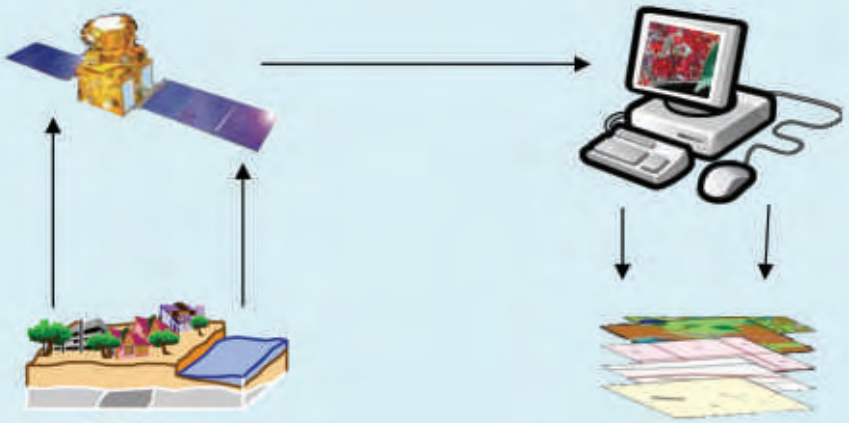
# Chapter 3 Utilisation of remote sensing satellites, data acquisition and processing

**Audit Objective 1: To assess the effectiveness of utilisation of the remote sensing satellites, acquisition and processing of remote sensing satellite data.**



**Data acquisition and Processing**

**3.1** NRSC was mainly acquiring remote sensing data from seven Indian Remote Sensing (IRS) satellites, and a few other foreign satellites like LAND SAT[6], NOAA[7], MODIS[8], ERS[9], IKONOS[10], QUICK BIRD[11] and RADARSAT[12].

The earth station complex located at Shadnagar, Andhra Pradesh acquires satellite data from all Indian and a few foreign satellites. Data recorded on digital media is transferred for archiving and general application in NRSC. The browsed and ancillary data is also transmitted from Shadnagar to NRSC using Spacenet[13], which is accessible to data users for browsing and data ordering. Thereafter, the NRSC Data Centre (NDC) sells data products based on the requests/ orders of users.

The details of IRS satellites are given in **Table 1.**

[6] LANDSAT is a series of earth observing satellite mission jointly managed by National Aeronautics and Space Administration (NASA) and the United States Geological Survey.

[7] NOAA is the satellite launched by National Oceanic and Atmospheric administration of United States Department of Commerce.

[8] Moderate Resolution Imaging Spectro-radiometer (MODIS) is a key instrument aboard the Terra and Aqua Satellites of NASA of United States of America (USA).

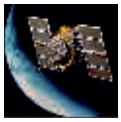
[9] It is a series of earth observing satellites of European Space Agency.

[10] IKONOS is the high resolution commercial remote sensing satellite of the company Space Imaging/GeoEye, USA.

[11] QUICKBIRD is the high resolution commercial remote sensing satellite of the company Digital Globe, USA.

[12] RADARSAT is a series of commercial earth observing satellite of Canada.

[13] Spacenet is a Wide Area Network for ISRO/DOS through satellites.





## Table 1
### Indian Remote Sensing Satellites in Operation during 2003-08

**(Amount: ₹ in crore)**

| No. | IRS Satellite | Date of Launch | Launch Vehicle | Launch Vehicle | Years in operation | Purpose |
|---|---|---|---|---|---|---|
| 1 | IRS – 1C | 28 December 1995 | Molniya[14] | 124.93 | 12 | Operational |
| 2 | IRS - P 3 | 21 March 1996 | PSLV-D3 | 76.62 | 11 | Experimental |
| 3 | IRS - 1D | 29 September 1997 | PSLV-C1 | 203.93 | 10 | Operational |
| 4 | Oceansat 1 - P 4 | 26 May 1999 | PSLV-C2 | 158.75 | 8 | Operational |
| 5 | Resourcesat-1 – P6 | 17 October 2003 | PSLV-C5 | 252.58 | 5 | Operational |
| 6 | Cartosat 1 - P 5 | 5 May 2005 | PSLV-C6 | 359.49 | 3 | Operational |
| 7 | Cartosat-2 P7 | 22 January 2007 | PSLV-C7 | 292.29 | 1 | Operational |

**Capacity utilisation of IRS satellites**

**3.2** The performance of the satellite depends on factors like the design capacity[15] of the satellites, elevation and the visibility circles and pay loads on the spacecraft such as number of sensors onboard and the availability of 'On Board Solid State Recorder'. The performance of the satellite is primarily assessed by the number of scenes that have been acquired. The earth stations of NRSC acquire the scenes[16] captured by a satellite when the satellite passes above NRSC earth stations.

Though designed capacity of each satellite was requested for, NRSC did not furnish the same and instead indicated the data product generation capability of the earth station as the designed capacity of the satellite. Due to absence of designed capacity of each satellite, the performance of each satellite with reference to their designed capacity could not be assessed by Audit.

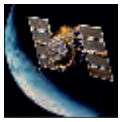
We further observed that there was a gap between scenes captured by the satellite and scenes acquired by earth station (data product generation capability) due to the constraints of the capacity of the earth stations. While admitting that the capacity of the earth stations was a bottleneck, DOS stated in December 2009 that data product generation capability of NRSC was augmented to acquire more scenes by establishing a polar earth station facility at Svalbard, Norway.

In the absence of designed capacity of the satellite, actual number of scenes acquired by earth station during the period 2002-03 to 2007-08 was compared against maximum number of scenes acquired in any of the above years (actual average capacity utilisation against maximum capacity utilisation) as detailed in **Table 2.**

[14] A Russian launch Vehicle.

[15] The capacity of a satellite to acquire certain amount of scenes is called its designed capacity.

[16] Scenes are minimum chargeable units/area based on technical/orbital parameters of each satellite. In respect of high resolution satellites, one scene has been standardised as one square kilometer.





## Table 2

### Capacity Utilisation of Remote Sensing Satellites in Operation during 2002-08

| No. | IRS (Year of Launch) | Maximum Capacity Utilisation* | Actual average capacity utilisation | Percentage of actual average capacity utilisation against maximum capacity utilisation |
|---|---|---|---|---|
| | | Scenes per year | | |
| (a) | (b) | (c) | (d) | (e) = (d)/(c) |
| 1 | I C (1995) | 48141 | 21780 | **45** |
| 2 | P 3 (1996) | 7200 | 2270 | **32** |
| 3 | I D (1997) | 32833 | 22174 | **68** |
| 4 | P 4 Oceansat-1 (1999) | 2880 | 1416 | **50** |
| 5 | P 6 Resourcesat-1 (2003) | 280908 | 155119 | **56** |
| 6 | P 5 Cartosat-1 (2005) | 111026 | 93619 | **84** |
| 7 | P 7 Cartosat-2 (2007) | 52140 | 28716 | **55** |

* It is the maximum number of scenes acquired in any of the 6 years under review or data generation capability of NRSC whichever is higher.

Further details pertaining to year-wise scenes acquired during the same period are given in **Annex-1**.

It can be observed from the table that three out of seven satellites (IRS - P3, IC and P4) could utilise only 32, 45 and 50 *per cent* of their maximum capacity.

NRSC replied in September 2008 that P3 was an experimental satellite and stopped functioning in 2003. DOS attributed the underperformance of P4 in July 2009 to *'onboard spacecraft power constraints'* from the end of 2001.

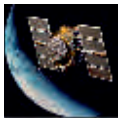
Thus, due to technical problems in the spacecrafts, the satellites could not be put to use to their maximum capacity. NRSC/DOS did not assess the impact of lower capacity utilisation on remote sensing applications projects of national importance.

**Recovery of expenditure/ Return on Investment**

**3.2** The proposal to launch remote sensing satellites is approved taking into account user requirements and data needs. For calculating Return on Investment (ROI), the capital expenditure on launch of remote sensing satellites and the yearly expenditure on operations & maintenance of satellites is compared with the revenue to be generated from the sale of data products generated from each satellite.

We also observed that no benchmark relating to recovery of expenditure incurred or ROI was fixed by DOS. The total capital expenditure on the seven satellites in operation during the review period was ₹ 1468.59 crore.

The operational returns from these satellites during the period 2003-08 are detailed in **Table 3**.





## Table 3

### Operational Returns of Indian remote sensing satellites

**(Amount: ₹ in crore)**

| Year | Operational Expenditure | Income from the sale of data products* | Operational Returns | Percentage of 'Income from sale of data products' to 'Operational Expenditure' |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) = (3) - (2) | (5) = (3)/(2) *100 |
| 2003-04 | 117.84 | 20.97 | (-) 96.87 | 17.80 |
| 2004-05 | 133.87 | 26.19 | (-) 107.68 | 19.56 |
| 2005-06 | 149.27 | 29.78 | (-) 119.49 | 19.95 |
| 2006-07 | 173.16 | 38.89 | (-) 134.27 | 22.46 |
| 2007-08 | 163.13 | 42.63 | (-) 120.50 | 26.13 |
| **Total** | **737.27** | **158.46** | **(-) 578.81** | **21.49** |

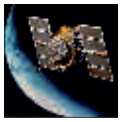
* Inclusive of the sale of data products to international customers through Antrix Corporation Limited (ACL).

It can be seen from the table that:

- Operational returns were negative in all the years and ranged from ₹ 96.87 crore to ₹ 134.27 crore indicating that realisation from sale of data products was not sufficient to even match its yearly operational expenditure. Percentage of Income from sale of data products to operational expenditure was very low and ranged from 17.80 *per cent* to 26.13 *per cent* with the average of 21.49 *per cent*. The under recovery of operational expenditure was ₹ 578.81 crore during 2003-08. All the seven remote sensing satellites in operation during the period 2003-08 were, therefore, not revenue neutral.
- Further, the capital Investment of ₹ 1468.59 crore made on seven operational satellites could not be recovered in the absence of any positive operational return during the period 2003-08. The recovery percentage of total expenditure incurred was mere 7.18 *per cent* as revenue generation was only ₹ 158.46 crore as against total expenditure of ₹ 2205.86 crore.

Thus, there is a need to improve the generation of revenue by sale of data products. This will help to increase the percentage of income from sale of data products to operational expenditure and ensure the long term sustainability of the programme.

NRSC replied in September 2008 that the price of the satellite data had been arrived at by considering only the operational cost of the satellite data product generation at NRSC. The cost of segments such as launch vehicles, satellite fabrication, etc., was not considered. Without quantifying intangible benefits, NRSC added that ROI should also consider the intangible benefits accrued through the utilisation of the satellite data.





The reply of NRSC is not acceptable, since recovery of operational cost averaged at 21.49 *per cent* only as against full recovery because sale price of data products was based on recovery of operational cost. NRSC needs to recognise and consider all associated costs for arriving at the cost of the data products. It also needs to revisit its operational policy with a view to at least recover operational costs.

**Data need assessment**

**3.4** Data need assessment in various remote sensing applications such as resource survey[17], mapping applications[18], oceanographic applications[19], etc., is to be made to help in planning the payloads of operational remote sensing satellites prior to launch.

We scrutinised the files[20] containing proposals for launch of IRS–P4, P5 and P6 satellites and observed that data need assessment on various thematic areas was not carried out for these satellites. DOS did not make available proposal files of IRS-IC, ID & P7 satellites in the absence of which we could not ascertain whether or not thematic data need assessment was carried out for these satellites.

We also requested for information in August 2008 on theme-wise data need and data supply in the areas of urban planning, drought monitoring, land use & land cover mapping, underground water resource mapping, mineral prospecting, environmental impact analysis etc., to examine the process being followed by NRSC in carrying out such exercise. NRSC expressed their inability in furnishing theme-wise data assessment and sales figures and replied in October 2008 that it had plans to collect information on themes in the future. Thus, we could not assess the extent of data gap against the data need in specific areas.

DOS, while noting the audit observation, replied in July 2009 that in future, efforts would be made to collect information on the intended use for data products disseminated by NRSC.

**Data Acquisition Facility**

**3.5** NRSC reported in July 2008 that operational efficiency of Shadnagar earth station was 98 *per cent*.

The details of passes[21] captured during the year and the number of passes/portion of passes not captured by data acquisition during the year is detailed in **Table 4**.

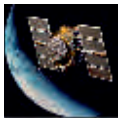
[17] Surveying resources of earth such as vegetation, water, mines, hydrocarbon etc.

[18] Mapping geographical and political boundaries which would normally help in rural/urban planning, coastal land use and regulation, utilities mapping and other various cartographic applications.

[19] Mapping of the resources, terrain, movements etc., of the ocean.

[20] Proposals relating to IRS-P3 were not scrutinised as it was an experimental satellite.

[21] Number of occasions on which the earth station captured data when satellites passed over the station.





## Table 4
### Satellite passes covered

| Sl. No. | Year | Total passes captured[22] by the earth station | Number of Satellites involved | Passes not captured by the earth station |
|---|---|---|---|---|
| 1 | 2003-04 | 6205 | 05 | 127 |
| 2 | 2004-05 | 6205 | 05 | 127 |
| 3 | 2005-06 | 6570 | 05 | 134 |
| 4 | 2006-07 | 6935 | 06 | 142 |
| 5 | 2007-08 | 7665 | 06 | 157 |
| 6 | 2008-09 | 6730 | 06 | 68 |
| | | **40310** | | **755** |

From the table, it can be seen that even though the number of passes not captured by the Shadnagar earth station was only 126 passes[23], the number of passes not captured showed an increasing trend from 127 in 2005-06 to 157 in 2007-08. However, the position improved in 2008-09. NRSC replied in September 2008 that number of passes not captured was due to very low elevation passes and occasional overhead passes which led to data losses and that it was natural in any operational scenario of remote sensing satellites data reception.

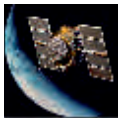
We also observed that scenes acquired from IRS satellites averaged 273641 per year during the period 2002-08. However, the number of scenes acquired reduced to 30 *per cent* during 2008-09. NRSC did not furnish reasons for sudden fall of 70 *per cent* in the acquisition of scenes of IRS in 2008-09.

DOS replied in July 2009 that operational efficiency above 95 *per cent* is the accepted benchmark. It added that NRSC earth station had only three antennae against which it was acquiring scenes from seven Indian Remote Sensing Satellites. It further stated that in case of known operational problems of one antenna, other can be configured to accept satellite passes. DOS further replied in December 2009 that data product generation capability of NRSC was augmented due to establishment of a polar station facility at Svalbard, Norway and, therefore, NRSC could acquire more scenes.

Reply of DOS underlined the fact that data product generation capability of NRSC was below the full capacity of the satellites to acquire and generate scenes. Hence there was a need to review and augment the data acquisition capacity of NRSC after conducting a realistic data need assessment.

[22] Considering the number of days in a year as 365.

[23] During the period 2003-04 to 2008-09, the number of passes not captured was 755. The average passes not captured during the 6 years works out to 126 (755 divided by 6).





**Utilisation of acquired data**

**3.6** NRSC had a system of archiving the data acquired by the operational Indian and foreign satellites. According to NRSC's archival policy of 1998 which was revised in December 2004, previous five years data were to be retained without purging. The data acquisition policy which was part of data archival policy stipulated that acquisition and archival of data depended on the following three aspects:

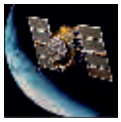
- Cloud free data sets for different application requirements.
- Cost of data acquisition vis-à-vis potential sales.
- Archived data sets which are unique in their characteristics.

Details of the scenes acquired, sold, revenue realised etc., are given in **Annex-2**. From these details, we observed the following:

- The percentage of idling of the acquired data ranged from 53 to 95 *per cent* in IRS, 92 to 99 *per cent* in MODIS, 68 to 97 *per cent* in NOAA satellites during 2002-09.
- The extent of such unutilised data from IRS satellites was high and increased from 69 *per cent* in 2002-03 to around 89 *per cent* in 2007-08. Only in 2008-09, the idling of data reduced to 53 *per cent*.
- Though data acquisition and archival policy stipulated acquisition of cloud free data and data acquisition based on potential sales basis, the low utilisation of acquired data is indicative of the fact that the data need assessment was not based on any scientifically conducted user requirement. NRSC did not furnish details of marketing strategy and action plan aimed at improving utilisation of acquired satellite data.
- According to NRSC archival policy, the policy was to be revised once in five years. NRSC also spent ₹ 41 lakh towards recurring storing charges of the archived data during 2004-08 in addition to payment of salary towards technical staff[24] of the archival wing. NRSC did not revise its archival policy after December 2004, as of January 2010.

DOS replied in July 2009 that NRSC had made wide publicity to the user community on the availability of such archived data-sets at reduced prices. The efforts of NRSC included participation in important geospatial workshops, release of advertisements in geospatial/general magazines and conducting user meets.

[24] The archival policy stipulated a manpower requirement of 38 technical staff (13 engineers and 25 technical assistants).





The reply of DOS needs to be viewed in the context that the operational remote sensing satellites were launched with a specific designed capacity to meet the data needs of the country and the region. Therefore, data acquired should have been adequately utilised if the data need assessment was realistic. In addition, the Tenth Five Year Plan document had also envisaged a quantum jump in technological ability, application expansion, aggressive marketing and virtual dissemination of knowledge keeping in mind the requirements of remote sensing user community in the country and the region. The fact remained that idling in IRS data was high and was between 53 and 95 *per cent*.

**Data Processing Facility**

**3.7** The efficiency of the data processing facility is measurable in terms of turn-around time[25]. One of the goals for Tenth Five Year Plan period (2002-07) was to supply high quality products from various satellites with improved turn-around time. The turn-around time achieved during 2002 to 2009 was as detailed in **Annex-3**.

NRSC fixed turn-around time of three days for standard products and five days for some specialised products. We observed that the turn-around time did not improve during 2002 to 2009. In addition:

- Data processed within one day decreased from 15.9 *per cent* in 2002 to 5 *per cent* in 2008 and 9.7 *per cent* in 2009.
- Data processed within one week (one day to seven days) decreased from 55.9 *per cent* in 2002 to 26.5 *per cent* in 2009.
- Data processed upto two weeks (one week to two week) increased from 16.5 *per cent* in 2002 to 30.7 *per cent* in 2009.
- Data processed upto one month (two week to one month) increased from 7.9 *per cent* in 2002 to 32.2 *per cent* in 2009.

Thus, turn-around time was increasing during the review period, pointing to the decline in efficiency of data processing.

DOS replied in July 2009 that even with increased complexity of the missions and complying totally with Remote Sensing Data Policy (RSDP), NRSC was able to supply the data products to the users within reasonable time. Reply of DOS has to be viewed in the background of the fact that though the RSDP of 2001 made data supply easier, processing time taken by NRSC had increased during the period under review.

We also observed that NRSC had spent ₹ 5.79 crore during 2003-08 on automation, establishment of new facility/ upgradation of existing facility in the data processing area and to equip the facility with the needs of every new satellite launched. Despite this substantial investment, NRSC was not able to make any significant improvements in turn-around time, as envisaged in Tenth Five Year Plan.

[25] Turn-around time is the processing time required to process the data into a deliverable finished product from the time of receipt of request for data.

**National Remote Sensing Coordination Committee**

**3.8** The Standing Committee of Parliament on Department of Space observed in August 2004 that in order to increase accuracy of IRS data and also for more realistic interpretation of acquired data, DOS needed to set up National Remote Sensing Coordination Committee to facilitate holistic implementation of the following proposals:

- Integration of Geographical Information System (GIS), Global Positioning System (GPS) and IRS technology to enhance accuracy of derived data.
- Production and distribution of satellite data.
- Processing of remote sensing data.
- Using functional approach towards difficulties faced by departments for accurate interpretation of the data retrieved.
- Updating of technology at par with world standards.
- Promotion of remote sensing applications in coordination with universities and research centres.
- Maintenance of national archive on remote sensing data with a view to preserving data and also constantly updating it.

We observed that the National Remote Sensing Coordination Committee, which was to ensure holistic implementation of remote sensing data, was not yet set up. NRSC stated in September 2008 that different committees such as NRSC Data Centre–Data Processing Coordination Committee were instituted to discuss various issues on data product generation and user requests. Reply of NRSC is to be viewed in the context of specific recommendation of the Standing Committee of Parliament to constitute a single committee to address several issues.

**Conclusion**

The performance of three out of the seven remote sensing satellites was below their maximum capacity in terms of remote sensing satellite data captured by them. The revenue realised from seven satellites in operation was not up to the desired level. The satellites were planned without adequate thematic data need assessment. Idling of acquired IRS data was high due to non-adopting of appropriate marketing strategy. While there was a need to review and augment data acquisition capacity of NRSC after conducting a realistic data need assessment, there were also delays in data processing impacting the delivery of available data products.

| Our Recommendations | Action proposed by NRSC on recommendations |
|---|---|
| **1.** NRSC/DOS may assess the need requirement of data in various thematic areas before planning and launching satellites and initiate action to maximise utilisation of remote sensing satellites already launched. | *NRSC stated in February 2010 that along with other stakeholders of National Natural Resource Management System (NNRMS), they would continue to strive to make the periodic assessment of its user requirements through more frequently convened NNRMS Standing Committees. NRSC also stated that they would launch more awareness and capacity building programmes for the users to make use of the newer products and services of the satellite missions, particularly the missions launched recently such as RISAT-2 and Oceansat-2; and the newer ones planned in the immediate future such as Resourcesat-2, RISAT-1, Megha-Tropiques, and SARAL. It added that a focused programme was being drawn to build necessary infrastructure augmentation at the State Remote Sensing Applications Centers as well as build necessary human resources skill for making use of the satellite data and the derived information at local level for decentralised planning.* |
| **2.** NRSC/DOS may consider formulating a marketing policy and adhere to it to enhance revenue to cover at least operational cost. | *NRSC stated in February 2010 that it planned to devise means to:*<br>● *enhance operational efficiency and effective product delivery mechanism,*<br>● *work out a document consolidating existing practices, competition, future opportunities, challenges, perceptions of user agencies to work out appropriate marketing strategy/ action plan for the coming years, and*<br>● *set up a Customer Relationship Management (CRM) / marketing cell in the near future working together with Antrix Corporation Limited.* |
| **3.** NRSC/DOS may also consider revising its archival policy to enhance utilisation of archived data. | *NRSC agreed in February 2010 that it was planned to re-visit the archival policy during 2010 and efforts would be made to publicise availability of archived data through NRSC website, generation of brochures/ leaflets etc.* |

| Our Recommendations | Action proposed by NRSC on recommendations |
|---|---|
| **4.** NRSC/DOS may prescribe ideal turn-around time for different categories of data. | *NRSC stated in February 2010 that it planned to implement the new technological initiative i.e., 'Integrated Multi-mission Ground Segment for Earth Observation Satellites' by 2012. The turn-around time was expected to improve significantly with the emergency products being delivered in a few hours and most of the standard products to be generated in 24 hours.* |