

IRS-1C mission planning, analysis and operations

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The IRS-1C mission planning activities began with the payloads choice as per mission objectives derived through users' requirements. Detailed mission specifications were drawn up for both space and ground segment elements of the mission after detailed mission analysis. The world referencing schemes for all payloads have been designed to enable users to specify the required data. A knowledge-base and graphical representation of spacecraft subsystems are some of the new features introduced for spacecraft health analysis. This article details the spacecraft operations carried out in the launch and early orbit phase and also on the performance of the spacecraft subsystems in-orbit.

THE mission planning efforts for the IRS-1C began with the studies for a mission with high resolution capabilities, better than IRS-1A/1B. Commensurate with the mission objectives set—high resolution, revisit capability, continuity of data services and so on—the payload choice, orbit and attitude analysis, spacecraft mainframe requirements, operational requirements of payload and onboard recording, launcher interfaces and associated ground segment system details were worked out. The study efforts were firmed up into exact mission specifications, detailed spacecraft configuration, mission operations profile, mission software, ground stations network, data products specifications, volume, processing and dissemination details in the course of the IRS-1C project. The mission planning activities involved integrating and interrelating the efforts of both space and ground systems to realize the operational system which would provide the continuity of satellite-based remote sensing data services in India. As the systems evolved, the IRS-1C mission evoked enough interest in the global scene and is now on its way to become a 'global' mission.

Mission specifications

After detailed studies, analysis and trade-offs, the mission specifications were arrived at. The specifications were laid down for orbit, orbit maintenance, attitude and attitude rates, data product types and accuracies, payload system specifications like signal-to-noise ratio, square wave response and mainframe systems specifications for

meeting power balance, fuel balance, link budgets and thermal regimes of operation for various operations. Table 1 provides the salient mission specifications.

Orbit and attitude

IRS-1C being a continuation in the series of remote sensing satellites, its orbit choice has to fall into the category of sun-synchronous orbit with descending node chosen for imaging and equatorial crossing time being 10.30 a.m. The only parameter chosen was the altitude and corresponding inclination to achieve sun-synchronism. The choice of altitude was mostly governed by the high resolution PAN camera. The technically assured realizable system for panchromatic camera at the time of decision was limited to near about 1 m in focal length. With this in mind and the required resolution of better than 10 m, orbit classes of 700 and 800 km were examined in detail. In addition, a repetitivity better than 30 days for multi spectral camera, 5 days for WiFS camera and a revisit of 5 days or better for PAN camera were also considered. The frequency of orbit manoeuvres to be 30 days or more was also specified. With the above considerations and keeping in view the contemporary missions of other space agencies, a sun-synchronous orbit of 817 km was chosen as the orbit for IRS-1C. It was analysed for all details like sun-angle variations, eclipse characteristics, ground stations' visibilities, clashes with other IRS missions over data reception station, attitude sensors mounting and fields of view. Under orbit analysis the effects of off-nadir viewing on PAN imagery like sun glint, world referencing scheme and orbit determination error analysis were also carried out. The pass pattern of IRS-1C which is different from IRS-1A/1B and the PAN off-nadir viewing geometry are shown in Figures 1 and 2.

Attitude analysis led to specifications on the pointing and drift rates of the platform. Considering that browse products should be accurate to at least 3 km, providing for temporal registration of data collected in different cycles and also accounting for sidelap requirements, the specifications for pointing were fixed at 0.15° in roll and pitch and 0.2° in yaw.

Drift rate specifications arrived at for IRS-1C involved the following:

Table 1. Salient mission specifications

Orbit and maintenance		Attitude		
Attitude	817 km	<i>Pointing</i>		
Inclination	98.69°	Pitch 0.15° (3 sigma)		
Local time	10:30 AM	Roll 0.15° (3 sigma)		
Node descending		Yaw 0.20° (3 sigma)		
Ground track	Within 1 km of referencing scheme			
		<i>Drift rate</i>		
Local time	± 5 min	Better than 3×10^{-4} deg/s on all axes		
Repetivity	24 days	<i>Determination</i>		
		0.01° for star sensor		
Revisit	5 days	0.07° for earth sensor + gyro		
		Location accuracy 1500 m		
Determination	Better than 900 m (3 sigma)			
Frozen perigee				
Power margin	: 20%			
Fuel margin	: 15 kg			
Link budget	: Better than 3 dB for all links			
	: Better than 1 in 10^{-5} BER for all links			
Payload tempo	: $20 \pm 3^\circ\text{C}$ gradient 1°C			
Battery temperature	: $2 \pm 2^\circ\text{C}$			
Payloads	PAN	LISS-III	SWIR	WiFS
SNR	> 64	> 128	> 128	> 128
SWR	> 20	> 35	> 30	> 30

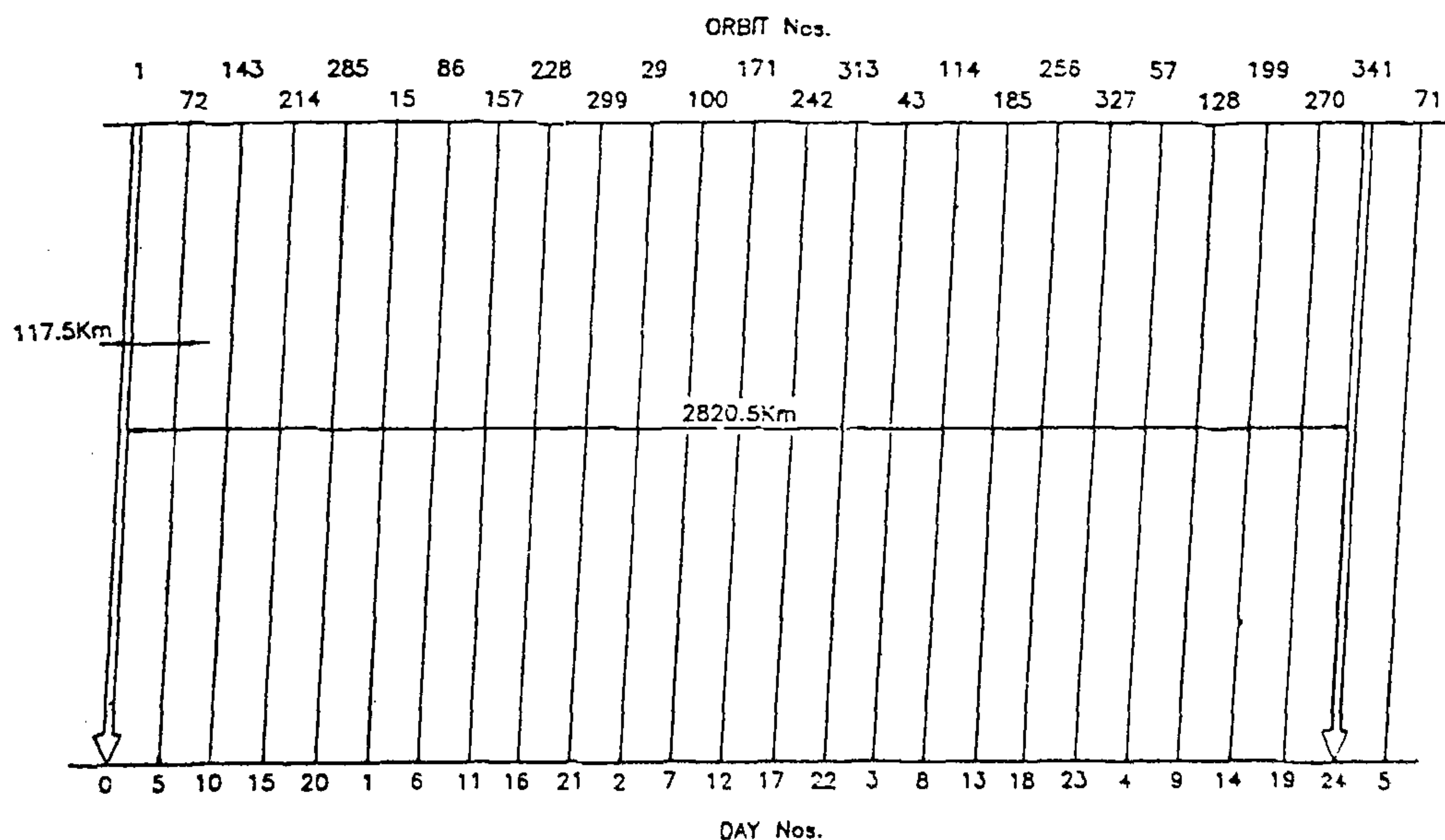


Figure 1. General trace pattern.

(a) Considerations of PAN mosaicing, i.e. stitching together 3 strips of 23.3 km and to make a composite scene of size 70×70 km but still retaining its geometry and radiometry intact, considering the fact that the midstrip is displaced by 8.6 km with respect to outer ones.

(b) Internal distortion in a scene of 10 s to be less than 1 pixel.

(c) Local distortion during imaging for about 250 ms to be less than 0.1 pixel.

(d) Pixel distortion due to attitude rate should be less than 10%.

Specification (a) works out to be more severe than (b), (c) and (d). Hence (a) was chosen as the design goal. The other factors which contribute to these specifications are the type of controllers used in the onboard attitude control system and the accuracies achievable by reference and update attitude sensors. The drift rate specification was given as 3×10^{-4} deg/sec with a design goal of 1×10^{-5} deg/sec. Towards this, a measurement circuit for drift rates in all the axes was also included to provide rates in steps of 10^{-5} deg/sec. The fine rate information from each gyro axis was included in the video data stream as part of the auxiliary data. This fine rate data would be useful in attitude determination using earth sensor and gyro, attitude determination using star sensor (especially for filling the duration of star gaps) and further in swath modelling and geometric corrections efforts during data products generation.

World referencing scheme and coverage

Path-row referencing scheme covering the entire globe has been worked out for IRS-1C mission also. The ground trace of the orbit is called a 'path'. In a 24-day cycle, the satellite completes 341 orbits. Thus, for referencing, 341 paths have been identified. Path 1 is assigned to the track which is at 29.7° W longitude. Choice of path 1 was guided by the requirement to avoid overhead pass over Shadnagar. Since it occurs between two nominal paths.

Along a path, the data are segmented into a number of scenes of convenient size. The lines joining the corresponding scene centres of different paths are parallel to equator and are called 'rows'.

Since the sensors of IRS-1C have different swaths, it is required to have a different referencing scheme for each sensor.

Figure 3 shows the scene layout of LISS-III (visible and NIR bands), LISS-III SWIR band and PAN scenes within one WiFS scene. The LISS-III (SWIR) scenes are framed such that their length is the same as LISS-III (VINIR) scene though its breadth is 7 km more than a LISS-III (VINIR) scene. As the swath of WiFS is very large, there is a side lap of about 85% between adjacent paths at equator. Similarly the overlap between adjacent rows is 676 km. The huge overlap between WiFS scenes of adjacent paths results in repeated coverage of the same area in a given cycle. A given scene can be covered completely on its day of pass and also by a combination of two scenes acquired on different days during the cycle.

The referencing scheme of PAN has evolved around the LISS-III scene centre. Further, each LISS-III scene can accommodate four PAN full scenes designated as A, B, C and D. The PAN scenes will be referred to by the same path and row numbers as that of LISS-III along with suffixes A, B, C and D. This layout for PAN is chosen for referencing scheme only. PAN sub-scenes are depicted in Figure 4.

The configuration of PAN camera is such that, in the nadir view, the PAN scene centre will fall in the ground trace of LISS-III. It is evident that scenes A and B are partially covered in the nadir view. Because of the steerability, complete data corresponding to A and C or B and D can be acquired fully by tilting the camera at $\pm 2.48^\circ$ from nadir. Such a coverage is planned for India and is expected to be completed in 48 days' time.

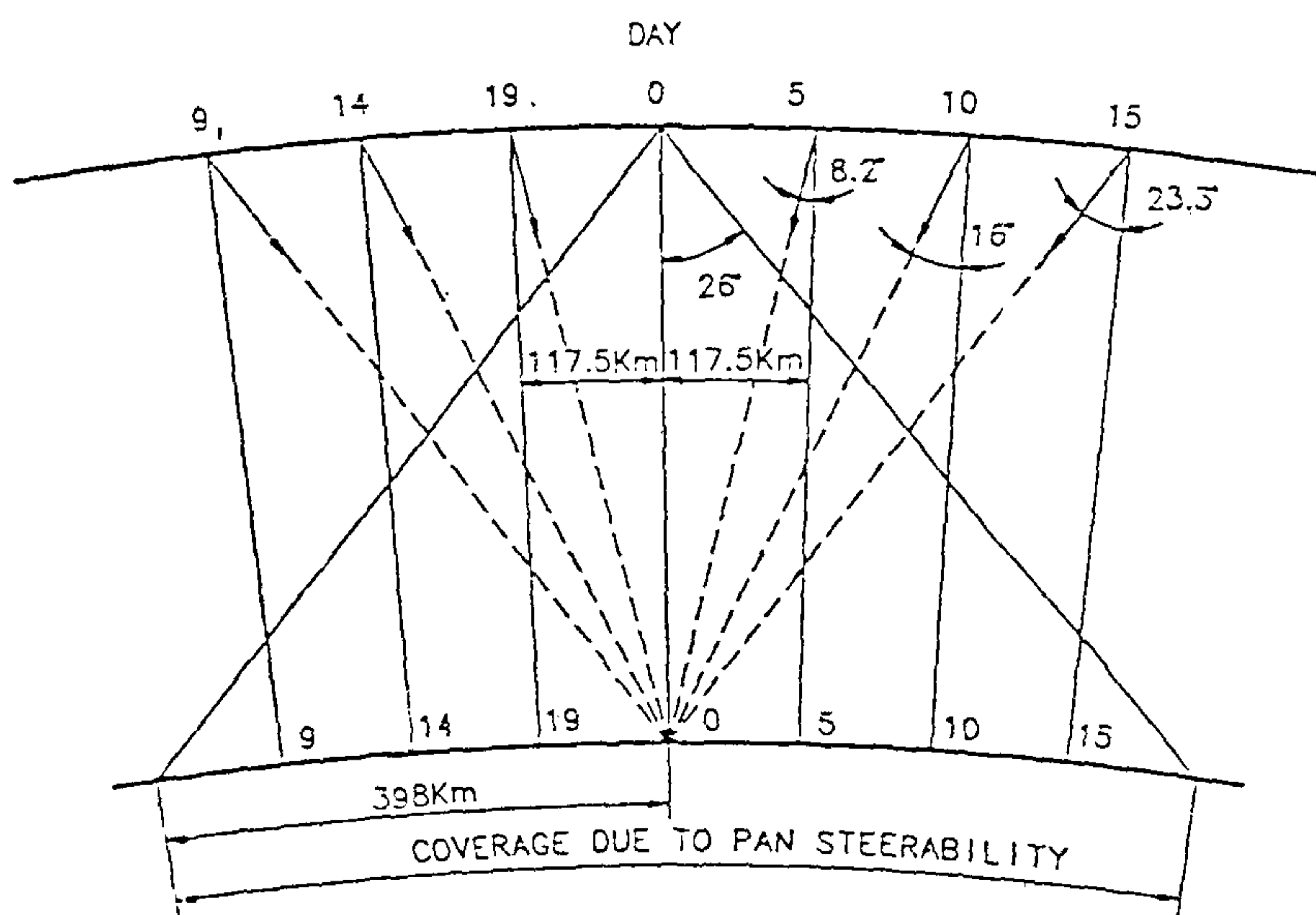


Figure 2. PAN off-nadir viewing capability.

Mission software

The mission software was designed and developed for IRS-1C on lines similar to that of IRS-1A/1B. The spacecraft health monitoring and control software offered new features in terms of integrated graphics support for realtime, dwell data and phase plane plots, graphical display of spacecraft subsystems, integrated archival of spacecraft telemetry data with flight dynamics parameters, generation of data commands with engineering units or bit pattern represented as icons. These were in addition to the features like real-time display, off-line display, off-line graphics display/plots and archival-retrieval of all types of data. The software was developed and implemented on VAX 400 system for real time functions and on DEC-Alpha with open VMS for all off-line functions. The software design underwent various reviews and test and evaluation at the operations centre. A totally new data table management software was also developed which was used for creating the parameter identification directory for spacecraft data interpretation. A new telecommand directory generator helped in creating the command database which was used for commanding the spacecraft in all phases of the mission. The sequence of events generator in conjunction with spacecraft events software was used for preparing step-by-step operations of the spacecraft prior to lift off till commissioning all required systems onboard.

The flight dynamics software provided for orbit and attitude determination in addition to ephemeris, events and real time display of flight dynamics parameters. The manoeuvres software generated plans, commands and pre-post-manoevre state vectors. The flight dynamics software was implemented and operationalized on DEC-Alpha Open VMS system. The orbit determination software was improved to utilize a new model and to provide accuracies better than 180 m. Orbit determination results are referenced to 00 UT epoch and used for providing the state vector information for data processing/reception sites on a daily basis. Orbit determination was carried out in the early orbit phase and the definite orbit was provided within 48 h for manoeuvres on day 3 of the mission. The manoeuvres software provided plans to correct injection errors, perigee freezing, path locking as per referencing scheme and suitable phasing with respect to IRS-P2. The orbit manoeuvre software also provides plans for maintaining the orbit during the normal phase of the mission.

A set of flight dynamics and data processing software packages driven by separate schedulers were designed, developed and implemented at the data reception station, Shadnagar for producing ancillary data for PAN and LISS-III data and optical disks for WiFS video data along with ancillary data. Ancillary data files are created for OBTR data separately. OBTR passes are handled by a separate scheduler. A 'CAL scheduler' helps in the conduct of payload calibration data passes.

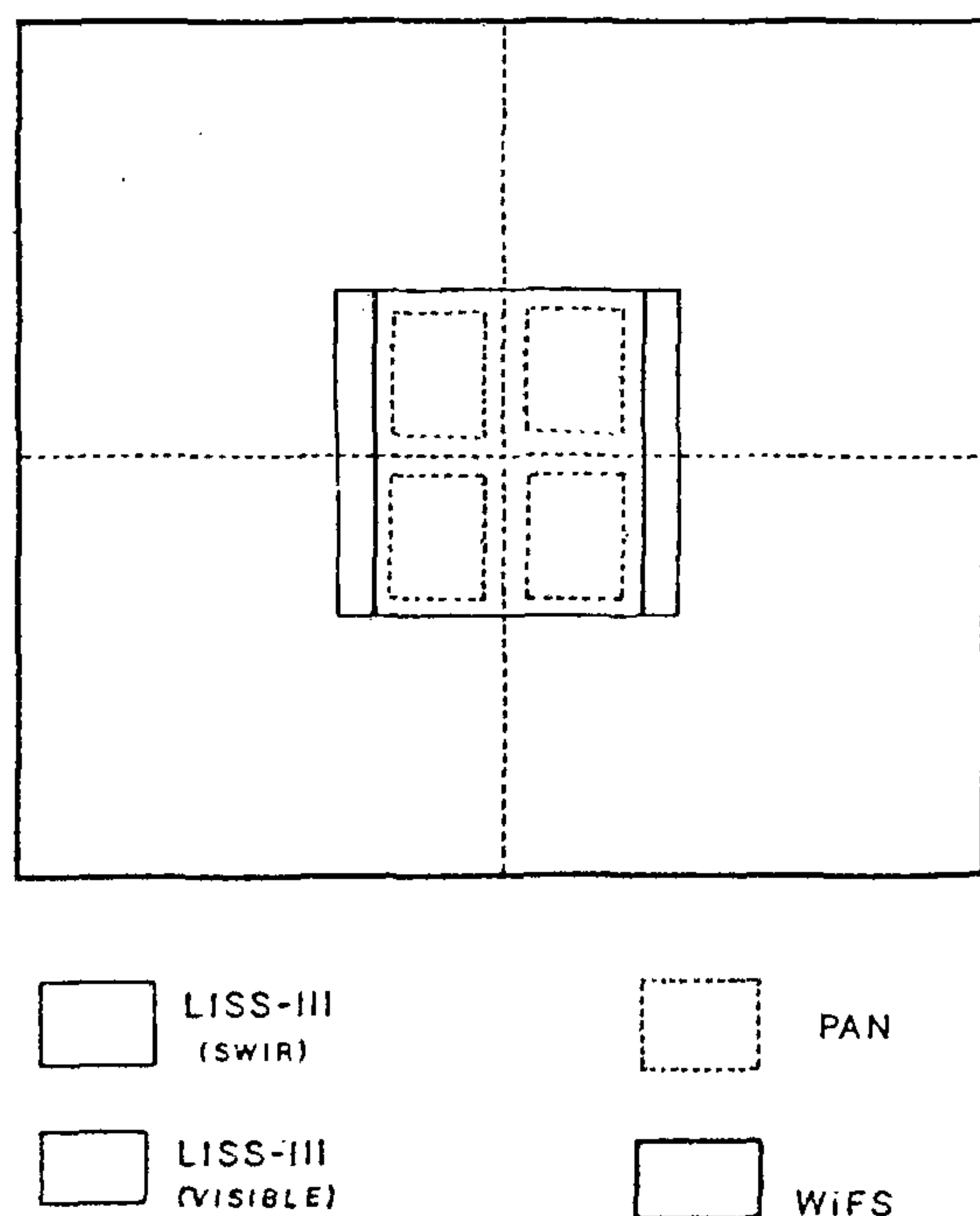


Figure 3. Scene layout of PAN, LISS-III.

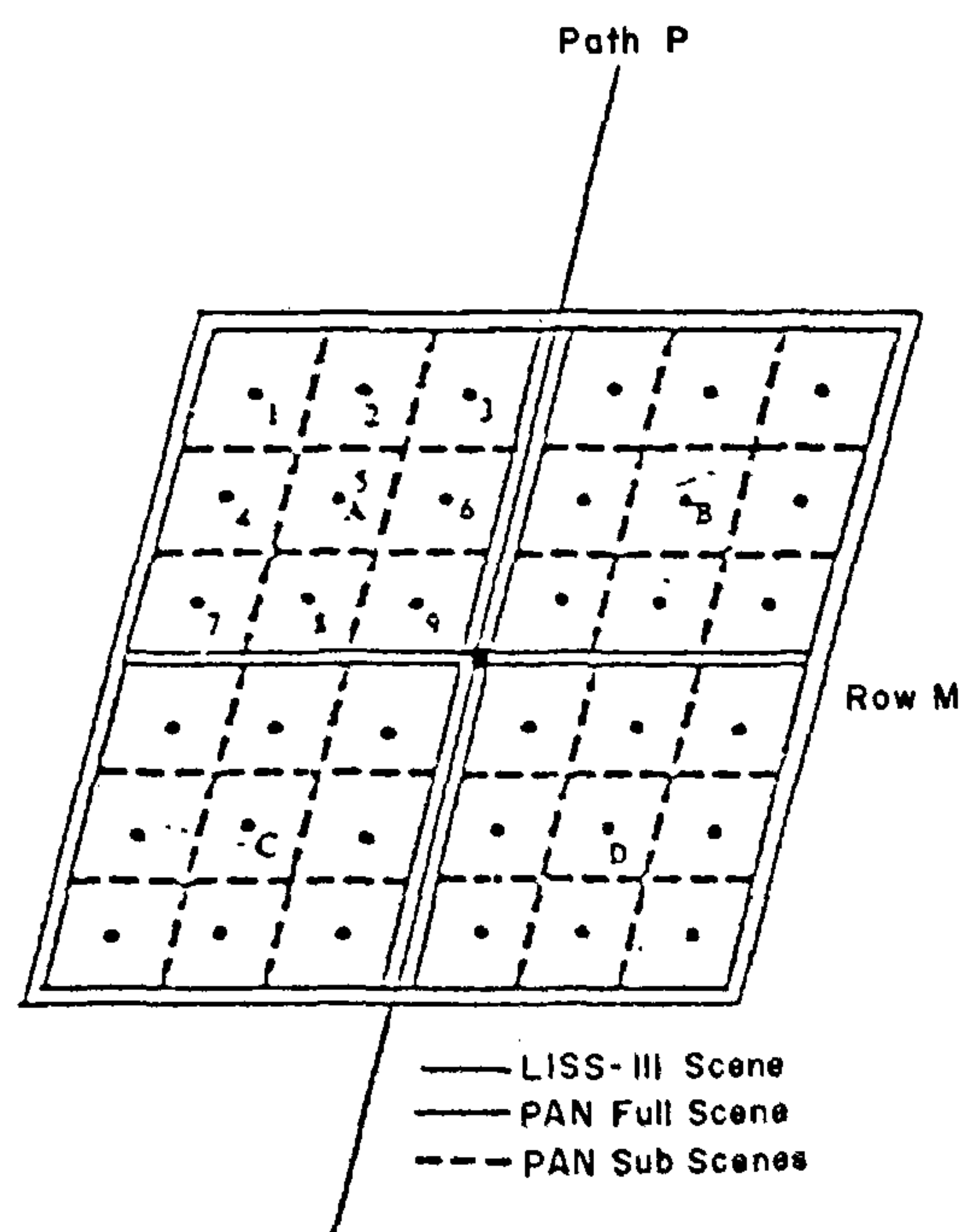


Figure 4. PAN subscenes.

Knowledge-base for IRS-1C health analysis

A knowledge base has been built for spacecraft health analysis. The knowledge for each subsystem is built in three stages.

A set of composite parameters (CPID) are defined. Each CPID has its unique identification number and mnemonic. It is defined in such a way that each represents a specific concept/information derived out of spacecraft parameters or other CPIDs. They can assume logical/arithmetic/character values. The default status/value of the CPID and the corresponding details are also provided.

Each CPID has an associated rule which contains the algorithm for deciding the value of the CPID using the present values of the spacecraft and flight dynamics parameters. The rule has its unique 'id' and it effectively incorporates the 'knowledge' in the form of an equation with logical/arithmetic operators and it assigns the value to the CPID.

Finally the anomaly is defined. Each anomaly has its own id and explicit mnemonic. The priority of the anomaly (critical/normal) and the enable/disable status for anomaly check are user-definable.

The knowledge base provides option for extending to trend monitoring. For this, derived PIDs (DPID) are defined whose values/status are set by special processing/routines.

For each subsystem CPIDs, rules and DPIDs were defined and spacecraft health analysis program was implemented at Spacecraft Control Centre. For real-time reporting of anomalies, a separate page has been provided in realtime display software. About 600 CPIDs were defined for IRS-1C health analysis and about 110 DPIDs were also defined.

Graphical display of spacecraft subsystems

A new feature introduced in IRS-1C enables display of spacecraft subsystem configuration and health display in real time. The spacecraft subsystem is represented in block schematic form showing all major interconnections, signal flow, powering schemes and monitorings, select/deselect, enable/disable status, heaters – location, monitoring status with wattage, temperature sensors location and monitoring, and equipment panels layout. The block schematics were cast as a number of graphical pages for display on TEK terminals. Colour code schemes were derived to indicate status changes, configuration links and alarm conditions. The mechanical and electrical layout of spacecraft was used while constructing the pages. The GDSP pages could accommodate more number of parameters than an ordinary display page and also gives the operations crew more information on the spacecraft configuration on the screen itself.

Mission documentation and reviews

All mission plans were translated into mission operations documents useful for conducting on-orbit operations. They were the pre-launch simulations plan, sequence-of-events, flight control procedures, contingency recovery procedures, health analysis plans, normal phase operations plans and display schemes. All mission documents and software packages underwent detailed reviews by expert committees and test and evaluation at operations sites.

Spacecraft operations profile and performance

The satellite IRS-1C was launched on 28 December 1995 at 06:45:18 UT from Baikonur Cosmodrome in Kazakhstan. The spacecraft was injected into a near sun-synchronous orbit and initial acquisition over Bangalore, Lucknow, Mauritius and Hartebeesthoek (HBK) South Africa was smooth. Immediately after injection, solar panels were deployed by onboard timers triggered by the snap signal received from the launcher. Commands were issued from Mauritius to initiate the sun acquisition. With this, the negative yaw axis of the spacecraft was made to face the sun and the solar panels were rotated to generate the power. The spacecraft went through the first eclipse and reacquired Sun after coming out of the eclipse. The commanded rate option of AOCE was useful in both initial acquisition and re-acquisition after eclipse exit. The NASA station at Pokerflat (Alaska) provided the spacecraft monitoring and commanding facility in orbit 2. Bearslake (Russia) station confirmed the correct spacecraft configuration of 3-axis acquisition. This operation was initiated from HBK and the operations were successful. Precision yaw sensor (PYS) south did not provide the expected update in orbit 2. However, the update from PYS (N) coupled with attitude values from magnetometer confirmed 3-axis acquisition. The four reaction wheels were spun up and the spacecraft was 3-axis stabilized on wheels and torquers. The mission profile is depicted in Figure 5.

The definitive orbit results showed the delta velocity requirement to correct the injected orbit of about 19 m/s. The apportionment was 4 m/s for in plane and 15 m/s for out-of-plane. For orbit manoeuvres, the single 11 N thruster was primarily used. For executing out-of-plane corrections using 11 N thruster, the spacecraft had to be rotated by 90°. The OPC requirement was more than IPC requirement because of large dispersion in inclination. The requirement of frozen perigee, phasing of IRS-1C with IRS-P2 and the eccentricity of the injected orbit made the IPC requirements day specific. Hence it was found that OPC could be carried out independently. A test Large Angle Manoeuvre (LAM)



Figure 5. IRS-1C mission profile.

rotation was carried out and proper operations of the spacecraft subsystems and procedures were established. Four out-of-plane corrections were imparted to the spacecraft during the period 1–10 January 1996. This established the nominal inclination plus a small bias (as required for local time maintenance) for IRS-1C sun synchronous orbit. The in-plane corrections were executed on specific dates to achieve the nominal altitude, eccentricity and argument of perigee as necessitated by a frozen perigee, sun synchronous orbit. This provided 7 paths phasing with IRS-P2 also in an identical orbit. Total fuel spent in the orbit acquisition process was about 12.25 kg. The orbit was locked to specific path of IRS-1C referencing scheme from 10 January 1996. Since then, the ground track maintenance has been executed by selecting the required 1 N thrusters and firing for required duration, typically 4 seconds. The ground track maintenance is planned to be carried out for a window of ± 1 km against pre-launch specification of ± 5 km. The local time maintenance is set at $10:30 \pm 5$ min. Operationally, it is planned to maintain a positive bias in inclination in the routine phase. After orbit acquisition, the spacecraft mainframe was configured for update Kalman filter mode for fine pointing. The safety features onboard the spacecraft, viz. hardware safe mode, wheel overspeed logics, spurious speed logic, auto change-over from S/W to H/W AOCE, auto reconfiguration logic, failure detection logic of solar array drive, battery taper charge regulators auto change over logic have been enabled. Software safe mode logic was used during orbit manoeuvres.

The payloads, PAN, LISS-III and WiFS were switched on 5 January 1996 for the first time. Since then they are regularly operated through auto sequencer. The calibration modes of PAN and LISS-III were also checked out. The onboard tape recorder was operated in wind, rewind, self-check, record and reproduce modes and found to be functioning satisfactorily. Prior to the turning on of payloads, the data handling systems of PAN and LISS-III were independently checked and links were ensured properly. With the imagery data also the links are checked out and were found proper. The X-band beacon was used for tracking and was found to provide adequate link margin.

The payload and OBTR operations in the routine phase are being carried out in time-tagged mode. Time-tagged commands logic was tested out in-orbit for normal block execution, edit and memory dump functions. Error detection logics for both command and delay functions are kept enabled.

The gyro drift values loaded at launch pad were trimmed with update signals from earth sensor and yaw sensors. The drifts are fine tuned by update Kalman filter regularly. Two gyros are kept ON continuously. During large-angle manoeuvres, the measurement of yaw angle rotated was provided by gyro 2.

The earth sensor systematic error correction processor was initialized on day 1 and has been trimmed with coefficients required to be uplinked from ground. The orbit timer reset is being done regularly once a week.

The star sensor in dual head mode has been sensing stars up to 6th magnitude. The data needs to undergo pre-processing before taking up attitude determination. The star sensor processor needs to be initialized once in a while.

The telemetry system was operated in real time, continuous/sampled recording, playback, dwell, star sensor storage/playback mode and the performance is normal.

The telecommand system was used for several on/off, data, time tagged and sequencer modes of operations. The performance is normal. Both main and redundant time tagged circuits have been in use for payload operations.

The tracking transponder has been used in coherent mode. Simultaneous ranging and commanding has been in operation from orbit 1. The modulation indices provided prior to launch for such an operation have been used in ground stations configuration.

The PAN payload-steering mechanism was released on 29 December 1995 in-orbit. The payload was test steered on either side and later stereo data from PAN was acquired on 15 and 19 January 1996. The basic stereo pair and ortho images have been produced. The payload has been steered to the required angles within $\pm 26^\circ$ and PAN data have been acquired. The payload steering is carried out prior to the actual operation of

the payload. The rotation rate is 0.059°/s and disturbance on spacecraft settles with the completion of rotation.

The solar array drive was enabled in orbit 1. The offset feature of solar array drive has been enabled for payload operations.

The power system performance has been normal. The solar arrays are generating near 900 W of power. The average DOD of batteries is around 9% and the ampere hour meter indicates near 1.0 overcharge factor for all orbits for both batteries. The performance of all regulators, DC-DC converters and current sensors is normal. Power margin of 21% is estimated even after 12 min operations of all payloads in all orbits. Nominally, mainframe load is 200 W.

The temperatures of various subsystems and spacecraft bulk temperature have shown close-match with pre-launch predictions. The batteries are maintained near 2°C and payloads within 17–22°C. Propulsion system components are all maintained above 10°C. Thruster bed heaters and some plumline heaters are kept on.

The performance of temperature sensors and sun sensors has been normal. One pressure sensor has shown normal reading while the other one showed an increasing trend and hence this was neglected for operations purposes. Solar panel sensors are working in union with solar array drive. The anomalous anti-sun side panel offset conditions obtained in some of the payload passes has been overcome by reducing the offset angle from 20° to 15°.

All the four reaction wheels are used for attitude control. The dynamic friction compensation circuit which is useful for wheels zero crossing in 3 RW mode only has been disabled after observing an anomaly w.r.t to wheel speeds getting stuck. The wheels performance has been satisfactory and attitude holding is also proper.

With Norman, USA joining the data reception station network, the payloads are being operated over its visibility also. The routine phase payload operations over Shadnagar and Norman, OBTR recording as required by users and OBTR dump over Shadnagar are mainly handled through time tagged-commands. The other operations include playback data collection, star sensor data collection and attitude determination, yaw maintenance through manual updates.

Also included in the routine phase operations are the payloads calibration once in a cycle of 24 days and orbit maintenance within specifications. PYS/DSS offset data commands are sent on a daily basis while earth sensor processor orbit timer is reset once in a week.

Global mission – payload operations profile

IRS-1C mission is conceived as a global mission, meeting the requirements of national and international users.

The spacecraft bus design supports all payload opera-

tions of 12 minutes each in all orbits. By design, with any one of the payloads operating in some of the orbits, the payload operation can even be extended by another 4 to 5 minutes. The onboard tape-recorder operations get interleaved between the realtime payload operations. The tape-recorder is capable of 24 minutes of recording which may take place in two to five segments typically. These recorded data are down loaded over Hyderabad station during night passes regularly. The actual profile of payload operations may vary from day to day and depends on requests by the users.

Payload operations – external

Payload will be operated on International Ground Stations (IGS) according to the request of each IGS and are upgraded for IRS-1C payload data reception. The IGS requests are integrated with the Indian user requests and an integrated request is generated. The integrated payload operation plan will be a conflict-free plan.

The IGS stations are spread all over the world. While some of the stations have overlapping visibility, others have continuous visibility and will extend the payload operation duration.

Payload programming system

The following factors about payload operations make it essential to pre-plan and program payload operations.

- a) All the three payloads can be operated in real time. The spacecraft configuration permits different combinations of operations. Each of the payloads has a redundant chain and multiple cross operations are possible.
- b) Payload data can be recorded onboard and played back later. At any time, either full swath data of LISS-III or half swath of PAN data are possible for recording. Depending on the user requirements, the recording will be programmed. Recording could be of several segments interleaved with PAN and LISS-III data. It is also possible to simultaneously record the data while it is operated in real time. The tape position is continuously monitored whether the tape is at EOT or BOT, before a recording or a dumping operation is programmed. The tape length required to record a particular planned session is assessed and its availability is checked.
- c) Different gains can be selected for each payload. There is a provision to select gain for each CCD/spectral range.
- d) PAN camera is steerable to cover $\pm 26^\circ$ from nadir viewing. While programming for stereo or triplet scenes, the tilt angle is selected to suit the B/H ratio specified by user.
- e) There are some spacecraft constraints in terms of power and thermal conditions for continuous payload

operations all through the orbit and payload needs to be programmed to keep safe power and thermal conditions. The real time and the recording operations will be interleaved and the spacecraft is checked for the power situation before further payload operations are planned.

f) Some scenes needed to be acquired may be already acquired and available in the archives, meeting all the requests of user.

g) Some of the scenes acquired, as they go through the product generation may found to be bad (bad cloud cover) and may need to be acquired again.

h) There are different priorities defined based on the type of service the user requires in terms of acquisition, repeated acquisition, cost, etc. The priority requests, therefore, need to be programmed first for data acquisition.

Payload programming operations

The following are the activities for payload programming:

a) The NRSA Data Centre receives requests from various users, for PAN, LISS-III, WiFS and OBTR operations. A software at the integrated information management system (IMS) will identify the requests to be serviced. For all these requests, the camera identification, preferred range of tilt angle (if PAN), area to be covered, preferred B/H ratio (if it is stereo requirement), dates of preference and priority are identified and passed on for further processing.

b) A sub module of a flight dynamics software breaks these requests into possible imageable slots. Then it produces multiple plans for a given request into different feasible slots and days. It will take all the requests of real time operations at Indian and foreign data reception stations, OBTR operations for record and dump and at the first instance provide a number of feasible payload operational plans for a given request slotwise and day-wise possibilities.

c) Taking these inputs for a given day, the multiple plans that are feasible for all the requests/slots combined are produced. These payload data acquisition plans are produced much in advance to the date of actual imaging. Later, out of all available plans, one plan most suitable is selected and this is transferred to SCC as image data acquisition plan (IDA).

d) After allowing for modifications or cancellations from users and removing the slots that cannot be serviced

due to spacecraft constraints, a selection of final plan will be done and a confirmed programming request (CPR) is generated.

e) The confirmed payload operations request will contain OBTR wind, rewind operation in addition to record, play back and real time operations. The request will indicate details like station ID, satellite ID, sensor ID, date of operation, start and end latitude.

f) The graphical display for any given acquisition plan enables the user to finalize from the different plan options, the one best plan for implementation. It also provides an interactive selection procedure for emergency request handling with features like visual depiction of payload swath and varied tilt angles.

g) A database package creates and maintains payload request information. It also maintains pending requests that are to be serviced in the next cycles. It maintains payload operations history and enables in rescheduling the serviced requests of poor quality, and their removal from the database. It also helps in reformatting the IDA and CPR for transmission to SCC.

h) The confirmed payload operation request is transmitted to SCC.

i) At SCC, this plan is translated into payload operations schedule files, combined with other command operations of satellite and generates with respect to visibility sessions, a sessionwise command schedule.

j) With these files, an indirect command file is generated which will be accepted by command generation software (CMD).

k) Later, after the payload passes of the day are completed, the telemetry-archived file and telecommand-temporary file are accessed and a consolidated telecommand archival file is generated, including voice and TT commands that are operated.

l) Finally, a command operational report is generated and transmitted to NDC for database updation.

m) It is planned that all the requests including the emergency requests are handled only through the NDC. In the case of emergency requests, the normal path is still followed and for that, request details like sensor, tilt angle and on/off time are sent to SCC.

n) The last minute urgent requests, by a proper authority, if any, are taken orally by NDC and passed on to SCC for implementation by fax/text message.

These operations are normalized again after implementation by running full chain and database is also updated.