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Methodological proposal for satellite communication on offshore self-elevating platform

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Abstract. The use of information and communication technologies has expanded the ways of working and communicating with others. However, these offer challenges when people or organizations are in places where communication is difficult. Self-elevating platforms and vessels with oil and fishing activities are in the middle of the sea, and the distance between them and the nearest port is very far. This affects the flow of information and communication that it generates to function properly. The objective of this work is to implement a satellite communication system for an offshore platform using various tools and equipment related to local area networks and satellite networks, specifically VSAT technology. The proposed and used methodology is based on experience and considers site analysis, site design, equipment installation and satellite communication tests. This has been tested in previous satellite link implementations. As a result, the parameters obtained in antenna pointing, isolation and latency tests are adequate and optimal. The applied methodology presents practical steps with specific results that can be replicated or adapted to any satellite technology implementation.

Keywords: Communication, offshore, VSAT, methodology, self-elevating-platform

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1 Introduction

An oil platform is a structure located on rock formations in the sea with the aim of extracting oil and natural gas on the seabed. (Ronalds, 2005), can also serve as a space for accommodation for staff (Fu, 2018). An oil platform is located in the middle of the sea, which makes communications from the platform to the nearest port (thousands of kilometres) present communication and information problems such as: the generation of reports of daily work, daily and constant use of email, material that is received or disembarked, requests and reception of food for personnel, materials and information about operability on the platform. Information and requests must be made through private communication channels, not only voice communication, but voice and data, as well as the use of services such as the internet. Some technologies that are not feasible or viable to solve the problem are:

- Sideband Radio Communication: Two-way communication only orally. This is a means of communication that is available for platforms or boats.
- Radio links or point-to-point antennas: It works in the form of a signal repeater, this requires having radio bases or communication towers at certain distances, for this reason it is not considered functional in its use, since there is no way to install radio bases or communication towers within the sea (Gulf of México).
- Wiring laying: Laying wiring to carry internet service from the point closest to land or the nearest port would generate a high cost in installation and maintenance.

VSAT is a technology developed with the purpose of being used in remote sites to maintain communication with distant places of difficult access. The use and implementation of this technology in a remote site very distant in the middle of the sea, where the oil platform is located, allows us to use internet services through cables or radio links. VSAT systems allow access to internet services through satellite links, thereby activating electronic and communication equipment for carrying out internal activities and generating data to the ground.

Satellite technologies are used in places where traditional communication is difficult to access due to environmental conditions or remote places, or high implementation costs that make it difficult to use traditional communications. There is a great diversity of maritime communication systems and projects for both platforms and vessels that are based on Radio Frequency as DSC. AIS, NAVDAT, VDES, TRITON, Mare-FI, MariComm, BLUECOM+, LTE-maritime, Inmarsat, Iridium, Thuraya, VSAT (Alqurashi et al., 2023).

VSAT or Very Small Aperture Terminal is satellite communication system in which the computer equipment, the antenna with the transceiver interact (Bhardwaj & Cyphert, 2020). That is, a HUB station communicates with the satellite, the satellite with remote VSAT sites creating a means of communications between these elements. The terminals can be in different locations and communicate to a central site through a satellite with the capacity to receive or transmit. The services and equipment for implementing a VSAT system are in relation to the needs of the users. There are three types of services or forms: point-to-point (use of one satellite), star (several satellites) and mesh (multiple satellites).

VSAT systems for oil platforms denote two bands Ku-band (12 and 14 GHz) and C-band (4 and 6 GHz), and Ka band (20 and 31 GHz). Ku-band systems take up less space, are cheaper and easier to install, and have limitations in speed and amount of data. The C-band recommended in situations of rain and hail, have greater congestion and weaknesses with terrestrial interference, and the Ka band transmits enormous amounts of data, does not require antenna rotation adjustments, but attenuation by rain is sensitive.

The antennas of the terminals of VSAT systems have a length of up to 3 meters. The main objective is communication, some applications, and uses of VSAT technologies are available in various areas: banks (ATMs), pipelines (monitoring and control), airlines, corporate communications, reception of television service, reception and sending of television service, maritime, mining, electrical, rural, educational, military, etc.

There are various satellite communication systems applied to maritime navigation such as INMARSAT, IRIDIUM, COSPAS-SARSAT, VSAT with HISPASAT, TELESAT, EUTELSAT AND TELENOR networks. Portable systems with lower communication coverage such as GLOBALSTAR, THURAYA. Global GNSS navigation satellite systems such as GPS, GLONASSS, GALILEO, BEIDO (Blanco Prado, 2022).

2 Background

The background presents a diversity of works related to the implementation or branding of satellite technology, including VSA technology. These are applied to various areas or contexts such as education, commercial communication, community communication, as well as security, among others.

Using a communication network simulator, the design of a satellite communication link is proposed to provide voice and data services to oil or marine platforms with coastal communication bases (Patil et al., 2018). The use of automatic VSAT systems allow to provide data communication to the fishing fleet in motion, these are located on the Peruvian coast belonging to an organization dedicated to the fishing industry which is located its operational facilities on land (Solano Aliaga, 2020).

Maritime services face security threats, especially through data leakage in VSAT communications between ships and coastal terminals. To address this issue, an analysis was carried out using recordings of maritime VSAT communications and forensic software tools designed to extract data from IP streams (Pavur et al., 2020).

In their communication design, Ma (Ma et al., 2021) employ VSAT technology in maritime communication and navigation, with a particular focus on voice and data services. This approach places a special emphasis on the reliability and availability of technology, as these qualities are what ultimately meet the necessary communication demand. Fiber optics, although an effective communication technology, is not always viable, especially in hard-to-reach areas or remote locations separated by seas. In these cases, satellite communication, and in particular VSAT (Very Small Aperture Terminal) technology, becomes a crucial communication tool for the maritime industry (Arosemena, 2020).

In (Koo et al., 2023), designs a multi-RAT gateway (MRGW) that enables dual connectivity between satellite and terrestrial networks, allows moving maritime vessels, including autonomous surface ships, to connect to multiple access networks. radio.

The MRGW integrates LTE and VSAT networks to manage traffic and facilitates communication between end devices and the ship's system, allowing wireless channel data collection and determination of the best navigation route.

One strategy used to support the mental health of people who are at sea by boat or platform is to provide some means of communication internally or to land to be in communication with their relatives or to hold meetings or medical consultations (Arosemena M, 2022).
The Peruvian National Police makes use of VSAT networks for communication from its remote terminals in the Loreto region using a commercial satellite communication provider. All requests for data and information are directed to the Directorate of Information Technology and Communications (Dirtic) of the Peruvian police (Rosadio Mejia, 2020).

In countries like Peru, there are areas that need Internet services for various purposes. However, the location of certain areas and their difficult access make it difficult to access certain communication services. In this context, satellite communication makes it possible to provide voice and data services through a satellite center to the community of Lurín (Arista Gonzales, 2022).

VSAT systems are viable to be implemented technologically and economically to provide communication and internet services in student classrooms located remotely with difficult access (Murillo Bravo & Chiquiza Garzón, 2020). The use of remote stations with TVWS technology over UHF allows the provision of internet to rural areas of difficult access, and educational institutions in the area (Franco Ibáñez & Shimabuko Ruiz, 2021).

In (Chiquiza Garzón & Murillo Bravo, 2020), an economic and technological study was carried out to provide connectivity and internet through a dual-band satellite medium with VSAT systems. This study is relevant to rural areas, where cable communications face significant and costly limitations. As a result of the study, it was concluded that the project is feasible to implement.

Through mathematical formulas it is possible to estimate the reliability of electronic components of VSAT terminals (IDU (Indoor Unit), BUC (Block Up converter) that have reached their useful life of a project lasting five years (Ticona Gregorio, 2023).

In situations of natural disasters, VSAT systems are an alternative for communication to possible damages that affect cell phone antennas (Prado Sánchez, 2019). Through satellite networks with VSAT networks, the seismic network that contemplates earthquakes and tsunamis can be monitored, sending messages or alerts of the situation of the soils and seas this, as a means of prevention and relief in the event of a natural disaster (Birouk et al., 2020). The use of VSAT maritime stations to send large volumes of information to vessels on hydrometeorological data (environment and ice status) in the Arctic is possible through the use of an AARI information system (Kuzmichev et al., 2021).

Not all the identified works present the procedure or methodology they followed to implement or carry out projects with VSAT systems, then some works that mention the methodology or procedure (Table 1) employee:

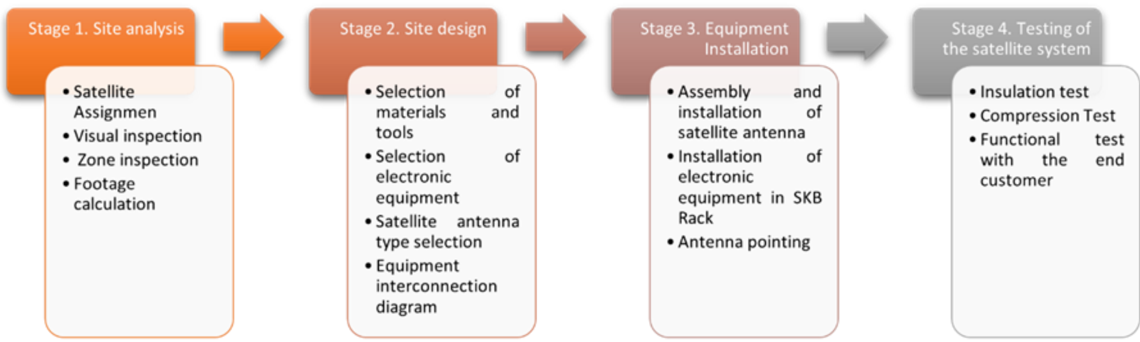
Table 1. Stages of work using VSAT technologies.

Stages	Ambit	Source
– Feasibility analysis – Design and Solution – Implementation	maritime	(Solano Aliaga, 2020)
– Choice of sample – Fault collection – Organization of fault information – Identification of the distribution – Calculations based on distribution – Writing formulas for each device	communications	(Ticona Gregorio, 2023)
– Definition type of research – TVWS System Design – Parameters of the designed system – Simulation techniques and instruments – Coverage simulation procedure	education	(Franco Ibáñez & Shimabuko Ruiz, 2021)

3 Method

The selection of the satellite contemplates technical and administrative aspects, the place of connection must be at a visible distance for the ground station, coverage in the geographical extension of ground station. The gain of satellite antennas, satellite coverage area plays a key role in link performance, good coverage presents optimal link performance. The ground antenna must present the correct parameters in azimuth and pointing elevation towards the selected satellite, and in a planned manner validate that the ground station does not have any obstacle to access the chosen satellite (Maral, 2004). To obtain the result, a proprietary methodology was developed consisting of four stages: site analysis, site design, equipment installation and satellite testing (Fig 1).

Fig 1. Stages Methodology.



3.1. Stage 1. Site Analysis

The analysis contemplates the appropriate location where the communication link will be located, and the place that will protect the communication equipment and infrastructure.

- Satellite assignment. Personnel must have the satellite's spatial location, it must be located true north, using a 360-degree circumference and clockwise travel.
- Visual inspection. It seeks to visually identify areas with an unobstructed view of the airspace, avoiding obstructions such as mobile cranes, drilling rigs and power generators on the platform.
- Tour of areas (inspection of the zones). The verification or adequacy of the spaces that will be assigned or have been assigned for the installation of equipment and infrastructure on the platform corresponds: The area assigned for electronic equipment must have air conditioning to maintain an optimal temperature for its operation; Request the position of the platform (Heading) to the personnel in charge; Know the satellite to be used and its position (For example, the azimuth satellite of 111 degrees); The area where the satellite antennas will be free of obstructions, or provide suitable alternate areas that do not present obstructions.
- Calculation of footage. Accurate estimation of the total meters of cable (coaxial) from the antenna to the electronic equipment. An average of 90 meters is commonly used by the transmission and reception line.

3.2. Stage 2. Site Design

The site design is an important guide to sizing the number of materials, electronic equipment, and additional material for implementation. The design of the interconnection between the antenna and the equipment inside the rack is also considered, and the energization of these.

- Selection of Tools and Materials. At this point, the satellite to be used is defined, based on the site analysis conducted in the previous point, the amount of material, electronic equipment, and type of antenna to be implemented is listed. The main tools to consider are: Coaxial cable, connectors, adapters, punch clamps, rattle wrenches with dice, combination wrench, screwdriver, hand labeler, Patch Cord, Nylon Belts, Blue Adhesive Tape, Red Adhesive Tape, Rubber Insulating Tape, Rack Screw.

- Selection of electronic equipment. With the previous analysis of the site, we proceed to select the materials to be installed, the electronic equipment that corresponds to the chosen satellite antenna. Also, the frequencies that the equipment will work, equipment specifications (electronic equipment, Satellite Modem, Switch, LNB, BUC, Feed Horn, Multi-contact Bar).
- Selection of type of satellite antenna and Rack. The proposal of satellite antenna to be implemented, rack and quantity of equipment to be used (satellite antenna, Rack 8 Spaces, mounting tray for modem) is available.
- Diagram of equipment interconnection. The equipment connection diagram is designed and built, ranging from the antenna to the placement of the rack container equipment.

3.3. Stage 3. Installation of equipment

At this stage, the assembly and fixation of the antenna to a solid structure that allows us to place the antenna permanently will be conducted. In the same way, the electronic equipment will be distributed within the Rack, which is strategically located in the assigned area within the platform.

- Assembly and installation of satellite antenna. In this stage, the assembly of the VSAT components is conducted in the assigned area, and the tube is placed with the appropriate height with metal clamps to the railing of the platform. Here, you have the previous address to perform the VSAT pointing. The coaxial cable is assembled with the necessary connectors or adapters that correspond to the antenna cable at the end of the transmission output of the equipment. Also, the assembly of the cable with the adapters and connectors of the end connected to the receiver. To avoid affecting the connectors due to being exposed to the weather, they are protected by using vulcanized tape (preferably black), and blue tapes for the LNB (Rx) and red for BUC (TX) after the black tape.
- Installation of electronic equipment in equipment container. The equipment must be placed and fixed inside the Rack in a strategically heated area with restricted access.
- Antenna alignment. Once the electronic equipment is fixed in the corresponding place, and the antenna armed in the assigned place, the alignment of the antenna or pointing of the antenna is conducted. A tool for this purpose is iSite, for which the transmission line must be disconnected from the modem and connected to it through the network cable. Once the antenna is optimally aligned with the alignment software, the TX line of the modem is connected, the modem is turned off or on to apply the configuration made. If the voltage obtained from the measurement is in the range of 15.30v to 16.50v, it is an optimal result.

3.4. Stage 4. Satellite system testing

Testing begins with both the satellite provider and the end user. Tests with the satellite provider aim to verify that our system does not cause interference with other satellites and that it operates efficiently and smoothly. On the other hand, by testing with the end user, it ensures that communication services are working properly and meeting their needs properly.

- Tests with the satellite provider. Testing with the satellite provider is done before testing with the end user. The insulation or alignment test, and the compression test:
  Isolation or alignment test, helps to determine that the antenna is correctly pointed at the satellite, and that no affectations are generated to nearby frequencies or satellites. The parameters should be in the range of 28db to 35db.
  The compression test aims to identify the saturation point of the modem, the BUC, and the coaxial cable. At the end of this test, the values obtained must be communicated to the network operations center, which will be responsible for making the necessary adjustments in the configurations of the VSAT terminal. These adjustments are conducted remotely, without the need for intervention by the technical team.
  NOC (network center monitoring) tests, tests to measure the traffic that crosses through the antenna remotely is obtained by means of the NOC.
- Functional tests with the end customer. Customer testing is conducted on-site, using the customer's equipment. During these tests, it is verified that computers, phones, and other devices correctly acquire your IP address. In addition, web browsing, sending emails and phone calls with IP equipment are evaluated, making sure that there are no delays or loss of voice in both directions. Using the ping tool, it is checked if the response times between the two points exceed one thousand milliseconds, which could indicate potential latency due to weather events or faulty components in the VSAT.

The results obtained in the tests conducted are optimal or adequate, which guarantees a high-quality communication between the site where the self-elevating platform is located and the satellite environment with the rest of the world. This includes an alignment with an intensity of 16.25 volts, achieving 32 dB in tests with the satellite provider, which is within the target range of 28 db to 35 db. In addition, satisfactory results were obtained in the saturation test. As far as local communication is concerned, there are no data losses or latency issues, with response times ranging from 598 milliseconds to 642 milliseconds. This ensures the ability to access the Internet, send messages, receive, and send emails, and maintain uninterrupted communication via IP phones when they are in use.

4 Conclusions

The methodology proposed and used is based on experience, proposes practical steps with specific results that can be replicated or adapted to any satellite technology implementation.

A data service was implemented using VSAT technology on an oil platform located in a remote location, applying a practical field methodology based on experience. Identifying the resources needed for implementation is of utmost importance, especially considering the remote location of the platform. The lack of any resource can affect the implementation of the communication system, which in turn can have economic repercussions for the end users. Satellite systems play a crucial role in communications, being used in various areas and in places with limited or no access to wired communications. VSAT systems are of great help for maritime communications on the high seas. In the case of oil platforms, the use of VSAT for voice and data communications represents a reliable and guaranteed solution.

The analysis and estimation of materials and equipment are essential to ensure their use according to the specifications foreseen for their implementation, which, in turn, contributes to the development of the project within the planned deadlines and resources.

References

Alqurashi, F. S., Trichili, A., Saeed, N., Ooi, B. S., & Alouini, M. S. (2023). Maritime communications: A survey on enabling technologies, opportunities, and challenges. *IEEE Internet of Things Journal, 10*(4), 3525-3547. https://doi.org/10.1109/JIOT.2022.3219674.

Arista Gonzales, A. L. (2022). Diseño e implementación de un HUB satelital con tecnología IDirect en el distrito de Lurín, provincia de Lima [Universidad Tecnológica del Perú]. Lima, Peru. https://repositorio.utp.edu.pe/handle/20.500.12867/3625?show=full.

Arosemena, M. R. (2022). Telecomunicaciones para el cuidado de la salud mental de la gente de mar. *Investigación y Pensamiento Crítico, 10*(2), 77-88. https://doi.org/10.37387/ipc.v10i2.298.

Arosemena, R. (2020). Comunicaciones satelitales al servicio de la industria marítima. *Investigación y Pensamiento Crítico, 8*, 103-121. https://doi.org/10.37387/ipc.v8i1.136.

Bhardwaj, A., & Cyphert, D. (2020). Direct benefit transfer using Aadhaar: Improving transparency and reducing corruption. In V. Kumar & G. Malhotra (Eds.), *Examining the roles of IT and social media in democratic development and social change* (pp. 185-210). IGI Global. https://doi.org/10.4018/978-1-7998-1791-8.ch008.

Birouk, A., Ibenbrahim, A., Azelarab, E. M., Kasmi, M., & Iben Brahim, A. (2020). New integrated networks for monitoring seismic and tsunami activity in Morocco. *Annals of Geophysics, 63*. https://doi.org/10.4401/ag-7954.

Blanco Prado, M. (2022). Sistemas de comunicación satelitales en la navegación marítima [Universidad de La Laguna]. Santa Cruz de Tenerife, España.

Chiquiza Garzón, S. E., & Murillo Bravo, S. B. (2020). Estudio de viabilidad para conectividad satelital no guiada de doble banda con tecnología de antenas VSAT, para proveer el servicio internet a salas de cómputo estudiantiles en áreas de difícil acceso [Universidad Cooperativa de Colombia].

Franco Ibáñez, F. G., & Shimabuko Ruiz, J. C. (2021). Diseño de un sistema TVWS para acceso inalámbrico a internet aplicado al sector educación del distrito Santillana - provincia Huanta – departamento Ayacucho, 2021 [Universidad Ricardo Palma]. https://hdl.handle.net/20.500.14138/4616.

Fu, F. (2018). Design of offshore structures. In F. Fu (Ed.), *Design and analysis of tall and complex structures* (pp. 251-293). Butterworth-Heinemann. https://doi.org/10.1016/B978-0-08-101018-1.00008-3.

Koo, H., Chae, J., & Kim, W. (2023). Design and experiment of satellite-terrestrial integrated gateway with dynamic traffic steering capabilities for maritime communication. *Sensors, 23*, 1201. https://doi.org/10.3390/s23031201.

Kuzmichev, A. P., Smirnov, V. G., Zakhvatkina, N. Y., & Bychkova, I. A. (2021, 11-16 July). Use of satellite communication systems for collecting and transmitting data on the state of the Arctic sea ice cover. *2021 IEEE International Geoscience and Remote Sensing Symposium (IGARSS)*.

Ma, Y., Jiang, H., Li, J., Yu, H., Li, C., & Zhang, D. (2021, 12-14 Nov.). Design of marine satellite communication system based on VSAT technique. *2021 International Conference on Computer, Internet of Things and Control Engineering (CITCE)*.

Maral, G. (2004). *VSAT networks* (2nd ed.). Wiley.

Murillo Bravo, S. B., & Chiquiza Garzón, S. E. (2020). Estudio de viabilidad para conectividad satelital no guiada de doble banda con tecnología de antenas VSAT, para proveer el servicio internet a salas de cómputo estudiantiles en áreas de difícil acceso.

Patil, G. G., Badekar, K. M., Kadam, A. S., & Patil, S. H. (2018). To study offshore satellite broadband & VSAT remote communication for oil rig. *International Journal for Scientific Research & Development, 6*(3). https://www.ijsrd.com/articles/IJSRDV6I31022.pdf.

Pavur, J., Moser, D., Strohmeier, M., Lenders, V., & Martinovic, I. (2020). A tale of sea and sky: On the security of maritime VSAT communications. *2020 IEEE Symposium on Security and Privacy (SP)*, 1384-1400.

Prado Sánchez, L. G. (2019). Estudio para implementación de un sistema de comunicaciones emergentes ante desastres naturales con tecnología V-SAT para la Universidad Católica de Santiago de Guayaquil [Universidad Católica de Santiago de Guayaquil]. http://repositorio.ucsg.edu.ec/bitstream/3317/12738/1/T-UCSG-PRE-TEC-ITEL-343.pdf.

Ronalds, B. F. (2005). Applicability ranges for offshore oil and gas production facilities. *Marine Structures, 18*(3), 251-263. https://doi.org/10.1016/j.marstruc.2005.06.001.

Rosadio Mejía, J. L. (2020). Uso de las redes VSAT en el sistema de comunicación de la Policía Nacional del Perú, Loreto [Universidad César Vallejo]. Lima, Perú. https://repositorio.ucv.edu.pe/bitstream/handle/20.500.12692/73176/Rosadio_MJL-SD.pdf?sequence=1&isAllowed=y.

Solano Aliaga, G. M. (2020). Implementación e instalación de una antena satelital automática VSAT Intellian, en embarcaciones de la empresa Hayduk, para brindar servicio de datos de internet en altamar, en la empresa BMP Consulting SAC – Lima 2017 [Universidad Tecnológica del Perú]. https://repositorio.utp.edu.pe/handle/20.500.12867/3625?show=full.

Ticona Gregorio, H. I. (2023). Análisis de confiabilidad de los componentes electrónicos de las terminales de una red VSAT banda Ku de un proveedor de servicios de telecomunicaciones [Universidad Nacional Mayor de San Marcos]. Lima, Perú. https://hdl.handle.net/20.500.12672/19723.