Ship Communication System Planning Analysis Using Very Small Aperture Terminal (VSAT) Single Channel Per Carrier (SCPC) With KU-Band Frequency

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Abstract—* For commercial frequency telecommunication purposes commonly used are C, Ku, Ka-band. C-band is the most popular frequency used in Indonesia, its low frequency is relatively more resistant to rain interference. However, the use of C-band frequency is no longer sufficient for future communication needs. Alternative solution with higher frequency usage than C-band, Ku-band. The advantage of Ku-Band frequency is that with smaller antennas can produce large bandwidth (broadband), the use of Ku-band frequency also avoids interference because it is relatively not used in terrestrial systems. Determination of satellite, concerning the type of satellite, coverage area (footprint), and availability of satellite links (C-Band or Ku-Band). In this thesis the satellites used in data analysis are SES-9 satellites, satellites that are on a 108 ° East orbit with the availability of Ku-Band 81 links. (C / N) Total_inroute and (C / N) Total_outroute for the analyzed links is 11.49 dB and 12.44 dB. This value is greater than the value (C / N) req of 10.22 dB (C / N)> (C / N) req. Ship communication system using VSAT SCPC with Ku-Band frequency can be applied.

Index Terms—**Ku-Band, VSAT, SES-9 Satellite, FEC**

I. INTRODUCTION

The need for information today is increasing, both for organizations and individuals. Along with that, technological development is also increasingly rapid, especially information and telecommunications technology. This can be seen in the daily activities of people who increasingly use the presence of these technologies to help complete work. The rapid development of information and telecommunications technology has been able to support services on land, sea and air. Perhaps in the past telecommunications technology was a complementary means, but now the position of telecommunication technology has changed, namely that it has become a necessity for everyone, both in big cities to the regions, all of them are almost using and utilizing telecommunications networks, coupled with global technology. can be accessed without limits of space and time, this technology we know as the internet (Interconnection Network). The internet can be accessed with transmission media both terrestrial, wireless and satellite.

Along with the increasing need for access to communications, both voice and data, now the need for the availability of transmission media is increasing throughout the region, one of which is satellite transmission. With this increase in demand, several satellite communication service providers were born.

PT. TYBYS as one of the companies engaged in the sea transportation mode always strives to improve the image of service to passengers, including in the case of telecommunications services on board so that passengers and crew members on board get updated information. With the number of passengers of PT. TYBYS which reached 4,231,532 people based on 2015 annual report data and the average journey of a passenger ranged from 1 s.d. 7 days. Therefore, telecommunication services both voice and data are needed for the convenience of passengers during the trip. In addition, the internal needs of PT. TYBYS such as telecommunication relations from ship to land (Head Office, Branch Office) and also the use of applications on board to support and facilitate the flow of information that reaches the ship.

Telecommunication technology currently extends its capabilities without limitation of space and time. In accordance with the times, telecommunications technology that is suitable for now in the case of telecommunications on board mobile and mobile that is by using VSAT technology. VSAT, an abbreviation of (Very Small Aperture Terminal) is a signal receiving station from a satellite with a dish antenna with a diameter of less than three meters. The main function of the VSAT is to receive and send data to the satellite. The satellite functions as a signal successor to be sent to another point on the earth. Actually the VSAT dish faces a geostationary satellite.

Geostationary satellites are satellites that are always in the same place in line with the rotation of the earth on its axis which is possible because it orbits at the same point above the earth's surface, and follows the earth's rotation on its axis. This VSAT satellite system uses a small (earth) terminal and can also be a mobile terminal, so that it can be applied to moving vehicles, such as ships.

For commercial frequency telecommunication purposes commonly used are C, Ku, Ka-band. C-band is the most popular frequency used in Indonesia, its low frequency is relatively more resistant to rain interference. However, the use of C-band frequency is no longer sufficient for future communication needs.

II. RESEARCH METHODOLOGY

The research methodology used is literature study, namely by reading from books, journals, and e-books that relate to the title of this thesis, data retrieval to find out the initial parameters needed in designing this communication system and research directly at PT. TYBYS. The scope of the discussion of the problem is limited to:

1. Network design is made according to the needs of PT. TYBYS with 512kbps bandwidth requirements.
2. This design uses the Measat 3B satellite.
3. Data calculation is taken using parameters and test results data provided by PT. TYBYS.
4. This design is made in technical terms.
5. Not discussed protocols and interfaces used.
6. Not discussed about network security.
7. Not discussed about VSAT antenna movement when the ship is moving.
8. It is not discussed about the influence of sea wave height on the movement of VSAT antennas and the effect on network quality.
9. Damping is not discussed during rain / extreme conditions.

III. NETWORK DESIGN

To plan a telecommunications system, it is necessary to make a flowchart / flow chart in order to facilitate the design process that will be made. In a VSAT network design there are two main things that are done, namely: determining bandwidth and determining signal quality. Flowchart of VSAT network planning can be seen in figure 1. as follows :

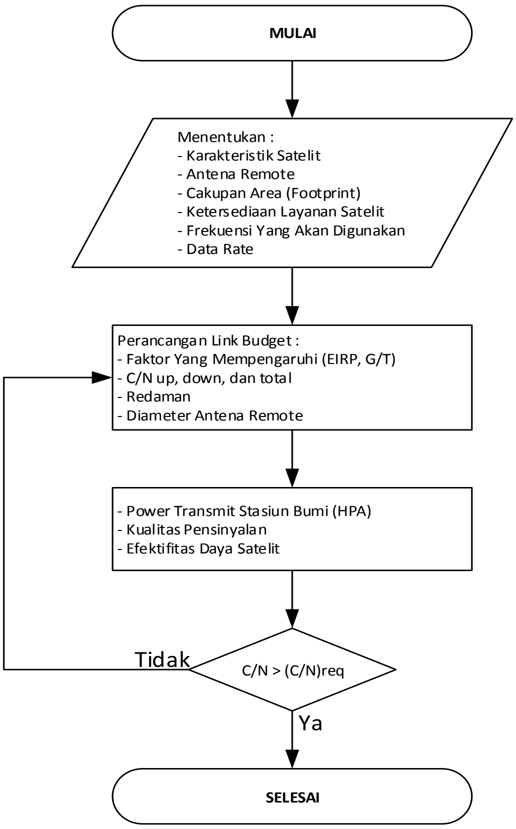

Figure 1. VSAT Network Planning Diagram

3.1 Network Configuration

Network configuration used in planning a VSAT network system uses a star topology as shown in Figure 2. because it is more economical and low traffic.

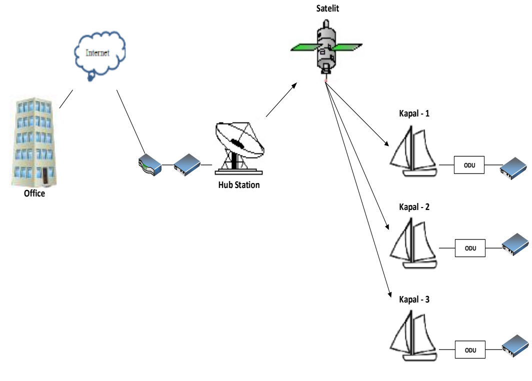

Figure 2. *Planned Network Configuration*

3.2 Link Budget

Performance analysis is done before the device is installed. In this final project, an analysis based on tools and assumptions based on the link budget calculation is carried out, to determine the right amount and value. At the Hub Station 7.3 m antenna is used and the remote site uses a 1.2 m 4W transmit antenna. The frequency used for uplinks and downlinks is 14 GHz and 12 GHz. The SES-9 satellite specifications used in this design are as follows (attached to Table 1):

Position: 108 ° East PAD: 0, Sat EIRPSL: 54 dBW IBOAGG / OBOAGG: 6/3 dB, G / TSL: 8 dB / K SFDSL: -78 dB.

Stasiun Hub is in Cibubur at the location coordinates of 6.57 ° LS and 106.75 ° East with a data rate of 512 kbps. Assuming the parameters used in table 3 :

Table 3. Parameter Assumptions used

Parameter	Spesifikasi
Modulasi	QPSK (N=2)
FEC	$^{9}/_{10}$
Roll of Factor	20%

3.2.1. BANDWIDTH CALCULATION

Rb = 512 kbps

Then the required bandwidth is based on formula 2:

$$\mathbf{BW_{OC}} = \frac{Rb(1+\alpha)}{(N\ X\ FEC)} = \frac{512(1+0.2)}{(2\ X\ 9/10)} = 341{,}33 \text{ kHz}$$

$$\mathbf{BW_{Allocation}} = 341{,}33 \text{ X } 1{,}2 = 409{,}596 \text{ kHz}$$

3.2.2. DETERMINE $(C/N)_{req}$

Using QPSK modulation, (EB / NO) the desired req = 8 dB, then (C / N) req can be calculated as follows according to equation (1):

$$\left(\frac{C}{N}\right)_{req} = \frac{EB}{NO} + 10 \log\left(\frac{N}{1+\alpha}\right) = 8 \text{ dB} + 10 \text{ Log}\left(\frac{2}{1+0{,}2}\right) = 10.22 \text{ dB}$$

3.2.3. SLANT RANGE

Can use the SatFinder Pro application, the data can be obtained from the satellite distance to the earth station at d = 35835.09 Km.

3.2.4. ATTENUATION CALCULATION

The attenuation that occurs and influences this design in the form of free space attenuation (Lfs), attenuator attenuation, and incorrect highlight attenuation. While the other attenuation is ignored so that it can be ignored. Then the attenuation value is obtained as follows:

Tabel 4. Attenuation Value

Comm.	Safety of Free Space	Safety False Highlight
Inroute	$L_{fs\ uplink}$ = 206,449dB $L_{fs\ downlink}$ = 205,120 dB	Tx = θ_{3db} $= 70\,\frac{\lambda}{D} = 70\,\frac{\frac{3 x 10^8}{(14 x 10^9)}}{1,2} = 1,25$ **LT** $= 12\left(\frac{0,1}{1,25}\right)^2 = 0,08$ dB Rx = θ_{3db} $= 70\,\frac{\lambda}{D} = 70\,\frac{\frac{3 x 10^8}{(12 x 10^9)}}{7,3} = 0,24$ **LR** $= 12\left(\frac{0,1}{0,24}\right)^2 = 2,08$ dB
Out route	$L_{fs\ uplink}$ = 206,459dB $L_{fs\ downlink}$ = 205,109 dB	Tx = θ_{3db} $= 70\,\frac{\lambda}{D} = 70\,\frac{\frac{3 x 10^8}{(14 x 10^9)}}{7,3} = 0,205$ **LT** $= 12\left(\frac{0,1}{0,205}\right)^2 = 2,84$ dB Rx = θ_{3db} $= 70\,\frac{\lambda}{D} = 70\,\frac{\frac{3 x 10^8}{(12 x 10^9)}}{1,2} = 1,46$ **LR** $= 12\left(\frac{0,1}{1,46}\right)^2 = 0,06$ dB

3.2.5 Determine (C / N) in Inroute Communication

Antenna Gain	G_{TX} = 42,74 dBi G_{RX} = 57,08 dBi
$EIRP_{ES}$	45,68 dBW
$(G/T)_{ES}$	37,79 dB/K
PFD	-133,849 dBW
SFD	-116,42 dBW/m^2
IBO_{CXR}	17,429dB
OBO_{CXR}	14,429dB
$EIRP_{SL}$	39,571 dBW
$(C/N)_{UP}$	20,49 dBW
$(C/N)_{DOWN}$	45,451 dBW
$(C/N)_{INRoute}$	11,49 dB
P_{TX} HPA	16,34 dBW

3.2.6 Determine (C / N) in Outroute Communication

Antenna Gain	G_{TX} = 58,42 dBi G_{RX} = 41,40 dBi
$EIRP_{ES}$	68,93 dBW
$(G/T)_{ES}$	13,99 dB/K
PFD	-103,889 dBW
SFD	-93,17 dBW/m^2
IBO_{CXR}	10,719dB
OBO_{CXR}	7,219dB
$EIRP_{SL}$	46,781 dBW
$(C/N)_{UP}$	43,73 dBW
$(C/N)_{DOWN}$	28,93 dBW
$(C/N)_{INRoute}$	12,44 dB

IV. RESULT ANALYSIS

To do an analysis of the network system, it is necessary to support data and calculate several parammeters. Measurement on the side of the SCPC VSAT HUB so that the signal sending process can get to the remote station (Ship). In the measurement and calculation results, a standard parameter of network feasibility will be obtained which becomes a reference when certain conditions occur.

In this analysis, the data will be used in link budget calculation. From these data will be compared with certain conditions, among others, the conditions when changing the diameter of the remote antenna type, changes in the FEC value, the effect of rain attenuation and propagation delay. From the basis of these calculations will be obtained the influence in $(C/N)_{\mathbf{up}}$ and $(C/N)_{\mathbf{down}}$ and also the HPA as an amplifier RF wave power before being transmitted to the satellite through the antenna. In Chapter 3 it can be seen the influence of the parameters that have been calculated on the transmission network system, so that it can be concluded to produce a parameter of a feasibility standard for ship communication using the VSPC SCPC.

4.1. Changing Design Parameter

4.1.1. Remote Antenna

The diameter of VSAT antennas generally ranges from 0.6 to 2.4 meters. The following changes in values that occur when a change in the diameter of the remote antenna in inroute communication can be seen as follows:

Tabel 4. Changes to Antenna Crossings

D	LT In	LR Out	GTx In	EIRPES	PFD	SFD	IBOCXR	OBOCXR	EIRPSL	(C/N)Up	(C/N)Down	(C/N)Tot
0,6	0,02	0,014	36,72	39,66	-139,869	-127,44	17,429	14,429	39,571	14,48	45,51	10,41
1,2	0,08	0,06	42,74	45,68	-133,849	-116,42	17,429	14,429	39,571	20,49	45,51	11,49
1,8	0,2	0,12	46,26	49,20	-130,329	-112,9	17,429	14,429	39,571	24,02	45,51	11,94
2,4	0,3	0,23	48,76	51,70	-127,829	-110,4	17,429	14,429	39,571	26,52	45,51	12,29

Changes to the diameter of the cross section can still be categorized as feasible due to $(C/N)_{Total} > (C/N)_{req}$. The larger the diameter of the remote station antenna, the greater the effective power of the earth station ($EIRP_{ES}$) is needed.

4.1.2. Changing FEC

FEC is a technique used by recipients to correct errors that might occur during transmission. The rate that is currently owned by the FEC is 1/2, 2/3, 3/4, 7/8, 9/10. This FEC will add a little total bandwidth to the satellite link. The FEC value will be reduced, assuming the rate parameter used by FEC = ½.

Tabel 5. Parameter Assumptions used

Parameter	Spesifikasi
Modulasi	QPSK (N=2)
FEC	$^1/_2$
Roll of Factor	20%

Rb = 512 kbps

$\mathbf{BW_{OC}} = \frac{Rb(1+\alpha)}{(N\ X\ FEC)} = \frac{512(1+0.2)}{(2\ X\ 1/2)} = 614{,}4$ kHz
$\mathbf{BW_{Allocation}}$ = 614,4 X 1,2 = 737,28 kHz

Changes to the FEC value will affect the amount of bandwidth occupied and bandwidth allocated, which affects $(C / N)_{up}$ and $(C / N)_{down}$, FEC with a smaller value is usually used during bad weather conditions.

Table 6. Influence on FEC and Cross Section Diameter

D	EIRPES	EIRPSL	(C/N)up	(C/N)down	(C/N)Total
0,6	39,66	39,571	11,931	42,961	9,7
1,2	45,68	39,571	16,146	42,961	10,69
1,8	49,20	39,571	19,666	42,961	11,3
2,4	51,70	39,571	22,166	42,961	11,65

In table above it can be seen that with a minimum cross-sectional area of 0.6 meters the carrier to noise does not meet $(C/N)_{Total} > (C/N)_{req}$ so that it cannot be recommended when the FEC is smaller or when the weather conditions are not can be recommended, because it will interfere with the ideal transmission system.

4.2. Effects of Rain attenuation

The effect caused by the effect of rain attenuation, namely EIRP which will be transmitted by satellite to earth station or remote becomes smaller and so that the transmission can run properly, the HPA or transmit power on the earth station is enlarged so that the transmission can run in bad weather conditions . As follows the EIRP satellite is in normal condition, only affected by attenuation on the cable as follows:

$EIRP_{SL\ SAT} = G_{TX} + P - L$
$P_{TX\ HPA} = EIRP_{SL\ SAT} - G_{TX} + L$
$P_{TX\ HPA} = 54 - 42{,}74 + 3 + 2{,}08$
$= 16{,}34$ dBW

4.3. Calculation of Satellite Power Links

Calculation of the power link on the satellite to calculate how much power is needed by the satellite to emit an RF signal. Satellite requires efficient transmit power will greatly extend the life of the satellite due to the availability of power available on the satellite.

$EIRP_{SL\ SAT}$ = 54 dBW = 251188,64 W

1. Inroute Comm.
   $EIRP_{SL}$ = 39,571 dBW = 9059,41 W
   Maka % penggunaan power =
   (9059,41/251188,64)x100% = 3,607%
2. Outroute Com.
   $EIRP_{SL}$ = 46,781 dBW = 47654,07 W
   Maka % penggunaan power =
   (47654,41/251188,64)x100% = 18,971%

In inroute communication the use of power is smaller when compared to communication on the outroute. In order to reduce the amount of power in outroute communication, the step that must be done is to reduce the amount of power transmit on the earth station.

4.4. Propagation Delay Analysis

Delay is an important factor that must be considered in communication, the delivery time by a terminal in the VSAT communication network to the terminal receives an answer or response from the data packet sent.

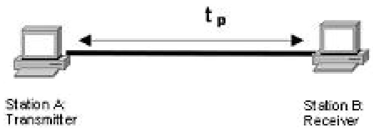

Figure 3. Delay Propagation Illustration

The propagation delay can be calculated as follows:

$t = d/c$
$t_{sl\ uplink}$ = 35835,09 Km
= 35835090 / (3×10^8) m/s
= 0,119 s = 119 sm

$t_{sl\ downlink}$ =35794,04 Km
= 35794040 / (3×10^8) m/s
= 0,119 s = 119 ms

$t_{sl\ total} = t_{sl\ uplink} + t_{sl\ downlink}$
= 119 + 119
= 238 ms

The longer the distance traveled, the greater the delay that will be caused, with the standard delay limit set by the ITU-T G.114.

V. Conclusion

With the advantage of a Ku-band frequency that is, with a smaller antenna can produce large bandwidth (broadband) can be applied. Based on result analysis, the design for the SCPC VSAT ship communication link using the Ku-Band frequency is feasible, but the effect caused by the change in the diameter parameter of the remote antenna to FEC is that the smallest diameter antenna cannot be recommended, because with the smallest FEC value when the weather conditions are bad, the network quality cannot be achieved.

REFERENCES

[1] Mark Long, "The Ku-Band Satellite Handbook", H.W. Sams, 1st Edition, Januari 1987.

[2] Saputra A. Indra, "Thesis; Analisa Sistem Komunikasi VSAT IP untuk Komunikasi Jaringan Privat Bank BRI", Thesis Jurusan Teknik Elektro Fakultas Teknik Universitas Mercu Buana Jakarta, Mei 2011.