IKONOS COLLECTION CAPABILITY WITH THE DIRECT TASKING FROM A REGIONAL OPERATION CENTER

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ABSTRACT:

The IKONOS satellite has a global operations network and each regional operation center can directly send the tasking packages to the satellite and collects and receive the images in real time mode over 320 Mbit/sec link. Space Imaging Eurasia is one of these operational centers among this network and its collection efficiency is the best within this network. Each operation center has the ability to autonomously task the satellite within their communication cone. The location of the communication cone is dependent upon the placement of Radio Frequency Terminal and the communication cone size is dependent upon antenna elevation angle. The minimum value for this antenna elevation angle is 5 degrees and once the antenna is settled to this extend and rotated around 360 degrees, the communication cone of a regional operation center having 4600 km diameter can be reached. Each regional operation center has local collection planning and sensor tasking, direct downlink of image data from the IKONOS satellite, local image catalog and archive and local product generation and distribution rights. In this paper I will present how Space Imaging Eurasia can access more area and more clear area in its communication cone. Results show the weather data usage and collection efficiency improvements in one particular satellite pass.

1. THE IKONOS SATELLITE

The IKONOS satellite is unique in its combination of qualities. Unlike normal "push broom" satellites (for example, LANDSAT or IRS), IKONOS is an agile satellite. "Agile" means the satellite can be directed to take images front, back, left and right of its nadir path. Also, IKONOS has the ability to do tasking while either in, or out of, direct contact with the ground station
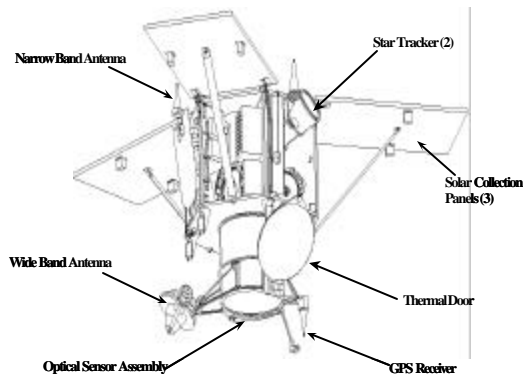

Figure 1 . The IKONOS block diagram

1.1 Narrow Band Antenna: Omni antenna used to receive the tasking packets from the ground station and transmit the real-time tasking response to the ground station. There is a time limit for the tasking package upload for the regional operation centers that operators have to send the imaging schedule to the satellite within 25 second after contact with the IKONOS satellite.

1.2 Wide Band Antenna: Gimbled antenna used to send real-time imagery and metadata to the ground station. The Imagery sent to regional operation centers after they have contacted with the IKONOS satellite and executed onboard software. The onboard software calculates the scan and slew durations for each image and sent this information to the subsystems and actuators to return the satellite exact place for imaging purpose. Wide band antenna collects the images in either right hand steering law or left hand steering law and then send these images in real time mode to the ground station over 320 Mbit/sec link.

1.3 Star Tracker : Used to determine the satellite's attitude which is needed to get precision pointing during imagery collection. Sometimes, when collection is being occurred the Star Tracker can see the SUN which can cause wrong orientation the satellite attitude.

1.4 Optical Sensor Assembly (OSA): the "camera" of the satellite. Actually, it has 10 meter long aperture but due to the on board attitude constraints it had to be shrink to the 2 meter long. The OSA has several mirror system to reflect the imagery onto the CCD arrays which transform imagery to voltage values. Then these voltage values are regenerated to create imagery again. OSA simultaneously collects black & white as well as multi-spectral imagery with the following specifications:

Spatial Resolution		Spectral Bands	
Black - White:	1-Mt.	Blue	0.45 - 0.52 mm
Multi-spectral:	4-Mt.	Green	0.52 - 0.60 mm
		Red	0.63 - 0.69 mm
		NIR	0.76 - 0.90 mm
		B & W	0.45 - 0.90 mm

A "push broom" satellite takes images continuously in a strip along its ground track. "Tasking" is performed by the owner of the satellite and is controlled by turning on the downlink or not turning on the downlink.

The IKONOS satellite turns "on" when it is time to execute a task. The satellite will turn "on" for either the Primary Operations Center (POC) or a Regional Operation Center (ROC) that has requested the use of the satellite. The ground station can then choose the exact areas needed for imaging.

2. IMAGE COLLECTION

2.1. Area of Interests

Customer Product Orders or as we defined them Area of Interests are submitted by Customer Operations Specialists according to the customer requirements. They define a priority for each of the product order. After that, Mission Planning and programming is performed by Satellite Operations Engineers by considering these priorities. All area of interests is subject to the prioritization and one of the mission planning software criteria for scheduling is that and it creates opportunity for each priority.

2.2. Mission Planning

Mission Planning provides interfaces to task the satellite-imaging system. For the IKONOS satellite, Mission Planning has capabilities to plan the collection of imagery within imaging windows assigned by Space Imaging, and to generate tasking requests for direct uplink to the IKONOS satellite during these windows. Because intelligence requirements tend to be more volatile than the requirements for other remote sensing applications, this is a particularly valuable feature in that it permits changes to be made to the tasking only minutes before scheduled contacts with the IKONOS satellite. This near real-time tasking also enhances the probability of cloud-free imagery because changes can be made to the plan based on current cloud forecasts obtained from weather data providers.

The field of view of IKONOS satellite for 60 degree mono collection is 700 widths. If the product orders' image region is candidate for that day, they would have an adjusted value for automatic scheduling by mission planning software. Satellite operations engineer has responsible to optimize the imaging times for the candidates image regions. Due to the bad weather conditions on affected image regions he can decide not to collect these image regions by zero out the adjusted value.

2.3. Image Collection process

Once the operator has finished the optimization the collection plan is saved. Then ground receiving system has returned to real time mode to capture the satellite signal.

About thirty minutes prior to each contact, the system prepares to receive data from the satellite. Tests may be executed to insure the system is ready to receive and record the data, and that the antenna points to the location where the satellite is expected to appear above the horizon, based on ephemeris data provided by the operating agency.

As the satellite rises above the horizon, the Antenna System acquires and tracks it until the end of the contact, which may be more than ten minutes in duration. For the IKONOS satellite, tasking that defines specific areas to be imaged is transmitted via the S-band uplink immediately after acquisition. When the sensor(s) on-board the satellite is activated, imagery is collected and transmitted via one or more X-band downlinks. The Antenna System receives and demodulates the X-band signal(s) and forwards the demodulated

data to Base Image Recording, which records them on disk arrays.

At the end of the contact with the satellite, the serial data stored on the disk arrays are converted into image files that are recorded on tapes and telemetry files that are processed to create support data elements that are stored in the database.
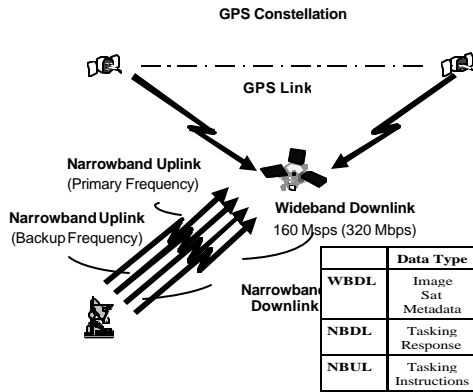

Figure 2 . Uplink and Downlink

3 Hours before the pass an optimization is performed for to be collected candidate image regions by running the mission planning software after which the collection plan is saved by considering the weather forecast which is received from weather forecast data provider company via ftp.

2.4.   Contact with IKONOS

2.4.1. Realtime mode :

10 minutes prior to contact ground station equipment connected to the antenna are switched to the real time mode. 3.5 minutes prior to contact the antenna points to the location where the satellite is expected to appear above the horizon in program track mode. Upon contact satellite authentication commands and collection plan are sent within a 25 second window to the satellite.

At the start of the activity window, the ground station RFT receives a narrowband (NB) signal from the satellite. The ground station RFT is also transmitting a NB to the satellite. If the high powered amplifier (HPA) on the RFT is not active, the satellite will not receive the signal. The command status indicator goes from "Unlocked" to "Locked" It indicates that the satellite's receiver is "locked" onto the signal transmitted by the ground station. Once the operator has verified that

the NB receiver on the satellite is working, the ground station signal must be modulated and the crypto signal and command sequence should be sent to the satellite within 25 seconds. The satellite maneuvering to the imaging place after onboard software execute the tasking package, this maneuvers called as slew maneuvers of the satellite and the satellite cannot take any image during that time since the actuators is returning the satellite exact imaging place.

2.4.2. How to Satellite Process Collection :

Onboard software receives the commands and processes them.Then it calculates the scan and slew durations for an image region.Scan is the actual collection time for an image region ,slew is the waste time between the image regions. Actually the satellite collects an image region then it returns another image region so we called this duration as slew.

While the satellite is collecting the image regions, Image Data is sent to ground in realtime over a 320 Mbit/Sec link. This image data is saved along with the metadata which is used for rough coordinate assessment. Then the browse image is subjected to cloud cover assesment. 24 hours later the real satellite attitude information is sent from (POC) and it is processed to have accurate coordinate information for the image regions.

3.   TOOLS FOR IMAGERY COLLECTION

3.1. Cloud Forecast

After getting 4 days cloud forecast information for the whole communication cone from the meteorological service provider the relevant satellite pass is either requested, modified or canceled from Primary Operations Center (POC) depending on cloud cover. As you can see from the Figure 3 Cloud Forecast Information, the Cloud Cover data is sent by the national meteorological institute for four days forth. The display has grid lines with 10 degree and at the top of the image there is a legend for the cloud predictions information. Left column is related with the prediction start time which is calculated by the agency with compound several meteorological data into the calculations and then the software does some calculations with iterations of the mathematical models. The right column has this iteration for the related days cloud cover information. For example the software was run on Wednesday 13 August for the 18 August 2003

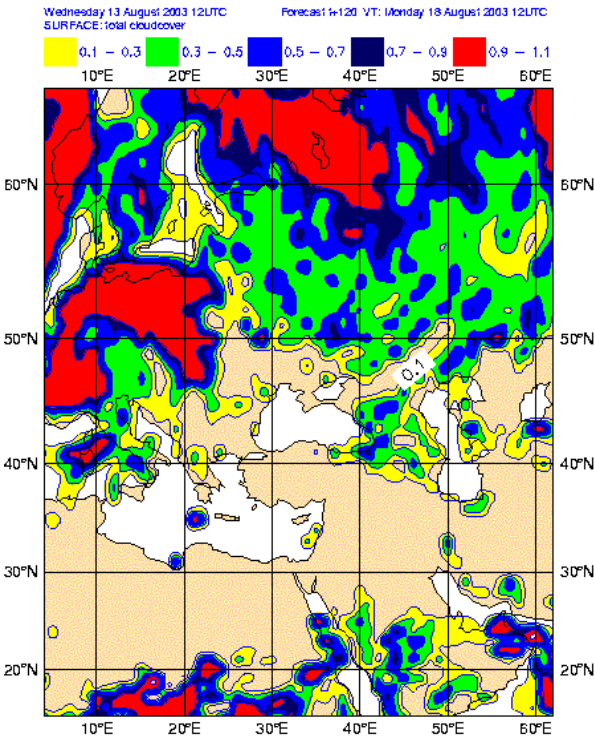1200 UTC cloud forecast data predictions in the Figure 3.

Figure 3. Cloud Forecast information

The legend also shows the cloud cover percentage for that day. For example the red color represent the area will be totally or 100 percent cloud covered. The yellow one represents the cloud cover will be 10 percent for the area and the beige one represent the area will be totally cloud free or 0 percent cloud covered. After getting 4 days forth cloud cover information for the whole communication cone from the meteorological service provider, the day after the new forecast information is updated with the more precise data for the upcoming days. Due to the prediction or iteration probability, sometimes the subjected area for the activity window could be cloud covered but the day after it can be clearer with the new iteration for that day.

Once the forecast data is near to the subjected day the cloud cover information will be more accurate. Then we decide take or don't take this activity window time depending on the cloud cover over the subjected area. Sometimes this prediction can give faulty information since it has a mathematical model and iteration method while creating this valuable information. Due to the wrong iteration it can cause faulty information. However, this cloud

forecast information is very useful and very effective while selecting satellite passes.
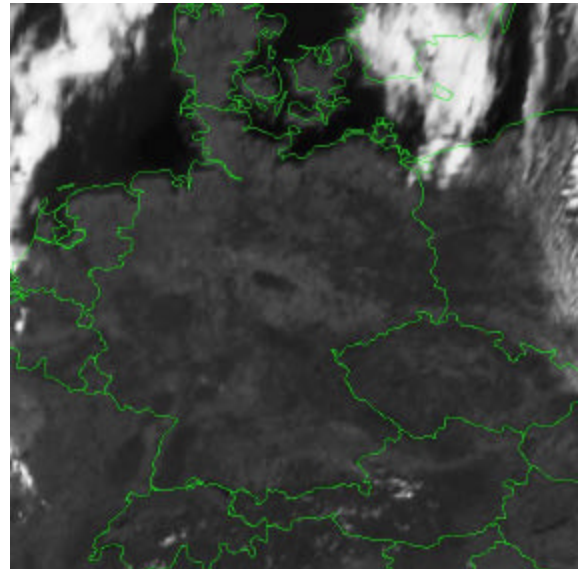

Figure 4. A meteorological satellite print out overlaying with country borders.

3.2. Meteorological Satellite Data Usage

The Space Imaging Eurasia company is using every kind of weather forecast information to gather into the collection optimization process. One of the most important one among these is the real time weather data coming from meteorological satellites. Meteorological service provider is sending half an hour basis currently available satellites meteosat and noaa data to the Space Imaging Eurasia ground station via ftp. Then satellite operator takes these images and compares with the previous image and with an animation tool the half an hour basis received images puts together and an animation is created. Then the cloud movement above the subject area is observed and if the area is cloudy then another cloud free region is scheduled by the operator. This process is continued up to 20 minutes prior to contact with the IKONOS satellite

3.3. Meteogram Data

Sometimes we need the use another tool to compare with the cloud cover information and meteorological satellite data. The meteogram data is used to support to the cloud cover information and it also include the humidity with a given hPa, temperature, pressure, wind at a given height of

atmosphere for a given geographical coordinate. This is very useful information for the exact geographical coordinate cloud cover forecast data. Figure 5 represent a sample of this tool.
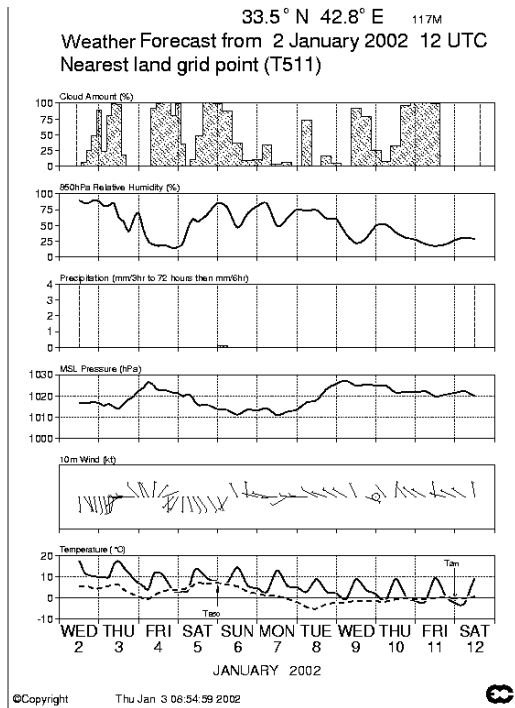

Figure 5 . Meteogram data

4. CONCLUSION

With these valuable meteorological data Space Imaging Eurasia proved that the total collected area and total cloud free area ratio is the best in Space Imaging network. This ratio is above the %90 for year 2003. This represents how Space Imaging Eurasia uses the cloud forecast and cloud movements effectively in the mission planning.

References from websites:

http://www.spaceimaging.com/products/ikonos/index.htm