CARLETON UNIVERSITY
SPACECRAFT DESIGN PROJECT 2005

FINAL DESIGN REPORT

Ground Station Selection and Feasability Analysis

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Ground Station – Receiving Station

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Ground Station – Site Analysis and Selection

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Abstract

A feasibility analysis of purchasing and operating a ground station versus using existing reception stations such as ones from Canada Center for Remote Sensing was completed. In terms of performance, possible cost advantages, and flexibility, the self owned and operated ground system was the best option. The system purchase was specified to be a ViaSat 5.4 meter remote sensing ground station. The existing option is for reception only at the current time due to the limited upload requirements needed for AEGIS. The stations flexibility allows for multiple channels to be added as well as an upload option, when and if more clients are found to utilize the system. A complete cost analysis was performed and compared in terms of expected performance of the AEGIS satellite system. Cloud cover is an expected issue in terms of the overall performance of AEGIS and work was done to create a self regulating imagery analysis program which determines whether the image is usable and sorts it accordingly. The parameters can be changed to various thresholds to always allow for the maximum number of usable images to be passed on to the client. Currently any and all image processing is planned in the ground segment, however future recommendations include possible inclusion on board.

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Nomenclature

v	Velocity of spacecraft $\left[\frac{m}{s}\right]$
M_{sat}	Total mass of satellite $[kg]$
M_{earth}	Total mass of Earth $[kg]$
T	Period of Satellite $[s]$
F_{net}	Net centripetal force acting on body $[N]$
F_{grav}	Gravitational force acting on body $[N]$
R_{Earth}	Radius of Earth $[km]$
h	Altitude of Satellite $[km]$
G	Gravitational Constant = 6.672*$10^{-}11$ $[Nm^2/kg^2]$
dB	Decibel $[-]$

Acronyms

AEGIS	Air-launched Earth-observing Ground Information System
BER	Bit Error Rate
bps	Bits per Second
BPSK	Binary Phase Shift Keying
CCRS	Canadian Center for Remote Sensing
CSA	Canadian Space Agency
DND	Department of National Defense
KSAT	Konsberg Satellite Services
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RGB	Red Green Blue
SGP4	Simplified General Perturbations 4
STK	Satellite Tool Kit
UTC	Universal Time

1 Introduction

Initially the scope of this project was constrained to creating a method to track the AEGIS satellite while in orbit. The reasoning behind creating an independent station to track AEGIS was to not only allow for the tracking of the satellite, but to spur a side project that could be readily achieved. The project being the creation of a fully operational satellite tracking facility at Carleton University. For little money, the hope was to have a project that could be improved year after year in a very tangible way as it would be operational. The multiple methods of tracking were looked at, and while signal tracking or radar tracking were most suitable for AEGIS, the biggest advancements and possibilities were in the field of optical satellite tracking. The costs to set-up an initial system were low and the possibility to use it as an adjunct to the Hertzberg telescope exists. The one downfall of an optical system however, was the ability to accurately track a low earth orbit satellite with accuracy. This was due mainly to the fast slewing speeds that would be needed and the little amount of time that would thus be left for exposure time. While it could be done the results would not have been sufficient to justify its use. As well optical satellite tracking heavily depends on weather, and as such wasn't as dependable an option.

As the project expanded to serve the forest industry specifically, the justification of an optical satellite tracking system decreased significantly. In its first year it would not be accurate enough to track the AEGIS satellite and while interesting as an area to improve and work in, it was not appropriate for use with AEGIS. Thus more focus was placed on designing an overall integrated ground system that would cover all ground aspects of the AEGIS satellite which was something that had not been done in detail before. Therefore what was initially the design of a satellite tracking system turned into a feasibility analysis of a ground station for the AEGIS satellite, as well as a usability study into image processing.

2 Requirements

The basic requirements of what the ground station needed to be was obtained or derived from the satellite specifications. The type of orbit and download requirements, which are documented in FDR-2005-3.2.1, specified the system location. Other requirements such as slew rates, data rate, frequency specifications, communications margins,temperature and structural needs were examined and are detailed below.

2.1 Slew Rates

Given a 600 km sun-synchronous orbit, it is possible to calculate the expected angular speeds that the ground station would have to match in order to continuously follow the satellite. To estimate the largest angular rates, a 21 day simulation was performed using Satellite Took Kit (STK) and the angular rates were calculated with reference to the ground station at the location near Rankine Inlet. For future reference we will refer to this station as the AEGIS ground station or simply ground station. Below is an image of AEGIS passing over the ground station over a 5 day sample period.

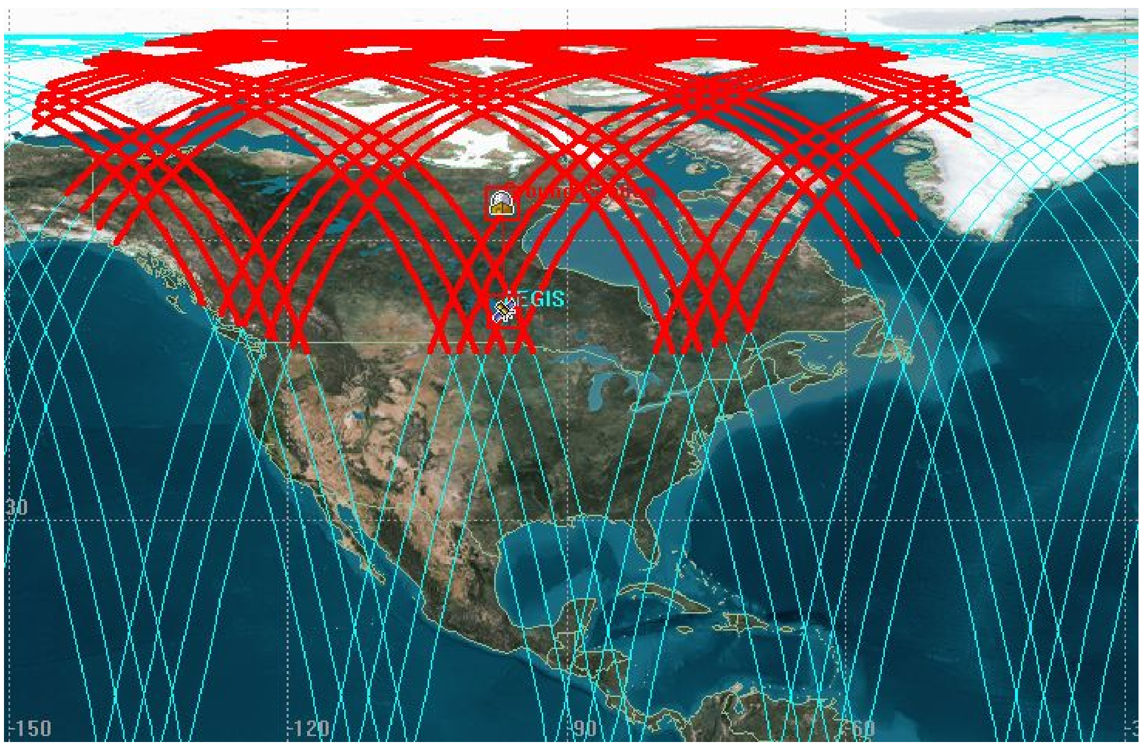

Figure 1: AEGIS over Ground Station for 5 days

Although in practice, we will only be accessing AEGIS during the south to north passes, for proper design and accuracy it is necessary to ensure all feasible passes and opportunities are taken into account when determining the maximum angular rates the station must be able to accommodate. The first step undertaken in determining maximum slewing rates was through the use of some basic orbital mechanics. From the following equations it was possible to approximate the values we would be expecting. They were mainly used to provide a figure of merit in which to verify the simulation numbers. While the exact same results were not obtained, this was expected because these set of equations estimate the earth as a perfect sphere and the co-ordinates at the center. For more accurate values, as stated before,an STK simulation over a 21 day period was used. The methodology of the hand calculations is seen below.

A motion of a satellite is governed by Newton's laws of motion. The derivation of Kepler's third law which is used to approximate the speed of the satellite is seen below. If a satellite with mass is considered, the net centripetal force acting on it is described below starting with the net centripetal force acting on a satellite body.

$$F_{net} = (M_{sat} * V^2)/(R_{earth} + h)) \tag{1}$$

However, this net centripetal force is the result of the net gravitational force of the two bodies.

$$F_{net} = F_{grav} = (G * M_{sat} * M_{Earth})/(R_{earth} + h) \tag{2}$$

Therefore equating both equations,

$$(M_{sat} * V^2)/(R_{earth} + h)) = (G * M_{sat} * M_{Earth})/(R_{earth} + h) \tag{3}$$

and reducing the above, we obtain:

$$V^2 = (G * M_{Earth})/(R_{earth} + h) \tag{4}$$

Finally, in combination with Kepler's third law,where T represents the period of the satellite.

$$T^2/R^3 = (4(\pi)^2)/(G * M_{Earth}) \tag{5}$$

The STK analysis was first performed using a base 21 day cycle from which maximum values were tabulated for angular rate, azimuth rate and elevation rate. In analysis of the results and orbital model, it was observed that the maximum values of concern to the ground station design would occur between an elevation rate of between 70 degrees and 90 degrees. Another iteration was performed to reflect those changes, however, a discrepancy was found between the straight 21 day analysis and the 21 day analysis with elevation cut-offs. Technically with the cut-offs we should have seen peak values in terms of angular acceleration but we did not, the reason was that the step size was too big and thus wasn't properly calculating the speeds when the maximum rate occurred. Therefore reducing the overall step size from 60 seconds to 5 seconds produced much better results. The final results can be seen in Table 1. 0.7072 deg/sec, 1.744 deg/sec, and 0.65944 deg/sec represent the angular rate, azimuth rate, and elevation rate respectively. These are the absolute minimum rates the ground station antenna must be able to move at to keep up with AEGIS.

Sample Constraints	Max Angular Rate (degrees/second)	Max Azimuth Rate (degrees/second)	Max Elevation Rate (degrees/second)
5 Days	0.635	1.337965	0.6493
21 Days	0.676	1.67	0.653
21 Days with 70 -90 degree cut-off	0.6632	1.744	0.63
21 Days with 70 -90 degree cut-off and 5 sec intervals	0.7072	2*	0.659

Table 1: Analysis of maximum angular rates

The one interesting result that can be seen in Table 1 is the starred value for the azimuth rate in the 21 day, 70-90 degree sample with 5 second intervals. This is due to the fact that as the satellite performs a near-azimuth pass; the azimuth rate will approach infinity. This is to be expected and by going back to our previous iteration, we can confidently set the minimum azimuth rate at approximately 2 deg/sec. In specifying this value, the station design must be suitable to track a near-azimuth pass and as such would require the elimination of the keyhole. It is also important to note that these values are all minimum values and as such, no safety or engineering factors have been included in them. The numbers for the final 21 day simulation are included as Appendix A of the report.

2.2 Data Rate and Frequency Specification

The data rate was given as a requirement from the satellite communications team and it specified that a data rate of 150Mbps was required. The total download time required was determined to be 53.3 seconds per picture. X band frequency was chosen and thus a major criteria was set. In terms of frequency allocations, the satellite X band transmitter is capable of transmitting anywhere in the range of 8 to 8.5 GHz. Receiving any signal in this frequency range is not a problem, however due to government regulations on transmitting frequencies; a search into available frequencies had to be performed. From Industry Canada and the "Canadian Table of Frequency Allocations MHz"[1], the only possible range allowed to receive in would be from 8.025 GHz to 8.4 GHz. This range represents earth exploration satellite communication from space to earth, and is where our signal if approved would be located in.

Since a range of possible frequencies was determined, a search of the area was completed to check for availability of frequencies. The full details can be seen as Appendix B attached to this report. These results dictate that a between a search area of latitudes 55-70 degrees and a longitudes of 90 - 105 degrees no specific frequency in that range would be out of the question. Due to the remote location of Rankine inlet, very few X band transceivers or receivers would be in an area of interaction.

In fact no registered X band operations exist in the area defined by the latitude and longitude described above, making the chances of acquiring a signal very high. Restricted and secret X band sites were searched for, as well to public sites, however no detailed information could be obtained from the Department of National Defence (DND), so the classified stations remain unknown. Since there are no clear obstacles in terms of signal allocation, an application for a signal license would have to be made to Industry Canada, however no true obstacle is seen that would prevent acceptance and granting of a license.

2.3 Communications Margins

The communication margins in terms of the down link can be seen in FDR-2005-1.5.1 The margin was determined jointly through calculation and was set as a minimum standard for which to meet. This is where the minimum standard of 0.7 dB is originated from.

2.4 Temperature and Structural Needs

Due to the northern location of the ground station, certain allowances and designs have to be taken into account to provide for the harsh environmental conditions that exist in the area. From statistics Canada for weather at Bakers Lake; which is located at a latitude of 64.18 degrees north and 96.4 degrees longitude statistics from the period of 1971-2000 were obtained [2]. These results provided a significant insight into the conditions at our actual site due to the extremely close proximity the two sites have in common. Overall, in a year there is an average of 100.8 days that are below minus 30 degrees Celsius. Also, sustained winds of over 63 km/hour occur approximately 14.8 days per year. If these two factors aren't taken into account, severe downtime and maintenance problems could occur for any remote ground station operating there.

3 Design Progression

Before comparing a independent station versus industry available solutions a major question had to be answered first. That was whether to build a station from scratch; meaning design the components and major subsystem versus buying a complete, packaged station. There are benefits and consequences to each action however; the main argument comes down to the purpose of having an independent station. The essential purpose of having a ground station was to have a reliable method of receiving information from the AEGIS satellite. It was apparent initially that the costs of buying a system were quite high and the costs of perhaps producing a workable system were in fact capable of being done quite a bit more cost effectively. However, a self built system would not have the same reliability, flexibility or performance capabilities of a purchased system. The expertise would not be there, nor would the back up and confidence in the system. For a first stage iteration of the ground station, it could not be justified because it could not be guaranteed to work in an acceptable manner that would make it feasible to finance.

Therefore, the major question or focus was instead turned to whether existing industry solutions would be better than the purchase and operation of a ground station. As the first year in the project it is essential to solve basic questions such as whether to pay for service or purchase and operate an independent station. After that primary question is answered, further development to refine the process can be done.

3.1 Upload Decision

The decision on whether to include an uplink aspect onto the ground station came early. The download requirements are significant enough to present an opportunity to recoup costs associated with the downloading of data, however, the uplink requirements were not. At 100 kb a day, the need for an independent uplink was diminished greatly. Added to that was the uplink transmission would have to be in the S band frequency and thus would require an additional antenna at a very significant cost. The costs to benefit ratio did not satisfy the requirements for a feasible option and thus it was decided to essentially outsource the uplink section due to these facts. The current option is to utilize CSA facilities to communicate with AEGIS, however as a more detailed picture emerges into the requirements needed for upload a better alternative may be found. Although some of the industry alternatives such as KSAT proved to not be feasible for download, KSAT does offer upload access. Discussions have been held and they are a viable suitor as this project expands. For the time being, the two CSA stations are detailed below from FDR-SAT-2004-3.1.A.

Parameter	Unit	St. Hubert	Saskatoon
General			
Antenna Diameter	m	10	10
Polarization	-	RHCP, LHCP	RHCP, LHCP
Antenna Gain	dBi	40	40
Antenna Ellipticity	dB	1.5	1.5
Earth-to-Space			
Frequencies	Mhz	2025-2120	2025-2120
Transmit Power	W	125	125
EIRP	dBW	42-59	42-59
Minimum Elevation Angle	°	5	5
Space-to-Earth			
Frequencies	Mhz	2200-2300	2200-2300
System Noise Temp(5° Elevation)	K	100	100
G/T(5° Elevation)	dB	20	20
Minimum Elevation Angle	°	$\leq$5(azimuth dependant)	Horizon

Table 2: CSA station parameters [3]

4 Ground Station Purchase Options and Selection

Different companies and organizations were looked at to determine the best solution for our needs, based upon the given set of requirements. Factors that were not firm requirements but were looked at as well were intangibles such as customer service, experience, reliability and overall knowledge. Many systems were disqualified for these reasons but many options were there to choose from.

A search was performed for a stationary, full motion remote sensing station capable of the required angular rates and ability to work in extreme temperatures. Based on the geographical area, it was decided that only companies in North America would be looked at to provide a solution. This was due to the fact that European providers would have trouble offering and providing help with installation and any maintenance problems that might occur over the years. This disposed of choices from companies like In-SNEC from France or Antrak from the United Kingdom. Instead focus was given to three companies in particular; ViaSat, Honeywell, and Titan. In analyzing the three companies, most of the product offerings were very similar both in design and price. For the capabilities that AEGIS required, most any system would be able to work sufficiently so the selection process was determined with reputation, working proof of performance and experience being heavily weighted. Based on this criteria ViaSat proved to be the best and because selected as they had over 60 remote sensing ground stations located around the world, one even operating out of Yellowknife which faces similar temperature conditions as our location. The basic design was a

5.4 meter remote sensing station, with the 5.4 meters representing the reflector size. These details are discussed in the following sections.

5 System Overview - ViaSat 5.4 Meter Remote Sensing Ground Station

As an overall system, the ViaSat 5.4 meter system is capable of acquiring data from all current remote sensing satellites and not just AEGIS. It is a proven commodity and a state of the art system capable of producing long term reliability with little maintenance. The customer service and customer care is ranked very high in industry and their reputation in the business ranks second to none. The system is ready to be expanded at any time and features the ability to add more channels as needed. The station can be seen in Figure 2 and some major subsystems are described briefly below. The system specifications can be found in Appendix C of this report.

Figure 2: ViaSat 5.4 meter Remote Sensing Ground Station

5.1 Antenna Subsystem

The antenna consists of a 5.4 meter dual shaped reflector and Cassegrain feed. Both the high efficiency X-band feed and the sub reflector are enclosed in one monopod type structure which maintains the accuracy of the alignment. This monopod structure is heated and pressurized to prevent ice build up and any negative performance effects due to weather.

With a gain to noise ratio of 31 dB/k, this system is good enough for every remote sensing satellite in the market. This fact will be touched on in more detail in the comparative analysis section. b A close-up image of the satellite antenna structure is seen in Figure 3 below with the appropriate labels included. The reflector is all aluminum and consists of a 1.22 meter diameter aluminum hub to which 16 aluminum panels are attached.

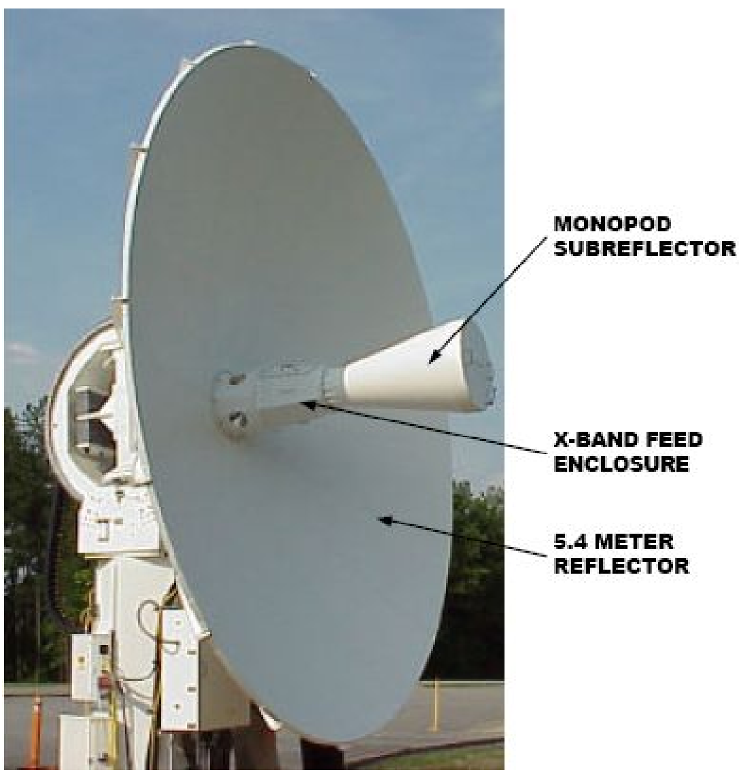

Figure 3: Antenna subsystem

5.2 Pedestal Subsystem

An X/Y pedestal is used to appropriately track the satellite as it makes it pass within the viewing area. Powered by two brushless DC motors for each axis, the system is capable of moving at a speed of 5 degrees per second in both axes. This makes the system easily capable of tracking the AEGIS satellite during all passes. As well, due to a tilt pedestal design similar to that seen at the Canada Center for Remote Sensing, the zenith keyhole seen during azimuth passes is eliminated. The X/Y pedestal in comparison to a three axis system allows for better accuracy and higher reliability due to the decreased speeds at which the antenna has to move to continually track the satellite. As well, lower costs are produced as only two axes have to be powered by the servomotors, as opposed to having to power all three.

In terms of the drive train, as stated before, each axis is powered by dual servo drive trains. Each drive train is then connected through a high efficiency gear reducer to a DC brushless servomotor.

5.3 Control Subsystem

In a brief overview, the control subsystem consists of all the required equipment needed to both monitor and control the operation of the antenna and its movements through the use of the pedestal. The basic core of the control unit is the 3880 Antenna Control Unit. The controller is responsible for providing drive signals and controls the autotrack features as required. Satellite tracking is an essential part of the design of the system. Utilizing SGP4 prediction software, the auto track system predicts where the satellite will be seen above the horizon and positions itself there. When a signal is acquired, it locks on by following the signal strength. If at any point the signal is lost, the system automatically goes back to its prediction software which it has been constantly updating even during signal lock. At the end of the pass, the data is analyzed to determine the pass effectiveness.

5.4 Radome

Due to the sever weather that is experienced, two options were available; a radome or a de-icing system. Since snow is a factor, as well as ice and wind, the radome was the obvious choice. Generating a shield for which the system can operate out of without significant interference,is essential a must for northern climates. A radome being installed can be seen in Figure 4.

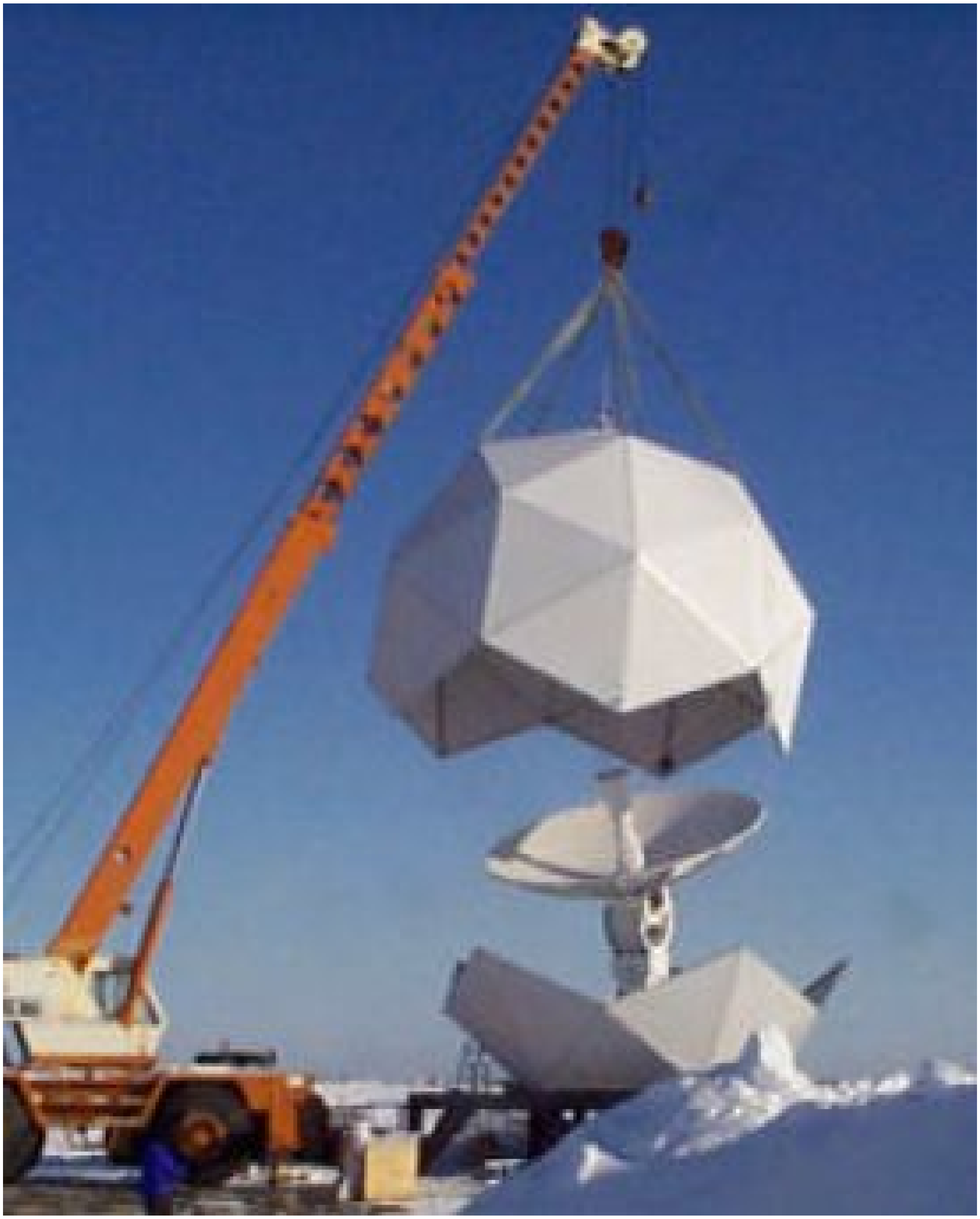

Figure 4: Radome being installed

6 Industry Alternatives

The main industry alternatives that were looked at were the CCRS sites at Gatineau and Prince Albert, a Honeywell site in Poker Flat, Alaska and Konsberg Satellite Services in Tromso and Svalbard, Norway. Figures 5, 6 and 7 show the access tracks each station could achieve with AEGIS.

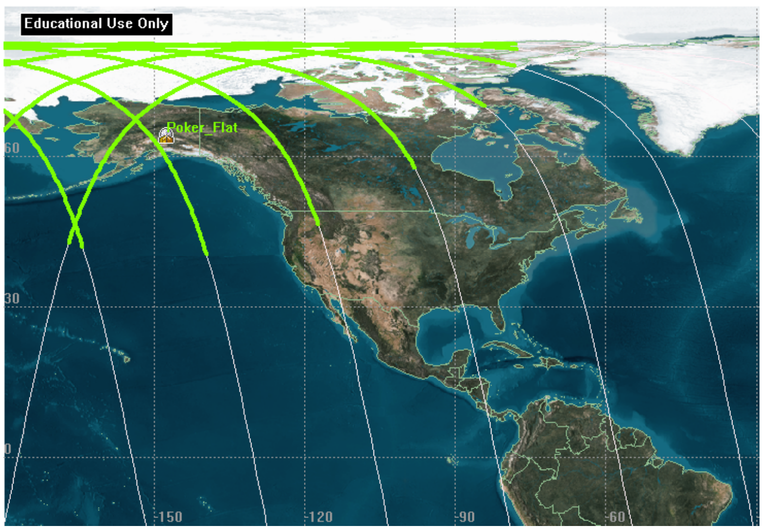

Figure 5: Access of AEGIS from Honeywell Technologies site at Poker Flat, Alaska

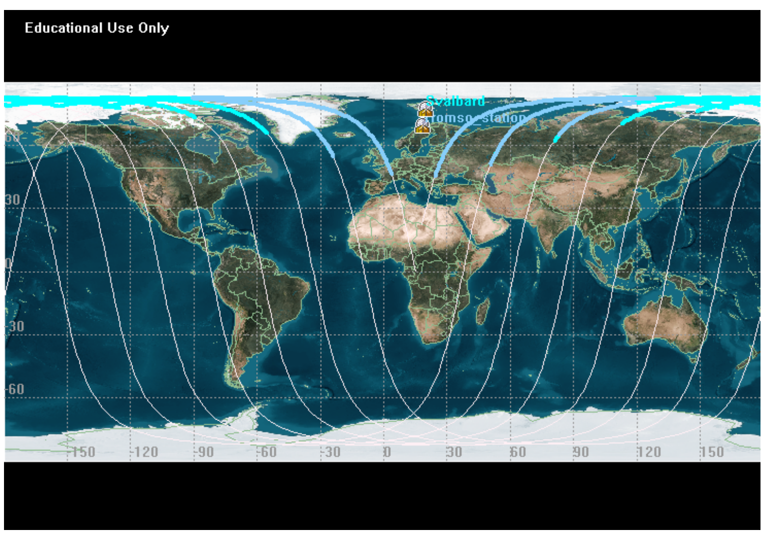

Figure 6: Access of AEGIS from Kongsberg satellite services two stations in Norway

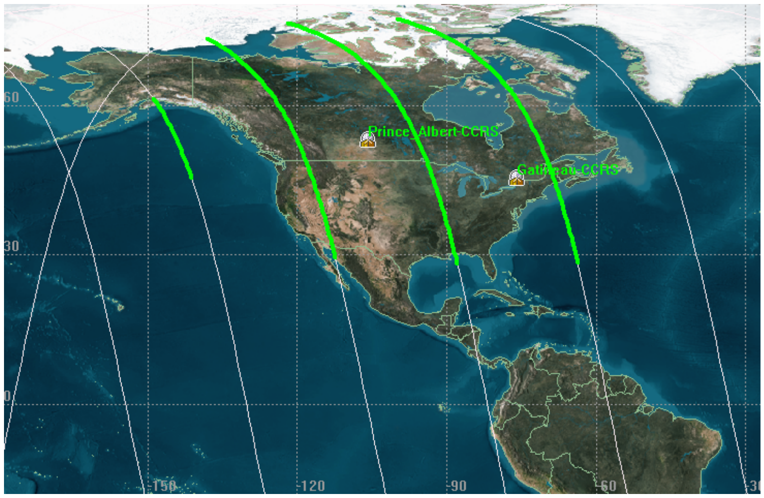

Figure 7: CCRS access of the AEGIS satellite

It is clear that in terms of the conditions the station would need to meet, such as downloading right after every picture as discussed in FDR-2005-1.2.1, the best alternative would be to use CCRS to provide reception services. Not only is it in the best location to maximize download according to our needs, it is also a clear Canadian alternative. For further analysis based on these facts, the ViaSat 5.4 meter system will be compared in terms of feasibility to the most logical based industry solution of utilizing CCRS.

The other stations when analyzed based on earlier requirements were feasible, and were thus examined. If the mission parameters indicate that a larger storage space was available, and northern data dumps were an option then perhaps these scenarios are better in terms of performance. Likewise if worldwide coverage is wanted, a station such as the ones Konsberg Satellite Services offer would probably be the most effective due to their world wide central location, and northern access.

7 Comparative Analysis

In comparing the two solutions, a wide variety of areas were looked at. Cost was a main driving factor in that if the ground station could not be shown to be financially viable, it would be an idea that could not work. The other factors examined were reliability, performance and risk.

7.1 Performance and Reliability

As seen by the comparison between Figures 1 and 7, it is important to note that CCRS would need two stations to cover the region of Canada versus the one station for AEGIS. As one can see in Figure 7 specifically, if U.S. forestry interests were to be taken into account, the CCRS stations would have an advantage in terms of location. However for this iteration the AEGIS mission is currently for Canadian forests exclusively. If this changes in the future, CCRS would be in a better strategic location but by that same argument, a new iteration would have to be performed for the AEGIS ground station to maximize location benefits based on requirements.

As will be described later, the need to use two stations to maximize the performance of AEGIS requires an additional cost burden on ground services. In a sample download schedule on June 1, 2006 it is seen that to maximize the number of pictures that are possible, both Gatineau and Prince Albert stations are required.

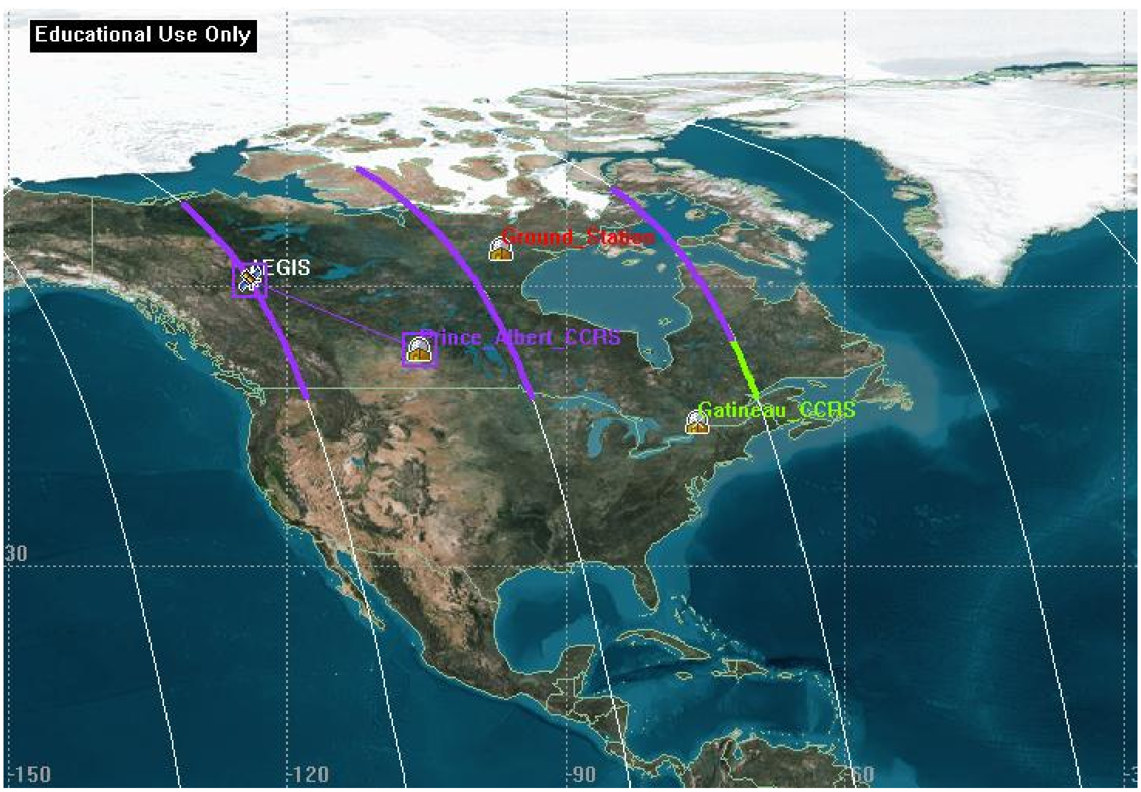

Figure 8: Sample access on June 1, 2006 from CCRS stations

As seen in Figure 8, both stations are required to maximize the possible download time. A cut-off was made at 48 degrees latitude as this was the earliest a useful picture could be taken from Canada. The schedule below shows the estimated schedule that would be programmed on June 1, 2006. One second has been allocated for switch over from picture taking to transmission, as per requirements set out in FDR-2005-1.5.1.

Pass 1 - 48 Degree Latitude Start

Segment	Universal Time	Action	Duration (Sec)	Ground Station Utilized
Start Pass	17:03:05			Gatineau
		Picture 1	76.85	
		Switch Over	1	
End Picture	17:04:23			
		Acquisition and Download	53.3	
End Link	17:05:16			
		Switch Over	1	Prince Albert
		Picture 2	76.85	
End Picture	17:06:34			
		Switch Over	1	
		Acquisition and Download	53.3	
End Link	17:07:28			
End Pass	17:09:46			

Table 3: Pass one download schedule from both CCRS stations

The first pass is really the only time at which Prince Albert could not receive the data through the entire country. At this point, the next two passes are fully covered by Prince Albert and for cost effectiveness it is the only one that is used.

Pass 2 - 48 Degree Latitude Start

Segment	Universal Time	Action	Duration (Sec)	Ground Station Utilized
Start Pass	18:40:19			Prince Albert
		Picture 1	76.85	
		Switch Over	1	
End Picture	18:41:37			
		Acquisition and Download	53.3	
End Link	18:42:30			
		Switch Over	1	
		Picture 2	76.85	
End Picture	18:43:48			
		Switch Over	1	
		Acquisition and Download	53.3	
End Link	18:44:42			
End Pass	18:47:13			

Table 4: Pass two download schedule completed from Prince Albert CCRS station

Pass 3 - 48 Degree Latitude Start				
Segment	**Universal Time**	**Action**	**Duration (Sec)**	**Ground Station Utilized**
Start Pass	20:17:03			Prince Albert
		Picture 1	76.85	
		Switch Over	1	
End Picture	20:18:21			
		Acquisition and Download	53.3	
End Link	20:19:15			
		Switch Over	1	
		Picture 2	76.85	
End Picture	20:20:33			
		Switch Over	1	
		Acquisition and Download	53.3	
End Link	20:21:17			
End Pass	20:22:54			

Table 5: Pass three download schedule completed from Prince Albert CCRS station

Two stations as previously discussed are needed when using CCRS services, so the question of reliability still exists. Due to the limited storage capacity and the need to transmit immediately after the picture is taken to maximize performance, station availability is a very important factor. Both the Prince Albert station and the Gatineau station would have to continuously track AEGIS for the entire pass and be in communication as to when to switch over. The communication problems are minimized due to the fact that both stations operate under SAS or Satellite Acquisition Services which serves as a blanket organization controlling all the reception services. CCRS currently boasts a 90 percent availability rate as stated in discussions with them, however whether that changes in the future remains to be seen. It has been conceived that CCRS may have plans to begin phasing out its satellite acquisition services, and thus depending solely on CCRS for data acquisition. This however, will carry some risk due to temporary downtime. That risk can be said to be mitigated by developing a back-up plan with temporary service providers until a suitable replacement can be found as CCRS is likely to give advanced warning to its clients.

7.2 Cost of ViaSat System

The cost of the ViaSat system can be seen below in the following table.

Item	Cost
5.4m X-band Autotracking Antenna System	$1 077 000
Shipping and Installation Rankin Inlet	$115 240
Additional Options	$120 356
Essential On-Site Spares	$85 875
Baseband Equipment	$200 000
Radome	$158 900
Site Acquisition Preparation	$150 000
Power Grid Layout	$150 000
Remote Access Site and Equipment (3 years)	$200 000
Labor and Maintenance from Remote Access Site (3 years)	$825 000
Frequency Fee (3 years)	$3 900
Total for 3 years	$3 086 271

Table 6: Cost of Ground System

The antenna system itself runs a cost of just over $1 000 000 Cdn. Included in this is the antenna and pedestal, tracking and control sub-system, as well as the receive sub-system. Shipping and installation is approximately $115,000 Cdn. Shipping is estimated based on Rankine Inlet and its available road access. Transportation issues related with the site selection are covered in FDR-2005-3.2.1.

The options supported was a BER test subsystem, as well as a gain to noise test. These testing units were chosen for flexibility and to ensure that if additional customers are found, a reliable system is able to be provided. In order to offer a service to other satellite operators, a highly dependable system would be needed that could protect against possible downtime, thus testing equipment would be needed to ensure this could happen.

Essential on-site spares such as an additional DC motor and power supply are needed for reliability and to decrease downtime. While the system is known to be highly reliable, to avoid any long periods of inactivity due to failure, these spares are essential. In Appendix C a full cost breakdown of every part is given. Baseband equipment refers to the transmission of the signal once received to the operating station located in Ottawa. FDR-2005-3.5.1 does not cover the costs for baseband equipment so an estimate was made in this report to encompass any equipment that would be needed.

Site acquisition and power layout are the costs related to the purchase of a small piece of land and the set up and power transmission to it. FDR-2005-3.2.1 provides the power breakdown in terms of site location. Based off of this information, estimates were made.

7.2.1 Mission Control Center

A centralized location was chosen in Ottawa to both act as a base for future operations and also to monitor and control the AEGIS mission. An office space of 2000 square feet in downtown Ottawa with heat, hydro, and water included was found to be a viable candidate for this center. As the transmission cost was assumed in the baseband costs, an additional sum of money was accounted for in order to take into account the purchase of equipment for communication and the integration of client needs. A team of people was placed together to operate and maintain the system, while looking for any expansion opportunities that could arise due to the extra access time that is available per day. Labor estimates were based on a cost of $ 275 000 Cdn per year for three years. This estimate was based on the hiring of one engineering manager to oversee communications and technical controls, a secretary to complete necessary paper work and act as a receptionist, a sales associate to outsource out station to other satellite operators, and an electronics engineering technologist to aid in the maintenance of the existing communication structures [4]. Also the cost of accounting, property and work insurance,taxes, and general travel expenditures of 50 thousand dollars per year are included in that estimate.

The frequency fee is the cost of purchasing a frequency license from Industry Canada. As stated before, due to the apparent lack of X Band transmissions in our designated area, the acquisition of one of these licenses should not be a problem. An approximate cost of 1300 dollars per year is expected, and more frequencies could be added at a later time.

7.3 Cost of Utilizing CCRS Stations

Item	Cost
Reception and Archiving Fee per pass	$250
Acquisiting Scheduling Fee	$50
60 Seconds on Access (Minimum Time) - 14 Days Notice	$166
Extra 15 Seconds After Initial 60	$34

Table 7: Cost of CCRS

The costs of using CCRS is shown above. Due to the price structure, maximizing the performance of AEGIS in terms of pictures also means that the costs would become much higher. Those prices are per pass, and it is appropriate that in ideal conditions there would be a minimum of three passes in which pictures could be taken. The way the cost structure is set, whether one picture is taken per pass or two, the costs stay roughly equal because the major cost is in acquiring the signal, not in the download. Below a cost per day for both 5 pictures and 6 pictures are given. If we assume that at least one picture per pass would be used, the cost variance between three and five pictures would be very minimal. Instead the major cost versus performance issue would only arise if two stations would have to be used, such as depicted in Figure 8. The costs for the total mission life is also shown.

Performance	Cost
Cost of 5 Pictures per day (1 station)	$1 670
Cost of 6 Pictures per day (2 stations)	$2 086

Table 8: Cost per day of CCRS

Performance	Cost
Total Cost for 3 years - 5 Pictures per Day	$1 828 650
Total Cost for 3 years - 6 Pictures per Day	$2 284 170

Table 9: Cost comparison for 3 year mission life using CCRS

7.4 Risk Analysis

In looking at the above costs associated with each solution, the ability to use an independent station as a viable alternative exists. One can see that tax, more specifically GST, is not calculated on the price of the system or that of using CCRS. This is due mainly to the unknown tax planning benefits derived from paying GST and thus the true cost cannot be calculated. Although there is a 7 percent GST rate, the costs of receiving back GST paid out, as well as the losses shown on the system can be used to reduce any income received which would reduce the overall tax burden carried. While GST is definitely not a benefit, to account it fully as a outflow of income did not seem justified and so for both CCRS and the AEGIS ground station, pre-GST prices were used. As well, the relative closeness in terms of overall pricing makes the exclusion of GST a reasonable decision as both would be increased by the same value approximately.

Income tax rates of 30 percent and an organizational minimum rate of return of 10 percent were used to perform a pricing analysis on the AEGIS ground system. This is based on a typical project funded by a corporation expecting a return. In terms of AEGIS with the forestry industry providing funding, this is a reasonable assumption as they do have to estimate costs based on the returns one would expect on investments.

		t=	0.3		d= 0.3		
	AEGIS Ground Station	MARR=	0.1		n= 8		
	Year	0	1	2	3	4	5
	Income Statement						
	Revenue		$0.00	$0.00	$0.00	$0.00	$0.00
	O&M Cost		$306,300.00	$306,300.00	$306,300.00	$306,300.00	$306,300.00
	CCA		$325,105.65	$552,679.61	$386,875.72	$270,813.01	$189,569.10
	Taxable Income		-$631,405.65	-$858,979.61	-$693,175.72	-$577,113.01	-$495,869.10
	Income Tax		$189,421.70	$257,693.88	$207,952.72	$173,133.90	$148,760.73
	Net Income		-$441,983.96	-$601,285.72	-$485,223.01	-$403,979.10	-$347,108.37
	Cash Flow Statement						
	Cash from operations:						
	Net Income		-$441,983.96	-$601,285.72	-$485,223.01	-$403,979.10	-$347,108.37
	CCA		$325,105.65	$552,679.61	$386,875.72	$270,813.01	$189,569.10
	Investment	$2,167,371.00					
	Salvage						$433,474.20
	Disposal Tax Effect						2656
	Working Capital						
	Net Cash Flow	-$2,167,371.00	-$116,878.31	-$48,606.12	-$98,347.28	-$133,166.10	$278,591.04
	Undepreciated Capital Cost	$2,167,371.00	$1,842,265.35	$1,289,585.75	$902,710.02	$631,897.02	$442,327.91
5 Year Life	**PW**	**-$2,305,656.74**					
	AE	**-$432,080.07**					
4 Year Life	**PW**	**-$2,478,633.92**					
	AE	**-$464,496.00**					
3 Year Life	**PW**	**-$2,387,681.48**					
	AE	**-$447,451.51**					

Table 10: Economic Analysis of ViaSat Facility

Due to the cost of purchasing the ground station, the initial cost is large. This places a high capital investment on the project. Although the cost is justified, one must be sure about the capabilities of AEGIS and the abilities to maximize the potential use of its imagery systems. Using CCRS as an example, the pay as you go type system would be a adequate fit if there was uncertainty regarding mission life or capabilities. Currently, with a three year mission life owning and operating an independent station is the best solution in terms of both cost and performance.

The pricing of an independent station is better due to the potential for using the system to download excess data from other remote sensing satellites. The system was specified to be flexible and to have the capabilities to track and receive data from all current remote sensing satellites. The potential market is there, due to the beneficial situation of having AEGIS as a client. This is especially true if CCRS stops its services in the coming years, with an anchor client in AEGIS that only uses 20 minutes per day, it is very feasible to operate a northern station. If an industry need can be proven, our northern location would enable us a wide access range in which to promote the AEGIS ground station's use for all other remote sensing satellites. The fact is that we could offer a reduced cost, essentially undercutting competitors simply due to the fact that we have a featured client in AEGIS. The possibilities of operating with a profit from the ground station in the future is there, and through a market analysis this could be planned.

8 Imagery Analysis

As previously discussed, much of the feasibility of the ground segment of AEGIS has to do with the performance of the satellite itself. One major problem that is there is cloud cover and the use of images that are covered in clouds is undefined. Currently there is no pre-processing unit designed to be on the spacecraft so images of total cloud cover could occur. This is the reason that an independent station is currently the best option. If there was a method to sort and file only the images that are deemed usable before download, then a much more efficient ground segment could be designed.

A program to analyze images was created to determine the amount of cloud cover and use of the image. Screen shots of the program and the methodology behind it is shown and described below. While it is in it's first iteration, if improved and implemented for next year as an integral part of the spacecraft, wasted downloads would not be an issue and the system would be much more effective. A more effective analysis could take place if proper cloud cover data was read, analyzed and targeted to determine if the payload is appropriate for the weather.

While some issues have come up with determining the difference between a snow background and clouds, as a first year program this is still being developed. By modifying the threshold values some differences could be seen, but much more work has to be done. In the mean time most of the Canadian forestry images are useful in the summer time so snow cover is not as big as an issue as cloud cover, but nevertheless can be improved upon. This methodology is explained in the next sections.

8.1 Objective

To improve the performance of the data collection and reduce the overhead in storing non-useful data, a cloud filtering subsystem was prototyped using Matlab. The system simply analyses the incoming images captured from the satellite data. Images with a large number of 'white' pixels are classified as being cloud obscured, and can be discarded or stored for transmission during non-critical periods if extra storage space existed.

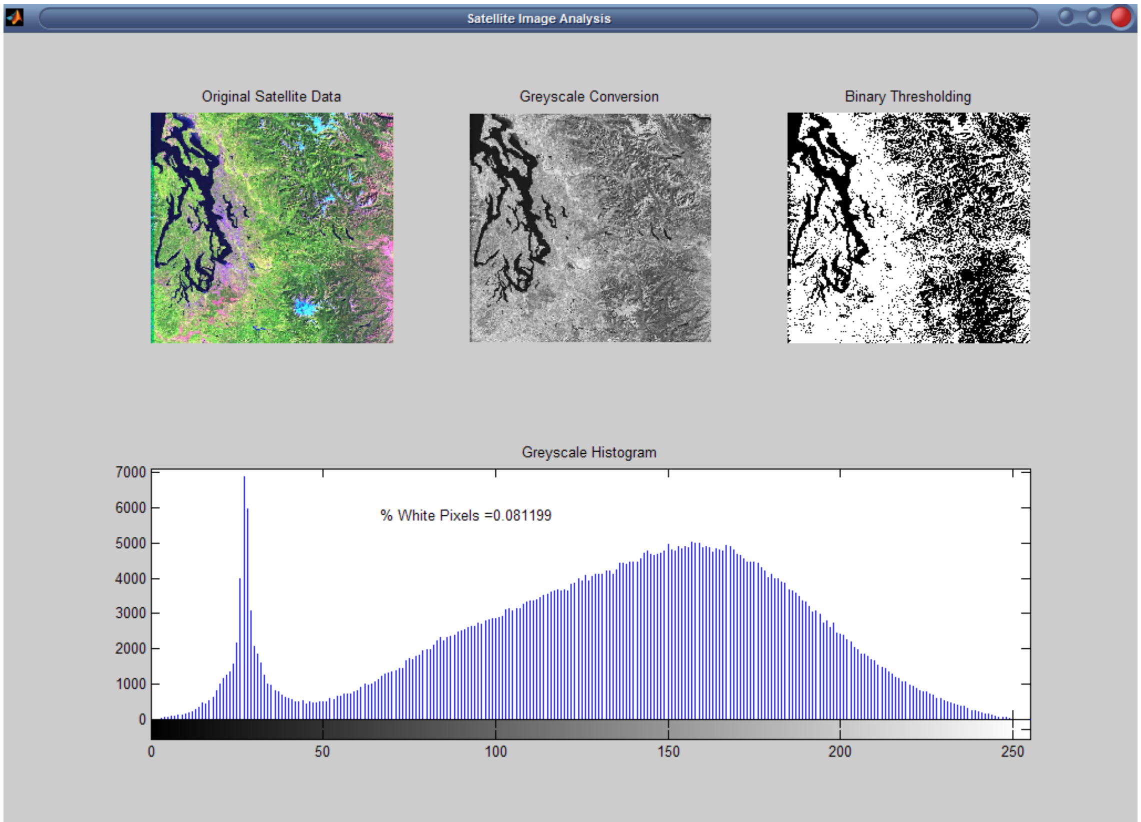

Figure 9: Clear Day Sample of Cloud Filter Program

8.2 Method

The Matlab suite was used to implement the basic image processing for the system. As the image processing toolkit provided by Matlab is very robust and provides a number of key image processing algorithms, the cost in terms of development and verification were significantly reduced. In addition, with the use of Matlab Real-Time compiler tools, the resulting system could be further refined to create an embedded processing system that could act in a stand alone fashion.

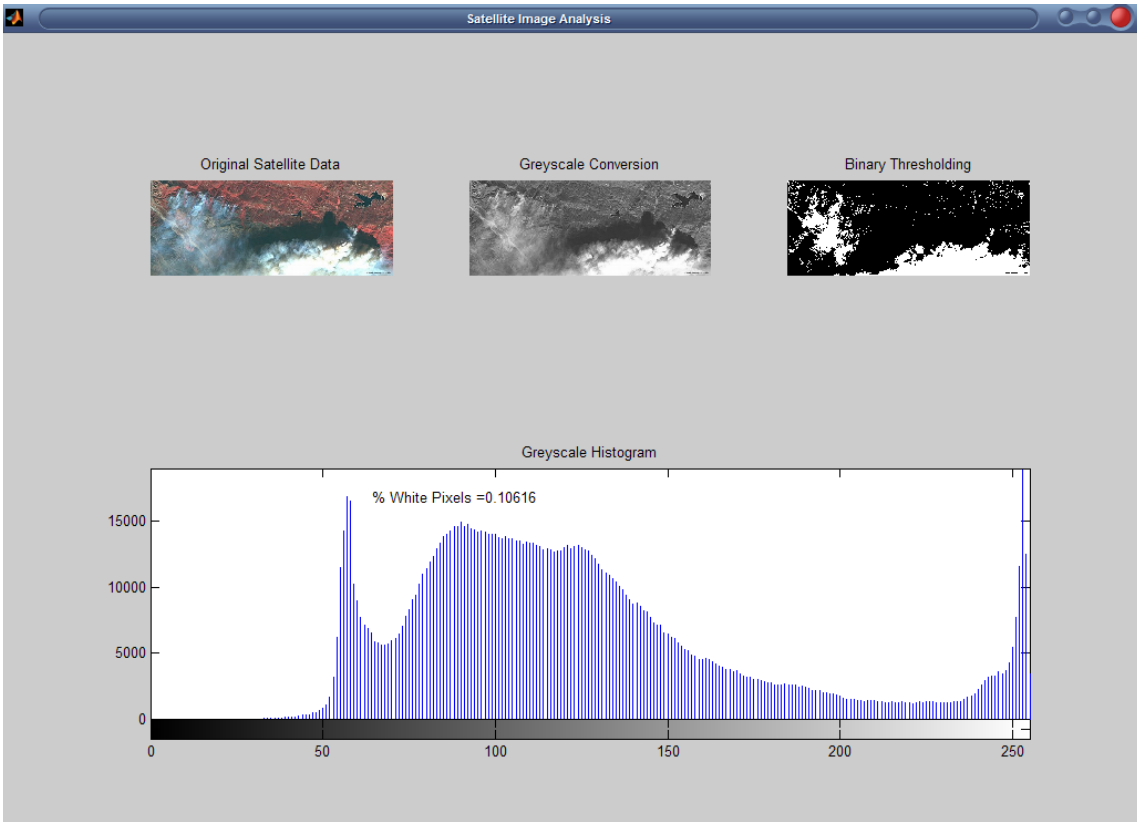

Figure 10: Cloudy Day Sample of Cloud Filter Program

8.3 Algorithm

The image is first read into Matlab, converting the base image format into a 2D array of 8 bit integers. The RGB image matrix is then converted to the greyscale color space, with 256 shades of grey. A histogram of the image is then computed, which yields the frequencies of all the pixels in the image. Finally, the number of white pixels, as determined by a given threshold is compared to the total number of pixels in the image. If this percentage crosses a given tolerance threshold, the image is concluded to be heavily dominated by cloud data and may be treated differently than the rest of the set.

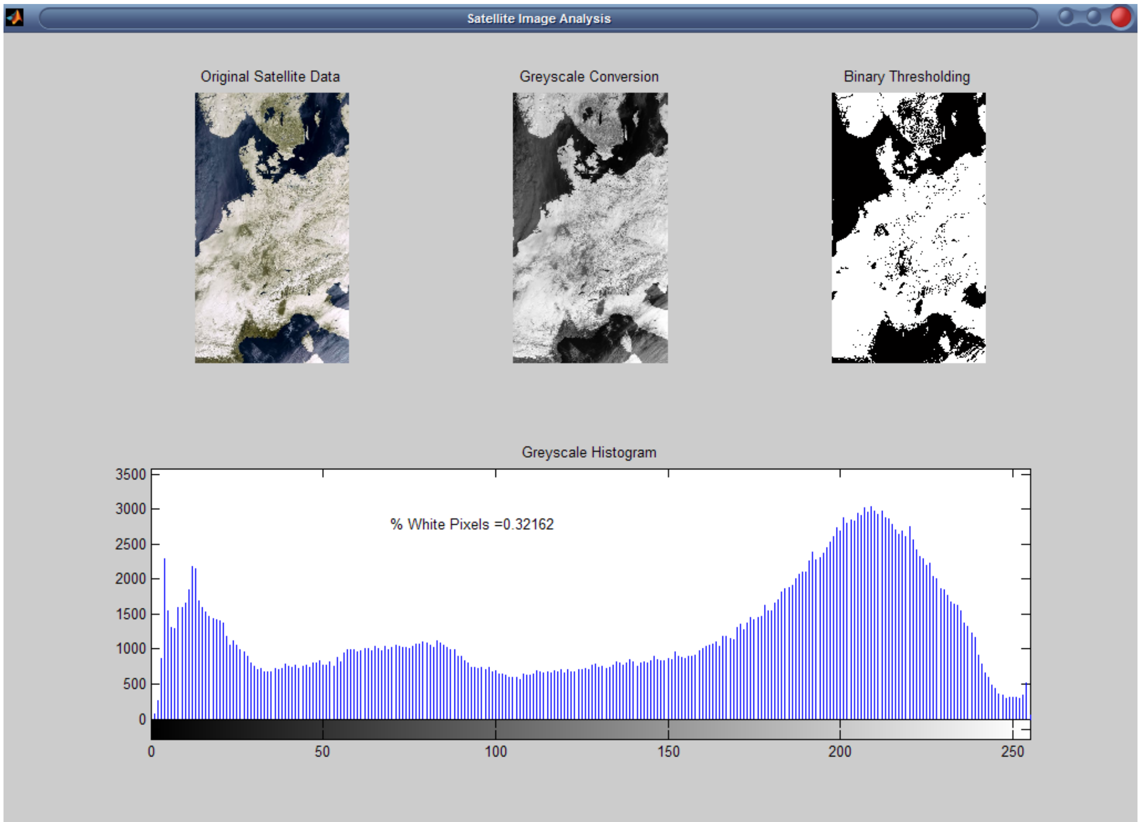

Figure 11: Snow Covered Land Mass Sample of Cloud Filter Program

8.4 Interface

The interface to this classification program takes two forms. The first is an user interface which simply displays the original, greyscale, and threshold image for side by side comparison. A histogram of the greyscale image is also provided for visualization of the various image frequencies.

The second interface provided is an automated script that batch analysis an entire directory of images.This means that the directory of images could be sorted before being sent. A list of images is generated dynamically, and then passed through the classification functions. Images that are detected as being 'cloudy' are copied to another target directory for further processing and analysis. The output could also be modified to simply output the list of files, rather than duplicate any files.

The actual images that were used to test the system can be seen in Appendix E.

9 Recommendations

- Identify firm project requirements and goals before separating team as a whole.
- Classify ground station team as part of satellite team to avoid detachment from requirements and on-going work
- Enhance the method of classification for cloudy images in the hopes of utilizing it as an a pre-processing on board tool with the satellite
- Snow cover versus cloud cover must be further analyzed to develop difference models so that snowy images are not wrongly sorted when processed.
- The method of examining cloud cover could be taken one step further through the removal of the cloudy images and reconstruction over multiple periods to maximize potential of every picture
- A marketing analysis should be completed to prove a market is available for an additional ground station service

10 Conclusions

The ViaSat 5.4 meter ground station provides AEGIS with the best option of downloading data. With a current set of requirements of 6 pictures per day on average, the costs involved can be deemed feasible. A cloud cover analyzing method has been developed, however much work has to still be completed in order to ensure the best efficiency of the system. Overall the requirements of the ground segment have been met with room for flexibility to accommodate for any or allof the other remote sensing satellites.

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A 21 Day simulation for Determination of Maximum Angular Rates with 70 - 90 degrees cut-offs, 5 second intervals)

Time (UTCG)	FromAngularRate (deg/sec)	FromAzimuthRate (deg/sec)	FromElevationRate (deg/sec)	RangeRate (km/sec)
04/06/2006 8:16	0.662255	1.741796	0.28936	-1.100937
04/06/2006 8:16	0.670665	1.980917	0.202373	-0.724105
04/06/2006 8:16	0.675838	2.156644	0.090135	-0.318584
04/06/2006 8:17	0.676985	2.194138	-0.032871	0.08996
04/06/2006 8:17	0.674063	2.078775	-0.151969	0.497667
04/06/2006 8:17	0.667182	1.853431	-0.254263	0.900715
04/06/2006 8:17	0.663246	1.744264	-0.28982	1.064678
05/06/2006 8:28	0.636351	0.383546	0.622683	-2.348774
05/06/2006 8:28	0.655003	0.529956	0.636071	-2.013237
05/06/2006 8:28	0.673001	0.8135	0.643756	-1.625039
05/06/2006 8:28	0.687633	1.388354	0.636984	-1.221633
05/06/2006 8:28	0.698367	2.763843	0.593424	-0.806268
05/06/2006 8:29	0.704786	6.44598	0.421606	-0.382747
05/06/2006 8:29	0.706632	9.904737	-0.089161	0.044727
05/06/2006 8:29	0.70383	5.013225	-0.497597	0.47175
05/06/2006 8:29	0.696494	2.220726	-0.613547	0.893944
05/06/2006 8:29	0.684918	1.172944	-0.642364	1.307173
05/06/2006 8:29	0.669544	0.711841	-0.644009	1.707734
05/06/2006 8:29	0.650926	0.475029	-0.63397	2.092508
05/06/2006 8:29	0.638378	0.38485	-0.624661	2.316011
06/06/2006 8:40	0.643134	-0.954791	0.554064	-2.091789
06/06/2006 8:40	0.660104	-1.274992	0.537825	-1.739515
06/06/2006 8:40	0.675436	-1.787387	0.495673	-1.344027
06/06/2006 8:40	0.687137	-2.526229	0.411139	-0.935819
06/06/2006 8:40	0.694771	-3.410354	0.261902	-0.518429
06/06/2006 8:41	0.698039	-3.976429	0.044362	-0.095829
06/06/2006 8:41	0.696811	-3.695929	-0.188047	0.327751
06/06/2006 8:41	0.691137	-2.852993	-0.365009	0.748034
06/06/2006 8:41	0.68124	-2.034972	-0.471404	1.160907
06/06/2006 8:41	0.667499	-1.442086	-0.527167	1.562614
06/06/2006 8:41	0.65041	-1.045085	-0.55219	1.949912
06/06/2006 8:41	0.644924	-0.957382	-0.55562	2.058825
06/06/2006 18:08	0.660011	-1.641858	0.346827	-1.279014
06/06/2006 18:08	0.670509	-1.945594	0.263744	-0.881542

06/06/2006 18:08	0.677263	-2.203034	0.154081	-0.473708
06/06/2006 18:08	0.679955	-2.328556	0.025519	-0.061361
06/06/2006 18:08	0.678483	-2.269847	-0.106394	0.351569
06/06/2006 18:08	0.672902	-2.052334	-0.224408	0.761123
06/06/2006 18:08	0.663423	-1.755747	-0.317833	1.163503
06/06/2006 18:08	0.658874	-1.639039	-0.346209	1.313544
07/06/2006 18:20	0.637863	-0.31196	0.628878	-2.331966
07/06/2006 18:20	0.657441	-0.444283	0.644543	-1.974967
07/06/2006 18:20	0.675148	-0.693926	0.654806	-1.584181
07/06/2006 18:20	0.689414	-1.216868	0.653211	-1.178472
07/06/2006 18:20	0.699713	-2.561433	0.620895	-0.761171
07/06/2006 18:20	0.705645	-6.887701	0.463986	-0.336151
07/06/2006 18:20	0.706969	-11.749599	-0.128655	0.092332
07/06/2006 18:20	0.70363	-4.76394	-0.547911	0.519847
07/06/2006 18:20	0.695765	-1.922799	-0.637523	0.942011
07/06/2006 18:20	0.683689	-0.983427	-0.654604	1.354712
07/06/2006 18:21	0.667861	-0.587451	-0.650698	1.754295
07/06/2006 18:21	0.648847	-0.387722	-0.63762	2.1377
07/06/2006 18:21	0.635834	-0.310998	-0.626874	2.364514
08/06/2006 18:32	0.646565	1.039703	0.540006	-1.999446
08/06/2006 18:32	0.66284	1.373956	0.517683	-1.643877
08/06/2006 18:32	0.67724	1.887601	0.466946	-1.247359
08/06/2006 18:32	0.687939	2.581421	0.372729	-0.839037
08/06/2006 18:32	0.694535	3.323883	0.218405	-0.422515
08/06/2006 18:32	0.696772	3.699569	0.0103	-0.001787
08/06/2006 18:32	0.694561	3.380963	-0.200656	0.418946
08/06/2006 18:32	0.687989	2.650863	-0.360538	0.835483
08/06/2006 18:32	0.677313	1.943347	-0.459363	1.243829
08/06/2006 18:33	0.662933	1.413215	-0.513036	1.640376
08/06/2006 18:33	0.645357	1.04596	-0.538081	2.022048
08/06/2006 18:33	0.644772	1.036729	-0.538529	2.033517
12/06/2006 8:17	0.661358	1.712586	0.307162	-1.167535
12/06/2006 8:17	0.669989	1.955439	0.227903	-0.8114
12/06/2006 8:17	0.67603	2.16299	0.117777	-0.406421

12/06/2006 8:17	0.678057	2.237002	-0.006447	0.002413
12/06/2006 8:17	0.675993	2.148138	-0.129961	0.411239
12/06/2006 8:17	0.669917	1.931306	-0.238299	0.816194
12/06/2006 8:17	0.66241	1.715208	-0.307663	1.131336
13/06/2006 8:28	0.636164	0.354864	0.62448	-2.355348
13/06/2006 8:28	0.65498	0.491892	0.638756	-2.017843
13/06/2006 8:29	0.673026	0.757354	0.647921	-1.629693
13/06/2006 8:29	0.68771	1.301509	0.644028	-1.22629
13/06/2006 8:29	0.698497	2.639	0.606777	-0.81088
13/06/2006 8:29	0.704969	6.508356	0.446212	-0.387264
13/06/2006 8:29	0.706865	10.713392	-0.089682	0.040354
13/06/2006 8:29	0.704107	5.044815	-0.514898	0.467567
13/06/2006 8:29	0.696809	2.137316	-0.623527	0.889988
13/06/2006 8:29	0.685262	1.10956	-0.648185	1.303475
13/06/2006 8:29	0.669909	0.66813	-0.647798	1.704318
13/06/2006 8:29	0.651304	0.444048	-0.636665	2.089386
13/06/2006 8:29	0.638188	0.356035	-0.626462	2.322755
14/06/2006 8:40	0.643625	-0.983079	0.548826	-2.072135
14/06/2006 8:40	0.659501	-1.285318	0.53215	-1.740695
14/06/2006 8:41	0.67482	-1.788175	0.488813	-1.345567
14/06/2006 8:41	0.686518	-2.500641	0.403675	-0.937726
14/06/2006 8:41	0.69416	-3.335258	0.256227	-0.520702
14/06/2006 8:41	0.697448	-3.862536	0.044497	-0.098454
14/06/2006 8:41	0.696252	-3.609318	-0.181457	0.324799
14/06/2006 8:41	0.690619	-2.82214	-0.356031	0.744791
14/06/2006 8:41	0.680772	-2.037349	-0.463186	1.157415
14/06/2006 8:41	0.667086	-1.456228	-0.520545	1.558921
14/06/2006 8:41	0.650054	-1.061352	-0.547028	1.946068
14/06/2006 8:41	0.645398	-0.985713	-0.550353	2.039137
14/06/2006 18:08	0.659259	-1.614209	0.360301	-1.329391
14/06/2006 18:08	0.669487	-1.904076	0.287576	-0.96523
14/06/2006 18:08	0.677074	-2.189635	0.181659	-0.558294
14/06/2006 18:08	0.680623	-2.356206	0.053686	-0.146041
14/06/2006 18:09	0.680001	-2.334766	-0.081595	0.267612
14/06/2006 18:09	0.67523	-2.134966	-0.205676	0.678682

14/06/2006 18:09	0.666492	-1.835912	-0.305652	1.083308
14/06/2006 18:09	0.658081	-1.611389	-0.359623	1.363767
15/06/2006 18:20	0.63772	-0.283756	0.630293	-2.337219
15/06/2006 18:20	0.657437	-0.405488	0.646741	-1.978515
15/06/2006 18:20	0.675182	-0.635263	0.658271	-1.587797
15/06/2006 18:20	0.689488	-1.121188	0.659247	-1.182122
15/06/2006 18:20	0.69983	-2.401692	0.633132	-0.764817
15/06/2006 18:20	0.705803	-6.877724	0.490925	-0.339754
15/06/2006 18:20	0.707166	-12.861653	-0.134457	0.088811
15/06/2006 18:21	0.703863	-4.692506	-0.566131	0.516443
15/06/2006 18:21	0.69603	-1.811455	-0.646375	0.938756
15/06/2006 18:21	0.683977	-0.912357	-0.65949	1.351633
15/06/2006 18:21	0.668167	-0.541239	-0.653802	1.75141
15/06/2006 18:21	0.649165	-0.355856	-0.639801	2.135022
15/06/2006 18:21	0.635685	-0.282881	-0.628279	2.369775
16/06/2006 18:32	0.647083	1.068256	0.534064	-1.977349
16/06/2006 18:32	0.662109	1.378141	0.511964	-1.647065
16/06/2006 18:32	0.676512	1.87881	0.460471	-1.251048
16/06/2006 18:32	0.687229	2.544192	0.366477	-0.843218
16/06/2006 18:32	0.693858	3.244615	0.21493	-0.427165
16/06/2006 18:32	0.696142	3.599463	0.012613	-0.006869
16/06/2006 18:33	0.69399	3.311878	-0.193072	0.413484
16/06/2006 18:33	0.687488	2.627812	-0.351327	0.829702
16/06/2006 18:33	0.676889	1.947349	-0.451053	1.237798
16/06/2006 18:33	0.662589	1.427171	-0.506305	1.634167
16/06/2006 18:33	0.645309	1.065275	-0.532618	2.011446
20/06/2006 8:17	0.660497	1.684033	0.323353	-1.228109
20/06/2006 8:17	0.669094	1.922499	0.252889	-0.898417
20/06/2006 8:17	0.675998	2.160266	0.14564	-0.494177
20/06/2006 8:17	0.678908	2.272722	0.021029	-0.085254
20/06/2006 8:17	0.677712	2.215026	-0.106403	0.324495
20/06/2006 8:17	0.672457	2.010946	-0.220769	0.731178
20/06/2006 8:17	0.663338	1.731873	-0.312072	1.131044
20/06/2006 8:17	0.661605	1.686785	-0.323896	1.19198
21/06/2006 8:29	0.63599	0.326848	0.626089	-2.361356
21/06/2006 8:29	0.654944	0.454254	0.641171	-2.022254
21/06/2006 8:29	0.673037	0.701245	0.651693	-1.634158
21/06/2006 8:29	0.687771	1.212594	0.650481	-1.230766
21/06/2006 8:29	0.698609	2.501088	0.619346	-0.815319
21/06/2006 8:29	0.705131	6.525985	0.471399	-0.39162
21/06/2006 8:29	0.707074	11.640026	-0.090338	0.036128
21/06/2006 8:29	0.70436	5.047537	-0.532565	0.463515
21/06/2006 8:29	0.697099	2.043463	-0.633049	0.886148
21/06/2006 8:29	0.685581	1.043367	-0.653604	1.299878
21/06/2006 8:29	0.67025	0.623678	-0.651288	1.700985
21/06/2006 8:30	0.651657	0.41295	-0.639139	2.086331
21/06/2006 8:30	0.638016	0.32793	-0.628081	2.328812

B Sample of Frequency Search performed 60 -70 degree latitude, 90 - 105 degree longitude parameters

Frequency Search - 8025-8400 MHz

Longitude 90 - 105 and Latitude 55-70 Highlighted

Tx Frequency (MHz)	Rx Frequency (MHz)	Latitude (ddmmss, NAD27 format)	Longitude (dddmmss, NAD27 format)	Station Location	Licensee Name	Frequency Authorization Date
	8303.125000	491606	1230627	VANCOUVER BC CKUV STUDIO	CHUM LIMITED CIVI-TV DIVISION ATTN: MR. ED YIU	25/09/2001
	8321.875000	492912	1234924	SECHELT BC	CANADIAN BROADCASTING COR PORATION ATTN: REGIONAL EN GINEER	16/06/1988
	8396.875000	491652	1230735	VANCOUVER B.C.(CENTURY PLAZ A HOTEL)	CHUM TELEVISION VANCOUVER INC MICROWAVE	17/05/1989
	8293.750000	485521	1253225	AMPHITRITE POINT BC	DEPT OF FISHERIES & OCEANS CANADIAN COAST GUARD (PACI FIC REG)	17/11/1981
	8340.625000	491606	1230627	VANCOUVER B.C. (CKVU-TV STUDIOS)	CHUM TELEVISION VANCOUVER INC MICROWAVE	17/05/1989
	8303.125000	482530	1232008	VICTORIA BC 1035 BELMONT AVE NUE	CIVI-TV A DIVISION OF CHUM LIMIT ED	15/07/2002
	8359.375000	493028	1150402	FERNIE BC	MONARCH BROADBAND WEST L TD.	04/01/1993
	8303.125000	493934	1193418	CHUTE LAKE BC (CHBC-TV-1 TX SITE)	CHBC SUB INC	04/04/1994
	8378.125000	490815	1194010	MT KOBAU BC	BCTV, A DIVISION OF GTNI	08/06/1982
	8303.125000	491619	965119	ST. MALO, MANITOBA	MTS Communications Inc. Netw ork Planning Manager	05/02/1993
	8359.375000	495220	970904	WINNIPEG, MAN.-FORT ROUGE OFFICE	MTS Communications Inc. Netw ork Planning Manager	27/12/1995
	8340.625000	495220	970904	WINNIPEG, MAN.-FORT ROUGE OFFICE	MTS Communications Inc. Netw ork Planning Manager	27/12/1995

	8303.125000	495220	970904	WINNIPEG, MAN.- FORT ROUGE OFFICE	MTS Communications Inc. Network Planning Manager	27/12/1995
	8321.875000	552920	1184450	BRAEBURN, ALBERTA (CBC SITE)	TELUS COMMUNICATIONS (AB) Tower Site Management (MW)	04/04/1999
	8284.375000	534440	1125315	LAMONT, ALBERTA	CTV TELEVISION INC. CFRN TV (MW)	02/01/1992
	8284.375000	543113	1124829	BOYLE, ALBERTA (SE-9-64-19-W4)	CTV TELEVISION INC. CFRN TV (MW)	30/06/1999
	8284.375000	552818	1144705	SLAVE LAKE, AB	CANADIAN BROADCASTING CORPORATION (MW)	18/04/1989
	8396.875000	503207	1021623	STOCKHOLM SASK	CTV INC. C/O CFTO - TV LIMITED	07/11/1989
	8321.875000	514900	1045012	ESK, SK	CTV INC. C/O CFTO - TV LIMITED	02/09/1998
	8321.875000	515919	1055720	COLONSAY, SK	CTV INC. C/O CFTO - TV LIMITED	02/09/1998
	8284.375000	501507	955723	LAC DU BONNET, MANITOBA	MTS Communications Inc. Network Planning Manager	29/08/2001
	8303.125000	501705	1000652	BASSWOOD, MANITOBA-CKND TX SITE	MTS Communications Inc. Network Planning Manager	22/12/1988
	8378.125000	490706	960121	PINEY, MANITOBA	MTS Communications Inc. Network Planning Manager	05/02/1993
	8359.375000	491619	965119	ST. MALO, MANITOBA	MTS Communications Inc. Network Planning Manager	05/02/1993
	8340.625000	491619	965119	ST. MALO, MANITOBA	MTS Communications Inc. Network Planning Manager	05/02/1993
	8321.875000	491619	965119	ST. MALO, MANITOBA	MTS Communications Inc. Network Planning Manager	05/02/1993
	8025.000000	531245	1055549	PRINCE ALBERT SASK	NATURAL RESOURCES CANADA PRINCE ALBERT SATELLITE STATION	24/04/1995
	8284.375000	530102	1034333	ZENON PARK SASK	CANADIAN BROADCASTING CORPORATION ATTN: TRANSMITTERS	20/09/1983
	8294.030000	520300	1020318	NORQUAY SASKATCHEWAN	CANADIAN BROADCASTING CORPORATION ATTN: TRANSMITTERS	19/08/1987
	8348.950000	525115	1022926	HUDSON BAY SASKATCHEWAN	CANADIAN BROADCASTING CORPORATION ATTN: TRANSMITTERS	19/08/1987
	8321.875000	495217	1062336	GRAVELBOURG SASK	CANADIAN BROADCASTING CORPORATION ATTN: TRANSMITTERS	29/08/1983

	8284.375000	495217	1062336	GRAVELBOURG SASK	CANADIAN BROADCASTING CORPORATION ATTN: TRANSMITTERS	29/08/1983
	8340.625000	530054	1050410	WELDON, SASKATCHEWAN	CANADIAN BROADCASTING CORPORATION ATTN: TRANSMITTERS	29/10/1986
	8340.625000	523826	1061010	ROSTHERN, SASKATCHEWAN	CANADIAN BROADCASTING CORPORATION ATTN: TRANSMITTERS	29/10/1986
	8396.875000	525022	1041906	STAR CITY SASKATCHEWAN	CTV INC. C/O CFTO - TV LIMITED	16/02/1994
	8303.125000	532007	1040854	NIPAWIN SASKATCHEWAN	CTV INC. C/O CFTO - TV LIMITED	16/02/1994
	8321.875000	503843	1054606	MARQUIS SASKATCHEWAN	CTV INC. C/O CFTO - TV LIMITED	12/01/1995
	8294.030000	525115	1022926	HUDSON BAY SASK	CTV INC. C/O CFTO - TV LIMITED	10/01/1984
	8396.875000	531439	1042634	GRONLID SASKATCHEWAN	CTV INC. C/O CFTO - TV LIMITED	16/02/1994
	8303.125000	530054	1050410	WELDON SASKATCHEWAN	CTV INC. C/O CFTO - TV LIMITED	16/02/1994
	8321.875000	505425	1022816	WALDRON SASK	CTV INC. C/O CFTO - TV LIMITED	07/11/1989
	8284.375000	500800	1021650	LANGBANK SASK	CTV INC. C/O CFTO - TV LIMITED	16/03/1984
	8340.625000	495003	1130930	NOBLEFORD AB	CRAIG MEDIA INC. (MW)	07/10/1998
	8321.875000	494647	1125214	LETHBRIDGE, ALBERTA-CISA TOWER	THE MIRACLE CHANNEL ASSOCIATION CJIL-TV (MW)	15/09/2001
	8284.375000	634416	683326	FROBISHER NWT TELESAT CANADA SITE	ABORIGINAL PEOPLES TELEVISION NETWORK INC. (APTN)	23/12/1991
	8303.125000	543105	1282815	COPPER MTN (CFTK-TV)	TELUS COMMUNICATIONS (BC) SHARON LEIGH	30/11/1999
	8378.125000	490530	1174910	RED MTN BC	BCTV, A DIVISION OF GTNI	17/11/1981
	8303.125000	501658	1191909	VERNON BC (CHBC-TV-2 TX SITE)	CHBC SUB INC	04/04/1994
	8303.125000	493028	1150402	FERNIE BC	MONARCH BROADBAND WEST LTD.	04/01/1993
7730.000000	8030.000000	500105	1251450	CAMPBELL RIVER BC 600 DOGWOOD ST N	TELE-MOBILE COMPANY Attn: Deanna Spring	14/01/2002
7730.000000	8030.000000	521907	1112603	BROWNFIELD, AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	01/02/2004

7730.000000	8030.000000	520339	1103436	NEUTRAL HILLS, AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	01/02/2004
7730.000000	8030.000000	561244	1194911	BEAR CANYON AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	01/01/2004
7730.000000	8030.000000	494026	1101634	ELKWATER NORTH, AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	01/01/2004
7730.000000	8030.000000	535137	1142011	RICH VALLEY AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	01/11/2003
7730.000000	8030.000000	524225	1151644	ROCKY MNT. HOUSE O'CHIESE RESERVE	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	05/08/2004
7730.000000	8030.000000	580354	1153633	TALL CREE NORTH, AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	01/07/2004
7730.000000	8030.000000	564432	1144909	GOODFISH, AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	14/04/2004
7730.000000	8030.000000	521207	1131446	DELBURNE, AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	02/02/2004
7730.000000	8030.000000	551319	1191422	SASKATOON MOUNTAIN AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	30/09/2003
7730.000000	8030.000000	551319	1191422	SASKATOON MOUNTAIN AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	30/09/2003
7740.000000	8160.000000	543053	1283453	TERRACE, BC	NAVIGATA COMMUNICATIONS INC.	01/10/1997
7740.000000	8040.000000	533230	1132156	EAST EDMONTON 38S, ALBERTA	ALTALINK (MW) ATTN: CLINTON STRUTH	01/06/2005
7740.000000	8040.000000	533230	1132200	EAST EDMONTON 38S, ALBERTA	ALTALINK (MW) ATTN: CLINTON STRUTH	01/04/2004
7740.000000	8040.000000	505743	1134306	LANGDON, ALBERTA	ALTALINK (MW) ATTN: CLINTON STRUTH	01/10/2004
7740.000000	8040.000000	525436	1145505	ALDER FLATS, ALBERTA	ALTALINK (MW) ATTN: CLINTON STRUTH	01/09/2004
7745.370000	8050.930000	493905	1231232	WATTS POINT BC - TELUS SITE	TELUS COMMUNICATIONS (BC) Sharon Leigh	
7745.370000	8050.930000	493911	1231234	WATTS POINT BC - TELUS SITE	TELUS COMMUNICATIONS (BC) Sharon Leigh	10/02/1993
7745.370000	8050.930000	493905	1231232	WATTS POINT BC - TELUS SITE	TELUS COMMUNICATIONS (BC) Sharon Leigh	
7745.370000	8050.930000	491545	1230920	VANCOUVER (REGENT CO) BC	TELUS COMMUNICATIONS (BC) Sharon Leigh	19/12/1988
7745.370000	8050.930000	493911	1231234	WATTS POINT BC - TELUS SITE	TELUS COMMUNICATIONS (BC) Sharon Leigh	10/02/1993
7745.370000	8050.930000	550109	1123026	AMESBURY, ALBERTA	TELUS COMMUNICATIONS (AB) Tower Site Management (MW)	01/04/1992
7745.370000	8050.930000	550109	1123026	AMESBURY, ALBERTA	TELUS COMMUNICATIONS (AB) Tower Site Management (MW)	01/04/1992
7745.370000	8050.930000	555100	1121020	CROW LAKE, ALBERTA	TELUS COMMUNICATIONS (AB) Tower Site Management (MW)	28/03/1991
7745.370000	8050.930000	555100	1121020	CROW LAKE, ALBERTA	TELUS COMMUNICATIONS (AB) Tower Site Management (MW)	28/03/1991
7745.370000	8050.930000	561939	1113537	GREGOIRE LAKE, ALBERTA	TELUS COMMUNICATIONS (AB) Tower Site Management (MW)	16/10/1986
7745.370000	8050.930000	561939	1113537	GREGOIRE LAKE, ALBERTA	TELUS COMMUNICATIONS (AB) Tower Site Management (MW)	16/10/1986
7745.370000	8050.930000	490418	1170456	SALMO RADIO BC	TELUS COMMUNICATIONS (BC) RADIO ENGINEERING (SHARON LEIGH)	06/05/1991
7745.370000	8050.930000	490525	1183632	PHOENIX BC	TELUS COMMUNICATIONS (BC) RADIO ENGINEERING (SHARON LEIGH)	09/04/1991
7745.370000	8050.930000	490525	1183632	PHOENIX BC	TELUS COMMUNICATIONS (BC) RADIO ENGINEERING (SHARON LEIGH)	09/04/1991
7745.370000	8050.930000	500726	1225734	WHISTLER CO BC	TELUS COMMUNICATIONS (BC) Sharon Leigh	07/09/2004
7745.370000	8050.930000	493136	1235109	SECHELT RADIO BC	TELUS COMMUNICATIONS (BC) Sharon Leigh	01/04/1982

7745.370000	8050.930000	493136	1235109	SECHELT RADIO BC	TELUS COMMUNICATIONS (BC) Sharon Leigh	01/04/1982
7750.000000	8050.000000	551319	1191422	SASKATOON MOUNTAIN AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	30/09/2003
7750.000000	8050.000000	561244	1194911	BEAR CANYON AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	01/01/2004
7750.000000	8050.000000	514612	1102817	NEW BRIGDEN, AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	01/02/2004
7750.000000	8050.000000	520339	1103436	NEUTRAL HILLS, AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	01/02/2004
7750.000000	8050.000000	520333	1124441	BIG VALLEY AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	01/02/2004
7750.000000	8050.000000	535647	1141154	DUNSTABLE, AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	01/11/2003
7750.000000	8050.000000	551319	1191422	SASKATOON MOUNTAIN AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	30/09/2003
7750.000000	8050.000000	580354	1153633	TALL CREE NORTH, AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	24/06/2004
7750.000000	8050.000000	522945	1153149	JACKFISH LAKE	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	05/08/2004
7750.930000	8045.370000	491545	1230920	VANCOUVER (REGENT CO) BC	TELUS COMMUNICATIONS (BC) Sharon Leigh	19/12/1988
7770.000000	8070.000000	491916	1230400	NORTH VANCOUVER 230 E 13 ST LION G.	NAVIGATA COMMUNICATIONS INC	29/09/2000
7770.000000	8070.000000	520339	1103436	NEUTRAL HILLS, AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	01/02/2004
7770.000000	8070.000000	522945	1153149	JACKFISH LAKE	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	05/08/2004
7770.000000	8070.000000	565617	1132900	CHIPEWYAN LAKES, AB	BELL WEST (MW) ATTN: VAUGHAN ARSENAULT	14/04/2004
7786.110000	8091.670000	491545	1230920	VANCOUVER (REGENT CO) BC	TELUS COMMUNICATIONS (BC) Sharon Leigh	11/09/1998
7786.110000	8091.670000	500105	1251450	CAMPBELL RIVER BC 600 DOGWOOD ST N	TELUS COMMUNICATIONS (B.C.) SHARON LEIGH, RADIO ENGINEERING	17/03/1993
7786.110000	8091.670000	554352	1202641	BEAR MOUNTAIN BC	TELE-MOBILE COMPANY Attn: Deanna Spring	05/06/2000
7786.110000	8091.670000	544845	1224611	FIRTH LAKE BC	TELE-MOBILE COMPANY Attn: Deanna Spring	05/06/2000
7786.110000	8091.670000	553854	1220203	BOWLDER BC	TELE-MOBILE COMPANY Attn: Deanna Spring	05/06/2000
7786.110000	8091.670000	581214	1171408	BOYER RIVER, ALBERTA	TELUS COMMUNICATIONS (AB) Tower Site Management (MW)	01/01/1999
7786.110000	8091.670000	535444	1222701	TABOR MOUNTAIN BC	TELE-MOBILE COMPANY Attn: Deanna Spring	05/06/2000

8415.625000	8321.875000	511240	1022723	YORKTON SASK	CTV INC. C/O CFTO - TV LIMITED	22/12/1993
8415.625000	8321.875000	513420	1033220	FOAM LAKE SASK	CTV INC. C/O CFTO - TV LIMITED	01/03/1992
8415.625000	8321.875000	510842	1045439	DUVAL, SK	CTV INC. C/O CFTO - TV LIMITED	20/08/1987
8453.125000	8378.125000	520751	1063949	SASKATOON, SK	CTV INC. C/O CFTO - TV LIMITED	20/08/1987
8471.875000	8378.125000	501455	1135114	NANTON ALTA	GLOBAL TELEVISION NETWORK A (MW) CANWEST COMPANY	29/05/1997
8471.875000	8378.125000	501455	1135114	NANTON, ALBERTA	GLOBAL TELEVISION NETWORK A (MW) CANWEST COMPANY	29/05/1997
8471.875000	8303.125000	531215	1054519	PRINCE ALBERT	CTV INC. C/O CFTO - TV LIMITED	27/03/1990
8471.875000	8303.125000	523826	1061010	ROSTHERN, SK	CTV INC. C/O CFTO - TV LIMITED	20/08/1987
8471.875000	8378.125000	510315	1140008	CALGARY CICT STUDIO AB-222 23 ST NE	GLOBAL COMMUNICATIONS LTD . CALGARY (MW)	29/05/1997
8471.875000	8378.125000	494255	1124756	LETHBRIDGE ALTA	GLOBAL TELEVISION NETWORK A (MW) CANWEST COMPANY	29/05/1997
8490.625000	8321.875000	495733	981635	PORTAGE LA PRAIRIE, MANITOBA	CRAIG MEDIA INC.	01/04/1996
8490.625000	8284.375000	515919	1055720	COLONSAY, SK	CTV INC. C/O CFTO - TV LIMITED	20/08/1987
8490.625000	8284.375000	514900	1045012	ESK, SK	CTV INC. C/O CFTO - TV LIMITED	20/08/1987
8490.625000	8284.375000	502652	1043000	REGINA, SK	CTV INC. C/O CFTO - TV LIMITED	20/08/1987
8490.625000	8284.375000	513420	1033220	FOAM LAKE SASK	CTV INC. C/O CFTO - TV LIMITED	01/03/1992
8490.625000	8284.375000	510842	1045439	DUVAL, SK	CTV INC. C/O CFTO - TV LIMITED	20/08/1987
8490.625000	8284.375000	514900	1045012	ESK, SK	CTV INC. C/O CFTO - TV LIMITED	20/08/1987
8490.625000	8321.875000	495733	981635	PORTAGE LA PRAIRIE, MANITOBA	CRAIG MEDIA INC.	10/09/1997
8490.625000	8378.125000	495344	970821	WINNIPEG, MANITOBA-TD CENTRE BLDG.	CRAIG MEDIA INC.	10/09/1997
8490.625000	8321.875000	495316	992829	CARBERRY MB	CRAIG MEDIA INC.	01/04/1996
8490.625000	8321.875000	495316	992829	CARBERRY MB	CRAIG MEDIA INC.	01/04/1996

C ViaSat System Specifications

ViaSat Satellite Ground Systems
4311 Communications Drive
Norcross, GA 30093 USA

Pricing and List of Deliverables

Ref.	Description of Item	Part / Model No.	Vendor	Qty
1	**5.4m Antenna and Pedestal**			
1.1	**X-Y Pedestal With:**	Model V10	ViaSat	1
	- Dual Speed Resolver Data Package (Qty 2)			
	- Pedestal Wiring For X-Data and Track			
	- Brushless DC Motors			
1.2	**Support Riser With:**		ViaSat	1
	- Dehydrator			
	- Servo Control Unit Including 4 PWM Amplifiers			
	- Power Distribution Unit			
1.3	**5.4-Meter Dual Shaped Reflector With:**		ViaSat	1
	- Solid Subreflector			
	- Monopod Subreflector Support			
1.4	**X-Band Autotracking Feed Assembly Including:**		ViaSat	1
	- 5-Horn Feed			
	- RHC Polarization Network			
	- Test Coupler			
	- MONOSCAN Network			
	- Data and Tracking Channel LNAs			
	- Feed Enclosure			
2	**Tracking and Control Sub-System**			
2.1	**Autotrack Antenna Control Unit**	Series 3880	ViaSat	1
2.2	**Tracking Receiver**	Series 924-16	ViaSat	1
2.3	**Station Control Computer (Or Equivalent) Including:**		Dell	1
	- 20-Inch Color Monitor			1
	- Keyboard and Mouse			
	- Printer			1
	- ViaSat RSGS Operational Control Software			
2.4	**Network Time Server W/ GPS Receiver**	TymeServe 2100	Datum	1
2.5	**Vertical Equipment Racks Including:**		Various	1 lot
	- Rack Slides			
	- Chassis Interconnect Cables			
	- Grounding Studs			
	- Power Distribution Strips			
3	**Receive Sub-System**			
3.1	**X-Band Converter Assembly, Including:**	Model 924-4		
	- Converter Chassis		ViaSat	1
	- Agile Downconverter with Integrated Synthesizers		ViaSat	2
3.2	**50m Range Cables**		ViaSat	1 lot
3.3	**IF Distribution Unit**	Model 924-7B	ViaSat	1
3.4	**QPSK/UQPSK Demodulator**	Model 924-1B	ViaSat	1
3.5	**Bit Syncronizer Chassis Including:**	Model 924-2	ViaSat	1
	- Standard QPSK/UQPSK/BPSK (Up To 150 MB/S)	Model 924-2-TBD	ViaSat	1
3.6	**Control Room Cable Kit**		ViaSat	1 lot

ViaSat Satellite Ground Systems
4311 Communications Drive
Norcross, GA 30093 USA

Pricing and List of Deliverables

4	**Management/Operations**			
4.1	**Systems Integration**		ViaSat	1 lot
4.2	**Program Manager for the Duration of the Program**		ViaSat	1 lot
4.3	**Systems and Quality Engineering**		ViaSat	1 lot
4.4	**Pedestal Foundation Requirements Drawing, Foundation Template and Anchor Studs**		ViaSat	1 lot
4.5	**Operation and Maintenance Manuals**		ViaSat	1 lot
4.6	**Vendor Manuals and/Or Data Sheets as Delivered by Vendor With the Equipment**		Various	1 set
4.7	**Standard Warranty**		ViaSat	1 year
4.8	**Painting, Preparation for Shipping & Crates**		ViaSat	1 lot
5	**Options**			
5.1	**BER Test System**			
	- Test Upconverter	Model 924-4	ViaSat	1
	- Test Modulator	Model 924-6B	ViaSat	1
	- Bit Error Rate Test Set	BERT 400	Reach	1
	- Additional Cabling		ViaSat	1 lot
5.2	**Power Meter for G/T Testing**			
	- Power Meter	EMP441A	Agilent	1
	- Power Sensor	8481B	Agilent	1
5.3	**Second Data Channel Downlink**			
	- QPSK/UQPSK Demodulator	Model 924-1B	ViaSat	1
	- Bit Syncronizer Chassis Including:	Model 924-2	ViaSat	1
	- - Standard QPSK/UQPSK/BPSK (Up To 150 MB/S)	Model 924-2-TBD	ViaSat	1
	- Frequency Agile Downconverter		ViaSat	1
	- Additional Cabling		ViaSat	1 lot

System Performance		
Satellites		
Orbits	LEO > 400 km, GEO	
Inclinations	All	
Coverage	Hemispherical, No Keyholes Above 2.5° Elevation	
Tracking	Autotrack and Program Track	
Data Channels	1, Expandable	
Frequency	8000 to 8500 MHz	
G/T (See Note 1)	31.0 dB/K	
BER (See Note 2)	< 2.5 dB QPSK < 3.0 dB AQPSK	
Accuracy		
Autotracking	0.05° rms (See Note 3)	
Pointing	0.10° rms	
Antenna		
Configuration	5.4-meter Cassegrain	
Polarization	RHC	
3 dB Beamwidth	0.45°, Nominal	
Axial Ratio	1.5 dB Max	1.0 dB Typical
Pedestal		
Configuration	X / Y (cross-elevation over elevation)	
Travel Limits	**X Axis**	**Y Axis**
Electrical	± 90.0°	± 90.0°
Mechanical	± 91.0°	± 91.0°
Safety	Fail-Safe Electromechanical Brakes Interlocks on Pins and Brakes Overall Pedestal Disable	
	X Axis	**Y Axis**
Velocity	5°/s	5°/s
Acceleration	5°/s²	5°/s²

D Cloud Filter Script Files

Cloud Filter Script File

```
function cloudfilter(im)
imgRGB = imread(im);
%imgRGB = imread('test1.jpg');
imgGRAY = rgb2gray(imgRGB);
% Create figure, setting up properties
hfig = figure('Toolbar','none',...
              'Menubar', 'none',...
              'Name','Satellite Image Analysis',...
              'NumberTitle','off',...
              'IntegerHandle','off');

subplot(2,3,1);
imshow(imgRGB);
title( 'Original Satellite Data' );

subplot(2,3,2);
imshow(imgGRAY);
title('Greyscale Conversion');

level = graythresh(imgRGB);
bw = im2bw(imgRGB, level);

subplot(2,3,3);
imshow(bw);
title('Binary Thresholding');

subplot(2,3,4:6);
imhist(imgGRAY);
title('Greyscale Histogram');

N=hist(double(imgGRAY(:)),0:255);
Nhist=[(0:255)',N(:)];
totalCount = 0;
whiteCount = 0;
whiteThreshold = 200;
for i = 1:length(Nhist)
    if(i>200)
        whiteCount = whiteCount + Nhist(i,2);
    end
    totalCount = totalCount + Nhist(i,2);
end

percentWhite = whiteCount / totalCount;
mystring2 = strcat('% White Pixels = ',num2str(percentWhite));
gtext(mystring2);
```

File Script File

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%-%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%-%%%%%%
% define path information
pathdir = 'c:\source_imgs';

% define targetdir for jpg
targdir = 'c:\target_imgs';

% get filenames in dir
dirinfo = dir(pathdir);
filenames = {dirinfo(~[dirinfo.isdir]).nam-e};

% loop over number of different files
for fl = 1:length(filenames)

        % create a figure
        fig = figure;

        % define filenames and paths
        curr_file = [pathdir filenames{fl}];

        % load the files
        img1 = load(curr_file);

        % process the image HERE
        imgRGB = imread(img1);
        imgGRAY = rgb2gray(imgRGB);
        N=hist(double(imgGRAY(:)),0:255);
        Nhist=[(0:255)',N(:)];
        totalCount = 0;
        whiteCount = 0;
        whiteThreshold = 200;
        for i = 1:length(Nhist)
            if(i>200)
                whiteCount = whiteCount + Nhist(i,2);
            end
            totalCount = totalCount + Nhist(i,2);
        end
        percentWhite = whiteCount / totalCount;

        % create jpeg in targetdir, name like current file
        if(percentWhite > 0.60)
            print(fig, '-djpeg', [targdir filenames{fl}]);
        end

        % close figure
        close(fig)


end;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%-%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%-%%%%%%
```

E Cloud Filter Test Images