

## Site evaluation for Earth observation ground station

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**ABSTRACT:** This paper presents key criteria for analysis and evaluation supporting the site selection of ground station for Earth observation (EO) satellite. Apart from the system configuration of the ground equipments itself, site conditions and satellite viewing capability are important factors requiring qualitative and quantitative assessment before construction and installation of the facilities. A case study is performed in Vietnam to demonstrate the process and its results.

**KEYWORDS:** Earth observation satellite, ground station, site selection

### I. INTRODUCTION

Earth observation systems are contributing actively and effectively in remote sensing application activities. Generally, their ground stations function to maintain the ground-satellite communication links, image processing and delivering to end-users. Site selection for the ground station remarkably influence the investment and efficiency of EO projects both in short-term and in the long-run of the investor or operator. This activity must be done during the very first phase of the implementation of the project.

In order to decide or to compare several locations for building EO ground station, criteria must be set with their rigorous analysis and evaluation. These key criteria can be put in to political, financial and technical categories. In the frame of this paper only technical issues are analyzed and evaluated.

Site conditions involve all the parameters to ensure the feasibility to build the ground station in a specific area. And satellite viewing capability is mostly related to ground-satellite link performance and much dependent on the satellite's orbit. Both of them need to be analyzed quantitatively before fixing the site for the EO ground station.

### II. SITE SELECTION CRITERIA FOR EO GROUND STATION

The overall configuration of an EO ground station is illustrated in the following figure.

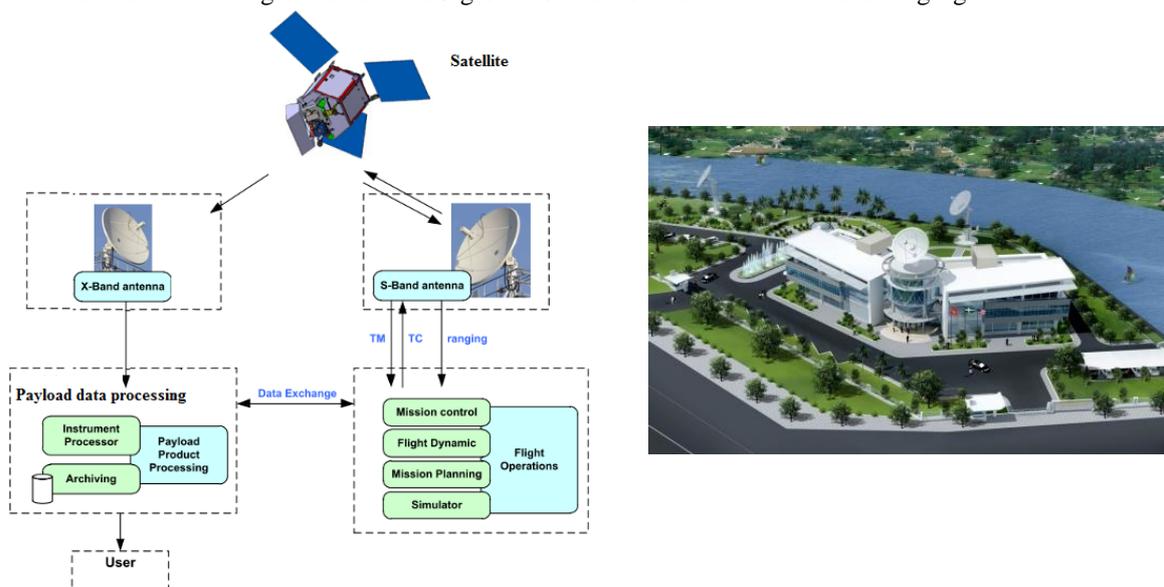


Figure 1. Typical ground segment for Earth observation satellites

Site analysis and evaluation for ground station serving an EO satellite is based on a lot of criteria before decision to its facilities. Earth station buildings are much different from typical buildings used for manufacturing or R&D in terms of purpose, installation and operation. Therefore, the suitable approach for site evaluation and analysis for this kind of station must be based on different set of criteria and assessment method. These criteria are categorized in to the following groups:



### 2.1 Function of the station

The very first question to be answered before choosing a site for the station is “what kind of the station is it?” The utilization purpose of the station determines its requirements and configuration. The ground station can be:

- Primary station: it is the main station in use to operate the satellite.
- Redundant station: used as a back-up solution for the primary one in case of its failure. Site requirements for a back-up station are looser than the primary one.
- Tracking, Telemetry and Command (TT&C) station requires unharmed radio frequency interferences for both uplink and downlink frequencies. Additionally, security and safety issues should be considered prior to its site selection.
- Image receiving and processing station which involves a lot of processing and archiving activities and their supporting facilities.
- Remotely-operated station requires secure communication link, adequate power supply solution and quick supporting services.
- Or all-in-one station: combination of both TT&C and image receiving and processing facilities.
- Military or civilian station which imposes different level of security, safety and accessibility.

### 2.2 Costs

Financial aspects shall be considered and estimated before installation of a ground station. They comprise of:

- Costs for land procurement, clearing and preparation of necessary facilities such as water, sewer, power, communication links, internal roads, walkways, parking areas, exterior lighting.
- Costs for constructions such as construction of the building, antenna tower, and installation of internal facilities.
- Operating costs are the estimated budgets to maintain the activities of the station when it is in use. They include utilities charges (electricity, gas, water...), maintenance and repair, fireprotection.

### 2.3 Site conditions

Site conditions for an EOS ground station are all the issues needed to be examined and evaluated for a selected area. These conditions include both technical and administrative criteria such as: geology, weather, RF and optical interference, horizon conditions, air traffic and aircraft protection, land ownership and commitments by local authorities.

In order to have a reliable analysis and assessment, relevant data and information shall be collected for the selected site. The data may be from 10 year record of meteorology or geology to evaluate the impact of land foundation or natural hazards such as earthquake, typhoon and whirlwind. In parallel site survey is performed to collect measure and analyze on-site parameters such as RF interference, surrounding obstruction or high-voltage power lines.



Potential impact by high-voltage power line

Figure 2.A site survey in Ho Chi Minh City, Vietnam

Survey for RF interference (RFI) must be performed frequently and carefully in order to detect potential harmful RF sources which may heavily impact the quality of the ground-satellite link.

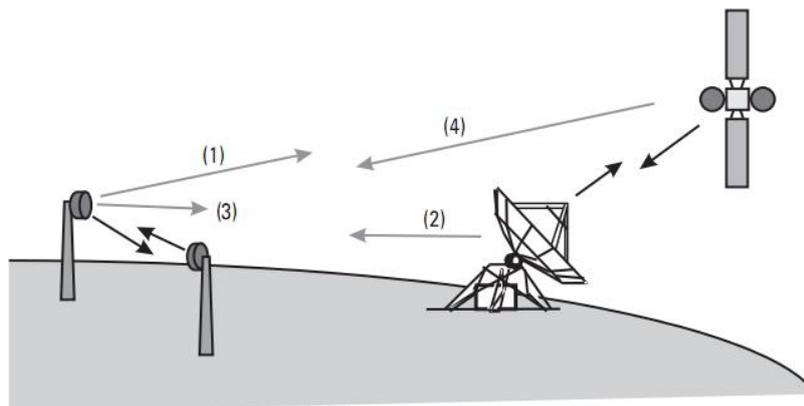


Figure 3. Potential interference between satellite links and terrestrial microwavelinks [1].

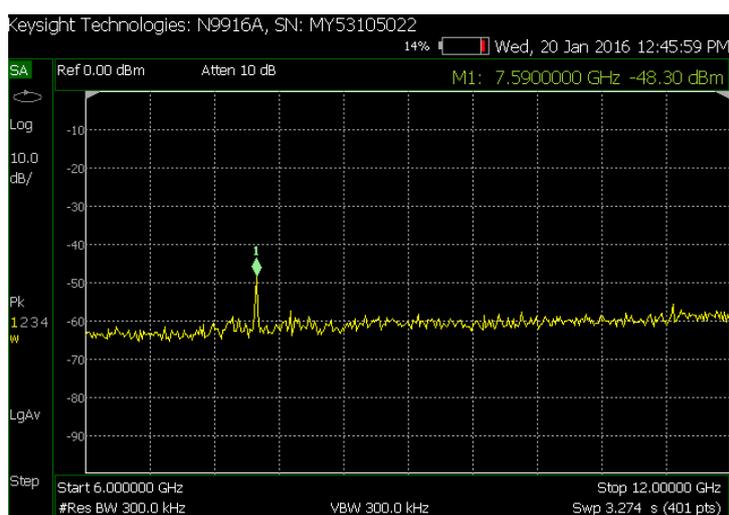


Figure 4. Example of harmful RF source detected in a RFI site survey

## 2.4 Satellite visibility

Satellite visibility is the average duration which one satellite can communicate with the selected ground and is very important criteria to evaluate the performance of the EO system. EO satellites own very typical orbit characteristics (normally Sun-synchronous low-earth orbit) with around 30 days of repeat cycle. Therefore, the satellite viewing capability is calculated by accumulation of the ground-satellite contact time over its repeat period.

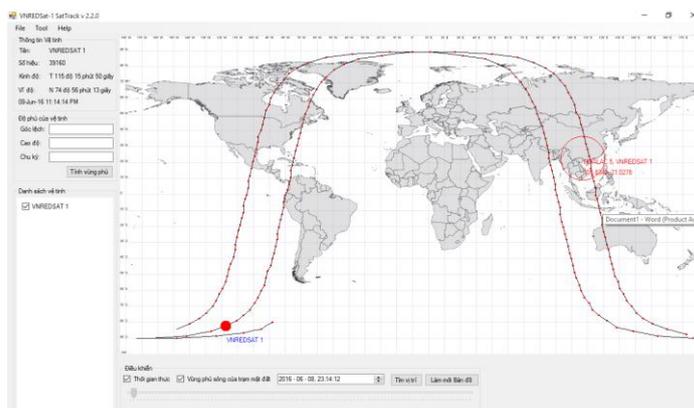


Figure 5. Orbit simulation of an EO satellite to estimate ground-satellite contact duration

(Simulation software developed by Space Technology Institute, Vietnam Academy of Science and Technology)



### III. CASE STUDY

Case study is done for the following locations in the Southern area of Vietnam:

- **Site 1: Cu Chi Industrial Park:**  
 Location: 10° 58' 34.28"North and 106° 29' 5.34" East, Ho Chi Minh City, Vietnam  
 Area: 208 ha.
- **Site 2: Ho Chi Minh Hi-Tech Park:**  
 Location: 10° 50' 13.44"North, 106° 49' 0.92" East, Ho Chi Minh City, Vietnam  
 Purpose: high technology enterprises  
 Area: 300ha.
- **Site 3: Long Thanh Industrial Park:**  
 Location: 10° 49' 41.42"North and 106° 56' 0.47" East, Ho Chi Minh City, Vietnam
- **Site 4: Industrial Park in Dong Nai Province**  
 Location: 10° 46' 29.84"North and 107° 10' 40.08" East, Dong Nai Province, Vietnam



Figure 6. Sites under study in Southern area of Vietnam (Google Map)

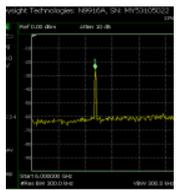
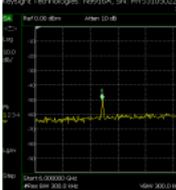
The EO satellite used for simulation is VNREDSat-1 (Vietnam Natural Resources, Environment and Disaster monitoring Satellite), the first EO satellite of Vietnam. VNREDSat-1 orbit characteristics are depicted in the following Two-Line Elements (TLE):

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1 39160U 13021B 16179.42519029 .00000102 00000-0 28989-4 0 9995
2 39160 98.1165 255.7176 0001610 80.4332 279.7050 14.62931921167734
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(Source: NASA)

According to its orbit parameters, VNREDSat-1 repeat cycle is 29 days. So orbit simulation is done for 29 days to calculate total satellite viewing period. The satellite viewing table can be generated by Satellite Toolkits (STK) or other similar tools such as self-developed VNREDSat-1 SatTrack software which is used as key tool in this paper.

The four sites have been evaluated as in the following table:

Criteria	Site 1	Site 2	Site 3	Site 4
<b>Site conditions</b>				
RF interference (frequency from 1Ghz to 12Ghz)	Acceptable	Acceptable	Harmful interference detected RF 	Harmful interference detected RF 
Air traffic and aircraft protection	Acceptable	Acceptable	Close to an to-be-built airport	Acceptable
Potential impact by high-voltage power line	Acceptable	Near-by high-voltage power line (figure 3), potential	Acceptable	Acceptable



		impact may be foreseen.		
Other site considerations	Acceptable	Acceptable	Acceptable	Acceptable
<b>Total satellite viewing time (seconds)</b>	37269	37239	37226	37230
<b>Recommendation</b>	<b>Acceptable</b>	<b>Not recommended</b>	<b>Acceptable with RF control methods</b>	

Table 1. Evaluation table for the four sites

The results show that Site 3 and Site 4 may be impacted by RF interference around frequency of 7.5Ghz which is out of the usable bands for normal EO satellite (S band and X-band). Therefore, these two sites may be considered for the ground station with appropriate RF control methods. Site 2 is close to high-power lines so it will be impacted by protection zone and noise. So this site is given lowest priority. Finally, Site 1 seems to be a best choice with highest priority with acceptable site conditions and maximum satellite time viewing period.

The case study takes into account two assessment considerations which are site conditions and satellite viewing period of the expected EO ground station. Other criteria is omitted due to its complexity and influenced by non-technical matters.

#### IV. CONCLUSION

In the near future, Vietnam will own and operate several EO satellites in orbit. Increasing number of in-orbit satellites leads to dense network of ground stations on earth. Therefore, ground stations must follow stringent planning in order to maximize the benefits from space. Site analyzing and evaluation for an EO ground station is a key part of the planning activities. Set of criteria may not be changed from project to project but they can be given different weights to stress the importance of the issues under consideration. On top of that, the approach to establish a target function for site selection should be completed to create an effective tool for any EO project.

#### V. Acknowledgements

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