

Study of Communication and Data Interfaces in Earth Observation Satellites Based on their Focus of Application

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Abstract

Over the last decades the earth observation data has played an important role for the well being of society and the earth as a whole. This dependence of the human race on the space data is ever increasing and expected to have a massive breakthrough in various needs and applications in future. This study attempts to identify and analyse the instruments and other technologies used in all the earth observation satellites till date, tabulating them with their characteristics and their significance. This study is done based on the secondary qualitative information collected from committees, organisations and data available free on the web. A brief study was made and an easier and better method to analyse the details of earth observation satellites has been figured from the review of all the information available. All the information gathered is tabulated according to the focus of their application i.e. land, water, atmosphere and disaster of the instruments carried by the earth observation satellites designed. This method would prove useful for the researchers and other users, mainly students which would give them an idea about the instruments and technologies comparison for the various satellites that are used for a particular focus. This research which is done on the focus of earth observation satellites on the earth summarises the different communication technologies used between earth and the observation satellites. Moreover the best method and the effective technologies has been analysed which is resulted from the table that had been created. Finally the researched information is distributed to the users through a website for access.

Keywords

Earth Observation Satellite, Satellite data, Applications

1 Introduction

Geographic information acts as a basis for understanding the geographic space from the spatial information collected by satellites. Society has now changed to a geo-information society with access to internet and mobiles associated with spatial and earth observation data. The data which is collected about the earth's resources are analysed and are used for the well being of the society (Kainz, 2005). Every satellite is designed specifically for a particular purpose or to serve an application with special sensors and instruments supporting them. Development in the telecommunication technologies and recent trends in sensor technology has made it possible to build small satellites to have the same potential as the large satellites and this has created an opportunity for all countries to develop their nation with some

research in space technology and earth observation (Karatas, 2009). British company, Surrey satellite technology help in providing small satellite missions for operational and commercial purposes. They help in designing communication payloads and launching them for many commercial applications including the earth observation and imaging (SSTL, 2011).

2 Earth Observations Dominance

Satellite imagery and other remote sensing data's are analysed from various organisations and surveys which are made with the information retrieved. Some of the private companies like Space Imaging, Orbimage, DigitalGlobe, GlobeXplorer, Spot Image, ImageSat International, and EarthSat use the imaging information from the earth observation satellites and are used by the governments and other organisations related to remote sensing for numerous applications (Luccio, 2005). Demand in the society has increased because of the increased web portals publishing, and the companies compete each other to provide the society with the latest images and data retrieved from these earth observation satellites.

There are numerous developments in this field of earth observation with many breakthroughs in the technology and the instrument being used. One of the crucial developments was the use of the multispectral sensors and which used the infrared and microwave regions to monitor the earth surface. A example is Nimbus which concentrated on bringing the details of the ocean topography, ice sheets. The sensors consists of the cameras, infrared and microwave radiometers and spectrometers, colour scanners and back scatter sensors Another breakthrough in the technology came with the emergence of the SAR (synthetic aperture radar) which can sense through the cloud cover and can gather details about the height, scattering properties of the land cover from knowing the time delay between the emission and return of the signals (Tatem et Al, 2008).

Earth observation by satellites is basically an application driven programme which concentrates on certain special applications and these satellites are sent on certain application driven motives. Some of the major applications on which remote sensing satellites concentrate are the agriculture, land use, forestry, urban development, environment, geology, coastal resources, marine resources, snow, glacier, volcanoes, disaster monitoring, mitigation and infrastructure development (Navalgund et Al, 2007). Earth observation on land, atmosphere, water and natural and dangerous hazards have become more important thus developing society and its awareness of all the issues, particularly reducing the losses due to these hazards and protecting the global environment.

Evolution of satellite data to the mobile phones and other climatic events assistance from the satellites and applications of the space data motivated my research over this study of earth observation satellite and technologies. With ever increasing climatic disaster like cyclone, floods, earth quakes, volcanic eruptions with almost all have now been forecasted and are helped for reconstruction and analysing the effects through the data observed from the satellite. Thus knowing that the data collected from the earth observation satellites and other space data are used to assist the research findings and analysis by the space organisation had resulted in the interest

over the technologies they use and the instruments they have for monitoring the earth.

3 Categorisation Based on Focus

This research is based on the two main questions and they are:-

1. What are the satellite missions that are designed specifically for earth observation and the corresponding interfacing technologies that help for a particular application?
2. How to summarise all the satellites and the corresponding instruments, in order for a clear understanding of all the technological and communication interfaces in these earth observation satellites?

The study method that is used determines the ways to answer these two questions and is based on the focus of the earth observation satellite on the application. Though the satellites and instruments can also be divided based upon their orbits, wavelength regions etc. Here they are done on their basis of their focus of application in this research. The main objective to have these categories based on focus is to have a clear idea of the processes, instruments and technologies that is being used, usually for the same application with some advancement in order to retrieve the data and work on post processing. The other main reason for using the classification in terms of using the tabular columns is that if the research was done in studying the technologies and other specification of a satellite with some tabulation for each satellite or a sensor instrument, then this would end up with many pages of data for analysis. But using this method of tabulating the technological details with respect to their application, author (1) did not have the necessity to have a long table and the user can navigate and research the satellite details with their application of their need which makes easy for the further researchers and students to understand the interfacing technologies in the earth observation remote sensing satellites.

This research on the instruments and technologies of the earth observation satellite was started by taking the list of all earth observation satellites that are present in space till this date and thus identified the possibilities of the classification of all the satellites in order to make the research useful for the further researchers to understand the study of instruments and technologies that are used for monitoring. It thus came to a result of classifying the satellites based on their application focus would help, as there were no previous study and classification that have been done with respect to this focus. Then, all the technological details of each earth observation satellites, were gathered in order to find a way to tabulate the different satellites with their focus. Figure 1 shows part of the table developed which classifies satellites in terms of their application focus i.e. on land, water, atmosphere and disaster.

EO SATELLITE NAME	FOCUS ON LAND	FOCUS ON WATER	FOCUS ON ATMOSPHER	FOCUS ON DISASTER
ACRIMSAT			✓	
ADEOS(MIDORI)-1	✓	✓	✓	
ADEOS(MIDORI)-2	✓			
AISSAT-1		✓		
ALOS	✓			✓
AQUA		✓		
ASTER		✓	✓	✓
AURA			✓	
BELKA	✓			
CALIPSO			✓	
CARTOSAT 1	✓	✓		
CARTOSAT 2	✓			
CBERS 1,2	✓	✓		
CBERS 3,4	✓			
CHAMP	✓		✓	
CLOUDSAT			✓	
COSMO-SKYMED				✓
EARTHPROBE/TOMS			✓	
ENVISAT	✓	✓	✓	✓
ERS 1	✓	✓	✓	
ERS 2	✓			
FENG YUN			✓	
FORMOSAT 3	✓			
FORMOSAT 5	✓			
GEO EYE	✓			
GOSAT				✓
GRACE	✓			
ICESAT		✓		
IKONOS 2	✓			
IMS-1	✓			
IRS A,B	✓	✓	✓	✓
IRS C,D	✓			
JASON-1		✓		

Figure 1: Part of the table showing earth observation satellites based on focus. (A-J shown, compiled-December 2010)

4 Methods adopted for classifying

The author ⁽¹⁾ classified the focus of the earth observation satellites into four main categories which the author believes are more useful and they are land, water, atmosphere and disaster, as almost all the earth observation satellites was covered under these categories. After identifying the main categories author ⁽¹⁾ made several discussions with author ⁽²⁾ to identifying the different fields for tabulation, required for the better understanding of the interfaces in satellites. They are the communication technologies which discusses about the uplink, downlink and other spectral bands with their frequencies. Next field is the data processing where the data

rate and information regarding the data compression, conversion are discussed for every instrument carried by the satellite. Applications of every instrument and the web links for further information are added as it would give a better understanding.

Separate tables are created for each focus of application. When the table is created for the application focus on land, the following satellites which concentrate for the application of land monitoring are identified from the table that were created during analysis of the focus of different earth observation satellites. Thus the different sensors that the satellites of our interest carry are researched and finally the instrument that the satellites use for the purpose of land monitoring is found and tabulated. Other sensors which concentrate on other application such as water or atmosphere other than land are not included in the land table.

Several sources are researched for the various technologies and the mission’s websites and books are studied to identify the different methodologies and other technologies that they use for the land observation. Thus the communication technologies and the data processing and other data related processing methods are studied to classify them and tabularize them for the clear understanding of the information researched. But sometimes some sensors have multiple applications, which are thus included in more than one category based on their focuses. Similarly three other tables are created for every application focus containing all the communication technological interfaces details with their information related to data processing and thus proving with their significance towards their application focus using the same method that was adopted for the focus on land.

5 Website Designing



Figure 2: Web pages

Finally a website is created using a PHP and CSS script and edited with Adobe Dreamweaver as a means of making this research to reach the students and others user for easy access and be helpful. The use of the hyperlinks makes the information

access easy and the screenshots are shown in figure 2. The website is created with various tabs that would give clear understanding of the research that has been done. Basic information tab is included in the website in order to include all the basics of the remote sensing and their technologies discussing about the satellites, orbits, sensors and electromagnetic spectrum. Video links and pictorial representation of the concepts are added to make the website more users preferable and thus making the concept reaches the user and students effectively. Separate web pages are created for each and every focus application and their corresponding technology that are discussed in the table such as instruments, communications, data and application. All the summarisation done as a result of the research is included in the website with all the web links which helps the users to get more information about the earth observation satellites and their instrument technologies.

6 Difficulties

Various difficulties happened during the decision making of identifying the methods to tabulate these earth observation satellites considering the different option in hand. This was a challenging task, as when deciding the different fields that need to be used in order to bring details that would be necessary to perform a detailed study about the different interfacing technologies in the satellites. There were some difficulties in making the website more dynamic and thus left for the future work. Moreover there were no access to most of the satellite data and hence this needs more research over several books, archives, organisational reports, space agency website to retrieve the technological details that were needed for the summarisation in the tables.

7 Results

From the table shown in figure 3 that has been designed with all the interfacing communication and data processing details as a result of the research gives more comparison of the different methodologies that the earth observations satellites contain perform their activities. The instrument detail gives the details of the various sensors that are used for the application of land, water, atmosphere and disaster, thus clear for the researcher and users to understand the different sensor used for different application. The communication technology infers the different bands that the satellites operate for the downlink and uplink with their transmission frequencies. The band L is the preferred band by the land observation satellites as this help in monitoring the land cover, surface moisture and vegetation and they are not affected by the dew particles compared with X and C. The land monitoring uses the HV and VH polarisation when compared to the HH and VV because the vegetations are not distinguishable in the latter. This band provides the resolution of up to 25m. Moreover from the table that had been resulted it is very clear that the S band is used for the TT&C (telemetry, tracking and control) and used for the communication links for the supporting instruments. Ka band is the preferred band for the monitoring of the surface temperature and operate in 37 GHz. Ku band is the preferred band for the radar altimeters and thus help in determining the earth parameters from the distance from the radiation gets reflected and operate in 13.8 GHz. C band is also preferred for the land monitoring and being in the middle of the microwave bands, is considered for more applications where resolution is not more concerned. X band is

the preferable band for the imagery and this can provide up to 5m resolution. The X band is used for its low wavelength and high resolution provided and thus can be used by the satellites to provide high resolution imagery of the earth's resources. Moreover this band have the ability to observe tiny particles and thus used for the weather observation and tiny water particles and aerosol in the atmosphere. Thus from the table it is found that most high resolution imagery and tiny article observation application for the satellites are done through the X band.

SATELLITE	INSTRUMENTS	FOCUS	COMMUNICATIONS	DATA PROCESSING	SIGNIFICANCE	LINKS
ADEOS (MDOR) 1	AVNIR	LAND, WATER	VIS (-0.40µm to -0.75µm) NIR (-0.75µm to -1.3µm, 0.42-0.50 µm used for coastal resolution-0.065 cm ² (apodized), have 3 bands-3.3 - 4.3 µm, 4.3 - 5.6 µm, 5.0 - 14.7 µm	linear cod array provides 5000 and 10000 detector elements	frequent observation of data in a width of 1400km to monitor land and coastal regions	http://www.nasa.gov/vis/visainfo/visainfo.html#ADEOS1
	IMG	LAND, ATM		interferogram scan time ≤ 10 s, data rate-882 kbit/s	spectra of thermal infrared radiation from the earth's	
ADEOS (MDOR) 2	GLI	ATM, LAND, WATER	36-channel VIS/IR radiometer/imaging spectromete employs piecewise linear method with cascade amplification for signal processing on four bands. 12 bit quantisation	transmits the information to the direct transmission system (DT) and the JOCSS, then transmitting the information to the MDR (Mission Data Recorder)	data will be used for the understanding of climatic changes and the carbon circulation	http://www.nasa.gov/vis/visainfo/visainfo.html#ADEOS2
	PRISM	MAPPING	wavelength-0.52 - 0.77 µm, Push broom method-5 CCDs each- Forward and Backward telescopes	quantisation- 8 bits	generates perfect digital elevation models	http://www.nasa.gov/vis/visainfo/visainfo.html#PRISM
ALOS (Daic hi)	AVNIR 2	LAND, WATER	VIS (-0.40µm to -0.75µm), NIR (-0.75µm to -1.3µm)	Data type Optical/Multi Spectral Radiometry High Resolution, processing level 1, done by RSP and scene shift system	mapping of the land surface and the oceans	http://www.nasa.gov/vis/visainfo/visainfo.html#ALOS
	PALSAR	LAND, WATER	microwave radar having wavelength 1.8band (-15.0cm to -30.0cm), 1.27GHz	Doppler algorithm is used for processing Backscattering coefficient, polarimetric data processing, no of bits/ sample-5, HH polarisation.	dry & night land obs, estimate vol of water in soil, vol of biomass in forests, conditions of waves	http://www.nasa.gov/vis/visainfo/visainfo.html#PALSAR
BELKA	MSS	LAND, WATER		belka 1 unsuccessful (Dnepr 1 failed 06 sec after launch)	ecological research, mineral prospecting	http://www.nasa.gov/vis/visainfo/visainfo.html#BELKA
	PSS	ATM	resolution upto 2.1 m.		cartography emergency situation &	http://www.nasa.gov/vis/visainfo/visainfo.html#PSS
CARTOSAT 1 (IRS-P5)	PAN CAMERA		X-band - QPSK modulated, single polarized- 105 Mbit/s, beam phased			http://www.nasa.gov/vis/visainfo/visainfo.html#CARTOSAT1

Figure 3: Part of the Table designed for satellites and their corresponding instruments (Focussing on Land)

The modulation techniques that were found from the table shown in figure 4 infers that QPSK is the more preferred modulation technique for various satellite communications used for the purpose of earth observations because of its optimum bandwidth and power requirements. This table also gives details of the various scanning techniques used such as whiskbroom, cross scanning etc by the satellites for various applications. The data processing columns from the table tabulates the details of the various data rates that the earth observation satellites use for various application such as digital data, images etc. This gives the information of the quantisation rate which is used for the processing of data. Some information regarding the data levels that the satellites have for processing the data have been retrieved from the satellite. From the various information tabulated in the results, the data rate that these satellites use for the earth observation had been increased to several Mbps from the older earth observation satellites like Landsat and this is seen from the usage of the X band which allow higher data rates in the order up to 500Mbps in Terra Sar-X which are used for the high resolution transmission to the ground station. The significance gives the idea of the various purposes that these instruments are used for the earth observation applications with the web links giving more idea towards the instruments and satellites.

Thus the results produced by this research give the various technological details needed for the communication and interfacing in a tabularized way for the better understanding of the earth observation satellites.

8 Future Work

The research can be improved in future with updating the information in the table that has been presented in this research. This research is very broad and so further research can be done for each application, focussing on more details of the instruments and explaining the technologies in detail individually. Focus can also be made on the antenna types and other data formats. Finally the website that is created as a means of making all the research findings and presenting all the details to the society can be improved by adding the facility of having a database of all the sensor details and technologies and providing the website with a search option making it more easier to navigate and get more details. This research can also be expanded with updating the satellites and their corresponding details as this work concentrates only on the satellites which are significant in the field of earth observation up to date.

9 Summary

Thus this research gives the study of all the communication and data interfaces present in the earth observation satellites tabulated and organized with respect to their focus on land, water, atmosphere and disaster. A website has been created in order make all the details available for access by students and other researchers.

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