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Optimization Telecommunications Infrastructure Projects for University Area

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***Abstract*—In 2018-2019, utilization of data-based telecommunication was increased 82%. Signal measurement in Universitas Airlangga Surabaya is still low coverage because the distance between telecommunication towers and buildings. Surabaya City Government regulates the control of telecommunication towers including tower height, land, aesthetic, and tower sharing. One approach to solve this problem involves the use of concept Outdoor Distributed Antenna System (ODAS) or known as Base Transceiver Station Hotel (BTSH) which is support Microcell Pole (MCP), fiber-optic cable transmission, with configuration A Multiple-Carrier Multiple-Technology (MCMT). The tower provider company needs Optimal Hotel BTS design with measurement methods like Signal Strength, Signal Quality, and Point of Interest (POI). Planning a project schedule and project cost is using Critical Path Method (CPM) and Analytical Hierarchy Process (AHP) for further consideration regarding some criteria like revenue, cost, and technical. This analysis found that the most optimal calculation based on criteria weight is alternative project-1, by build a BTS Hotel in campus C, an 8 MCP tower, MCP fiber-optic cable with length ± 2418 m, and connecting campus A, B, C with length ± 8818 m, then project duration in 137 days with cost estimation IDR 7.8 billion.**

***Keywords*— BTS Hotel, MCP, CPM, AHP.**

I. INTRODUCTION

IN GLOBALLY, voice and SMS users are shifting to data-based telecommunications [1], and this increase reach 82% during Q1 2018 – Q1 2019 [2]. In Indonesia, availability of telecommunications infrastructure has trigger the growth of wireless internet users. Universitas Airlangga Surabaya with 3 location (Campus A, B, and C) are wide area that need an internet with good capacity and high coverage, to support internet access in building area.

Build an infrastructure tower must follow regulation of telecommunication in Surabaya city including tower height, land, aesthetic, and tower sharing [3]. A solution to this problem is proposed with technology named Base Transceiver Station Hotel (BTSH) with concept Outdoor Distributed Antenna System (ODAS) and Microcell Pole (MCP). The design of BTS Hotel must support multi-carrier and multi-technology (MCMT), so can be used by several cellular operators (collocation) with placing BTS devices in one room [4][5].

This condition is trigger the tower provider company to collaborate with Universitas Airlangga in providing solution to improve telecommunication network. Analysis of infrastructure development will using basic measurement drive-test Signal Strength, Signal Quality, and Point of Interest. The right decision can help to optimize investment cost and avoid no potential towers in collocation. For this reason, the optimal design of the BTS Hotel telecommunication infrastructure project at Universitas Airlangga is needed.

II. METHOD

This research is the analysis of optimization telecommunications infrastructure projects with MCMT (multiple-carrier, multiple-technology) model, through a drive-test signal strength and signal quality, then design a network that considerate a point of Interest (POI) from campus building and new building plan. Morover, to decide fiber-optic cable network that used to data transmission, conducted a survey in cable path existing. To analyze project schedule and cost, this research using method Work Breakdown Structure (WBS) to create an analysis data, Critical Path Method (CPM) to estimate time and cost, and software Microsoft Project. Then, method Analytical Hierarchy Process (AHP) also used to make a right decision for optimize project design.

A. Concept of BTS Hotel

BTS Hotel is unites wireless traffic sources into one base station called Hotel and use the concept of Outdoor

Distribution Antenna System. So the power supply devices, safety, shelter, and cooler can be managed properly and centrally [6]. The components BTS Hotels are transmitter antennas which are used to transmit signals using fiber-optic cables[7]. Telecommunication technology with BTS Hotels can be used in several configurations including A multiple-carrier, Multiple-technology (MCMT) [8], several operators and technologies can be used according to design requirements.

B. Signal Strength & Quality

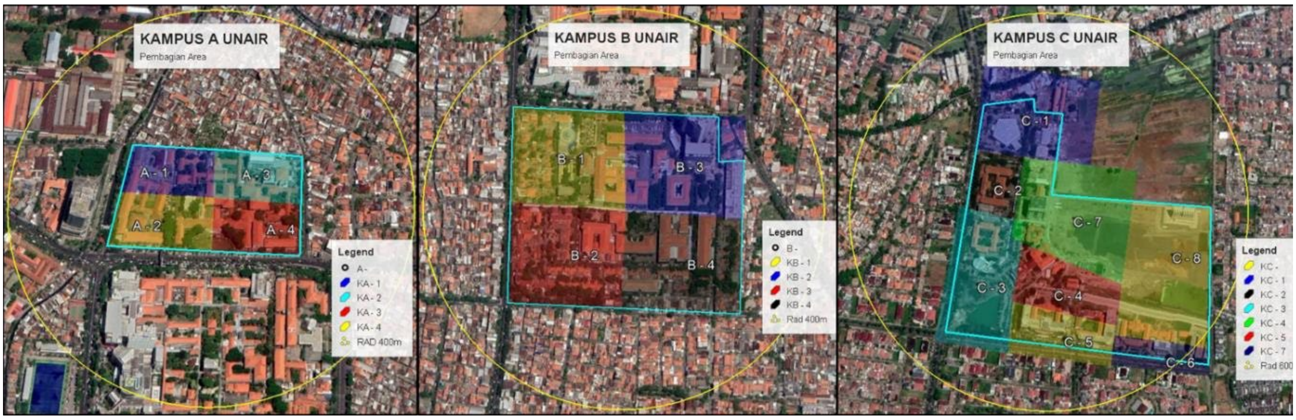
Signal Strength that received by user or receiver in unit dBm which the smaller the value, the weaker the level of power received. Receive Signal Code Power (RSCP) on Universal Mobile Telecommunications System (UMTS) and RSRP (Reference Signal Received Power) on Long Term Evolution (LTE) technology is an indication of the signal strength received by the user. While Signal Quality is measured on RSRQ (Reference Signal Received Quality) which is an indicator of the quality of Radio Frequency (RF) signals received by users on LTE technology. Table 1 shows the categories and indicators values in signal measurements on the field.

C. Drive Test & Point of Interest (POI)

Signal sampling methods to determine network performance, determine signal strength, and analyze actual conditions, the results are used as a reference to optimize a

Table 1.
Parameter Signal Strength & Signal Quality [9][10]

Signal Strength Legend			Category	Signal Quality Legend		
Color	**Indicator**	**RRGGBB**		**Color**	**Indicator**	**RRGGBB**
Blue	-85	0000FF 87CEFA	Excellence	Blue	5	0000FF
Sky Blue	-90		Very Good	Sky Blue	2	87CEFA
Light Green	-100	00FF00		Light Green	-1	00FF00
Green	-105	008000	Good	Green	-7	008000
Yellow	-110	FFFF00		Yellow	-10	FFFF00
Orange	-115	FFA500	Fair	Orange	-14	FFA500
Red	-120	FF0000		Red	-20	FF0000
Black	-140	000000	Poor	Black	-40	000000



(a) (b) (c)

Figure 1. Location object (a) Campus A, (b) Campus B, (c) Campus C Universitas Airlangga Surabaya.

network to achieve the desired performance or criteria [11]. G-Net Track is an application used to measure wireless networks used in research [10]. The technology to be measured by RSCP, RSRP & RSRQ. The RSCP & RSRQ focus on survey results with a value of <-105 dBm, while for RSRQ at a value of <-7 dB in the Good, Fair & Poor category. Further analysis determines POI location or building that is the target of telecommunications signal coverage and also the location of existing towers.

D. Critical Path Method (CPM)

CPM can facilitate planning in a series of types of project work which is a critical part of the completion of the project as a whole thing. The use of CPM simply intends to make large schedules on large projects into smaller schedules so that schedules can be more easily managed [12][13]. The study will make a design with several alternatives, so from these alternatives an analysis is carried out for the duration of the implementation and project cost estimation

E. Analytical Hierarchy Process (AHP)

The method of decision making involves a number of criteria and alternatives chosen based on consideration of all related criteria [14][15]. In determining the criteria that influence decision making, several literature studies and information from previous projects that have been done at the tower provider company. Respondents from this research of tower provider's employees is in the Project & Implementation Directorate and Asset & Operations Directorate, with position manager and above who already have experience in planning, execution, maintainance projects in the telecommunication field.

III. GENERAL DESCRIPTION

This research locations are at Universitas Airlangga, Surabaya, for Campus A, B and C. All three campuses are located in far locations. Campus C is the most extensive campus which approach 23.6 HA where there is still a lot of empty land and Campus C is an area for new building development. While campus A & B's land is already full with old buildings, and building development will focus on renovation and demolish old buildings. Picture 1 shows research location with area clustering.

A. Analysis Drive-test Result

Drivetest Signal measurement to determine the level & quality of the signal refers to the value of RSCP, RSRP & RSRQ. In Picture 2 shows that for the average RSCP score is in the Excellence & Very Good category. While the RSRP and RSRQ scores show that there are still many Good, Fair, and Poor criteria. With this data, it means that Universitas Airlangga campus location has got a good signal and good quality level for UMTS 3G technology. While for 4G LTE technology, improvements are still needed. Picture 3 shows exisiting tower locations inside and outside campus for all operators (TSEL, XL, ISAT, H3I & SF), and drivetest signal measurement indicators.

B. Design of BTS Hotel and Pole MCP

Parameter in determine alternative design are data result of signal measurement that included in the category of Good, Fair, and Poor, POI target determination, mapping with potential tenant in join project planning to develop coverage

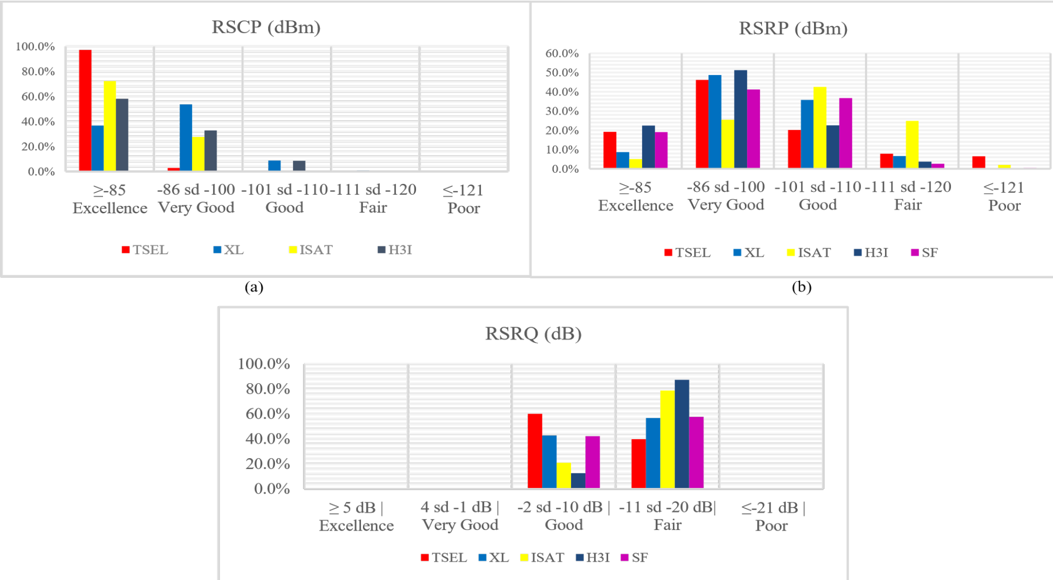


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Figure 2. Measurement Result (a) RSCP, (b) RSRP, (c) RSRQ.

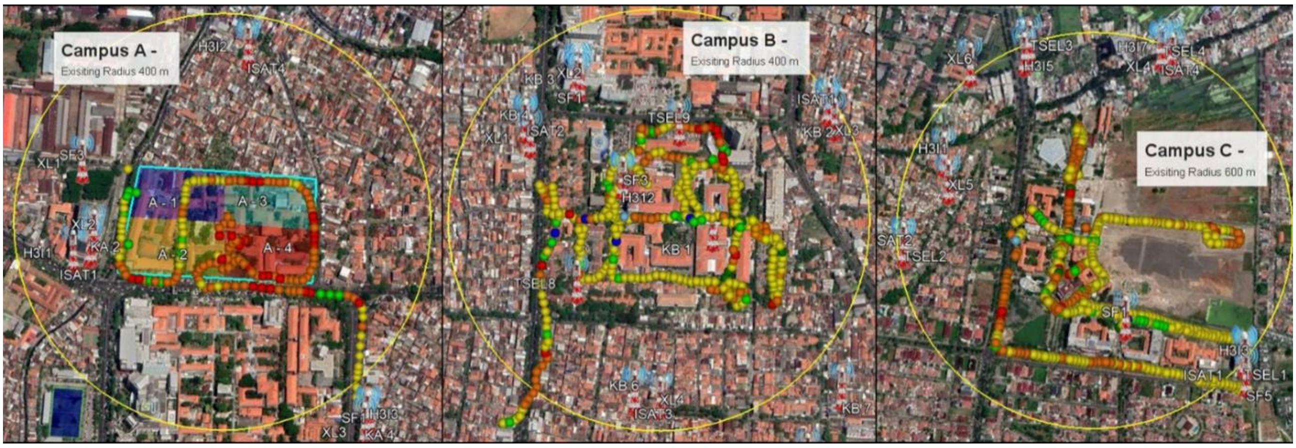


Figure 3. Indicator of Signal Measurement and Existing Tower Location in Campus A, B, C.

Table 2.
Alternative List MCP P1, P2 & P3, FO Length Access per MCP, and Prediction Potential Tenant

Site Name	Lat	Long	Location	FO (m)	Prediction Potential Tenant					Alternative		
					TSEL	XL	ISAT	H3I	SF	Alt 1	Alt 2	Alt 3
Unair Mustopo 1	-7.26484	112.75918	A	364	P2	P2	P1	P1	P1	1	2	3
Unair Mustopo 2	-7.26552	112.75999	A	371	P1	P2	P1	P1	-	1	2	3
Unair Dharmawangsa 2	-7.27344	112.757	B	237	P3	-	P1	P3	P3	1	2	3
Unair Dharmawangsa 3	-7.27243	112.75897	B	342	P3	P1	P1	P3	P3	1	2	3
Gor Unair 1	-7.26525	112.78427	C	373	P2	-	P1	P2	P1	1	2	3
Gor Unair 2	-7.2637	112.78444	C	341	P1	-	P2	-	P2	1	2	3
Rumah Sakit Unair	-7.27025	112.78484	C	15	P2	P1	-	P2	-	1	2	3
Asrama Putri Unair	-7.26902	112.78566	C	375	P2	-	P2	P1	P3	1	2	3
Unair Dharmawangsa 1	-7.27079	112.75874	B	390	P3	-	P2	P3	P3		2	3
Fkm Unair	-7.26842	112.78286	C	43	-	P2	-	-	P2		2	3
Farmasi Unair	-7.26637	112.78526	C	401	-	-	-	-	P3			3
Airlangga Dormitory	-7.26716	112.78934	C	910	-	-	P3	-	-			3
Asrama Putra Unair	-7.27076	112.78933	C	41	P3	-	P3	P3	P3			3

and signal quality, and the potential for structuring existing towers inside the campus area. Design according to the Table 2 below and mapping coordinate point is shown in Picture 4 (a).

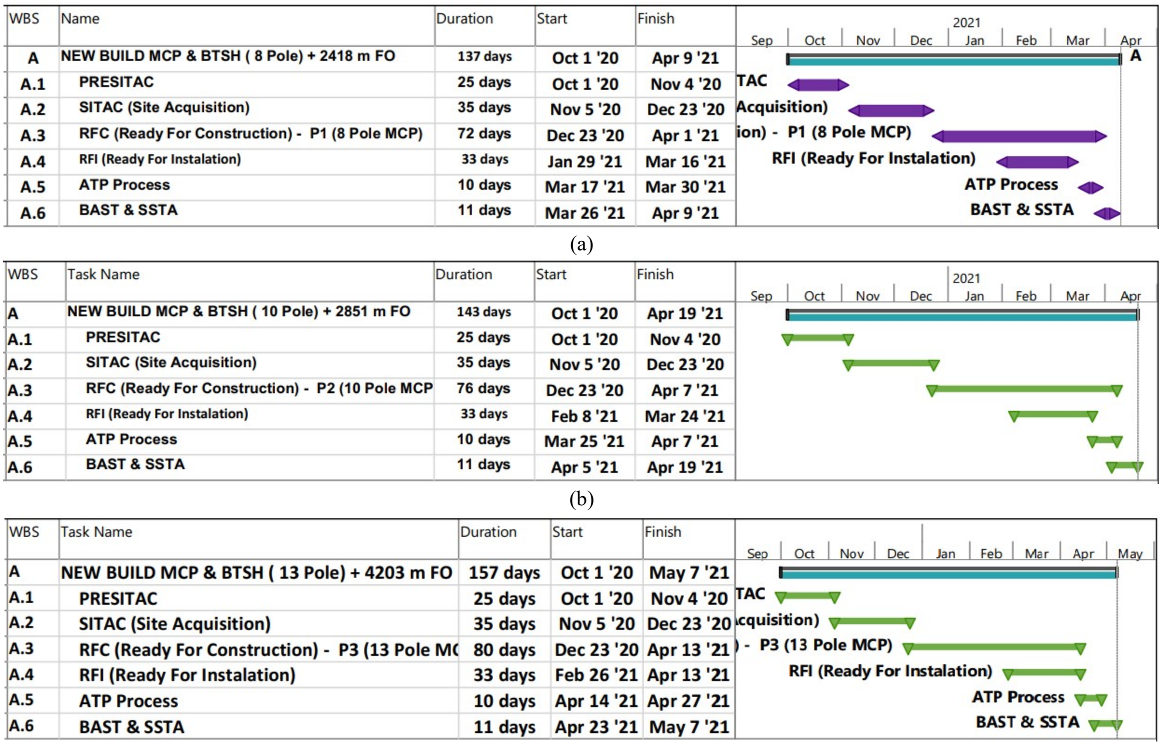
After determining the location of each MCP, then the path of fiber-optic cable, access each MCP and fiber-optic that connecting Campus A, B, and C with path fiber-optic backbone existing, with cable length ±8818 m that shown at

(a) (b)

Figure 4. (a) The Coordinate Point of Alternative Design. (b) Path of Withdrawal FO Campus A, B, C and FO Access MCP

Table 3.
Path of Fiber-Optic Cable As Connector Campus A, B, C

Cable Path	Length (m)	Address
HH_21 - HBTS	3052	Kertajaya Indah - Raya Dharma Husada Indah - Dr. Ir. H. Soekarno
HBTS - HH_05 Kampus A	4968	Dr. Ir. H. Soekarno - Mulyorejo - Kaliwaron - Kedungtarukan - Tambang Boyo
HH_05 Kampus A - HH_02 Kampus B	798	Tambang Boyo - Dharmawangsa - Kertajaya
Total Cable Length	8818	



(c)

Figure 5. Gantt Chart, Critical Path & Project Step (a) Alternatif Design 1, (b) Alternatif Design 2, (c) Alternatif Design 3

Picture 4 (b). The route of address name that passed to connect Handhole shown at Table 3.

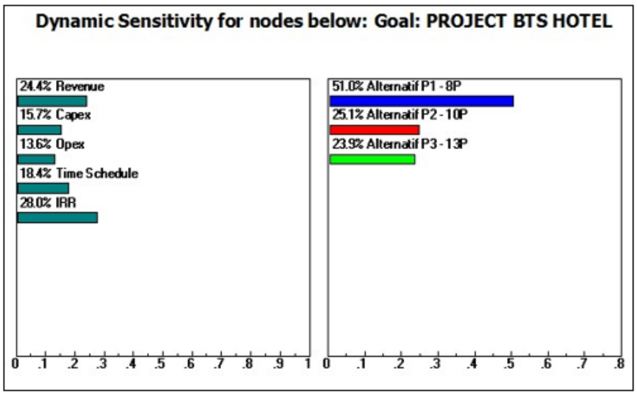
C. Analysis of Critical Path and Project Cost

Calculation of project duration is an important aspect in every design alternative. It shown at Picture 5, the milestone of project BTS Hotel and MCP. Otherwise, the determination of critical path is from Work Breakdown Structures (WBS). Alternative P1 needs 137 days, P2 143 days, and P3 needs 157 days.

Recapitulation of criteria score is seen at Table 4 which is also calculate revenue potential, estimation total of Capital Expenditure, Operational Expenditure, and IRR for each alternative design.

Table 4.
Recapitulation Score of Design BTS Hotel

Alternative	Count of Pole	FO Access (m)	Revenue	CAPEX	OPEX	Time Schedule (Days)	IRR
P1	8	2418	24,360,000,000	1,979,535,800	1,979,535,800	137	18.7%
P2	10	2851	27,600,000,000	2,245,819,750	2,245,819,750	143	17.7%
P3	13	4203	31,920,000,000	2,620,045,675	2,620,045,675	157	15.5%



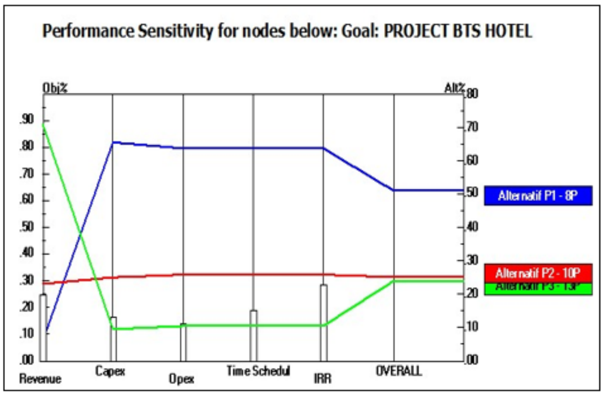


Figure 6. Project BTS Hotel (a) Chart of Dynamic Sensitivity (b) Chart of Performance Sensitivity

D. Selection of Optimal Design

In Picture 6 (a) Dynamic Sensitivity, it seen that criteria weight IRR got the highest score with 28%, then Revenue with score 24,4%. Both of these criteria become important factors as indicator of efficiency from BTS Hotel project investment and potential tenant for each MCP that built. The third criteria is Time Schedule with score 18.4%, it shows that the faster project completed by tower provider company, then potential revenue will received faster and less pinalty. OPEX criteria is the lowest score because in maintenance cost, both preventive maintenance or corrective maintenance is not too high in every year.

The most optimal design alternative project based on this research result is design alternative Project-1 that illustrated in Picture 6 (b), with built a BTS Hotel at Campus C, built 8 tower MCP (2 location at Campus A, 2 location at Campus B, and 4 location at Campus C), length of fiber-optic cable ±2418 m from hand-hole to MCP and as connector Campus A, B, C with length ±8818 m, then duration of project is 137 days with cost estimation IDR 7.8 billion.

IV. CONCLUSION

This research result shown that several location in Universitas Airlangga got a lack of RSRP and RSR score, so BTS Hotel become a high potential alternative for the construction of telecommunications towers. Hotel BTS and MCP design can use the results of the drive-test then offered to prospective customers in joint project planning to determine the demand for alternative development priorities. Potential of next MCP through structuring existing macro towers inside campus area. IRR and revenue are the highest score criteria from respondent, and the lowest criteria is Operational Expenditure.

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