operation Div	2016.11~2017.1

3. Trainings

3.1 1st Training in Japan

Table 3.1-1 JICA 1st Training Schedule in 2015

Date	Time			Contents	Lecturers		Remarks/Location
					Name	Organization	
Apr. 6(Mon)	10:00	～	12:30	Moving to JICA Tokyo International Center (TIC)		JICA Staff	Hatagaya, Tokyo
	14:00	～	15:00	Program Orientation	Mr. Seiji Shimada	JICA Staff	JICA HQ
Apr. 7(Tue)	10:00	～	11:30	Courtesy Visit to JICA HQ	Mr. kenji Muto	JICA HQ	Koujimachi, Tokyo
	14:30	～	16:30	Lecture: Trendo of Broadband Services/Outline of System conficuration	Mr Eiichiro Ichikawa	NTT East	Hatsudai, Tokyo
Apr. 8(Wed.)	10:00	～	12:00	Lecture: Trend of FTTX R&D at Access Network Service Systems Laboratories	Mr. Yuji Aoyagi	Access Network Service Systems Laboratories, NTT	Tsukuba City
	13:00	～	15:30	Study Tour: FTTX components in the Laboratories			
Apr. 9(Thu.)	9:30	～	12:00	Study Tour: International Exibition of FOE and accessories at Tokyo Int'l Exbision Center	Mr. Junya Yamaguchi	Japan Recom Co.	Tokyo Int'l Exibition Center, Tokyo
	13:30	～	16:00				
Apr. 10(Fri.)	10:00	～	12:00	Lecture: NTT's FTTX Solutions	Mr. Eiichirou Ichikawa	NTT East	Shinagawa, Tokyo
	15:00	～	17:00	Study Tour: Exibition Booth for in-house broadband system			Shinjuku, Tokyo
Apr. 11(Sat.)							
Apr.12(Sun)							
Apr.13(Mon.)	10:30	～	12:00	Factory Visit: Production line of optical cables at Fujikura Factory in Sakura City	Mr. toshiyuki Tanaka	Fujikura	Sakura City, Chiba Pre.
	13:30	～	15:30	Lecture: Management System of Optic Fiber Cabling			
Apr. 14(Tue.)	10:00	～	11:30	Lecture: Operation and Mainetenance of FTTX Network	Mr. Shinji Inoue	NTT-ME	Saitama-Shintoshin, Saitama Pre.
	13:00	～	15:30	Factory tour: Manufacturing process, quality control, and inspection process	Mr. Takeo Takahisa	Japan Recom Co.	Higashi-Matsuyama, Saitama Pre.
Apr. 15(Wed.)	9:50	～	12:00	Practice: Ataching works of optic closures at Ohmiya Training Center of Mirait Technologies Co.	Mr Tetsuhiro Shimizu	Mirait Technologies Co.	Ohmiya City, Saitam Pre.
	13:00	～	16:30				
Apr. 16(Thu.)	9:50	～	12:30	Lecture: Outside facilities i.e. man-hole, undergrand cable tunnel, etc. of NTT East in Yokohama	Mr. Kiyoshi Tsuji	NTT East	Kan-nai, Yokohama
	13:30	～	15:30	Lecture: Installed facilities of FTTX access system at Kan-nai area, Yokohama in Kanagawa Branch	Mr. Takuya Morita	NTT Infranet	
Apr. 17(Fri.)	10:00	～	11:30	Evaluation of the training contents	---	---	TIC

Table 3.1-2 Participants of JICA 1st Training

No.	Position/ unit	Name	Remarks
1	Manager/Backbone & Access network section /Technology &Strategy Div/BTL	Mr.Sonam Rinchen	
2	GIS officer/Engineer/Operation Div./BTL	Mr.Ugyen Dorji	
3	Senior Technical Officer /In charge Central Region/ BTL	Mr.Rinchen Chogyel	
4	Technical Officer/Maintenance section /Western Region,/BTL	Mr.Puran Gurung	
5	Technical Officer/ Maintenance section/ /Western Region/ BTL	Mr.Thinley Dorji	

3.2 2nd Training in Japan

Table 3.2-1 JICA 2nd Training Schedule in 2016

Date	Time			Training Contents	Lecturers		Remarks(Location)
					Name	Organization	
6th, April (Wed.)		～		Arrived at Haneda Airport			
	14:00	～	16:30	Briefing/ Courtesy visit to JICA HQ	Mr. Seiji Shimada	JICA HQ/JICA Tokyo	JICA HQ /JICA Tokyo
7th (Thu.)	9:30	～	12:00	Visiting International Exibition Center for FOE (FIBER OPTICS EXPO), participating seminor, and studying various products	Mr. Jun'ya Yamaguch	Japan Recom	Int'l Exhibitation Center
	13:00	～	16:00				
8th (Fri.)	10:00	～	12:00	Lecture : Outline of applications by Broaband Infrastructure	Mr. Takanori Uchida	NTT East HQ	NTT East (Hatsudai)
	14:00	～	16:00	Lecture : Outline of Broadband Monitoring/Eemergency Com. System for	Mr. Hiroyuki Kawasaki	Japan Radio Corporation	Mitaka City
9th (Sat.)		～					
		～					
10th (Sun.)		～					
		～					
11th (Mon.)	10:00	～	12:00	Study tour/lecture : Japanese Trend of FTTX R&D	Mr. Yuji Takayagi	NTT R&D (Tukuba)	Ibaraki Pref.
	14:00	～	16:00	Study visit : FTTX facilities in the Laboratories			
12th (Tue.)	10:00	～	12:00	Lecture : Trend of Broadband Service in Japan and Outline of FTTX network	Mr. Ei'ichiro Ichikawa	NTT East	NTT East (Shinagawa)
	15:30	～	16:30	Lecture : Broadband policy of Japan	Miz. Chihomi Mukai	Ministory of Internal Affairs and Communications	Kasumigaseki-Tokyo
13th (Wed.)	10:30	～	12:00	Study Tour : Manufacturing lines of Optical Fiber Core and Cables	Mr. Toshiyuki Tanaka	Fujikura Corp.	Fujikura Factory in Sakura City
	13:00	～	15:30	Lecture : Outline of Optical Fiber Engineering and Management System for Cabling			
14th (Thu.)	10:00	～	11:30	Lecture :Outline of broadband network operation	Mr. Shinji Inoue	NTT-ME	Saitama City
	13:30	～	15:30	Study Visit : Accessories for Engineering and Manufacturing line	Mr. Takeo Takahisa	Japan Recom	Higashisaitama city
15th (Fri.)	9:20	～	12:00	Lecture: Broadband Access Technology	Mr. Yoshihiro Miyamoto	NEC	NEC Showroom (Shinagawa)
	14:00	～	15:00	Evaluation and Closing Ceremony	Mr. Seiji Shimada	JICA HQ	JICA HQ

Table 3.2-2 Participants in JICA Training in 2016

No.	Position/ unit	Name	Remarks
1	Chief Executive Officer	Mr. Tshewang Gyeltshen	
2	Director, Technical Department	Mr. Pushpa Mani Pradhan	
3	General Manager, Corporate Service Division	Mr. Karma Jurme	
4	General Manager, Technology & Strategy Division	Mr. Karma Tshewang	
5	General Manager, Operations Division	Mr. Jichen Thinley	
6	General Manager, Marketing	Mr. Sangay Wangdi	
7	Senior Manager, Backbone Network Section, Operations Division	Mr. Sonam Phuntsho	

3.3 In-House Training

Table 3.3-1 JICA /BTL FTTX training Curriculum (18th -22nd July 2016)

	AM		PM	
	9:15~10:45	11:00~13:00	14:00~15:30	15:45~17:00
18th July (Mon)	1)Opening Ceremony *1 2)Opening Lecture*2	Re-Test*3	1) BTL Network Configuration*4 2)Special lecture by JICA CR *5	FTTX design (Theory) *6
19thJuly(Tue)	FTTX design (Practice) *6	FTTX Design (Practice) *6	FTTX O&M (GIS mgt) *7	FTTX O&M (GIS mgt) *7
20th (Wed)	FTTX Construction (Theory) *8	FTTX Construction (Splicing/OTDR) *8	FTTX Construction (Splicing/OTDR) *8	FTTX Construct (troubleshooting)*8
21st (Thu)	Safety Management (Theory) *9	Safety Mgt (Case-study)	Post-Test *3	B/B service overview *10
22nd (Fri)	FTTX Construction (GPON application &products) *8	FTTX Construction (GPON application & products) *8	Lecture by BTL Management *11	Closing Ceremony *1

Remarks: Persons in charge and each works performed;

*1: Mr.Pema Khandu (HRD manager) →Coordinate the program

*2: Mr.Karma Tshewang(GM T&S)→Address of the training purpose and message

*3: Mr.Junya Yamaguchi(JICA Expert)→Pre and Post evaluation

*4: Mr.Mr.Sonam Phuntsho (Dy GM,Backborn)→Outline of BTL network configuration

*5:Mr.Yamada(JICA Bhutan Chief Reprehensive) →Leveraging Development Cooperation By Applying ICT: Debriefing on JICA Project Research "Application of ICT in Developing Countries"

*6:Mr.Ugyen Dorji(GIS unit officer)→FTTX design method

*7:Mr.Kamimura(JICA GIS Expert) →GIS application method for FTTX O&M

*8:Mr.Rinzin Dorji(Technical officer, OSP) →FTTX construction method(practical training: splicing/measurement method/ GPON application)

*9: Mr.Junya Yamaguchi(JICA Expert) →Case-study by safety work model sheet

*10:Ms.Sonam Lhadon (Sales Executive Officer,Marketing Div) →present/introduce BB service menu in BTL

*11:BT management(CEO) →Special lecture(BTL policy and strategy)

Table 3.3-2 List of Participants in the Training Course (18th -22nd July 2016)

Sl.No.	Name	Years of service in BTL	Exchange/Region
1	Sangay Phuntsho	10	Haa, WR
2	Chokey Gyelpo	*	Paro, WR
3	Kencho Wangdi	22	Paro, WR
4	Kinley Tenzin	11	Wangdue, WR
5	Pemba	26	Wangdue, WR
6	Wang Dorji Singer	5	Punakha, WR
7	Tashi Dorji	11	Punakha, WR
8	Tshewang Dorji	4	IP Services, WR
9	Tshering Dorji	6	IP Services, WR
10	Kumbu Dorji	11	OSP, WR

3.4 JICA /BTL FTTX tour training Curriculum

Table 3.4-1 BTL Tashigang office 20th Dec 2016.

	AM		PM	
	9:15~10:45	11:00~13:00	14:00~15:30	15:45~17:00
A Group	FTTX design/ GIS (Theory) *1	FTTX Design/ GIS (Practice)	FTTX Construc (Splicing/OTDR)	SaftyManage (Case-study) *2:
B Group	FTTX Construc (Splicing/OTDR) *2:	SaftyManage (Case-study)	FTTX design/ GIS (Theory) *1	FTTX Design/ GIS (Practice)

*1: Mr.Gempou(GIS unit)

*2: Mr.Rinzin Dorji(Technical officer,OSP)

*3: Mr.Junya Yamaguchi(JICA Expert)

Table 3.4-2 BTL Trongsa office 23rd Dec 2016**.**

	AM		PM	
	9:15~10:45	11:00~13:00	14:00~15:30	15:45~17:00
A Group	FTTX design/ GIS (Theory) *1	FTTX Design/ GIS (Practice)	FTTX Construc (Splicing/OTDR)	SaftyManage (Case-study) *2:
B Group	FTTX Construc (Splicing/OTDR) *2:	SaftyManage (Case-study)	FTTX design/ GIS (Theory) *1	FTTX Design/ GIS (Practice)

*1: Mr.Gempou(GIS unit)

*2: Mr.Rinzin Dorji(Technical officer,OSP)

*3: Mr.Junya Yamaguchi(JICA Expert)

Table 3.4-3 BTL Phuntsholing office 30th Dec 2016.

	AM		PM	
	9:15~10:45	11:00~13:00	14:00~15:30	15:45~17:00
A Group	FTTX design/ GIS (Theory) *1	FTTX Design/ GIS (Practice)	FTTX Construc (Splicing/OTDR)	SaftyManage (Case-study) *2:
B Group	FTTX Construc (Splicing/OTDR) *2:	SaftyManage (Case-study)	FTTX design/ GIS (Theory) *1	FTTX Design/ GIS (Practice)

4. List of Granted Materials and Machines

Table-4-1 List of Equipment (for implementing experiment works and training)

No.	Items	Quantity	
		Planned	Actual
1	GE-PON Equipment (GE-PON system & Access Cabinets)	1	0
2	Splicing VAN	1	1
3	Splicing Machines	2	2
4	Small Excavator (wheeled mini excavator) with attached: Mini bucket, Skid steer for trenching and soil clearance. *2	0	1

Remarks; Planned numbers were quantity of Minutes of Meetings on 27th Sep, 2013

*1 Bhutan Telecom has already introduced G-PON system and prepared the investment Plan & Budget for it. BT's investment plan was discussed after submission of proposal for JICA Technical Grant to Japan. It was felt that the GE-PON from JICA project is not necessary for this project. So BT decides to procure GPON system with our own planned budget.

*2 This equipment is essential for digging trenches in the town for laying cables in narrow locations. It will also be required for all trenching works at the trial sites since the town planning's of both the trail sites have already been completed. BT currently does not have any excavator of its own. To be able to efficiently implement the trial sites as well as other FTTX trenching works that BT will implement in future, an excavator of this kind is felt very essential. Since BT does not have any budget provisioned as such for an excavator, it would be highly helpful if an excavator could be considered as part of this project.

Table4-2 List of Equipment (for renovating O&M system and training)

No.	Items	Quantity	
		Planned	Actual
1	GIS Software ArcGIS 10/10.1. Or Intergraph Software for Fiber Management (G-technology) *3	1	0
2	Hybrid Computer desktop (24") with High resolution Graphic card with CPU	1	1
3	for digitizing the network infrastructure system	1	1
4	High version Lap top for mapping of GIS system	1	1
5	Two in one Color Printer & scanner for printing of maps (A3 & A4 size paper)	1	1
6	Digital Camera with external card →Tablet iPad *4	1	1
7	External Hard drive(terabyte) for GIS data backup	1	1
8	GPS Pathfinder office 5 *5	0	1

Remarks; Planned numbers were quantity of Minutes of Meetings on 27th Sep, 2013

*3 The National Land Commission of Bhutan is considering to provide this Software License to GIS users in Bhutan with minimal fee annually. In this case, BT itself will bear the license fee to NLC from project cost instead of purchasing the software.

*4 we often experience loss of signal due to either design trees or buildings while collecting data from the field with GPS due to which we are not able to collect correct data for many areas. We

have raised this issue with the JICA CA and GPS/GIS JICA expert and they have instructed and recommended to **use New Technology of GIS platform with tablet (ipad)** as a tool to acquire signal from mobile towers. This will not only help proper design of the network for this project, but will be highly useful for collecting accurate data of the rest of BT's network nodes.

*5 While retrieving data from the GPS back in the office, we fail to import data from the receiver, often receive error data, keeping in mind soon after JICA CA joined his office, we put up the problem to him which, he further discussed with the GPS/GIS JICA expert and the feedback was to use **GPS pathfinder office 5.6** as an effective solution, while handling DGPS(Geo-XT) receiver.

Table 4-3 List of Equipment (for implementing experiment works and training)

No.	Items	Quantity	
		Planned	Actual
1	OTDR	2	2
2	Power Meter	2	2
3	Fault locater	2	2
4	Tools kits	2	1
5	FTTH passive Indoor materials: Outlets, patch cords, etc. *6	N	N
6	Ducting Rods, 200 meters.	5	3
7	Shimelar	10	10
8	Safety belts	10	10
9	Wretch range	10	10
10	Side cutter	20	20
11	Cable web cutter	20	20
12	Water Pump	3	3
13	Connector Punching tools	20	20
14	Cable ladder	5	5
15	Soil remover	20	10
16	Air blower	3	3
17	Gas detector	3	3
18	Optical fiber cables, etc. *6	N	N
19	Leakage voltage detector *7	0	5
20	Between Road surface cutter (Hydraulic Power) with attached: Disc cutter(Concrete , metal &stone), Trash Pump, Hydorlic Power Pack-Beaver (Rock breaking, concrete & cement cutting and demolishing) *8	0	1

Remarks; Planned numbers were quantity of Minutes of Meetings on 27th Sep, 2013

*6 The Requirement will be decided by the outcome of the investigation during the construction of the trial site (September 2014 ~October 2014)

*7 This equipment is required to check whether any leakage of current exists from an electric line to a telephone pole. After CA's site survey during BT's Installation works at sites, he felt that there is a necessity of this equipment, though it was not included in the required equipment list initially, it is deemed very important for considering the safety aspect of the engineers of BT.

*8 This machine is most required and essential for this project as there are many completed black topped roads to be cut for laying of the fiber optic network. This machine is best technology to cut a narrow bitumen road so that BT can implement proper design fiber access network. This

machine will help BT in future for further laying of the fiber optic network even after completion of the project. Till now BT was using human labor and excavator to cuts between road that cuts wider area of the road but due to the policy change in Municipal office, only very narrow road cuttings are permitted. Although this equipment was not requested before, it became very necessary for execution of this project due to change of policies in Dzongkhags and Municipal offices.

ANNEX 1-5

Work Plan/Activity

Enforcement item \ Period	2014												2015												2016											
	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1. Preparation for start-up of the Project																																				
2.Work Plan making / Discussion																																				
3.Understanding of baseline/Index setup																																				
4. Agreement of the work plan(BT,GNHC,JICA)																																				
5. Outline lecture of FTTX																																				
6.Development of Guideline Specification concerned materials												(Modify)														(Modify)						(Final)				
7.FTTX Technical manual preparation					(Draft										(Modify)							(Modify)				(Modify)					(Final)					
8.Preparation of supply equipment for 2nd trial construction																																				
9.1st FTTX field trial construction																																				
10. 1st FTTX training enforcement																																				
11.2nd FTTX field trial construction																																				
12.Facility management(O&M) by GIS/GPS sys																																				
13. 2nd FTTX training enforcement																																				
14 Incountry training (each regional Area)																																				
15.Overseas Training(in Japan)																																				
16.Hold a workshop/IT seminar																																				
17.Project Progress arrangement & conclusion																																				
18.Project progress meeting																																				

6. Project implementation framework and JCC memo

6.1 Implementation Framework

GNHC takes the responsibility of the implementation, while BT works as the implementation agency. Both of GNHC and BT organizes Joint Coordinating Committee (JCC) together with Ministry of Information and Communication (MoIC), which administrate the telecommunication sector, and JICA Bhutan Office, while BT carries out the Project fostered by JCC.

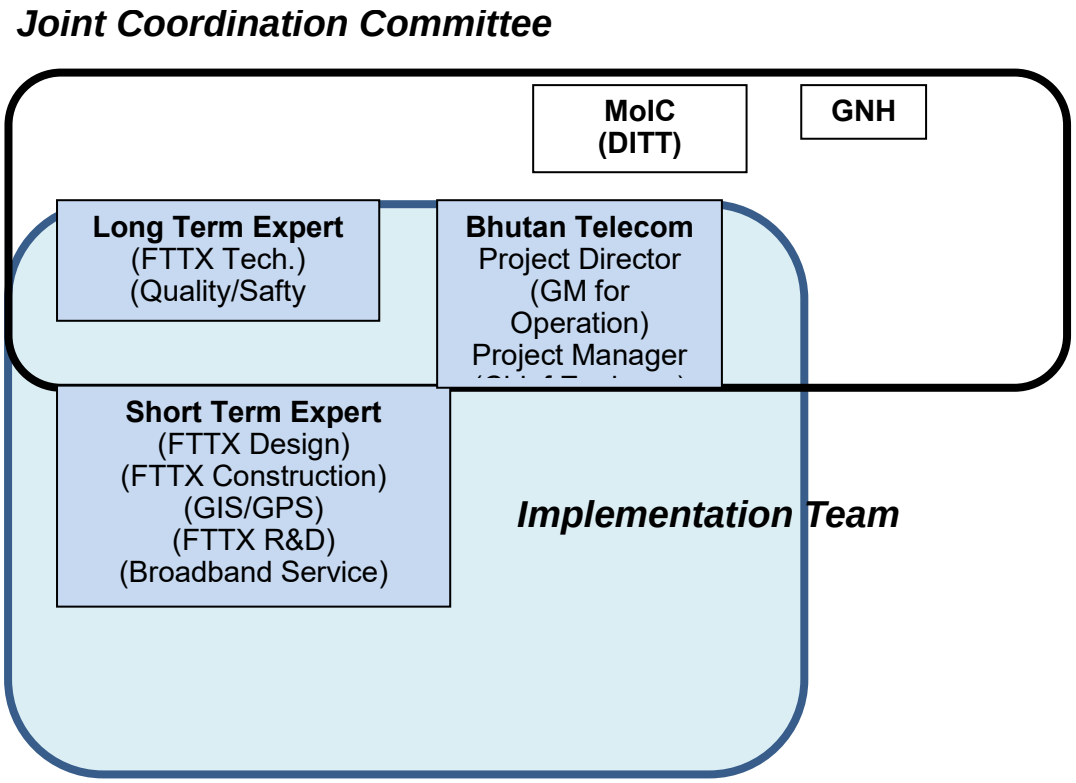


Fig. 1. Administrative Framework on the Project

6.2 Performance of Works

Outlines the performance of each work, which are planned period, performed period and relation to the activities in table 1.

Table 1 Performance of Performance

Step/ Itemized Works	Activity	Period planned	Period performed
1. Kick off		May 2014	May 2014
2. Preparing Work Plan and Discussion		May 2014	May-Jun.'14
3. Understanding baseline / Index setup		May 2014	May-Jun.'14
4. Forming consensus on work		Jun.2014	Jun.-Jul.'14

Step/ Itemized Works	Activity	Period planned	Period performed
plan(BT,GNHC,JICA)			
5. Lecture of Outline of FTTX		Jun.2014	Jul. 2014
6. .Development of Guideline Specification, inspection, safety work	Activity 1-1	Jul.-Aug.'14	Aug.-Oct.'14
7. FTTX Technical manual preparation			
Developing Draft	Activity 1-2	Aug.-Sep.'14	Jun.-Oct.'14
1st review	Activity 1-3	Apr.-Jun.'15	May-Jul'15
2nd Second Review, Biding	Activity 1-4	Apr.-May'16	Apr.-Sep.'16
8. Preparing procuring list for 2nd experiment work	Activity 3-1	Sep.-Oct.'14	Aug.-Dec.'14
9. 1st Experiment Work			
9.1 Field Survey	Activity 3-1,& 3-2	Oct. 2014	Dep. 2014
9.2 FTTX design instruction on the spot		Oct. 2014	Oct. 2014
9.3 Implementation of 1st experiment work		Nov.-Dec.'14	Nov.-Dec.'14
9.4 Assessment & analysis on 1st Experiment Work.	Activity 3-3	Jan. 2015	Dec. 2014
10. 2nd Experiment Work			
10.1 Survey and Field investigation	Activity 3-4	Sep.2014	Oct.-Dec'14
10.2 Guide Design method		Oct.2014	Oct. 2014
10.3 Construction technique		Oct.-Dec.'15	Sep.-Nov.'15
10.4 Reviewing the 2nd Experimental Work.	Activity 3-5	Jan. 2016	Nov. 2015
11. Human resource development (the schedule was changed at the 2nd JCC meeting)			
11.1 Developing course curriculum		May 2016	May 2016
11.2 developing course materials		Jun. 2016	Jun. 2016
11.3 Implementing training		Jul. 2016	Jul. 2016
11.4 Analysis and Evaluation of training		Aug. 2016	Aug. 2016
12 Facility management by GIS/GPS sys			
12.1 Studying existing O&M system	Activity 2-1	May-Jun.'16	Jun. 2016
12.2 Finding problems and issues to be solved	Activity 2-2, 3	Jun. 2016	Jun. 2016
12.3 Proposing an optimal O&M system		Jun. 2016	Jun. 2016
12.4 Instructing how to operate the system	Activity 2-4	Jul. 2016	Jun.-Jul.'16
13. 2nd training (on O&M system)			
13.1 Implementing O&M system training by C/P	活動 2-4	Jun.-Jul.'16	'Jun.-Jul.'16
13.2 Evaluation of training		Jun.-Jul.'16	Jul. 2016
14. In-country training (4 regional telephone offices)		Sep.-Dec/'16	Sep.-Dec/'16
15. Training in Japan			
15.1 1st training course in Japan		Apr.2015	Apr.2015
15.2 2nd training course in Japan		Apr. 2016	Apr. 2016
16. Workshop in Bhutan		Nov.-Dec.'16	Dec.2016

6.3 JCC Meeting memo

JCC Meeting aimed to share various information concerning with the project implementation, find out problems, and take necessary actions to smooth the project implementation, while the meeting contributed a lot to smooth implementation. The following table gives the timing scheduled and actuary done.

Table 2.1-1 Timing scheduled and actually done of JCC Meeting

Times	Scheduled	Actually done
First JCC Meeting	Jul. 2014	Jul. 2014
Second JCC Meeting.	Jan. 2015	Jan. 2015
Third JCC Meeting	Nov. 2015	Dec. 2015
Fourth JCC Meeting	Jul. 2016	Aug. 2016
Fifth JCC Meeting	Dec. 2016	Dec. 2016

6.3.1 1st JCC Meeting

Before starting the Project in April 2014, the Work Plan and PDM were reviewed because one year pasted after R/D was signed in October 2013 and surroundings of BT's business were varied. Base on the advices by JICA Bhutan Office, Chief Adviser discussed those with C/P of BT and revised Work Plan, PDM and other related documents, and then submit those to the JCC Meeting. The revised ones were accepted by the JCC members at the meeting.

Photo 2.1-1 JCC Meeting

Major parts of modifications are;

- PDM:modifying Objectively Verifiable Indicators
  In the preliminary survey (September 2013), the indicator value of the Overall goal that was undetermined, Objectively Verifiable Indicator and the means of Verification and the activity outcome were revised to concrete numerical values and description contents.
- Standard of employed Optic Fiber System:
  Although GE-PON (Gigabit Ethernet-Passive Optical Network) was to employed for the experiment work when the Detail Planning Survey was carried out in October 2013, BT decided to introduce G-PON (Gigabit Passive Optical Network) system for access network in January 2014 because of required costs for developing fiber network in access system.
  In May 2014, G-PON system was decided to introduce in the access network. Based on the discussion with the C/P before starting the project, therefore, G-PON system was to be employed in experiment work in order to avoid dual investment and O&M complexity would-be caused by coexist of 2 kind standards.

BT was to procure materials and systems of G-PON for the experiment work, while materials and system related to the GE-PON system were canceled.

- Granted machineries and materials
  In order to make the experiment work more efficient, a small excavator, a road surface cutter, etc. was added in the list of granted machineries and materials. (Refer to ANNEX 6-1 for details)
  Materials and machines, and quantities on planned and actual basis of those are referred to Sec.5.

- Sites of experiment work
  Although the Detail Planning Survey in October 2013 selected 2 sites of Phuntsholing in the South of Bhutan and Mongar in the East, those sites were changed with Paro in the West and Jakar in the Central because of reasons of safer works and more effective usage of optic fiber network.

6.3.2 2nd JCC Meeting

At the meeting in January 2015 the information about progresses between Jul. 2014 to Dec.2014 of i) development of 3 kinds of technical manuals, ii) formulating FTTX operation and maintenance system, iii) implementing experiment work in Jakar. Some of JCC members suggested inquiring opinions to related managers of telephone offices on draft versions of 3 manuals. Then those opinions were reflected on draft versions of 3 manuals.

6.3.3 3rd JCC Meeting

3rd JCC meeting was held in Dec. 2015 and it was discussed and evaluated on the existing construction method as well as progress of the Project from January 2015 to December 2015. Major agenda were 1st training course in Japan, performance of 2nd experiment work in Paro, and development of manuals. JCC members shares that the Project progressed on schedule.

6.3.4 4th JCC Meeting

Activities from Jan. 2016 to Jul. 2016 were reported at the 4th JCC Meeting held in Aug.2016, and discussions were made on evaluations, improving points in every work, the schedule in next term. Major works were the performance of 2nd training course in Japan, internal FTTX training. Otherwise Work Shop (IT seminar) scheduled in Nov. 2016 was accepted and agreed among the members

6.3.5 5th JCC Meeting

In January 2017 5th JCC meeting was held and the progress of the Project was reported during August to December in 2016, and achievements of the project as well as FTTX development strategy after the project were discussed over at the meeting.

The project itself was implemented as planned in total, and expected deliverables were developed and delivered. Field staffs who experienced trial works also attended to the meeting introduced their activities and exchange opinions as well.

Unfortunately 3 counterparts out of 7 retired from BTL for study abroad, etc. during the period. BTL immediately replenished 3 staff staffs to assign as the counterpart. Chief Representive of JICA Bhutan Office pointed out that the technical cooperation project aims to develop the human resources; therefore the counterparts must be in charge of transferring and instructing BTL staff.
Technical Director of BT explained that it is possible for BT to achieve the overall goal from the aspect of technical and financial capability, maintenance and operation system, and development plan, and the attendees to the meeting approved on.

IT Workshop, 2016
JICA Technical Cooperation Project for Optical Fiber Techniques in Telecommunication Engineering in Bhutan
30th November, 2016
Venue: Hotel (Taj Tashi) Conference Hall, Thimphu, Bhutan

To:

……
…….

Subject: Invitation for participating in the IT workshop on Leveraging ICT to enhance Public Service Delivery

Dear Sir,

Bhutan Telecom as part of the current JICA Project for the Optical Fiber Techniques in Telecommunications Engineering is organizing a day long IT workshop on the 30th of November 2016 at Taj Tashi, Thimphu. The workshop will focus mainly on leveraging ICT in delivering efficient public services. In keeping with this theme, besides the presentations on e-services by the government agencies like G2C, RUB, IT Park, and Ministry of Health, we have presenters all the way from NTT (Nippon Telegraph and Telephone Corporation), Japan presenting on the latest R&D topics in the access networks including the utilization of Fiber-To-The-Home (FTTH) broadband networks.

We would therefore like to request your good office to kindly nominate at least……(insert number) officials to partake in this IT workshop.

For your ready reference, we have attached to this letter a copy of the tentative agenda for this IT workshop, venue details, prescribed nominee listing format and brief information about the JICA Project for the Optical Fiber Techniques in Telecommunications Engineering.

We thank you in advance and look forward to receiving your nominations. We would appreciate if you could kindly fill in the names of the nominees in the prescribed format and share with us within 18th of November 2016 through email at sonam.phuntsho@bt.bt or yamaguchi@recom.co.jp.

Best Regards,

Yours Sincerely,

Tshewang Gyeltshen
Chief Executive Officer

IT Workshop, 2016

JICA Technical Cooperation Project for Optical Fiber Techniques in Telecommunication Engineering in Bhutan

30th November, 2016

Venue: Hotel (Taj Tashi) Conference Hall, Thimphu, Bhutan

I.OBJECTIVES OF THE PROJECT

The purpose of the BTL-JICA Technical Cooperation Project (2014-2017) is "Capacity of BTL's engineering in optical fiber access network design, construction, and maintenance will be developed."

II.OBJECTIVES OF THE WORKSHOP

a. Share updates/achievements on the JICA Project for Optical Fiber Techniques in Telecommunications Engineering
b. Interact/Share information on various ICT activities being implemented by different agencies in Bhutan & Japan
c. Highlights on the R&D activities in particular on the access network in light of the ever growing demand for data

III.ORGANIZATION OF THE WORKSHOP

Bhutan Telecom Limited with assistance of the JICA Expert Team

IV.PARTICIPANTS

Around 100 participants will be invited to attend the Workshop from counterpart agencies (Bhutan Telecom Limited), Ministry of Information & Communication (MoIC), Gross National Happiness Commission (GNHC), Ministry of Health (MoH), Ministry of Education (MoE), Department of Disaster Management (DDM), Department of Road (DOR), National Land Commsion Secretariat (NLCS), Royal University of Bhutan (RUB), JDWNRH ,IT Park ,FabLab-Bhutan, City Corporation, Bhutan Power Corporation, TashiCell and JICA Bhutan Office.

DATE, VENUE AND AGENDA

Date : 30th Nov, 2016
Duration: One day (09:30～17:00)
Venue : Taj Tashi HOTEL (Samten Lam, Chubachu,Thimphu)
Dress : Formal
Agenda: Attachment1

IT Workshop, 2016

JICA Technical Cooperation Project for Optical Fiber Techniques in Telecommunication Engineering in Bhutan

30th November, 2016

Venue: Hotel (Taj Tashi) Conference Hall, Thimphu, Bhutan

Agenda		
08:00- 08:30	Registration	
08.30 - 09:00	Arrival of Chief Guest	
09:00 - 09:10	Welcome address	Mr.Tshewang Gyeltshen ,BTL CEO
09:10- 09:20	Opening Remarks	Mr. Koji Yamada, Chief Representative of JICA Bhutan Office
09:20- 09:30	Keynote Address by Chief Guest	His Excellency Lyonpo D.N. Dhungyel, Minister, MoIC
Group photo with Minister		
09:40 – 10:10	The Achievement of the JICA Project	Mr.Karma Tshewang ,JICA Project Director/ BTL Director (Technical)
Presentation by each ICT origination/sector		
10:10 – 10:40	e-Government: ”Public Service Delivery Initiative”	Mr. Garab Dorji, Dy. Chief ICT Officer, Good Governance Division Cabinet Secretariat
10:40 - 11:00	*Morning Tea/coffee break*	
11:00 – 11:30	e-Health: “Evidence based decision making for better health through ICT”	Mr. Trashi Phuntsho, ICT Officer, Ministry of Health
11:30-12:00	e-Education: “ICT in higher education”	Mr. Sonam Penjore, Manager, Educational Technology Division, Royal University of Bhutan
12:00-12:30	Thimphu TechPark: ”Bhutan’s first IT Park”, and its role in developing Bhutan’s IT Industry”	Dr. Tshering Cigay Dorji, CEO Thimphu TechPark Limited
12:30-14:00	Lunch Time	
14:00-14:40	Japan: ”The latest R&Ds for access Network in Japan”	Mr. Hirofumi Amano, Vice President Head of NTT Access Network Service Systems Laboratories
14 :40-15:20	Japan: “ Utilization of FTTH Broadband Network”	Mr. Kamba, Senior Manager, Strategic Business Development, NTT-East
15:20-15:50	“Benefits of having FabLabs in Bhutan”	FabLab-Bhutan/JICA Bhutan Office
15:50-16:00	Closing Speech	Mr.Junya Yamaguchi, JICA Project Chief Advisor
16:00 – 17:00	Farewell Coffee/Tea Break/Open Discussion	

ANNEX 2: List of Products

ANNEX 2-1

Technical Cooperation Project
For
Optical Fiber Techniques in Telecommunications Engineering

GIS O&M Guidelines
(Operation & Management)

July 2016

JICA

Bhutan Telecom Limited

1. GIS Data collection Introduction

1.1 Introduction

(1) Introduction of GIS

GIS is the abbreviation for Geographic Information System, and is a system which carries out processing, management, and analysis for geographical information integrative. Structure management and maintenance, and customer information management are performed by using GIS. In order to create the data of GIS, it is necessary to collecting data by using a DGPS receiver.

(2) Introduction of GPS

GPS is the abbreviation of" Global Positioning System". This system calculates the position correctly on the earth using a satellite. Latitude and longitude can be calculated in about (few cm - 3m) accuracy using the radio wave from the GPS Satellite placed at altitude about 20,000 km. There are satellites, such as Glonass of Russia besides GPS now. Moreover, Japan is using the Quasi-Zenith Satellite system. This system adjusts position information on GPS, and highly accurate positioning is possible for it. Now, systems, such as GPS, GLONASS, and Quasi-Zenith Satellite (QZSS), are called GNSS (Global Navigation Satellite System).

1.2 Equipment Used

DGPS receiver (Trimble TerraSync)
Digital Camera

1.3 Work Method

(1) Survey Standard

The survey standard to be used is carried out as follows.

System	Geodetic
Datum	WGS84
Format	DMS (Deg, Min, Sec)

(2) Plan Preparation

1) Work Plan Preparation

The following items shall be determined and the operation plan for control point survey shall be prepared.

- Work flow
- Organization structure
- Equipment used
- Data acquisition item
- Communication method and structure

2) Equipment preparation

The DGPS receiver to be used is charged and the data memory is checked.

(3) Field Work

GPS Observation

- GPS observation shall be performed using DGPS receiver.
- It observes in the place which has a space open the sky.
- The GPS observation data shall be collected as point data.
- An observation report which include the point name, time, observer, address and others, shall be prepared.
- Line data shall be collected while moving from one point to another from the beginning of the work.

(For the method operating the DGPS receiver, the TerraSync Operation Manual, which has been prepared as separate booklet, shall be referred.)

GPS Observation Report

Name	**Box001**	Operated by	○○○○
		Checked by	○○○○
Dzongdey	○○○○	Date	2016/7/18
Dzongkhag	○○○○		
Dungkhag	○○○○		
Gewok	○○○○		
WGS84 Geodetic	**N**	**E**	**H**
	27° 28′ 0″	89° 38′ 30″	2500.00
Note			

Figure 1 GPS Observation Report (Example)

Field Photographs

The photographs of structure shall be taken. The long, medium and close-up shots of the structures are selected.

Figure 5 Field Photograph - Close-up
(An Example)

Figure 6 Field Photograph – Long
(An Example)

(4) Calculation

- Daily data of GPS observation shall be downloaded to a PC at the end of the work.
- Post processing differential adjustment shall be applied to the downloaded data.
- A list of coordinates of the structure shall be prepared.
- GPS observation data, photographs shall be classified, organized and managed using the folders by point.

STATION	WGS84								
	LATITUDE				LONGITUDE				HEIGHT
BLN-17	14	47	33.99	N	121	1	17.22	E	96.589
BLN-2	14	50	47.73	N	120	45	52.91	E	46.647
BLN-3	14	54	15.29	N	121	2	34.84	E	128.071
BLN-4	15	11	23.80	N	121	2	39.55	E	121.017
BTN-B	14	35	13.15	N	120	35	31.90	E	47.985
NEJ-61	15	18	15.43	N	120	54	13.16	E	62.013
PC-24	14	54	8.68	N	120	41	44.80	E	45.882
PC-29	14	49	52.91	N	120	58	2.80	E	55.107
PC-03	15	15	17.36	N	120	42	40.88	E	64.97
PC-04	15	15	17.81	N	120	52	2.38	E	58.049
PC-05	15	14	33.86	N	120	58	52.16	E	66.723
PC-06	15	13	44.58	N	121	5	26.19	E	101.982
PC-10	15	10	22.30	N	120	55	33.43	E	54.52
PC-11	15	9	37.67	N	120	40	7.49	E	81.568
PC-14	15	4	55.05	N	120	32	56.04	E	149.069
PC-15	15	3	58.29	N	120	39	18.62	E	69.078
PC-16	15	3	10.78	N	120	52	21.68	E	52.312
PC-17	15	3	0.31	N	121	1	25.09	E	111.317
PC-18	14	58	14.74	N	120	12	56.20	E	115.149
PC-19	14	58	49.26	N	121	1	14.27	E	126.772

Figure 7 Point list (An Example)

1.4 Outputs

The outputs shall be submitted to the GIS manager.

- GPS Observation Raw Data
- Point List (Excel Format)
- Observation Report
- Photographs of the Field Work
- Line Data (Shape File)

All the outputs shall be submitted in a digital format.

1.5 Others to be considered

- All the field works shall be performed as paying attention to security and safety such as traffic accidents.
- The batteries and storage memory shall be checked before the commencement of the work to avoid unnecessary trouble.

- The working parties shall have an organization structure which enables communication with the GIS manager at all times.
- DGPS receiver is a delicate instrument, so be careful of handling.

2. DGPS Receiver Operation Manual (Trimble: Terra Sync)

Terra Sync Operation Manual

The procedure of acquiring DGPS using Terra Sync is as follows:

(1) Start Terra Sync

↓

(2) File Preparation

↓

(3) Various Setting (First Operation Only)

↓

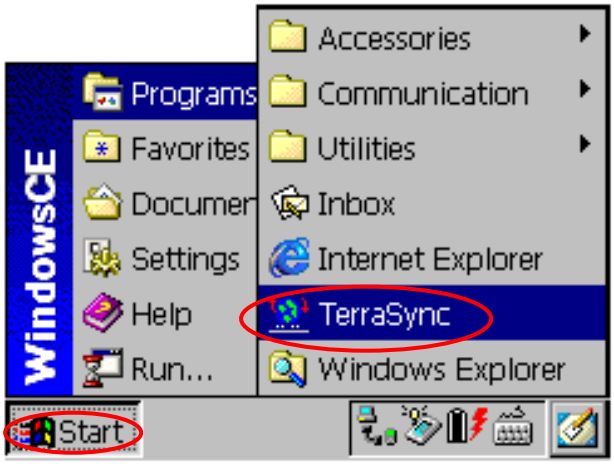
(4) Start Acquisition

↓

(5) End

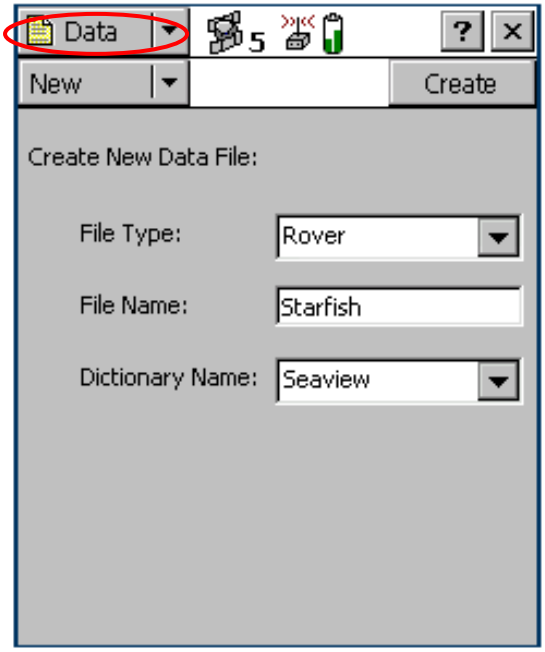
2.1. Start Terra Sync

Click Terra Sync from <Start>.

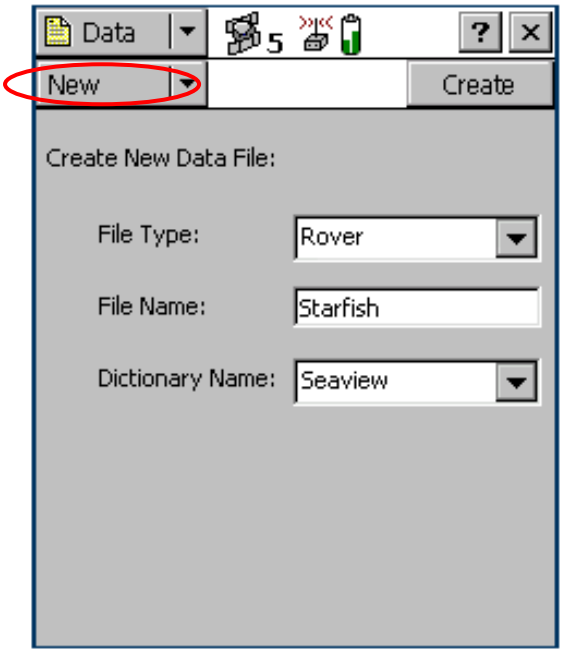


2.2. File Preparation

- Click <Data> from the drop down menu.

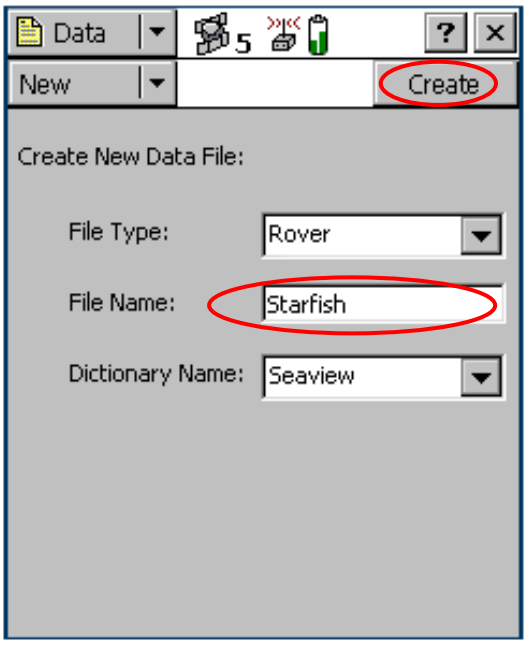


- Select <New File> from the drop down menu in the second row.

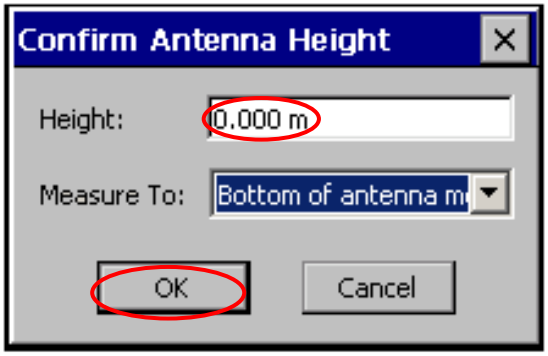


- Enter a file name, and click <Create>.

  (By default, month, day, and time are automatically entered.)

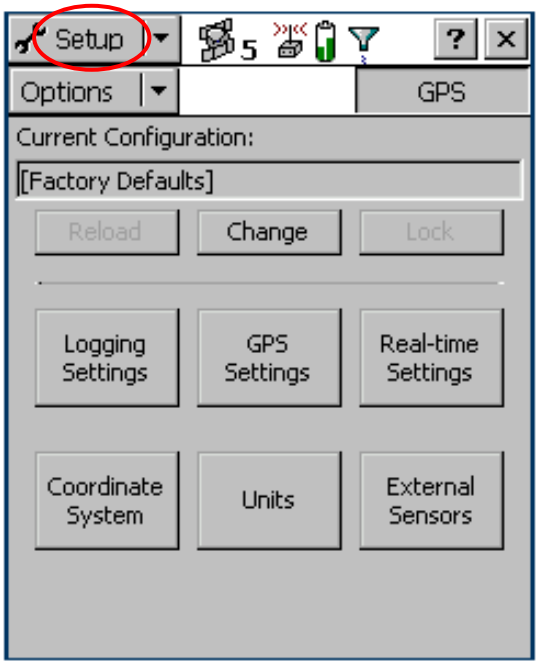


- Enter the height of antenna in the Confirm Antenna Height box. After entering, click OK

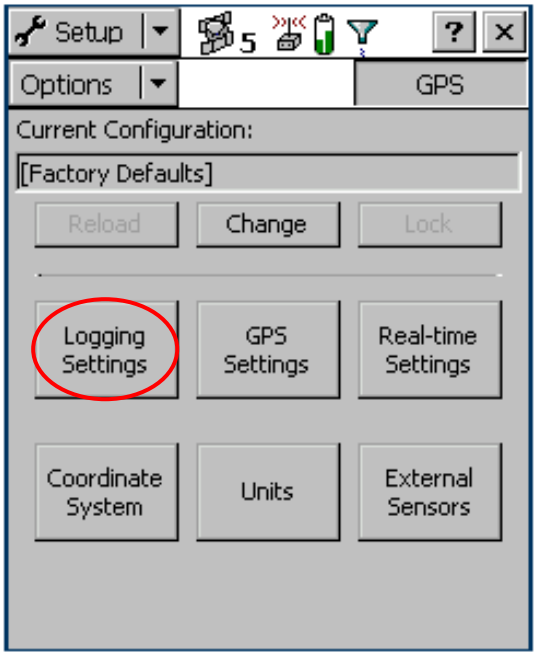


2.3. Setting Log Interval (First time only)

- Click <Setup> from the drop down menu at the top row.



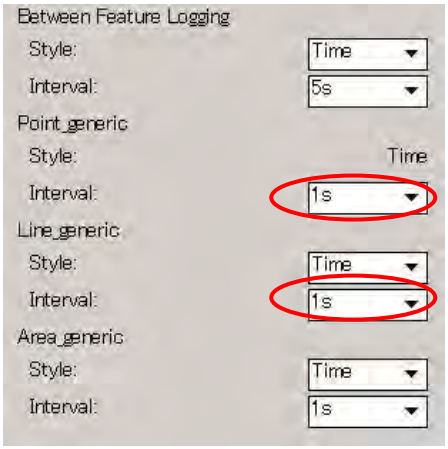
- Click <Logging Setting>.



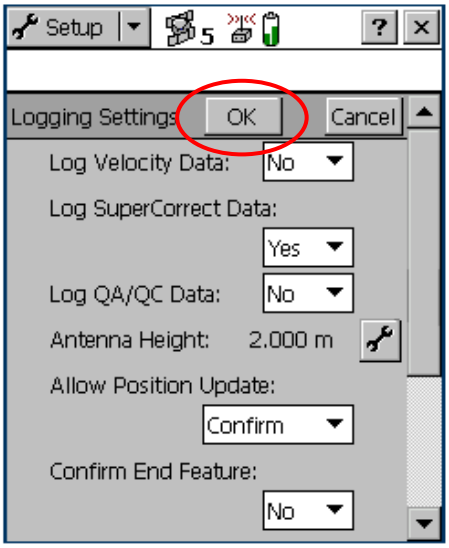
(Setting Values)

Point generic Style →<Time>Interval →<1s>

Line generic Style →<Time>Interval →<5s>



・ After setting, click <OK>.



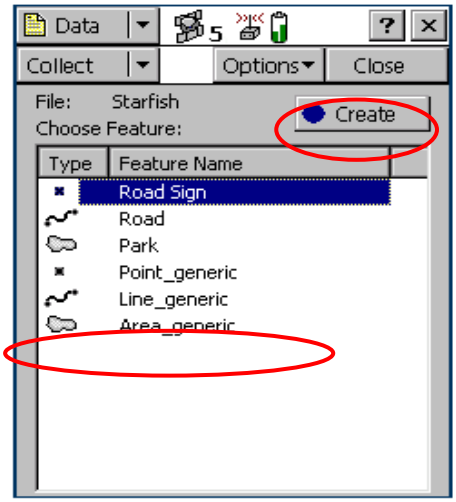
2.4. Data Acquisition

(1) Line Data Acquisition

1) Start Acquiring

・ Select <Data> from the top drop down menu.

・ Select Feature (Line_generic) →Click<●Create>.



Note: <■ OK> is a "save and finish" button. Do not click at this time.

When acquisition is commenced, a pencil icon is displayed at the top right of the form, and the number of acquired points are counted. When <Map> is selected from the top dropdown menu, a path from the beginning to the current position will be displayed.

2) Pause and Restart

- Click (II) at the second row in the <Map> display. Or click the pause button (**Pause II**) at the second row of the <Data> display.
- To resume, click the start button (▶) at the second row of the <Map> display. Or select the log button (**Log** ▶) at the second row of the <Data> display.

3) Finish

Click the red square button (■) at the second row of the <Map> display. Or click the OK button with a red square (■**OK**) at the third row of the <Data> display.

Button		Description
■ OK	OK	Closes and saves the current feature and returns to the Collect Features screen.
Cancel	Cancel	Returns to the Collect Features screen without saving the current feature.
Log ▶	Log	Starts logging GPS positions.
Pause II	Pause	Suspends logging of GPS positions. For more information, see Pausing and resuming logging.
Resume ▶	Resume	Starts logging GPS positions again after you have pausing logging. For more information, see Pausing and resuming logging.
Options	Options	Opens the option list for this form. For a detailed list of the available options, see Options.

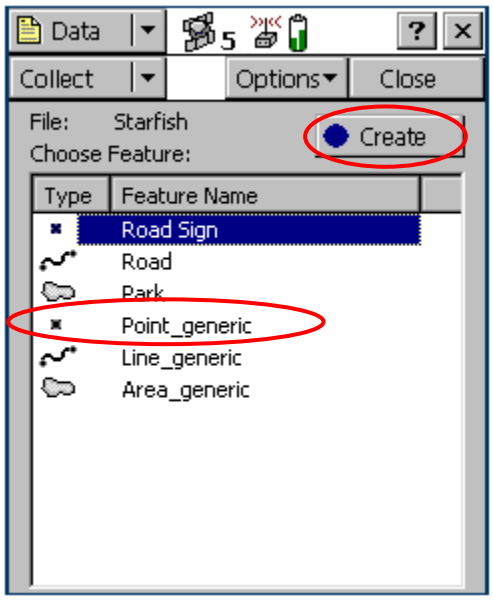
Attribute entry form: Fields

Field	Description
Mark as updated	Select this check box to indicate that you have visited a feature and checked its position and attributes, without making any changes to the values stored. This field only appears if you are updating an existing feature that has been imported from GPS Pathfinder Office. It is not available if you are creating or updating a new feature.
Attribute fields	The attribute entry form includes a field for each attribute defined in the data dictionary for this feature type.

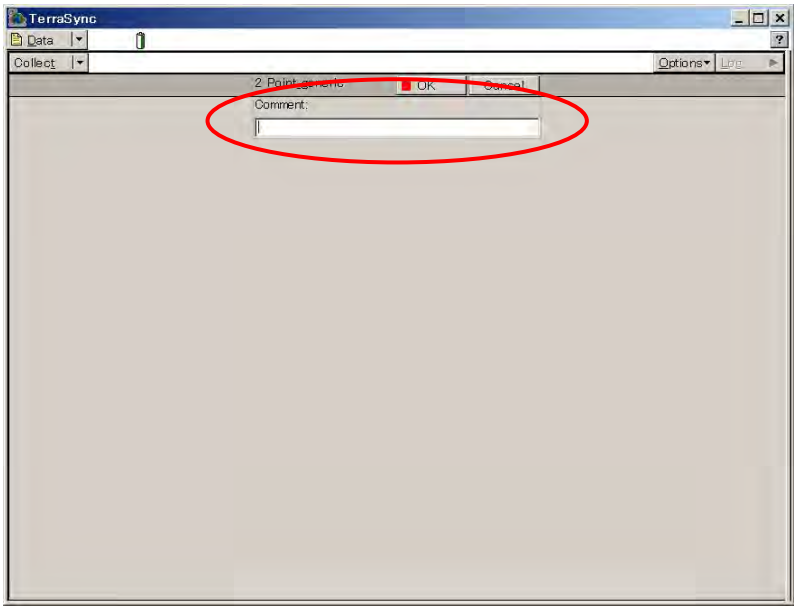
(2) Point Data Acquisition

1) Start Acquisition

- Click <Data> from the top dropdown menu.
- Select Feature (Point_generic)→Click <●Create>.



- Enter the name of Structure at the Comment box.



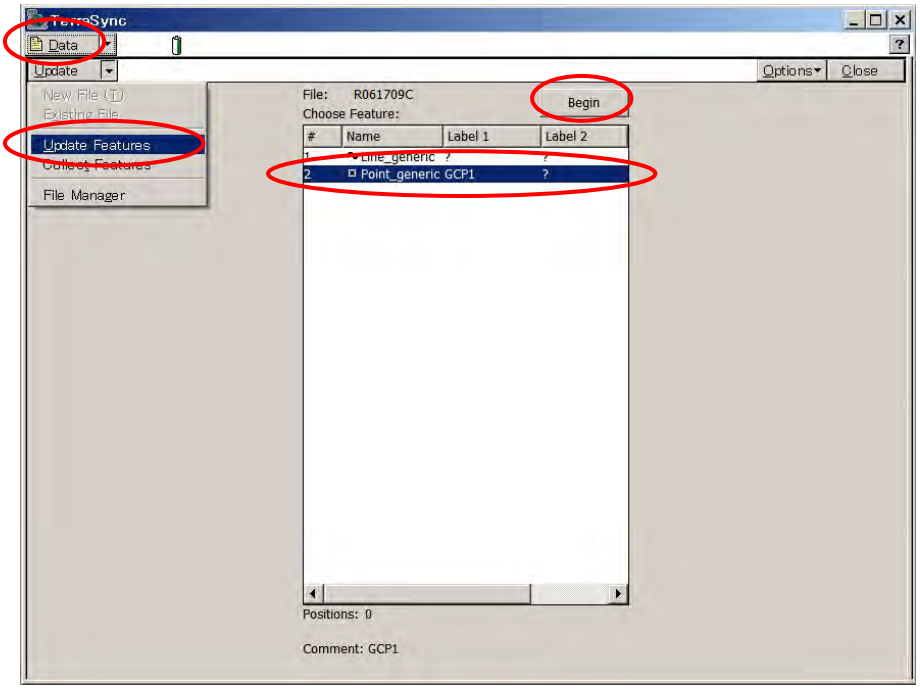
Note: <■ OK> is a "save and finish" button. Do not click at this time.

When data acquisition is started, the double circle icon (◎) will be displayed, and the number of acquired points will be counted.

The following is the same as in the line data.

(3) Resuming Data Acquisition

- Click <Data> from the top dropdown menu.
- Click <Update Features> from the bottom dropdown menu.
- Select a feature to be resumed, and click <Begin>.



(4) Finishing TerraSync

Click the ✕ button at the top right corner of the form to end TerraSync.

The operation using TerraSync ends here.
GPS Pathfinder Office, installed in a computer, will be used to process the acquired data.

2.5. Others to be noted

- A PDA loses its program when an internal battery runs out completely.
- When battery runs out messages such as “unstable signal” or “Cannot acquire data from the receiver” will be displayed. When this happens, change the batteries and start the data acquisition again. If the operation failed again, start from the beginning.

ANNEX 2-2

TECHNICAL COOPERATION PROJECT
FOR
OPTICAL FIBER TECHNIQUES IN TELECOMMUNICATIONS ENGINEERING

3. Guidelines for Testing and Troubleshooting Fiber Optic Installations

Develop by Mr. Rinzin Dorji

JULY 2016

JICA
BHUTAN TELECOM LIMITED

3.1 Once a fiber optic cable plant, network, system or link is installed, it needs to be Tested for four reasons:

a. To insure the fiber optic cable plant was properly installed to specified industry standards.
b. To insure the equipment intended for use on the cable plant will operate properly on the cabling
c. To insure the communications equipment is working to specifications
d. To document the cable plant and network for reference in case of future problems

3.2 **Tools and Test Equipment Need**

The following tools are needed to test and troubleshoot the fiber optic cable plant, System or link properly.

a. Optical Loss Test Set or power meter and test source with optical ratings matching the specifications of the installed system (fiber type and transmitter wavelength and type) and proper connector adapters. An OLTS that merely tests cable plant loss may not include a calibrated power meter needed for testing transmitter and receiver power, so a calibrated power meter and source are a better choice for link or system testing.
b. Reference test cables with proper sized fiber and connectors and compatible mating adapters of known good quality. These do not generally need to be "reference quality" but only in good condition, generally defined as having connector losses of less than 0.5 dB.
c. Visual fiber tracer and/or visual fault locator (VFL)
d. Connector inspection microscope with magnification of 100-200X and fixturing for proper connectors. Video microscopes are recommended
e. Cleaning supplies intended specifically for the cleaning of fiber optic connectors
f. Optional: OTDR with long launch and receive cables (100 m for Multimode, 1 km or more for single mode)

3.3 Testing And Troubleshooting The Installed Cable Plant

All fiber cable plants require certain basic tests to insure they were installed correctly and meet expected performance values. These are guidelines for testing and troubleshooting the cable plant itself. The most valuable data one can have for troubleshooting is the installation documentation.

Note - Cleaning: Before any testing, connectors should be cleaned carefully to ensure that no dirt is present on the end face of the connector ferrule as this will cause high loss and reflectance. Protective caps on connectors, often called "dust caps" – some say that's because they usually contain dust – do not necessarily keep connectors clean. Use cleaning supplies intended for

cleaning fiber optic connectors only as other materials my leave residue or cause harm to the connectors.

3.4 What Can Go Wrong?

There are a number of possible problems with fiber optic cable installations that are caused by installation practice. These include:

a. Damage to the cable during installation caused by improper pulling techniques (such as not pulling the fiber cable by the strength member,) excess tension, tight bends under tension, kinking or even too many bends. Most of these problems will be seen on all fibers in the cable.
b. Damage to the fibers in the cable during cable preparation for splicing or termination. Fibers may be broken or cracked during cable jacket or buffer tube removal or fiber stripping. This may affect all fibers in the cable or buffer tube or just one fiber.
c. High loss splices caused by improper splicing procedures, especially poor cleaving on mechanical splices or improper programming of fusion splicer's. Most fusion splicer's give feedback on most problems if the operator is properly trained. Individual fibers can be damaged when being placed in splice trays or tubes of fibers damaged during placement in splice closures.
d. High loss connectors may be caused by bad processes or damage after termination. Adhesive/polish connectors may have poor end finishes or cracks in the fiber at the end of the ferrule or internally. Prepolished/splice connectors are generally high loss due to poor mechanical splicing processes during termination causing high internal loss.

Note- for Cable reel testing; Before installation, it is advisable to test all cable as received on the reel for continuity using a visual tracer or fault locator. Cables showing signs of damage in shipment may need OTDR testing to determine if the cable itself is damaged. Obviously, no cable showing damage should be installed

3.5 Test insertion loss after installation

a. After installation, splicing (if applicable) and termination, all cables should be tested for insertion loss using a source and meter or OLTS (optical loss test set)
b. Generally cables are tested individually (connector to connector for each terminated section of cable and then a complete concatenated cable plant is tested "end-to-end", excluding the patch cords that will be used to connect the communications equipment which are tested separately.
c. It is the concatenated cable test that is used to compare to the link power budget and communications equipment power budget to insure proper operation.
d. Insertion loss testing should be done at the wavelength of intended operation if known or at two wavelengths with appropriate sources (850/1300 nm with LEDs for multimode fiber, 1310/1550 nm with lasers for single mode fiber, 1490 for FTTH.)
e. Unless standards call for bi-directional testing, double-ended testing with both launch and receive cables is adequate

f. Data on insertion loss of each fiber should be kept for future comparisons if problems arise or restoration becomes necessary. Recording data on a label inside the patch panel or enclosure is common practice.

g. Long cables with splices may be tested with an OTDR to confirm splice quality and detect any problems caused during installation, but insertion loss testing with an OLTS (light source and power meter) is still required to confirm end-to-end loss. Cables with insertion loss near expected values do not also need OTDR testing. Cables tested with an OTDR should have the data kept on file for future needs in restoration

3.6 Troubleshooting

a. First determine if the problem is with one or all the fibers in the cable. If all fibers are a problem, there is a likelihood of a severe cable installation problem. If all fibers are broken or have higher than expected loss, an OTDR will show the location of the problem on longer cables but premises cables may be too short and need physical inspection of the cable run. If the problem is caused by kinking or too tight a bend, the cable will have to be repaired or replaced. Generally OSP cables will be spliced as in a restoration and if the cable is a short OSP cable or a premises cable, replaced.
b. High loss fibers have several potential causes, but bad splices or terminations are the most likely cause for field terminated cables. In some cases, using improper termination practices will result in high loss for all fibers, just as in kinking or bending losses, not just one fiber.
c. Testing for high loss fibers should start with microscope inspection of terminations for proper polish, dirt, scratches or damage
d. If dirt appears to be the problem, clean the connectors and retest.
e. If other connector damage is found on visual inspection, retermination will probably be necessary. Sometimes scratches can be polished out with diamond film by an experienced technician.

f. Prepolished splice connectors with internal splices will generally look OK when inspected with a microscope unless damaged after installation. The most likely cause of loss with these connectors is high splice loss in the internal splice. They can be tested with a visual fault locator coupled into the fiber at the far end. Highlight loss will be seen as an illumination of the connector ferrule. Some connectors have translucent back shells and can be tested with a VFL coupled directly into the connector.
g. If the reason for high loss is not obvious and the connectors are adhesive/polish style, the problem may be a fiber break in the back of the connector. A VFL may help in finding fiber breaks, depending on the connector style and the opacity the cable jacket.
h. Cables with a fiber or fibers showing very high loss or no light transmission at all should be tested for obvious breaks in the pigtail fiber or cable, generally at the splice or connector, with a visual fault locator or high resolution OTDR if the cable is of sufficient length
i. Splice loss problems can be pinpointed during OTDR testing. Confirmation with a VFL should be done if the length from the end of the cable is short enough (~2-3 km) where a

VFL is usable. The VFL can find high loss splices or cracks in fibers caused by handling problems in the splice tray.

j. High loss links where the excessive loss is only a few dB can be tested like a patch cord with a single-ended test with a source and power meter. When tested in this manner, a high loss connector will show high loss when connected to the launch cable connector but not when connected directly to the power meter detector which picks up all the light from the fiber

Hints for troubleshooting

a. Having access to design specifications and installation documentation and specifications will greatly assist troubleshooting.
b. If possible, interview the installer to help uncover processes that may lead to issues in installation, such as pulling methods, lubrication, intermediate pulls, splicing or
c. High loss and reflection even when connectors look OK in microscope.)

3.7 Testing and Troubleshooting Patch cords

Patch cords are short factory-terminated cables usually with standard heat-cured
Epoxy/polish connectors on each end. They are used to connect equipment to the cable
Plant and as reference cables for testing insertion loss

Likely Problems

Most patch cord problems are connector problems, caused by damage due to handling or numerous mating when used as reference cables for testing other cables.
Connectors may also be damaged by breaking fibers at the back of the connector due to excess stress during handling or by placing other equipment on top of them in enclosures or patch panels.

3.8 Testing and Troubleshooting Steps

a. All patch cords, especially those used as reference cables for insertion loss testing, should be tested for insertion loss.
b. Patch cords should be tested with an optical loss test set (optical power meter and source) using single methods with one reference cable used as a launch cable.
c. This will test the connector mated to the reference cable and the fiber in the patch cord, which is short enough it should have no measurable loss.
d. Since the connector connected to the power meter will not be connected to fiber but presented directly to the detector of the power meter, it effectively has no loss.
e. After testing in one direction, reverse the patch cord and test the other end.
f. In both directions, factory-made patch cords should have a loss of less than 0.5 or whatever performance the user has specified with patch cord vendors.
g. High loss connectors should be inspected with a microscope for dirt or damage.

h. If other connector damage is found on visual inspection, retermination will probably be necessary but may not be cost effective, so the patch cord should be replaced. Sometimes scratches can be polished out with diamond film by an experienced technician.

i. Some optical loss test sets include fiber interfaces on both source and meter ports, so all testing is done double-ended, even if the cable under test is directly connected to an input port. A test set such as this makes reverse testing less effective since reversing test direction may not have any significant effect. Test ports on an OLTS like this should be kept covered when not in use and cleaned periodically. Damaged fibers inside an OLTS will require factory repair

3.9 Testing and Troubleshooting Communications Equipment

After the cable plant has been tested, the communications equipment should be properly connected using matching known-good patch cords. If the cable plant loss is within the loss budget of the equipment (including the loss of the patch cords), the Communications link should work properly. If the link does not work, most likely potential problems are the following

a. Improper connections
b. Cable plant problems
c. Malfunctions of communications equipment

3.10 Testing and Troubleshooting Steps for Communications Equipment

a. Improper connections.
   i. The system requires a transmitter be connected to a receiver, of course, so it is important to verify this connection for each link. Even if the cable plant is properly documented, fibers may have been crossed at intermediate connections, so using a visual tracer or visual fault locator will allow quick confirmation of the connection

b. The functioning of the communications equipment:
   i. If it is connected to the cable plant but not operating properly, begin by checking the power at the receiver on one end of the link.

   ii. Disconnect the cable at the receiver input and measure power with an optical power meter. Make sure the equipment is trying to transmit a signal. Some equipment has a testing mode to force transmission of a test signal or the equipment may simply keep transmitting to try to complete a connection
   iii. If the receiver power is within specifications, the receiver or electronics beyond the link may be the problem. Use equipment diagnostics or consult the manufacturer for assistance.
   iv. If the receiver power is too high, it may be overloading the receiver and an optical attenuator should be inserted at the receiver end to reduce the power to the proper level.
   v. If the receiver power is lower than required by operating specifications, the cause is either low transmitter power or too much loss in the cable plant.

vi. To test transmitter power, disconnect the patch cord connecting the transmitter to the cable plant and measure the optical power. If the power is low, there is a problem with the transmitter or patch cord

vii. If the transmitter power is low with a known good patch cord, the equipment may need maintenance (cleaning) of the output port or replacement.

viii. If the transmitter test as good but receiver power is low, the problem is probably in the cable plant. First try to switch the communications link to spare fibers to see if that solves the problem. Next test the loss of the suspect fibers in the cable plant with an OLTS to determine if the cable plant loss is excessive.

c. Cable Plant Problems

i. High loss in the cable plant can be caused by damage after installation and testing. Use a visual tracer or visual fault locator to confirm continuity and an OLTS to test loss. See directions above on testing the loss of the cable plant

ii. If the cable plant is long enough (>100m), it can be tested with an OTDR to pinpoint problems

iii. If the cable plant loss is not the problem, there are other possible issues related to the bandwidth of the cable plant.

iv. Single mode links may suffer from problems caused by reflections at connectors or mechanical splices

v. Reflections in single mode terminations or splices near the source may cause nonlinearities in the laser transmitter which distort pulse shapes, causing high bit error rates (BER).

vi. Reflections near the receiver or at both ends can cause multiple reflections in the cable that create “optical noise” that causes BER.

vii. Reflections can be tested, if the cable plant is long enough (>100m), with an OTDR to pinpoint problems.

viii. Reflections can be reduced by introducing an index-matching gel or fluid in the joint (Vaseline or mineral oil works, but is messy to clean up) to see if that solves the problem.

ix. Highly reflective connectors or splices should be replaced as soon as possible. Remember most single mode terminations are made by fusion splicing factory-terminated pigtails onto installed cabling.

3.11 Update Documentation

After completing tests, troubleshooting and repairs, update documentation to reflect the necessary procedures and any changes to the network. If the fix is to switch to spare
Fibers and suspect fibers are not fixed, not that on documentation to prevent future problems

OUTLINE of FTTX Techniques in Telecommunications Engineering

July. 2014

Junya YAMAGUCHI
Chief Advisor
JICA Technical Cooperation Project for Optical Fiber Techniques in Bhutan

Table of Contents

ANNEX 2-3

1. Background

ANNEX 2-3

1.1 Current BT's inventory

- Existing Facilities
  - ✓ Long-distance Communications Transmission Network (City to City)
    - Digital Microwave System by Japanese grant aid(1992-1994)
    - OPGW by BTL(2003~2004) and BPCL(2010~2012) has done, The system has reached to all Dzongkhags.
    - This network provides Long-distance transmission line, and TV broadcasting transmission line
  - ✓ Local/Access Network (Intra city)
    - Legacy facilities (metal cable)
    - ADSL
    - FTTX・・・・on going

1. Background

ANNEX 2-3

1.2 Background of the Project (1)

- Government Policy(10th Five Year Plan / 11th Five Year Plan)
  - ✓ Provision of unified governmental service throughout the country
  - ✓ Introduction of e-government, telemedicine, e-learning & Community, information center, etc.
- Bhutan Telecom's 5 year plan (2012 – 2017)
  - ✓ Covering the big cities with fiber cables (OPGW, ADSS, Fig-8, Underground) by approx. 90% in population.
  - ✓ Implementing fiber optic local access Network, such as Fiber-to-The Cabinet, Fiber-to-The Building, Fiber-to-The Home (FTTC/FTTB/FTTH)

1. Background

1.2 Background of the Project (2)

- Customer demand/request for Broadband service
  - With increasing demand for higher bandwidth from the customers for broadband Internet, smart phones, tablets, and video traffic

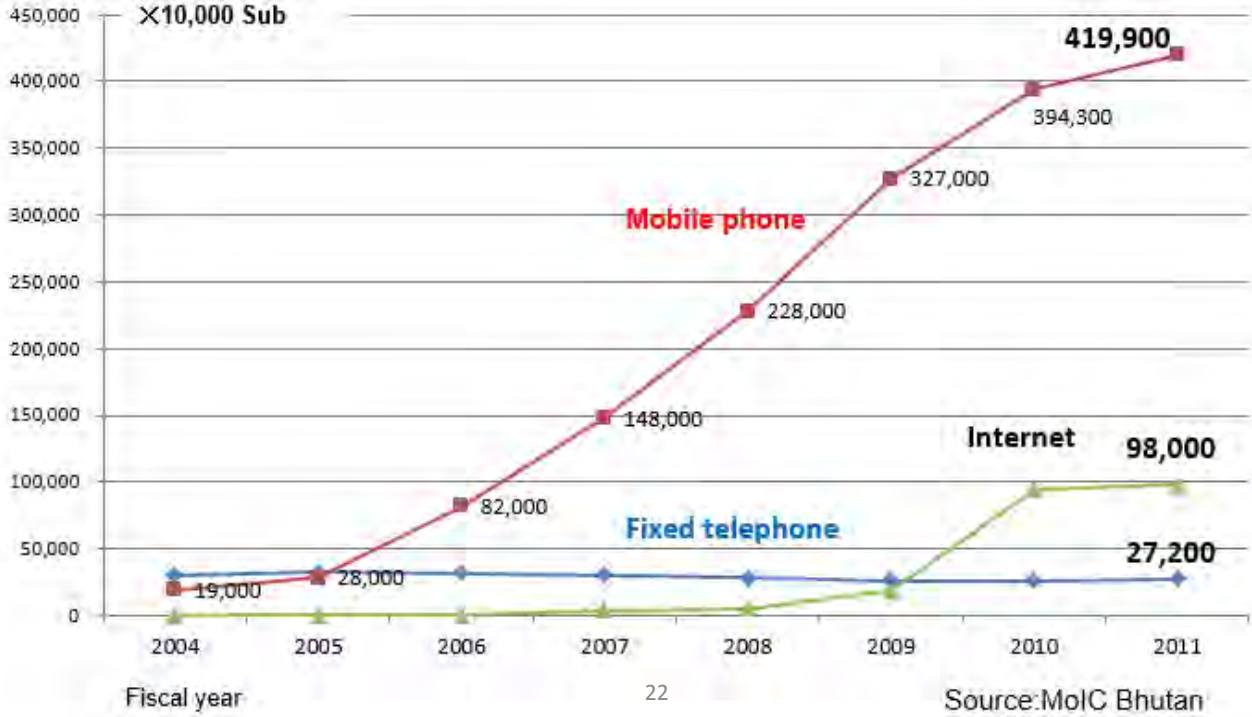
- Importance of Optic Fiber Access network toward broadband services
  - Optic fiber access generally applied on;
    - ✓ Secured broadband business use,
    - ✓ Broadband access lines in concentrated areas,
    - ✓ Approach links to base-stations from mobile switches, and
    - ✓ CATV, etc.

- BT's Challenges

The existing engineers are working on planning, designing & implementing fiber networks

1. Background

1.3 Trends in the number of users of fixed telephone, mobile phones, Internet in Bhutan



2. Basic Technology for FTTX

ANNEX 2-3

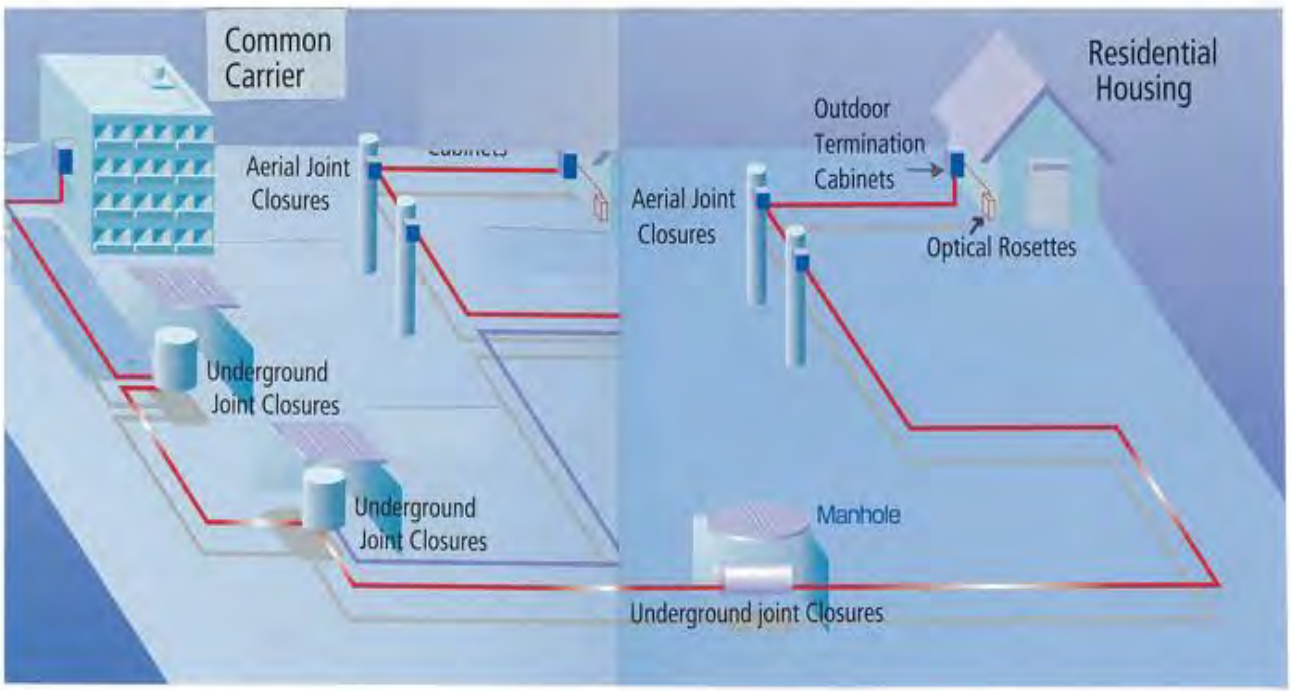
2.1 Configuration of OSP FTTX facilities

- Fiber-optic cable (Underground cable, aerial cable)
- Optical drop wire
- Optical premises cable
- Optical joint closure (Underground type, aerial type)
- Optical cabinet
- Optical rosette/Outlet

(Refer attachment)

Configuration of OSP FTTX facilities

ANNEX 2-3



OSP:Outside telecom Plant

Source:Japan Recom

2. Basic Technology for FTTX

ANNEX 2-3

2.2 Features of Optical fiber

- light in weight
- low loss
- large transmission capacity
- vulnerable to bending
- vulnerable to twist
- free from electromagnetic induction
- dual structure of core with clad
- causes of light loss (Radiation loss by bending, Fresnel reflection, Rayleigh scattering,etc)

2. Basic Technology for FTTX

ANNEX 2-3

2.3 Type of optical fiber splicing/connection method

- Fusion splicing method
- Mechanical connection method (connector)

2.4 The concept of fiber transmission loss

- Loss calculation of optical fiber cable (S)

  S=l(km) × Lλ(dB/km)

  Lλ: optical fiber attenuation (1 ~ 1.5dB/km)

  l : cable length in km

- Optical fiber transmission loss (performance verification) D

  D = Fiber optic cable loss (S) + Connector loss + Splice loss (dB)

2. Basic Technology for FTTX

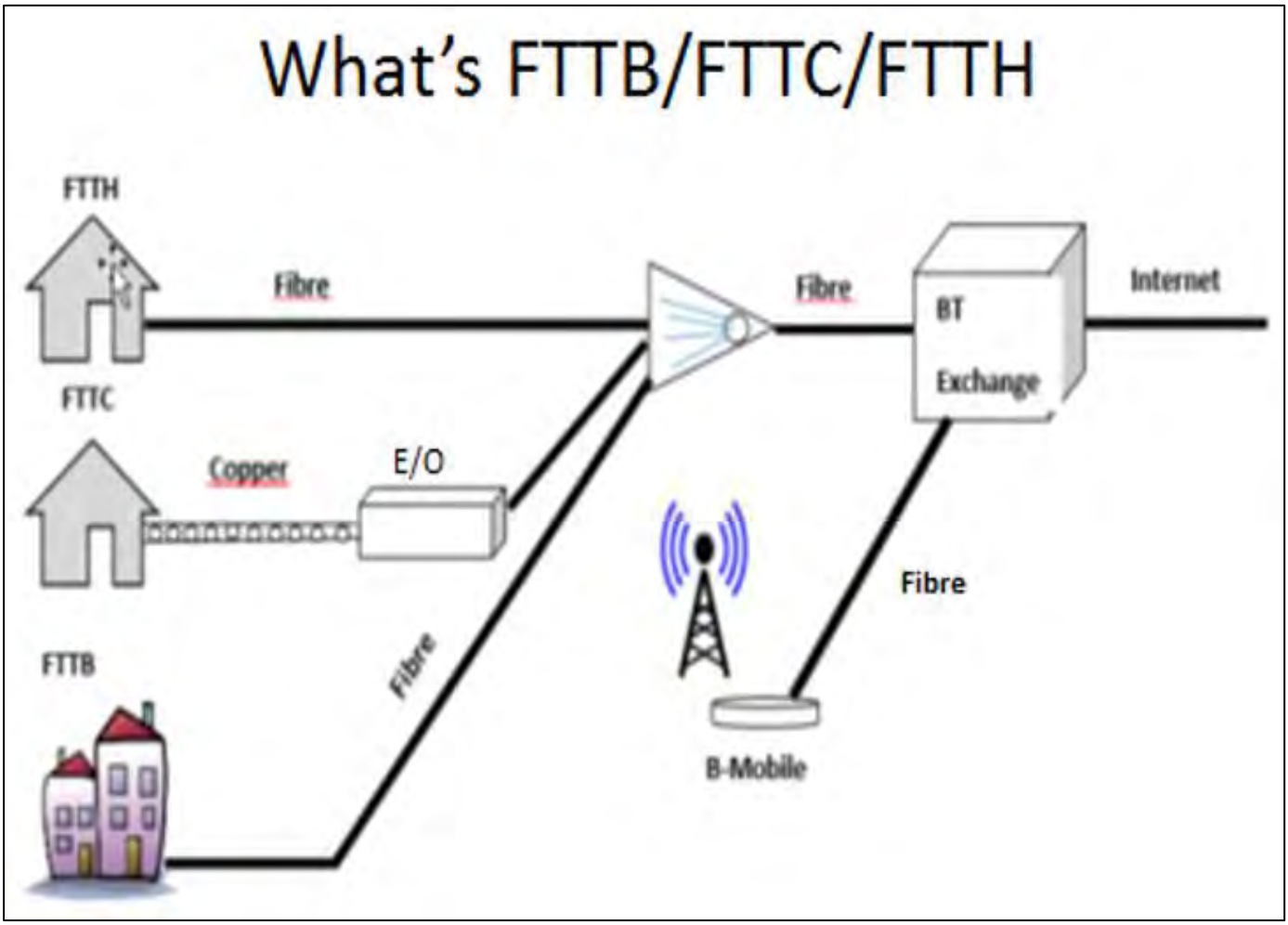
2.5 Fiber-optic measurement equipment

- OTDR
- Optical power meter

2.6 Optical subscriber wiring method of optical subscriber cable

- FTTC
- FTTB
- FTTH

(Refer attachment)

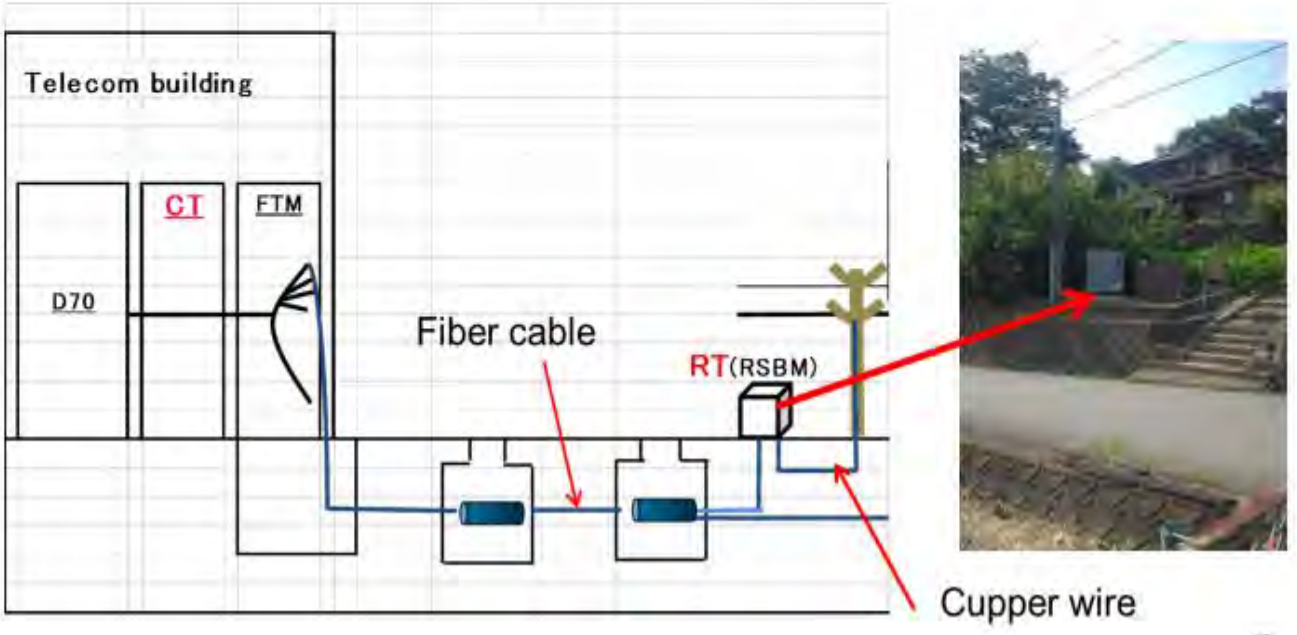


2. Basic Technology for FTTX

ANNEX 2-3

FTTC : Fiber To The Curb

Fiber cables from Telephone office to a corner of the road (Curb) /telephone poles, and then distributed to houses by radio system (FWA)

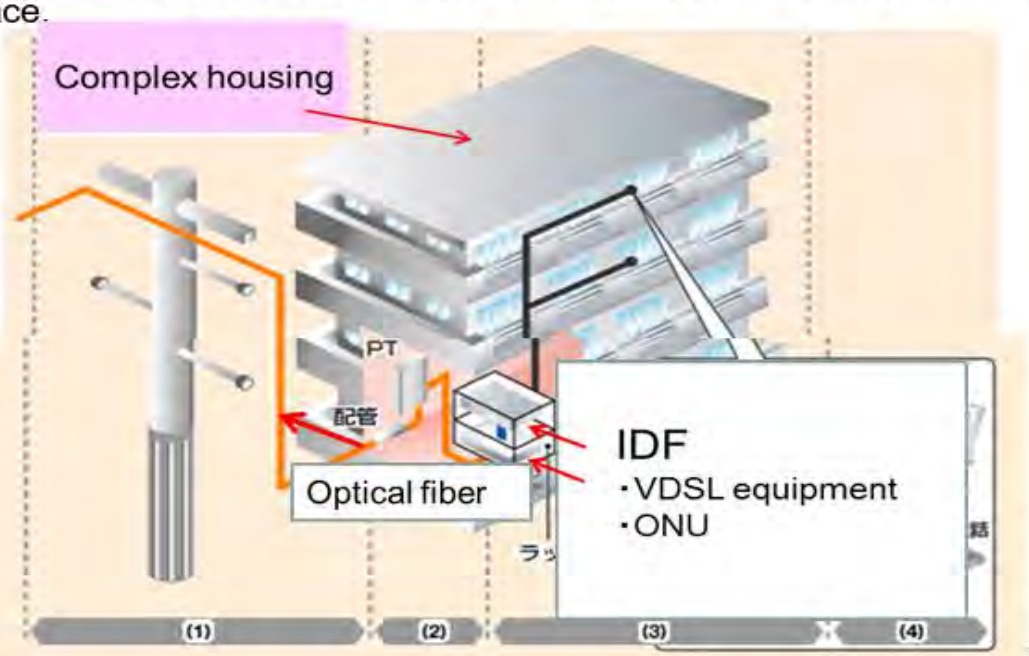


2. Basic Technology for FTTX

ANNEX 2-3

FTTB : Fiber To The Building

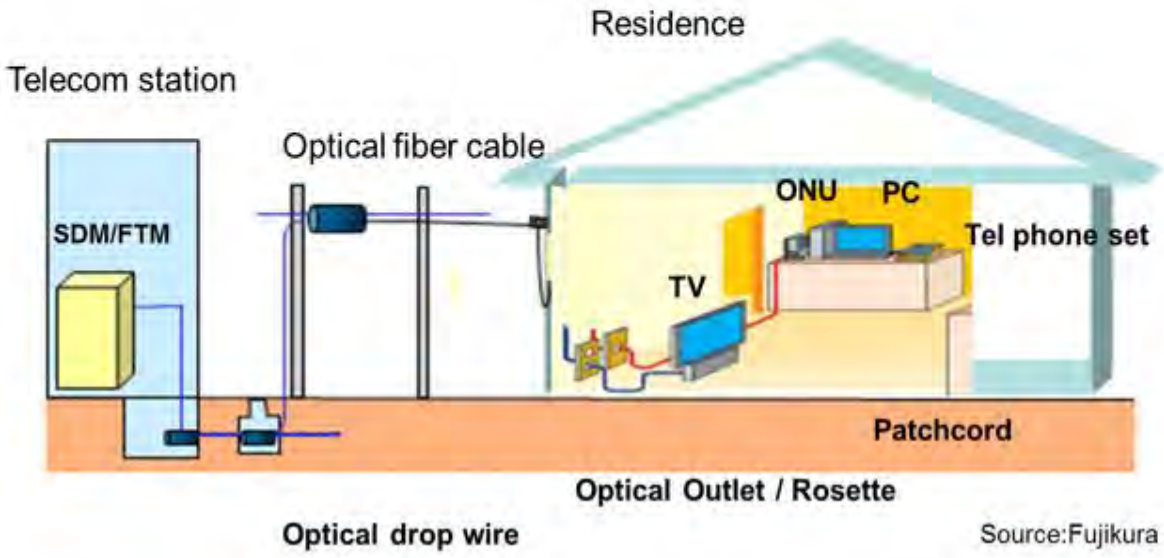
Fibers cable From Telephone office to MDF inside housing complexes or office buildings, and connecting to existing cupper wire each room/office space.



2. Basic Technology for FTTX

ANNEX 2-3

FTTH : Fiber To The Home



3.Notes for optical cable installation worl

ANNEX 2-3

3.1 Optical cable laying work

- Allowable bending radius: 20 times of cable outer diameter (when installing), 10 times (when fixing)
- confirmation of laying tension

3.2 Optical cable splicing work

- keeping your hands clean
- Keeping the working spot/place clean where optical fiber connecting (To eliminate dust, dirt)
- Cleaning tools such as optical fiber stripper, optical fiber cutter, etc

3.3 Optical cable measurement working Method

- Do Not look into the laser light
- Clean the connection part of the measuring equipment

4. Safety work

ANNEX 2-3

- Safety measures (Construction signs, Safety corn, a guide for traffic, etc.)
- Wearing safety belt on a pole, a helmet, and etc.
- Gas detection before Joint BOX(tunnel) works (continuous ventilation)
- Electric shock prevention (check a distance to the power line, and implement electroscopic)

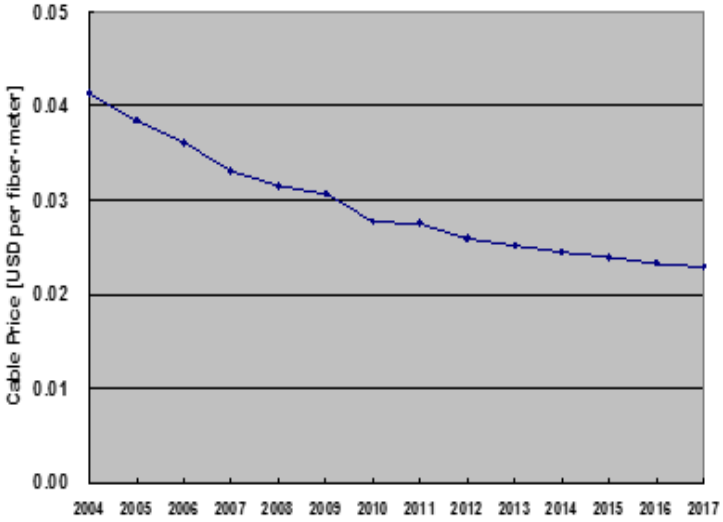
5. Trend of optical fiber technology (1/6)

ANNEX 2-3

- Changes in the optical fiber cable market
  - ✓ With the Innovation and widespread use of optical fiber cable,
    - Reduction of the optical fiber cable transmission loss (Refer Fig1)
    - Fiber-optic cable price has been reduced(Refer Fig2)

Fig1:0ptical fiber loss

Fig2:Single-mode Fiber Optic Cable Price Trends

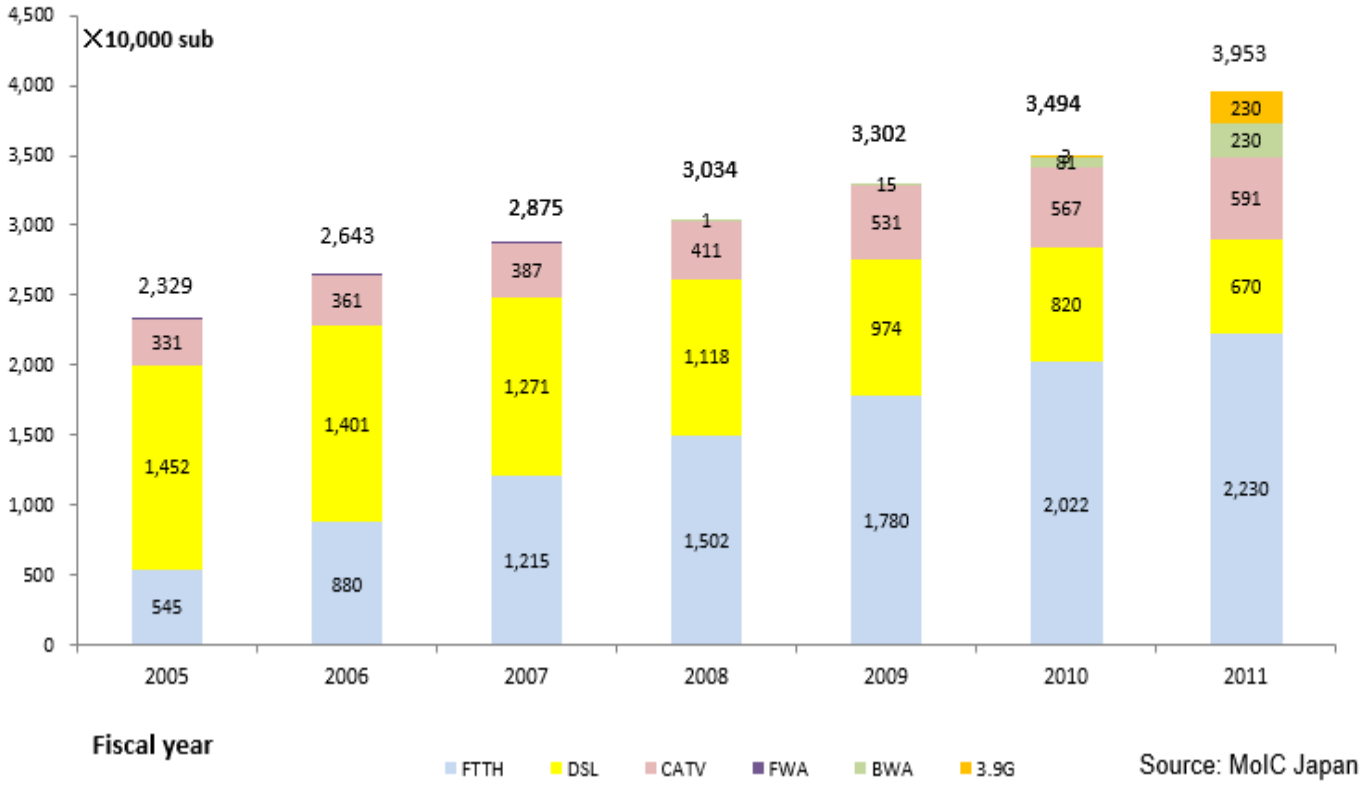


Source: CRU International

5. Trend of optical fiber technology (2/6)

ANNEX 2-3

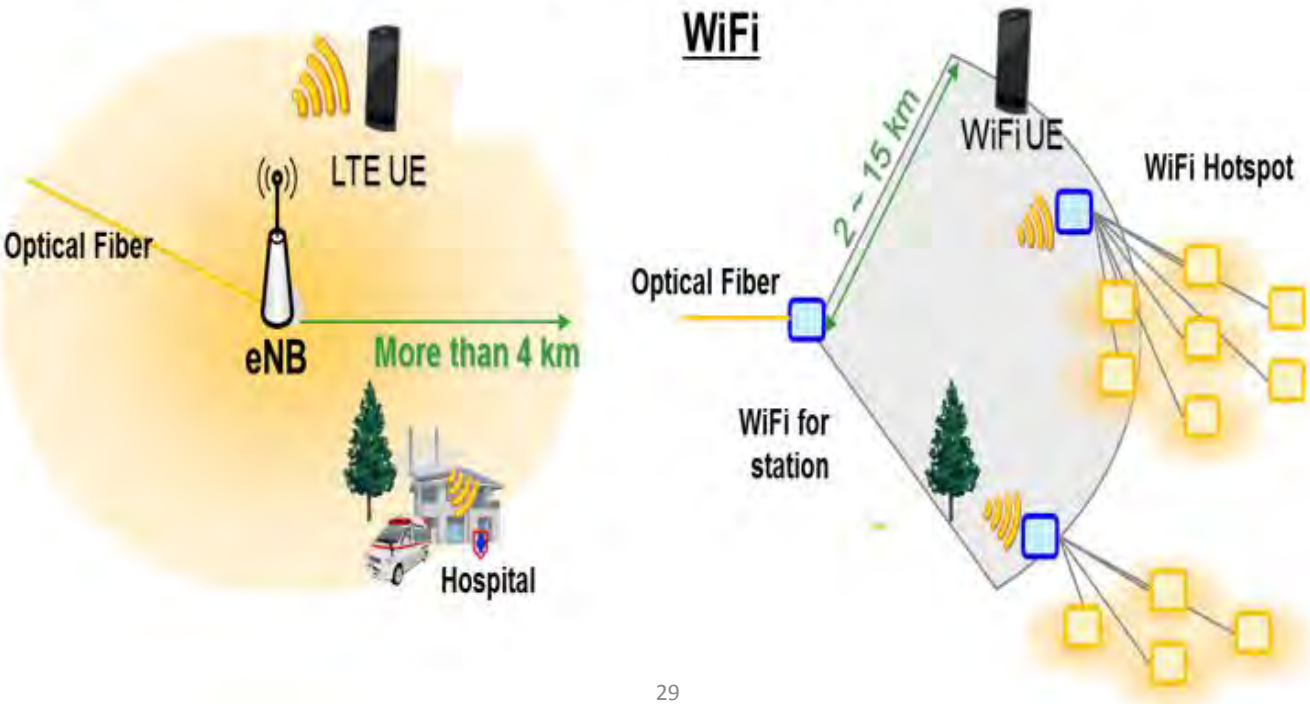
➢ **Changes in number of broadband subscribers in case of Japan**



5. Trend of optical fiber technology (3/6)

ANNEX 2-3

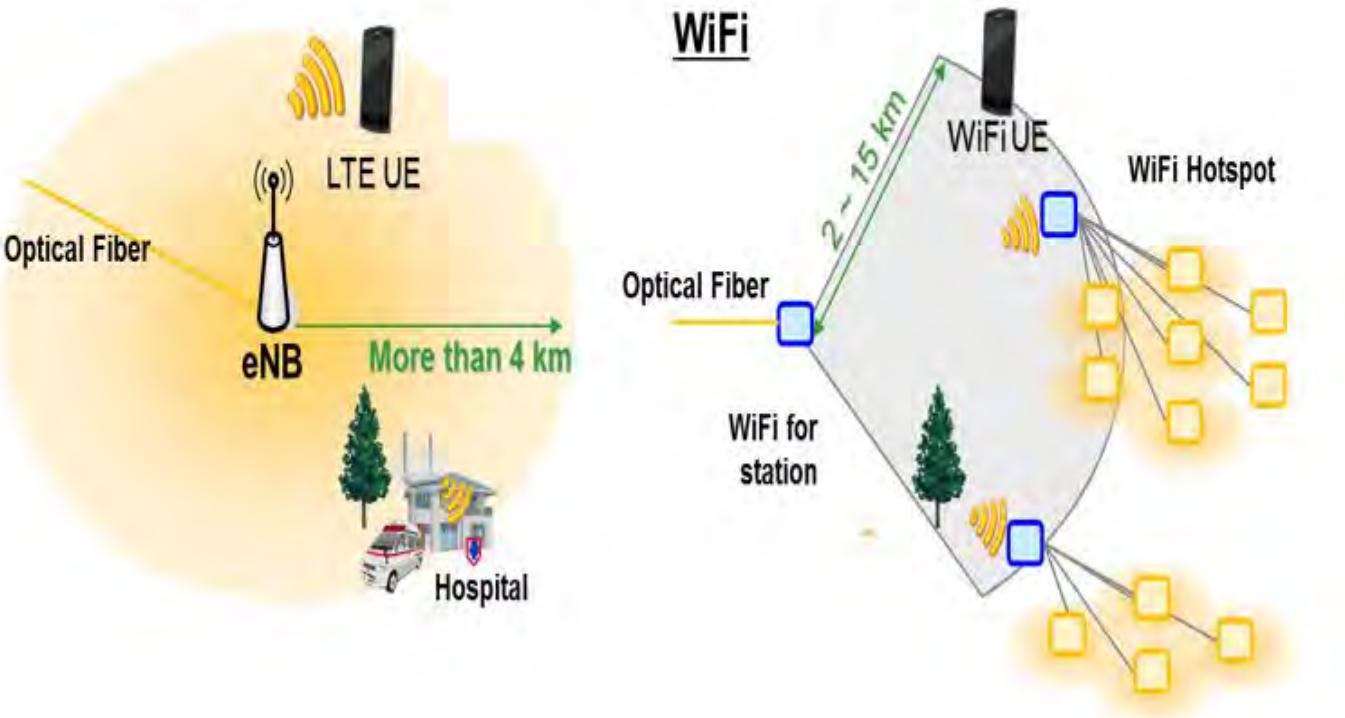
➢ Examples of FTTC configuration with FWA for distribution



5. Trend of optical fiber technology (4/6)

ANNEX 2-3

- Examples of FTTC configuration with FWA for distribution



5. Trend of optical fiber technology (5/6)

ANNEX 2-3

Introduction of FTTH does not only replace legacy cable (cupper) with a fiber optic cable network for high-speed/high-capacity communications transmission rate, but promoting broadband telecommunication society/industry

5.1 Expansion and development of IT business

1) Key infrastructure of broadband society.
   - e-business: Electric money, Electric stock dealing, Electric transfer sys
   - e-government: Electric tax-payment, Electric resident data sys
   - e-health : Electric medical recording sys, Remote image diagnosis

2) Supporting Mobile and wireless network expansion

   It become to supply fiber optic cable for the base station of LTE, and the to the hot spot of Wi-Fi

3) Providing IT provider, CATV operators, etc. with fiber cores and/or transmitting band.

5. Trend of optical fiber technology (6/6)

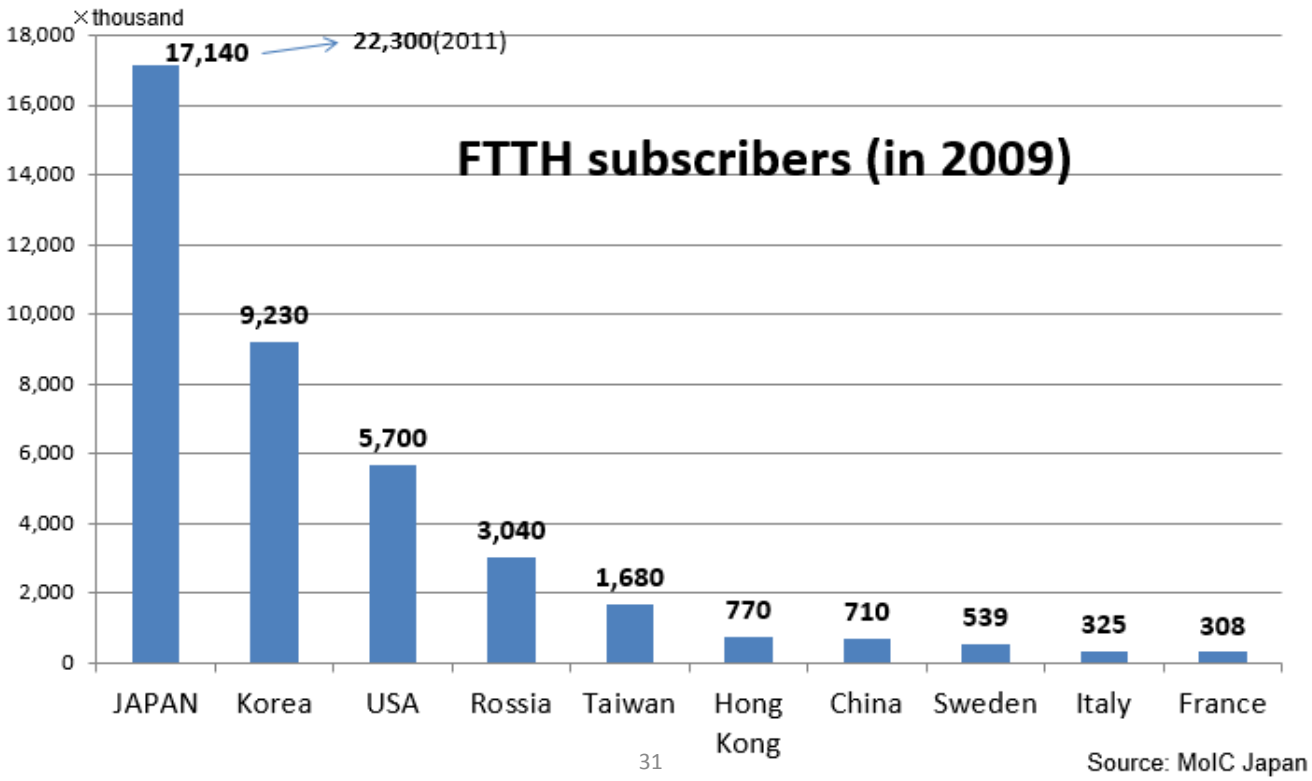
5.2 Efficient construction operation, improvement of customer service (promotion of DIY)

A flexible optical fiber Patchcord and an Optical Rosettes enables remote constructions, and decrease man-power works at the field.

(Below half of the former radius →The miniaturization of apparatus or a termination box →Improvement in work of interior wiring）

Source:Fujikura

Appendix 1

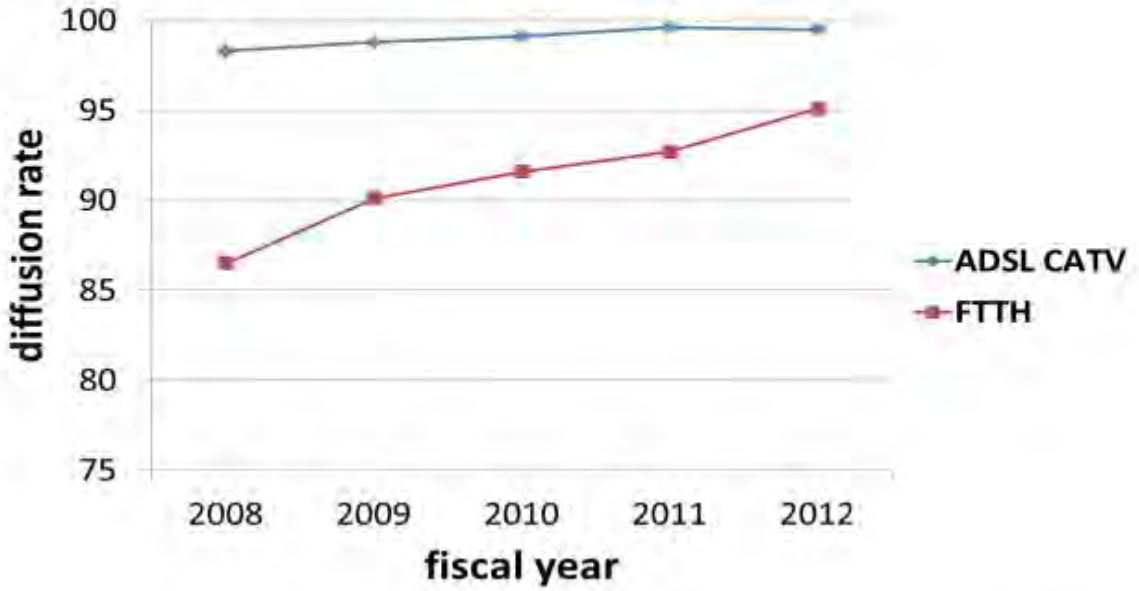


Source: MoIC Japan

Appendix 2

ANNEX 2-3

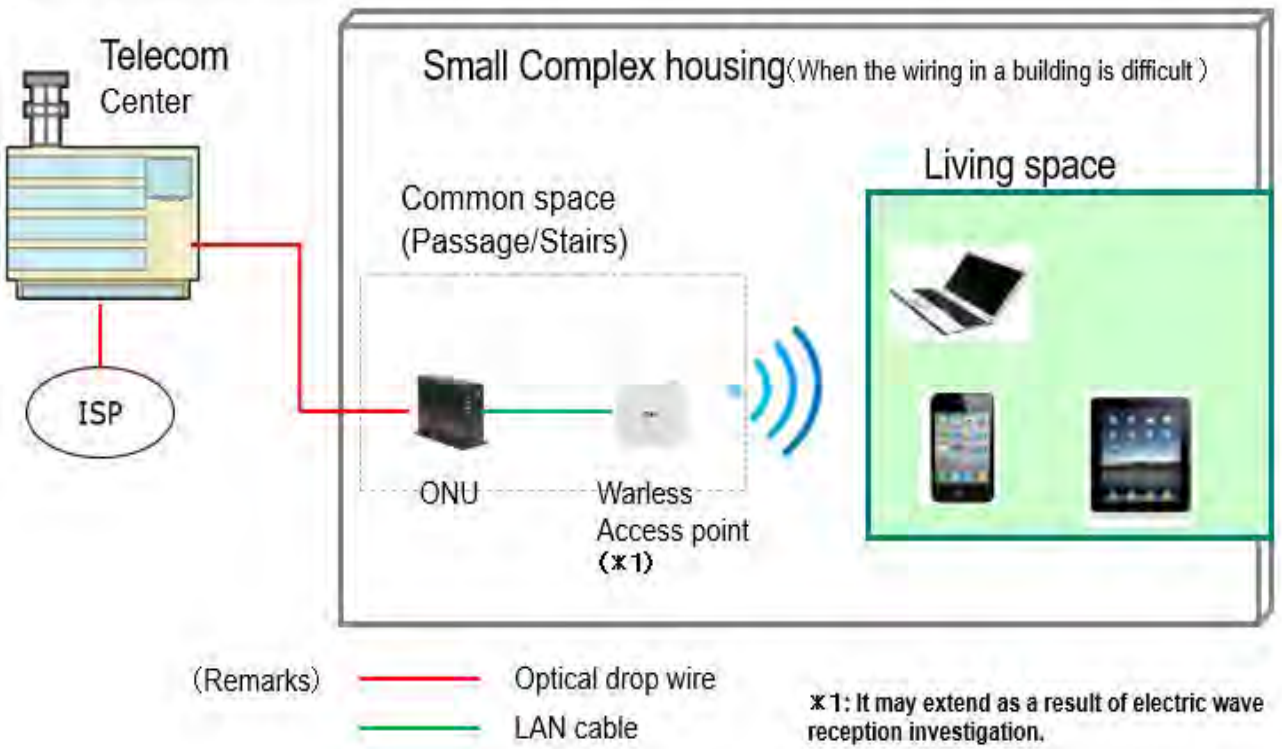
Diffusion of Broadband in Japan



Source: MoIC Japan

Examples of (FTTX + WiFi) configuration

ANNEX 2-3

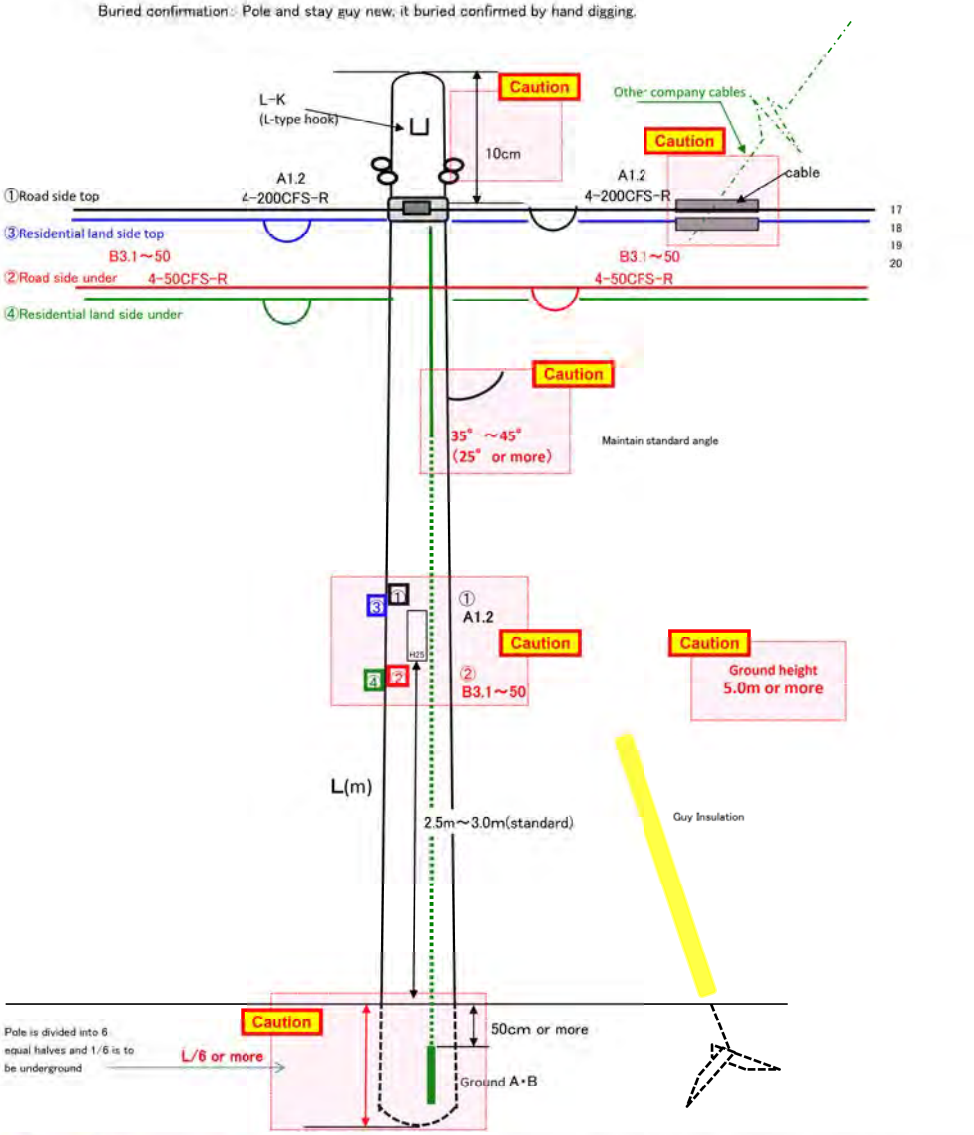


【Construction Check point】

1. Pole

Embedment length: 1/6 or more of the pole total length

Buried confirmation: Pole and stay guy new, it buried confirmed by hand digging.



2. Cable

Line number: Optical fiber cable(NTT) tape line number, Tracer **No1:Blue, No2:Yellow, No3:Green, No4:Red, No5:Purple**
(1Tracer color,2white,3Brown,4Gray)

No1 Tape		No2 Tape		No3 Tape		No4 Tape		No5 Tape	
Blue	1	Yellow	5	Green	9	Red	13	Purple	
White	2	White	6	White	10	White	14	White	
Brown	3	Brown	7	Brown	11	Brown	15	Brown	
Gray	4	Gray	8	Gray	12	Gray	16	Gray	

Cable and drop type: Underground=WBB, Aerial=SSW, SSZ, Drop=1/2/4/8SM etc

Fiber type: Single(0.5mm/0.25mm)or Tape

New: Not drawn forcibly on cable new

New: Extra length ensure underground cable in joint boxes.
(Basically, Splice=About 1lap、Through=Cable organize possible length)
Removal: Check of remove networks and will be the marking.

splice: Fiber radius of curvature=3cm

3 Other(safety etc)

Cable protection(Cable cross, Cable contact, Duct opening etc)

Treatment is clean of Cable and Fiber. → Also consider maintenance of that.

Connection check and design, If the difference always report. → Involved to management of GIS

Attach the Pole nameplate and Cable nameplate → It is important for the future of maintenance.

Enforcement of cleaning fiber splice machine every taime.

Does not work inside-consuming tension and under the suspended load.

Preliminary site survey for the second trial work in Jakar

August 2014

JICA Project Team

1. Underground Infrastructures

1.1 Underground Joint box conditions

During our physical survey we have encountered few joint boxes that are completely buried underground that we could not make out the exact location. Therefore, we need to confirm by clearing the covered mud before the construction begins.

Followings are the joint boxes that are not visible on the ground:

Joint box buried point

① JB6 ② JB9 ③ JB11 ④ JB14 ⑤ JB15 ⑥ JB17

Particularly the Joint box no.9 seems to be under Asphalt(Blacktop) and we have to very careful and follow the safety mesures to remove the asphalt and open the joint box cover without damaging the others property. After comletion of construction work it is necessary to reinstate the work as usual.

1.2 Method of Opening and Closing the Joint Boxes

Usually workers in the field open and close the joint box cover using their hand and sometimes crowbar, spade etc. which is not a proper method as per the standard, because it can lead to injury. Always use a proper method by using the key hole present in the joint box as shown in the diagram.

（1） Current Method （2） Shape of the local joint box lid (Round Type)

1.3 Water inside the joint box

Since, the Joint box No 18 is located near the stream and it is likely to be filled up with the water. Therefore, It is always necessary to drain out the water timely. Make sure that, during the construction work we there should not be water filled up in the joint box which may hamper our work.

2. Aerial cable

2.1 Rules and Regulation to use BTL property

During the survey we have observed that, other utility agency like CATV and BPC utilized our poles and cable route, which is not at all feasible in telecommunication context. The way they laid their cable is too massy and spoil the appearance of our networks and such those cables needs to be remove immediately.

It is very important to amend and draft the rules between BTL and other utility company if they are to use our property or network. We have identified seven location where the network is too bad. BTL property used by other utility company as shown in the diagram.

（1）B15（CATV :Reservoir winding）

（2）B37（CATV: To high）

（3）B23（Power line proximit）

2.2 To maintain BTL existing Networks

After observation of the existing BTL networks, we have come across at several location where cable needs to be properly tension on the pole clamps, some pole need strong stay guy, and also few poles needs to be replaced etc.

（1）B7　Loose aerial cable supported by drop wires

→Properly fix the cable on pole clamp

（2）B22～B23　Clearance between Electric pole and aerial cable

→Maintain standard clearance and cable protection

（3） B28 Loosen stay guy→Repair or remove if not requied

2.3 Add new poles in existing network

During the designing phase, we have observed that, the clearance of the cable needs to be maintained at few locations. Therefore, we should erect new poles to maintain the clearance before it get damaged by people or vehicles.

For example, one pole need to erect between pole no B8 and B9 and name it as B8D. And also one in between B73 and B74 and name it as B73D.

2.4 Method of aerial cable splicing on the Pole.

As per BTL, splicing of aerial cable is done on the ground by keeping some cable provision and later after completion of splicing it is put back on the aerial pole.

Although, we wanted to use the same method but we should be cautious of provisioning the cable and also how we maintain cable by making coils on the poles, otherwise get twisted and break the cable.

3. Other

3.1 Maintain work quality during construction

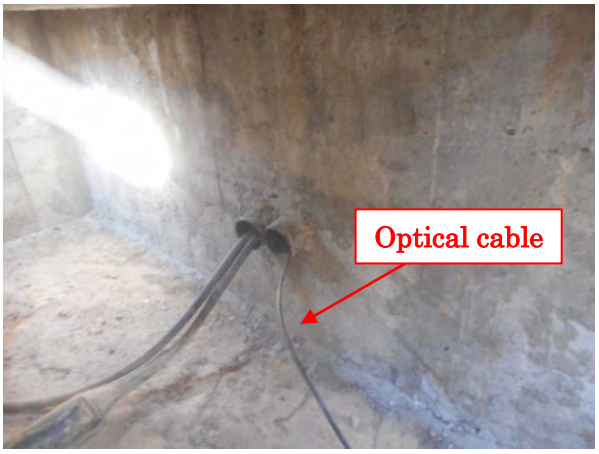
By looking at the underground existing network, the site engineer did not have much idea construction part. In most of the joint boxes there isn't any cable provision and cable protection which will lead to serious action in future.

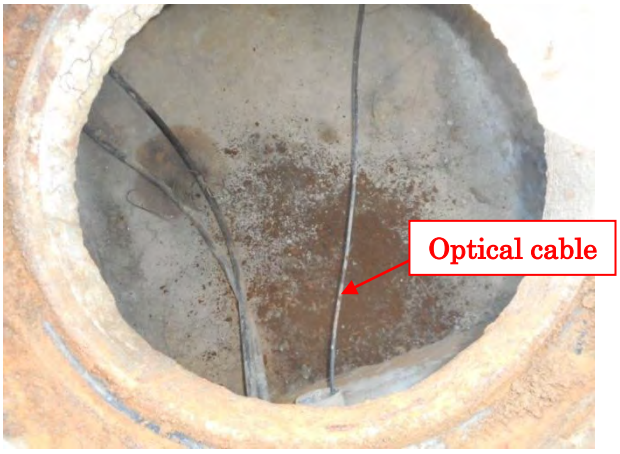
In other word, cable being pulled with high tension from one joint box to another without keeping any extra length in the joint boxes.

There is always a chance to fall heavy and sharp objects inside the joint box and damage the cable underneath. Besides, there is also high risk of damaging the existing cable when new cables being pull from the same duct.

Therefore, It is always important to remember while carrying out the construction or maintenance work to follow the standard working procedures and method so that everyone would take up the work more efficiently and smoothly at present and in the near future.

Scenario for existing optical fiber cable inside joint box





Completion Report 2nd trial
Field work

31/10/2105

1. Work Activity

Underground ,Aerial cable and Poles information

Sl. No	Cable Spec	Length(m)	Location	Install date
1	40 SM AC	680	Pole no J1 - J15	15/09/2015
2	40 SM AC	2100	Pole no J16 - J59	17/09/2015
3	24 SM AC	1300	Pole no J60 - J86	21/09/2015
4	40 SM UG	1245	BT Office to JB 7	24/09/2015
5	40 SM UG	1955	JB 9 - JB 18	29/09/2015

Sl. No	Pole Spec	No of Pole	Location(pole no)	Install date
1	BC Pole	3	Chamkar(J1,5D,11D)	10/9/2015
2	BC Pole	3	Above School(J12D, 20D)	11/9/2015
3	BC Pole	4	Jalikhar End86S1,86S2,86S3, 86S4)	12/9/2015
4	BC Pole	4	Jalikhar End(86S5,86S6,86S7, 86S8)	14/09/2015

2. Closures and Accessories setup location

sl no	Pole No	Closure Type	Support Rod	Spiral	Splitter	FAS case TC	Splice Tray	Unit saperator	FAS Plug	FAS Socket	Install date
1	J15	3AO-Z-C	1	5	3	2	1	2	24	3	7/10/2015
2	J20	AOT-M-Z	1	4							7/10/2015
3	J23	AOT-M-Z	1	2							8/10/2015
4	J26	AOT-M-Z	1	2							8/10/2015
5	J31	AOT-M-Z	1	5				2		1	7/10/2015
6	J36	AOT-M-Z	1	4.5							8/10/2015
7	J54	AOT-M-Z	1	5							8/10/2015
8	J59	3AO-Z-C	1	4	3	2	1	1	24	3	6/10/2015
10	J63	AOT-M	1	6							9/10/2015
10	J66	AOT-M	1	6							9/10/2015
11	J78	AOT-M	1	5							9/10/2015
12	J86	AOT-M	1	6							9/10/2015

3. Acceptance Test Report

<Physical Inspection Result for JICA Trail work> 31/10/2015

No	Location	Description	Work Executed	Modified date	Action Taken
1	J14	No stainless steel band at utility pole	Only spiral	3rd Nov 2015	Tied the spiral with stainless band at pole no J14
2	J8D	Pole number plate error	Vertical writing the J8D	3rd Nov 2015	corrected the pole name Tag
3	J5D	Pole number plate error	Letter J missing at pole no J5D	3rd Nov 2015	corrected the pole name Tag
4	J2	Fiber contact with the electric wire	No protection of cable from electric	16th Nov 2015	Protect the cable with spiral sleeve
5	J66	Remove the clamp	Clamp is not required	1st Oct 2015	Completed the task by removing the clamp
6	J78	Add required spiral for cable excess length	used only one spiral	17th Nov 2015	Added two more spiral sleeve at J70
7	J70	Protection of cable from trees branches and bushes	Protect at several places	18th Nov 2015	Protect the cable with spiral sleeve at two places nearby Pole J70
8	Each JB	Spiral protection for cable in every duct in the joint box	Only JB13	21st Nov 2015 22nd Nov 2015	Inserted protection sleeve for cable in every Joint boxes
9	J86S1	Adding a drop wire clamp	Two of the drop remains in one of the drop wire clamp	25th Nov 2015	Used separate drop wire clamp for each drop cable

Feedback/Comments and Suggestion at 2nd Trial work

1. General Evaluation

		Good/Easy	Normal	Difficult/Hard
a	Ribbon Type Fiber cable	5	4	1
b	Aerial cable closure	6	3	1
c	Underground closure	8	2	0

2. Trainees Feedback and comments

a. Ribbon type fiber cable

・A ribbon cable allows more fiber to be placed in smaller cable, which makes restoration work much quicker.

・BTL existing fiber were so hard, where we use to face lots of difficulties especially during expansion (while pulling cable) where as ribbon type is very flexible and good quality.

b. Aerial cable closure

・Aerial cable closure tray is sized to provide excellent fiber loop retention for controlling the bend radius, designed with drop wire slots and termination to terminate very easily

・It is designed to protect against any weather condition, light in weight as compared to existing closures in BT.

c. Underground closure

Protected and designed with compact seal to avoid water seepage, very light in weight with control radius for fiber bend.

Provisional space inside the closure for splicing and as well as placing the connectors inside the closure in order to reduce the fault and also the identification of fiber inside the closure is very easily.

Therefore, all trainees recommends to purchase the similar closures having better quality, reliability and durability.

Result of in-house training: FTTX engineering course

22nd July 2016

1. Training term:
   18th July to 22nd July 2016
2. Training Place:
   BTL training room at Thimphu BTL
3. Curriculum/instructor
   Refer attachment:a
4. Trainee name list
   Refer attachment:b
5. Evaluation(Pre & Post test)
   Refer attachment:c
6. Result of questionnaire
   Refer attachment:d

Attachment-a

JICA /BTL FTTX training Curriculum

18th -22th July 2016.

	AM		PM		
	9:15~10:45	11:00~13:00	14:00~15:30	15:45~17:00	
18th July (Mon)	1)Opening Ceremony *1 2)Opening Lecture*2	Re-Test *3	1) BTL Network Configuration*4 2)Special lecture by JICA CR *5	FTTX design (Theory) *6	
19thJuly(Tue)	FTTX design (Practice) *6	FTTX Design (Practice) *6	FTTX O&M (GISmanagement) *7	FTTX O&M (GISmanagement) *7	
20th (Wed)	FTTX Constructio (Theory) *8	FTTX Constru (Splicing/OTDR) *8	FTTX Construc (Splicing/OTDR) *8	FTTX Construct (troubleshooting*8	
21st (Thu)	SaftyManagemen (Theory) *9	SaftyManage (Case-study)	Post-Test *3	Broband service overview *10	
22nd (Fri)	FTTX Constructio (GPON application & products) *8	FTTX Const (GPONapplicatio& products) *8	Lecture by BTL Management *11	Closing Ceremony *1	

*1: Mr.Pema Khandu (HRD manager) →Coordinate the program

*2: Mr.Karma Tshewang(GM T&S)→Address of the training purpose and message

*3: Mr.Junya Yamaguchi(JICA Expert)→Pre and Post evaluation

*4: Mr.Mr.Sonam Phuntsho (Dy GM,Backborn)→Outline of BTL network configuration

*5:Mr.Yamada(JICA Bhutan Chief Reprehensive) →Leveraging Development Cooperation By Applying ICT: Debriefing on JICA Project Research "Application of ICT in Developing Countries"

*6:Mr.Ugyen Dorji(GIS unit officer)→FTTX design method

*7:Mr.Kamimura(JICA GIS Expert) →GIS application method for FTTX O&M

*8:Mr.Rinzin Dorji(Technical officer,OSP) →FTTX construction method(practical training:splicing/measurement method/ GPON application)

*9: Mr.Junya Yamaguchi(JICA Expert) →Case-study by safety work model sheet

*10:Ms.Sonam Lhadon (Sales Executive Officer,Marketing Div) →present/introduce BB service menu in BTL

*11:BT management(CEO) →Special lecture(BTL policy and strategy)

Attachment-b

Participants list for Fiber Training

18th -22nd July 2016

Sl.No.	Name	Years of service in BTL	Exchange/Region
1	Sangay Phuntsho	10	Haa, WR
2	Chokey Gyelpo	*	Paro, WR
3	Kencho Wangdi	22	Paro, WR
4	Kinley Tenzin	11	Wangdue, WR
5	Pemba	26	Wangdue, WR
6	Wang Dorji Singer	5	Punakha, WR
7	Tashi Dorji	11	Punakha, WR
8	Tshewang Dorji	4	IP Services, WR
9	Tshering Dorji	6	IP Services, WR
10	Kumbu Dorji	11	OSP, WR
11	Kinga Tshering	11	OSP, WR
12	Dilip Pradhan	14	OSP, WR
13	Tashi Norbu	13	Kanglung, ER
14	Yeshey Dorji	22	Mongar, ER
15	Sonam Rinchen	11	Rinchentse, SWR
16	Ugyen Tenzin	11	P/ling, SWR
17	Dawa	22	Trongsa, CR
18	Tandin Wangdi	11	Jakar, CR

* Sick leave

Attachment-c

Level evaluation of trainees

22nd July 2016

Sl.No.	Name	Pre-Test (2016.7.18)	Post-Test (2016.7.21)
1	A	66	90
2	B	*	*
3	C	56	80
4	D	58	90
5	E	54	78
6	F	60	90
7	G	72	86
8	H	74	92
9	I	68	78
10	J	70	94
11	K	70	94
12	L	60	80
13	M	84	92
14	N	84	88
15	O	60	92
16	P	64	92
17	Q	64	90
18	R	52	88

* Sick-leave

Attachment-d

Result of questionnaire for FTTX engineering training

Date: 22nd July 2016

1. Comment/Feedback to this training program

1.1 Text book/presentation materials

a. Good (17) b. Normal (0) c. Bad (0) Total: 17trainee

Reason/comment:

・Since text book was compiled by expert, all necessary data,information was attached as per the trainees requirement. Which makes trainee to understand in simple way and easier. So I found text book was good. Text book is good for reference since it is simple and easy to read.

・The book which was issued by the instructor was related to our field work and day-today life.

・I don't have a idea of FTTC,FTTB,FTTH, and FTTX, so after doing this training. I came to know about the fiber. So this training is very important for us. Also I came to know about our Telecom link fault fiber to copper through FTTC, FTTB and FTTH.

・It is a new knowledge for us to training of Risk prediction in Safety work management.

・From this text book , I have learned about how to come up with different method on installation during construction of new FTTx(FTTC,FTTB,FTTH) shelter and gained new knowledge and experience and skills in addition to my existing work skills.

1.2 Training term

a. Normal (13) b. Long (0) c. Short (4) Total: 17trainee

Reason/comment:

[Normal]

・Training term was normal all of trainee got chance, for example for splicing fiber, discuss with trainees when problem occurs. I found the training was fabulous and interactive.

・Training term was good for trainee to learn about FTTB,FTTC,FTTH and about troubleshooting. If the training is more in practical it will be good for us to do practically in the fields.

・The training term is normal because we could complete on time and we get enough time to learn and also to do practical too.

・In my view all training duration is good and normal as we could learn a lot in different topic and subjects. So, I will discharge same learned skills in my area with proper working methods and procedures.

・The time management was very good.

・This training duration is normal and its okay for FTTx training in Bhutan.

・All are included in normal term.

[Short]

・Term is too short as we could not discuss much more in every session. If it is more we can discuss more and gain more knowledge.

・The training term is too short, because we are not getting to learn in details.

1.3 Training instructor

a. Good (17) b. Normal (0) c. Bad (0) Total: 17trainee

Reason/comment:

・Training instructor are knowledgeable.

・As per my view the training instructor was well prepared and expert. They come to solve any problem whenever arises problem.

・Good explanation and communicable.

・For me training instructor are good and very knowledgeable about the fiber. From our instructor we have learned more about fiber like FTTB, FTTC, FTTH and troubleshooting.

・Instructor was good because all the instructors could make us understand and guide us well, if we have doubts.

・All the instructors are good as they have brief in detail in all subjects which is very much understandable.

・Training instructor was very good at teaching.

・The training instructor are well performed and experts which we clearly understand each and every teachings theory and practical's.

2. Comment or Opinion throughout the training

・Training was important to me because it is related to my work. So after attending this training I got more knowledge, more ideas from instructors. Thank you so much to all the instructors.

・Training was very fantastic and perfect, which made all trainees how to handle equipment, maintain safety which was most, which kept all trainees to aware while working in relevant field.

Training mainly deals with the optical fiber,we lastly came to know how to deal with splicing machine and how to splice fiber when there is fault.

・I have learned many things about fiber through theory and practical of splicing machine,OTDR and designing of OSP and fiber cable layout in our areas. Moreover I have gained many knowledge on GIS and Safety management.

・We got the knowledge how to splice which is necessary in our day-today activities.

Since we got the knowledge of global instrument system.

・In my opinion I would like to thank our management and the JICA organization for conducting such important training for our BT staff. By doing this training I came to know about the FTTB,FTTC,FTTH and FTTX, also about troubleshooting. So, I would be grateful if the management could give such training in future.

・We are much thankful to JICA and BTL for giving very useful training. After this training. I'm planning to use ideas which I got from this training. Hope to change the working style of OSP and future working plans.

・We gain some knowledge on fiber and GIS use and I will try to bring some changes, if I work in fiber line. This training is very good for us which was given by JICA and our management.

・Through this training, I learn many things, which will be very helpful for my future work field. I will be able to convey my training ideas to my friend.

・Overall I would like to say that it was so relevant and make us learn more. We got a lot of new ideas which will definitely help us when going back to our working place.

Therefore, I would like to thank a lot to the management and to my all instructor for letting us giving new knowledge.

・In order to carry out safety work, we have understood that it is important to muster the safety awareness during daily field work.

・After this training, I will adapt the same working procedures in my region with full sincere and dedication to the best of my capacity and knowledge. However in case of fiber splicing, we are in need of one splicing equipment as we do not have one at present. Doing training once Thimphu theoretically is not enough to gain the experience all copper cable are doing away slowly and steadily.

・Throughout the training I have learned a lot and after going to my station I will be working and making best use of training. I thank JICA for providing wonderful training.

・Throughout the training I have learned a lot and after going to my station I will be working and making best use of training. I thank JICA for providing wonderful training.

・Lastly thanks to BTL management and especially the instructors for providing such training which will definitely improve our knowledge and useful to day-to-day work.

Review of the achievements of the JICA Technical Cooperation Project

Project for Optical Fiber Techniques in Telecommunications Engineering

20th January 2017

JICA FTTX Project Team

Achievements of the JICA Technical Cooperation Project

Contents:

1.Achievements of the Project

ANNEX 2-9

(1) Outputs and indicators

Output1:FTTX technical manuals are developed.

Output2:O&M system is developed

Output3: Field trial site is completed

(2) Project Purpose and indicators

Capacity of BT's engineering in optical fiber access network design, construction, and maintenance is developed.

(3) Others

- Short-term Training in Japan
- In-house FTTX training
- IT Workshop

2.Results of Review based on DAC Evaluation Criteria

The result of project is evaluated using the 5 evaluation criteria of DAC

1. Relevance: how much PJ Purpose is valid to the Overall Goal
2. Effectiveness: how much PJ output benefits BT
3. Efficiency: how efficiently are the outputs achieved with permissible Inputs of the project
4. Impact: impact of PJ purpose and outcomes on the Cross-Cutting Issue under Overall Goal
5. Sustainability: Whether or not the outputs/outcomes of the PJ can be sustained post PJ completion and for how long

Results of Review based on DAC Evaluation Criteria

1. Relevance

- ✓The objective is realized with Japanese technology, techniques and knowhow, meets the national development plan, Japan's cooperation policy

- ✓Knowhow on safer and more effective Japanese engineering, operation & maintenance including constructing plan, safety work transferred to BT

Results of Review based on DAC Evaluation Criteria

2. Effectiveness

- ✓Development of the manuals and implementing trial works by BT's 17 staff enhanced the engineering, operation & maintenance knowhow in BT
- ✓ BT staff can now independently plan/design, construct, operate & maintain with improved confidence and quality

Results of Review based on DAC Evaluation Criteria

3. Efficiency

- ✓JPY 170 million was invested for this 3-year project: April 2014 to February 2017

- ✓ 3 main outputs of the project, development of manual, operation & maintenance system, trial works were completed within schedule without any major hindrance, and overall objectives achieved

Results of Review based on DAC Evaluation Criteria

4. Impact

- ✓Japanese best practices and knowhow on fiber optics engineering transferred through the Project will have long-term positive impacts on:
  - ➢ BT's FTTX network development
  - ➢ Royal government's ICT initiatives in making public service delivery efficient.

Results of Review based on DAC Evaluation Criteria

5. Sustainability

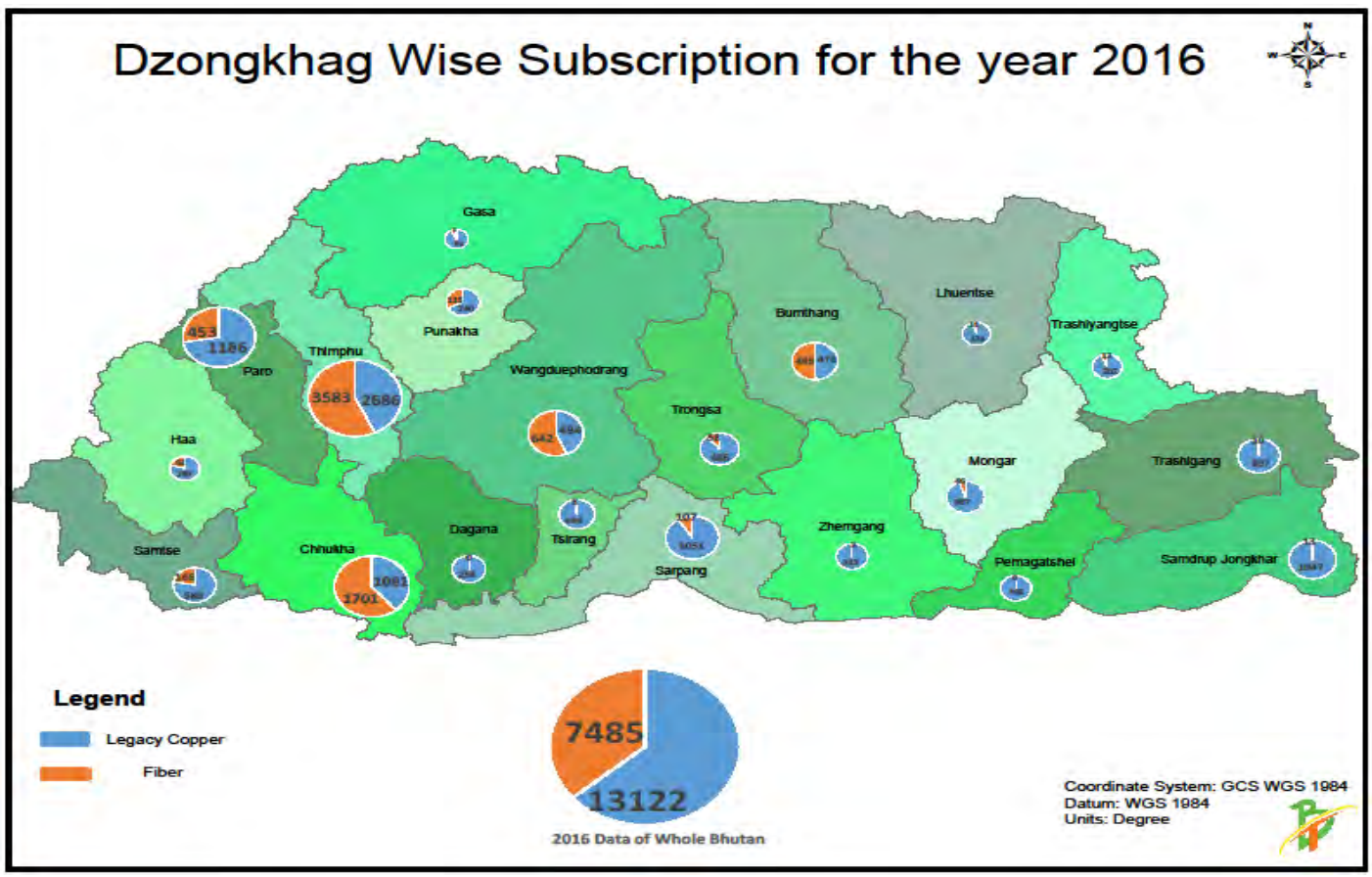
- ✓Outside plant section of BTL has been installing, maintaining, operating access network since BTL's establishment.
- ✓BT besides the JICA FTTX project has been deploying fiber in the access network replacing the legacy copper pairs to meet the increasing demand for high speed broadband
- ✓Fiber is the future, and therefore outputs of this Optical fiber engineering project are here to stay as part and parcel of BT's FTTX networks.

Achievement of Overall Goals after completion of the project

1. Prospects to achieve Overall Goal

- ✓Post completion of the FTTX Project, BT will use the Jakar trial site as an example network to refer to during its own fiber expansion works in the access networks.
- ✓To enhance data connectivity in light of the ever-growing demand for data, BT will invest every year Nu. 40~50 million to expand fiber in the last mile/access networks. As projected in the Project Design Matrix, by 2019, BT should have fiber in the access network in 90% of the Dzongkhags.

BT installed FTTX access network in four Dzongkhags out of 20 (20% of FTTX coverage ratio) at the end of the year 2013 before the start of JICA project, and in October 2016 the coverage ratio of FTTX has reached 85% (17 Dzongkhags).



Achievement of Overall Goals after Project Completion

2. Plan of Operation and maintenance

- ✓ Overall planning and designing of FTTX networks will be the responsibility of the Corporate Planning and Strategy Division
- ✓ Implementation and O&M of FTTX will be the sole responsibility of the respective Regions of the Operations Division.
- ✓ Besides the fiber network of trial site at Jakar, BT has fiber in the access networks deployed in 17 out of 20 Dzongkhags of the country the O&M of which are currently being taken care by the Regions and exchanges. Therefore, post completion of the FTTX project, the O&M of it should not be of any major concerns

Post Project...

Going Forward...

- ✓ Use trial site in Jakar as a model for FTTX expansion works
- ✓ Use the manuals developed through the project as guidelines and update wherever relevant
- ✓ Update and Enhance GIS database of FTTX networks and related resources/infra
- ✓ Operate & maintain trial network at Jakar and rest of the FTTX networks in the country with the help of tools and accessories provided through the project. Except for splicing Van, BT exchanges/Regions are provided with similar tools for maintaining both FTTX networks (access) and fiber networks on the backbone links across the country.

ANNEX 2-10

Throughout the project /Recommendation

on the JICA Technical Cooperation Project

20th January 2017

JICA FTTX Project Team
Chief Advisor :Junya YAMAGUCHI

Contents

1.Overall the project as a whole(1/2)

1) I have tried to this project as using past experience and knowledge.

- I have gotten full cooperation from BTL and achieved the project objectives.
- Especially, it was meaningful that trial construction was completed done without accident/injure.

1.Overall the project as a whole(2/2)

- It was always in the face of dangerous situation

◆High place work（Pole） →**Fall down**

◆ Work site that approach the high-voltage line →**Electric shock**

◆ **Work with tension** →**Bruise**

◆ Underground canal → **Oxygen shortage accident**

2.Recommendation(1/3)

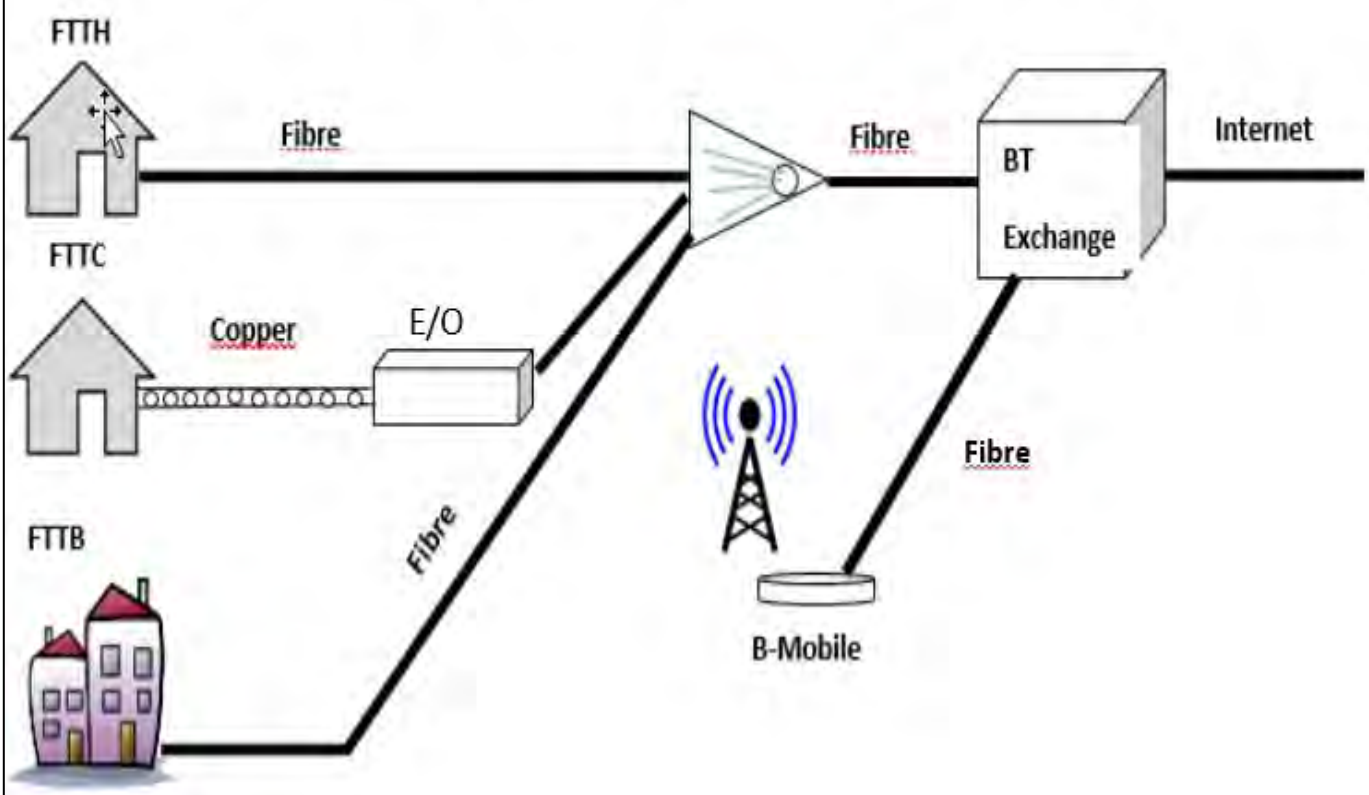
(1)Expansion FTTH/B from FTTC

・FTTC has disadvantages not only in the speed which is lower than fiber, but also in the efficiency of O&M, stability and reliability of services.

・Viewpoint of countermeasure for the disasters, FTTH which has less active equipment outside of central offices is superior than FTTC.

（I understand the budget and installation cost, but in the long run, business will prosper.）

What's FTTB/FTTC/FTTH



2.Recommendation(2/3)

(2)Examining Possibility of collaboration with other organization.

- N LC's JICA Project uses the base map on a scale of 25,000 and BT's facility management need 1,000 or 2,500. This kind of base map will be used by other authority of water and road management etc.
- BT is recommended to examine the possibility of collaboration with NLCS to extend GIS usage to telecommunications facility management.

2.Recommendation(3/3)

(3) Provision of safety tools and equipment for safer construction works

As FTTX cabling works are usually done at height on telephone poles or underground in a manhole, accidents such as falling from height, electric shock, oxygen shortage are the major concerns. So, it is desirable to prepare such safety tools and equipment such as safety belt , helmet, ladders, leakage detectors etc.

3. Light and shadow in the PJ(1/4)

ANNEX 2-10

1) Shadow side

- Three C/Ps retired in the middle of the period
- C/P is responsible for transfer technology to BTL colleagues , but their perception were weak.

2) Light side

In the present /past JICA project granted various telecommunication equipment and vehicles for construction /maintenance, etc.

After delivery, Staff of BTL has maintained those well and been using for long since then.

The following are some examples.

2) Light side

2-1)JICA granted various equipment

1992~1997:Transmission Equipment /Steel Tower/Generator /Battery

Staff of BTL has maintained those well and been using for long since then

2-2) JICA granted various vehicle ANNEX 2-10

- 2002:Crane truck

- 2015 : Excavator

- 2003: OSP-VAN

2015 : Splicing-VAN

- 2003 : Fork-lift

2-3) A lack of some necessary construction machines and tools moves the staff to use the available substitutes

Fig-1 Case of using forklift (Aerial cable Installation)

Cable installing work by cable jack

(Method of sending cable in Japan)

Use a forklift as a substitute cable jack when a jack is not available