Transportable Ground Receiving Stations

Direct Access to Earth Observation Data

Over the last thirty years, users of space imagery have grown accustomed to the situation where the image data is purchased from a few centralized suppliers acquired via a relatively small number of ground receiving stations. These stations are normally big facilities with large permanently mounted antennas and a number of fixed buildings housing powerful on-site receiving, processing and archiving facilities. Needless to say, a large financial investment is needed both to build such a facility and to maintain and run it. Typically the cost of constructing and equipping a large fixed ground station facility lies in the range US$ 6 million to US$ 12 million, with some large facilities costing as much as US$ 20 million. Thus, even in the richer and more highly developed industrialized countries, there may only be a single national ground receiving station. As for the poorer, less developed countries - who may often be those who could make best use of space imagery - the constraints imposed by their poor economic and financial situation mean that the great majority of them do not possess such stations. The result is that often the image data only reaches users in these countries several weeks or months later at the end of a long and rather expensive supply chain. In which case, its value may well have been diminished or lost. In many countries, lack of direct or rapid access to Earth Observation (EO) data has led to a low uptake and acceptance of this type of data.

By Professor Gordon Petrie

The African Situation

An extreme example of this situation is found in Africa where there is only a single permanent ground receiving station in the whole continent - at Hartebeesthoek, located near Pretoria in South Africa - that can receive high-resolution space imagery, as distinct from low-resolution weather satellite imagery. During the mid-1990s, the on-board data storage recorders of Landsat-5, SPOT-1 and SPOT-2 had all failed and SPOT-3 had broken down and ceased to operate. Thus only direct reception of the image data being produced from these satellites was possible. This meant that, apart from the southern part of Africa that was covered from the Hartebeesthoek station, coverage of the continent was limited to those areas around its periphery that could be obtained from the ESA stations at Maspalomas, Canary Islands and Fucino, Italy and from the Saudi Center for Remote Sensing, all of which are located outside the continent. This meant that substantial parts of western, central and eastern Africa could not be covered by Landsat or SPOT imagery. This presented a serious situation, especially given the problems arising from drought, floods, famine, environmental change, civil war and refugees that have afflicted so much of this huge area and the resulting need to monitor these events.

German Transportable Ground Stations

To remedy this dire situation, in 1994, the German Space Agency (DLR) built a ground station that could be transported to the area and set up quite quickly. This was established near Libreville in Gabon. In fact, although the station was designed to be transportable to other areas where natural disasters occurred, its value has been such that it has remained in Gabon as a permanent station. But even so, although coverage of the surrounding region can be obtained using this station, quite some time may elapse before the image data reaches users in neighbouring countries. Following on from this successful initiative, DLR built two further transportable ground stations that came into operation in 1997. One was based in Córdoba, Argentina for a year. Then, after modification in Germany, it was set up in Bishkek, Kyrgyzstan in Central Asia to collect data both for environmental purposes and for the monitoring of geophysical phenomena associated with the movement of the Central Asian plate. The second station is located in Ulan Bator, Mongolia where it receives SAR data from the ERS-2 satellite. This is being used on an EU project to map parts of Siberia and Central Asia.

The trailer-mounted antenna of the RAPIDS transportable station with its 2.6m diameter dish antenna. The system uses two hydraulically driven rams to provide a smooth precision-controlled tilt movement of the dish during the automatic tracking of satellites such as SPOT and ERS. The trailer can be set up on jacks while operating from a fixed position. (Source - NRI)

Military Requirements & Users

Besides those agencies concerned with environmental and disaster monitoring and natural resource management, another potentially large user community with a need for the direct reception and rapid dissemination of space image data within a local area are military units operating in the field. These require the data to help monitor the location, disposition and movement of enemy or potential enemy troops and supplies. with a view to devising counter measures. In this particular context, there is a need for a ground receiving station that is both air and ground transportable and can be deployed and made operational within a very short time, often in quite remote areas. Needless to say, autonomous operation of such a ground station quite independent of ground facilities is a complete necessity. Furthermore, being able to process, analyze and produce copies of the data received from non-military satellites locally in the field reduces the time needed to place this potentially valuable data into the hands of military operational planners and field units

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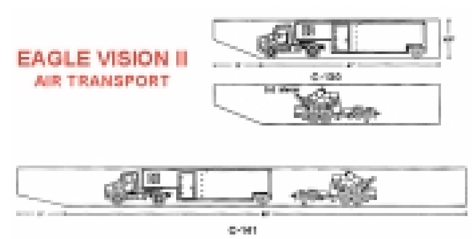
Eagle Vision

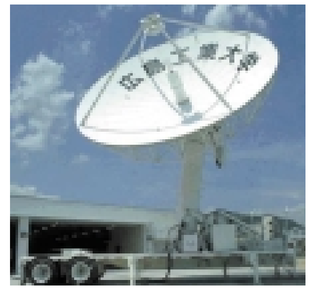
The need for such a capability was identified as a result of experience gained during the Gulf War when SPOT imagery proved to be very useful for military intelligence and operational planning purposes. However, often it was delivered too late for users to be able to utilize its full value. Obviously the availability of on-site receiving and processing capabilities would overcome this shortcoming. As a result, in 1993-94, the American defence authorities commissioned the construction of a compact, transportable ground station called Eagle Vision. This could receive and process image data direct from commercial remote sensing satellites - at first, from SPOT, but later from other satellites (Landsat, IRS, etc.) equipped with optical sensors and from the ERS and RADARSAT satellites providing radar imagery. Thus it could receive and disseminate a wide range of unclassified commercial panchromatic, multi-spectral and SAR imagery to military users. The principal contractor for the supply of the system was Datron/Transco Inc. based in California. The actual system comprises a 3.6m diameter antenna mounted on a transportable trailer and a containerized shelter that houses the receiving, processing and storage systems. These can be transported as two individual loads by a Lockheed C-130 military transport aircraft. The system has mostly been based at the USAF base at Ramstein, Germany and has been used extensively during the recent conflicts in the former Yugoslavia.

Eagle Vision II

In 1997, a follow-on system, Eagle Vision II (EVII) was ordered by the US National Reconnaissance Office (NRO) for use by the US Army. The system has been developed by the Environmental Institute of Michigan (ERIM). In 1999, an upgrade was put in hand by ORBIMAGE so that the system will be able to receive the pan and multi-spectral data (with 1m and 4m ground pixel sizes respectively) from the forthcoming OrbView-3 and -4 satellites. The EVII system comprises a 30ft (9m) long expanding van and a 5m diameter antenna mounted on a trailer. Again this can be accommodated either as two C-130 loads or as a single load in the larger C-141 military transport aircraft.



The Eagle Vision II ground station comprises a 9m long expansible van and a trailer-mounted tracking antenna. The diagram shows how the two units are air-transportable - either as two separate loads in a C-130 military transport aircraft or as a single load in the larger C-141 aircraft. (Source - US-ASPO)



The 7.3m diameter antenna system from Datron/Transco mounted on a 40 ft. (9m) long trailer that forms part of the transportable ground receiving station supplied by the Vexcel Corporation to the Hiroshima Institute of Technology in Japan. (Source - Vexcel Corporation)

Other U.S. Developments

Besides these systems supplied to military users, Datron/Transco also developed a transportable station similar to Eagle Vision for lease to civilian remote sensing agencies. As its name, SPOT-Light, suggests, it was originally developed for the reception and production of SPOT imagery. Since its introduction, it has been used on projects in Africa (Kenya) and Alaska. Most recently, it has been stationed in Dubai where it has been used as an interim receiving station for the reception of Landsat and IRS image data by Space Imaging Middle East while a larger permanent ground station is being built there. In 1997, Datron/Transco also built a trailer-based 7.3m diameter dish antenna for the transportable ground station supplied by the Vexcel Corporation to the Hiroshima Institute of Technology in Japan. The other components of the station, including Vexcel's 3D SAR processing system, are housed in two transportable shelters. Since then, Vexcel has launched its compact Apex ground station jointly with the SMARTech company which provides the antenna and receiver. This Apex station can be produced optionally as a transportable system.

Canadian Developments

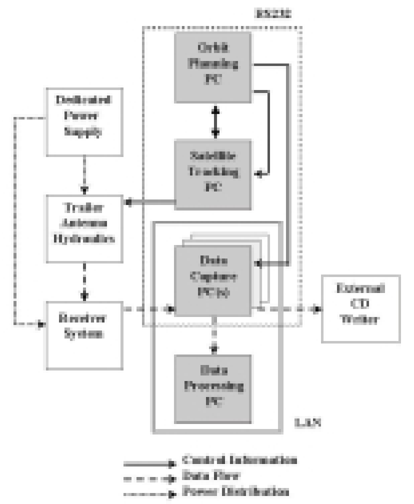
The development of similar transportable ground acquisition and processing systems has also been undertaken in Canada. One of these is the Fast TRACS system first produced by Macdonald Dettwiler Associates (MDA) in 1996. Again it comprises two air-transportable units - a trailer-mounted 4.3m diameter tracking antenna (supplied by Scientific Atlanta) and a container housing the acquisition, processing and archiving units. A second Canadian system is the IOSAT (now Satlantic) Sentry system. Like the others described above, it comprises a 5.4m tracking antenna mounted on a trailer together with a container-based operations shelter housing the electronics and computer-based equipment used for data acquisition and processing. The Sentry system was ordered by the Canadian Space Agency (CSA) in June, 1996 and became operational in December 1997. In 1998, it was used during the large NATO amphibious landing exercises carried out in Newfoundland, the Sentry system being located in a Canadian Forces command base in Halifax, Nova Scotia.

Costs

Although the various developments outlined above demonstrated the feasibility of building compact transportable ground receiving stations, the costs of most of these systems still lie in the millions of dollars per unit. This has meant that, while the needs of the military forces in highly developed countries could be met by constructing, deploying and operating such stations, the expense was such that they could not be considered seriously for non-military use in the developing countries where they are much needed.

BURS

In the U.K., Bradford University Remote Sensing (BURS) Ltd. was formed in 1994. Previously under the banner of its parent, Bradford University Research Ltd. (BURL), it



Block diagram showing the connections and data flow between the various sub-systems of the RAPIDS station. (Source - NRI)

had developed a very successful range of reliable, low-cost receivers and software to collect image data from both geostationary (e.g. Meteosat) and polar-orbiting (e.g. NOAA AVHRR) weather satellites. Much of this development was carried out in collaboration with the Natural Resources Institute (NRI) at the University of Greenwich under its LARST (Local Application of Remote Sensing Techniques) programme. Many of these receivers were supplied to develop-

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ing countries under aid or technical assistance programmes. Few failures have been experienced with these receivers in what has been a very successful programme. The receivers have proven to be of great value locally both for weather forecasting and for wide-area resource planning and management. Needless to say, this success led inevitably to the question of developing receivers that could handle the much larger data streams from higher resolution satellites at a relatively low cost. In 1992, this led, in the first instance, to BURL (with funding from NRI) developing a prototype receiver that could accept Landsat MSS data using a very small (2m) diameter antenna. However, because of the decision not to continue with the MSS sensor on Landsats-6 and -7, this development did not proceed further - since only Landsat 5 had an operational MSS sensor.

RAPIDS

However, starting in 1994, with backing from NRI, this led to the development of the so-called RAPIDS (Real-Time Acquisition & Processing Integrated System). Besides BURS and NRI, the Dutch national aerospace laboratory, NLR (Nationaal Lucht-en Ruimtevaart Laboratorium), has also been a partner in this development. This resulted in a system that could track and receive data from the SPOT and JERS satellites. Additional backing to extend the capability of the system to receive SAR data from the ERS satellites was provided by the British National Space Centre (BNSC) in 1996.

• RAPIDS Data Capture

RAPIDS is a transportable ground receiving station that is capable of tracking and collecting image data from satellites emitting tracking beacon signals on S-band (2.2 GHz) frequencies and transmitting image data on X-band (8GHz) frequencies - as used by remote sensing satellites such as SPOT and ERS. The antenna unit utilizes a hydraulically driven tracking system that is particularly effective at high elevation angles. Indeed, by cutting down on the need for horizon-to-horizon coverage and confining data capture to these higher elevation angles (45), smaller, lighter antenna dishes can be used which are much easier to move and control. This arrangement still allows data to be collected over the area within a diameter of approximately 1,000km around the station (depending on site conditions). The RAPIDS antenna (2.7m in diameter) is trailer mounted, but it is normally operated with the trailer locked in a fixed position. A set of four patch aerials, each with its own low noise amplifier, is placed at the centre (focal point) of the dish antenna to provide the information needed for the automated tracking of the satellite using the S-band beacon signals. Reception of the X-band image data signals is carried out separately by another aerial placed in the centre of the four patch aerials. The X-band receiver electronics with separate demodulators for SAR and optical data signals are housed in a special case that can be placed under cover and connected by cable to the tracking antenna.

• RAPIDS Data Processing

Four PCs, that are linked to one another by standard RS232 serial links, are used to control the overall system and to process and store the captured data. The first of these is used for planning the acquisition and tracking of specific satellite orbits. A second PC controls the antenna motions to carry out the automated tracking of the satellite using its S-band beacon signals. The third and fourth PCs are used to collect, store and process the captured image data. This data can be transferred elsewhere for processing via an Ethernet LAN or it can be backed up on to conventional mass storage media. The final processing can be carried out with the QOPT package developed by BURS for use with optical data or the QSAR package developed by NLR for the processing of SAR data.

• RAPIDS Deployment

So far, three of these RAPIDS stations have been constructed. The cost of the standard configuration is approximately $500,000 per unit; the acquisition licences are an additional charge. One of the units is operated by NRI and has been used both in the UK and on an ESA-supported mission (via its Data User Programme) concerned with flood monitoring in Bangladesh. The second example is operated by NLR in the Netherlands and has also been deployed on a demonstration mission in Indonesia. It is also scheduled to be exhibited at the forthcoming ISPRS Congress in Amsterdam. The third unit is being evaluated by the UK's Defence Evaluation & Research Agency (DERA) and is currently deployed in the West Indies on its MONSAR project. This uses ERS SAR data to produce DEMs and interferograms to monitor the active volcanic eruption on the island of Montserrat.

Conclusion

It has been most interesting to follow these developments in transportable ground receiving stations that have taken place over the last six or seven years, both for military use and for monitoring purposes in developing countries. Of course, some observers will comment that, with the explosive growth of the Internet over the last few years, space images can readily be delivered to the users via this route. However, as anyone with experience of working outside the most highly developed and industrialized countries can confirm, telephone networks are poorly developed in most of the rest of the World and, in many poorer countries, especially in areas outside their capital cities, the Internet is simply a dream. For the military community and, for many developing countries, transportable ground receiving stations are devices with real application potential.

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The 3.6m diameter tracking antenna mounted on its trailer that forms part of the Eagle Vision transportable ground receiving station operated by U.S. military forces. (Source - Datron/Transco)