Data processing system of IRS-1C and data quality evaluation

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The Department of Space, Government of India, recognized the need for harnessing space technology for various applications and acquired state-of-art capabilities in the development and establishment of operational remote sensing satellites. Considering the success of IRS series so far, the Department of Space took up the development of IRS-1C satellite.

The IRS-1C satellite is an improved version of the earlier IRS missions, both in terms of sensor and re-visit capabilities. The National Remote Sensing Agency at Hyderabad, India, receives and processes data from remote sensing satellites, including IRS-1C. In this article we give details on the entire gamut of data processing facilities including filming, photo processing and quality control facilities, and also give a detailed account of the various systems – both hardware and software. As great emphasis is placed by DOS on ensuring quality of the sensors as well as data acquisition and processing systems, therefore, data quality evaluation is also dealt with separately in this article.

THE Department of Space (DOS), considering the need for remote sensing technology in India, planned a series of Remote Sensing satellites to be built indigenously. To receive and process the data from remote sensing satellites, facilities were set up at National Remote Sensing Agency (NRSA) at Hyderabad, India.

At NRSA/DOS, since 1979, facilities were established for receiving and processing data from Landsat and Metsat satellites. Gradually, these facilities were upgraded to handle SPOT, IRS and ERS-1 data. Over the years NRSA/DOS has gained expertise in the development of indigenous hardware and software for data processing and reception. The facilities at NRSA are geared up to receive and process data from IRS-1C satellite. The main centres involved in the development of this facility are NRSA, SAC and ISAC.

The data from IRS-1C are received at the Data Acquisition Facility established at Shadnagar on High Density Tapes (HDT) and are sent to Balanagar Data Processing facility for further analysis. The browse processing is carried out routinely and then the HDT is sent to the archives for storage. Based on the user request, the NRSA Data Centre processes the data in users defined format through an Integrated Information Management System (IIMS). Depending on the request either for photo or digital products, the data are generated to meet the user's need. Figures 1 and 2 depict the different stages of photo products generations respectively. Typical sequence for photo products generated include: data processing, film recording and processing, quality check and photo products generation. Finally, the product is quality-checked and dispatched to the users. Similarly, for digital products, the data request is processed at data processing system and then sent for digital quality control, after which the data are made available to the respective users. All the activities, as mentioned above, are carried out under the control of IIMS. The following sections provide the details of each of the systems as well as the data products-generation mechanism.

Data Processing Systems

Data processing system (DPS) is a very important element in the data products generation chain. Its main function is to convert the raw video data of various sensors of IRS-1C recorded on HDTs at the Level-0 system facility (Earthstation, Shadnagar) into different types of products after performing radiometric and geometric corrections.

As large volumes of data are to be processed (for example: 112 MB of raw data for one LISS-III scene) to meet the throughput requirement of generating 42 products per day and also to perform various other activities like swath modelling, data quality evaluation (DQE) and ground control point (GCP) library updation, etc. three computer systems, viz. DPS-I, DPS-II and DPS-III have been configured. The system configurations of DPS-I and II are identical to each other (Figure 3). Standard, geocoded and special products of LISS-III, PAN and MIR data are generated using DPS-I and DPS-II. DPS-III is used to generate WiFS data products and also supports swath modelling as well as performing radiometric and geometric DQE on various products and updates GCP library (Figure 4).

Based on the load and the capacity of each DPS, a master scheduler distributes work orders to DPS-I, DPS-II or DPS-III (WiFS) for products generation. This master

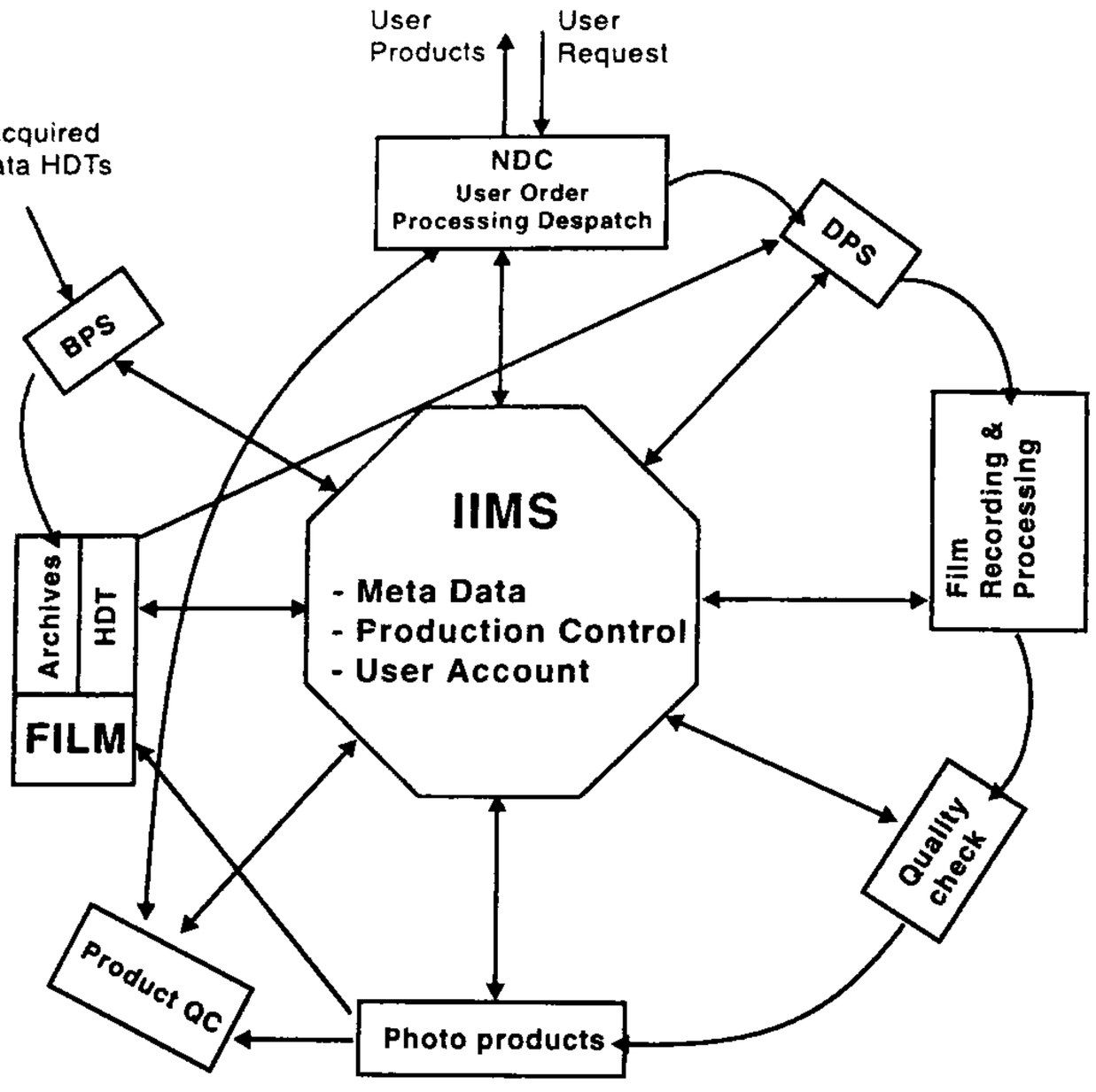


Figure 1. Photo products generation flow.

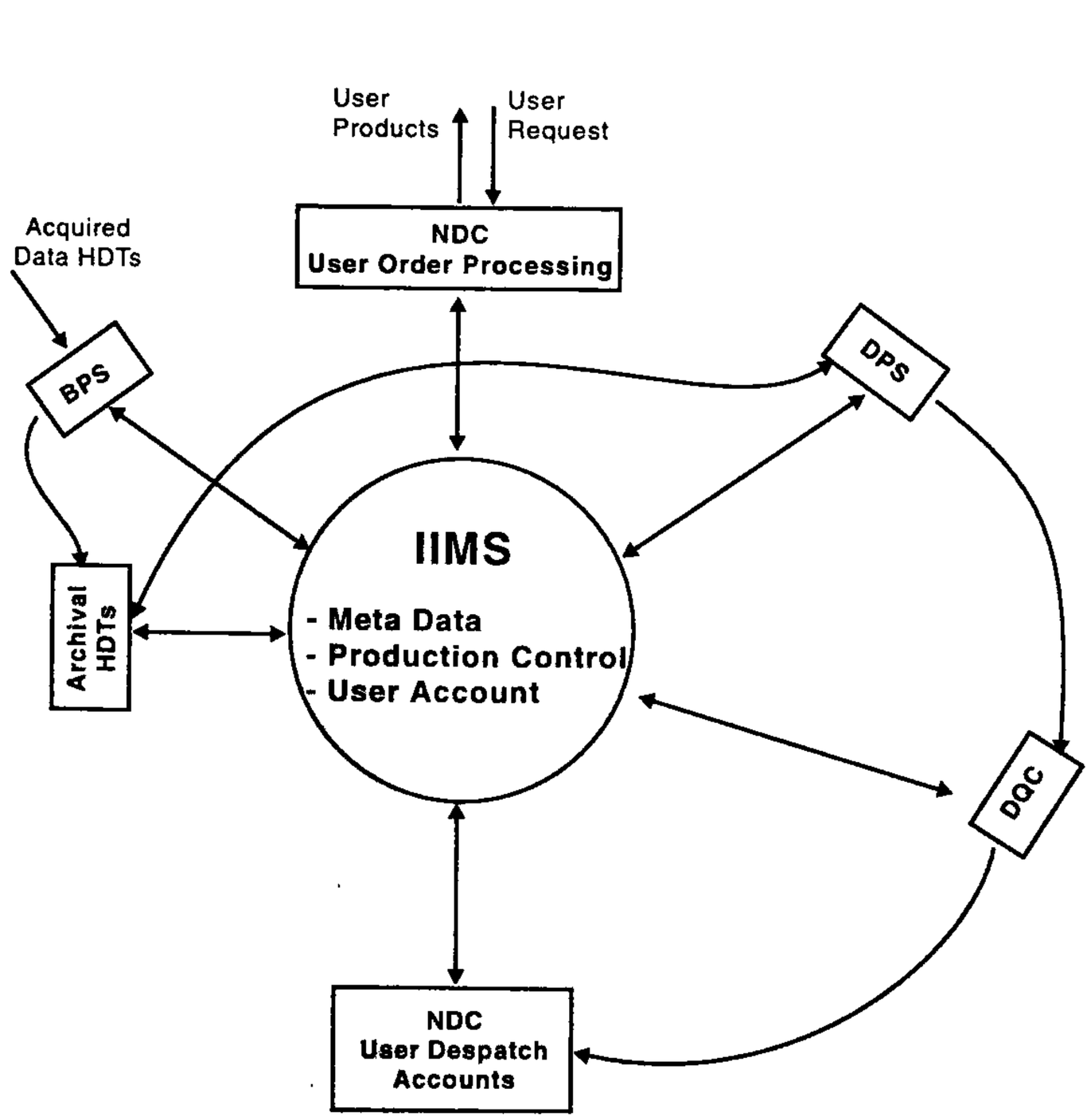


Figure 2. Digital products generation flow.

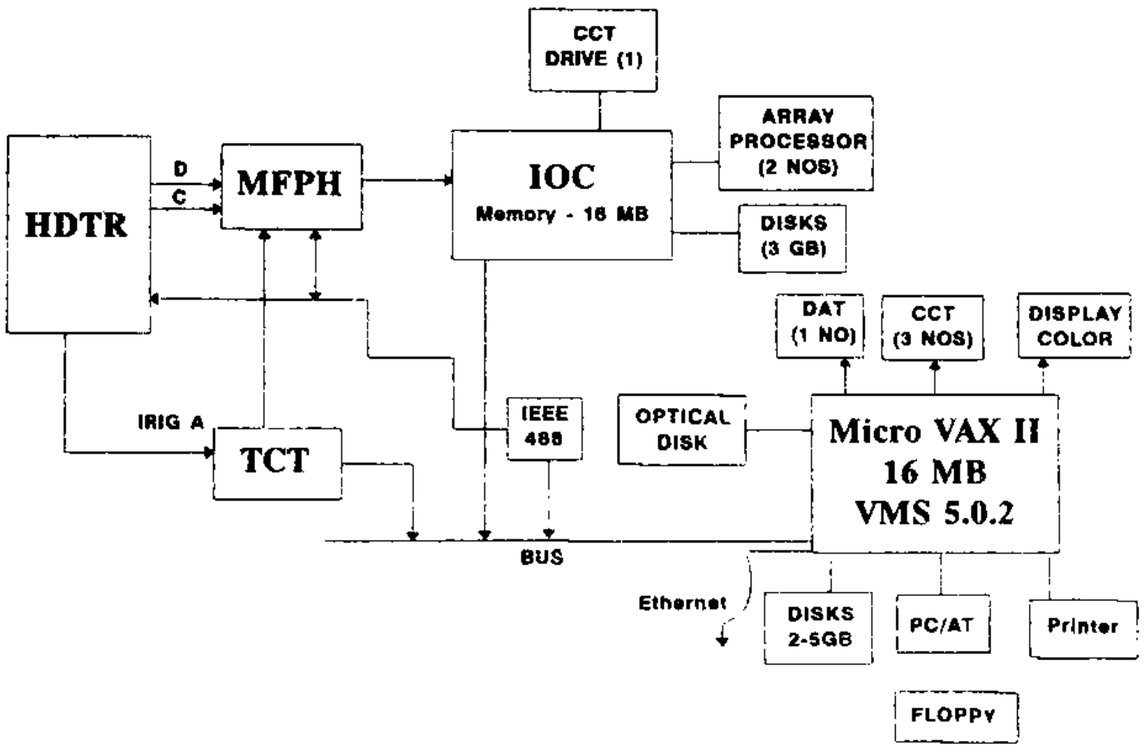


Figure 3. Data processing systems I and II.

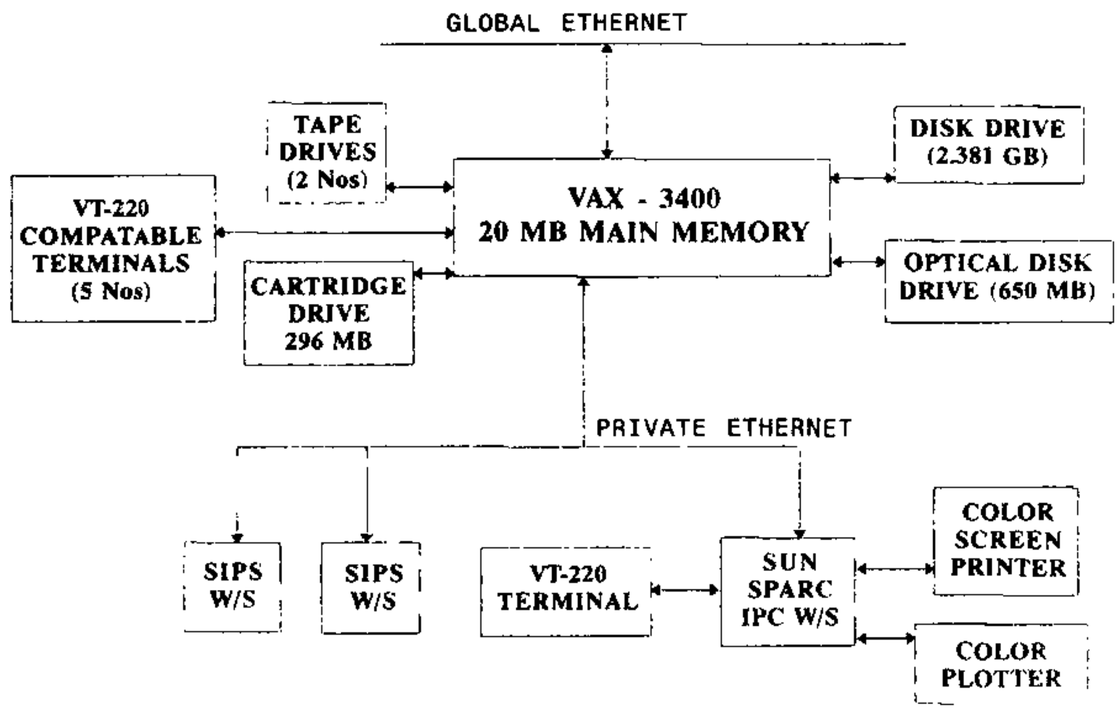


Figure 4. Block diagram of DPS-III.

scheduler performs functions like normal request queuing, priority request queuing (for out-of-turn generation of urgent products), initiation of jobs on multiple DPSs for swath modelling, DQE and WiFS backdated requests etc.

Specified number of products requested by users which are registered by NRSA Data Centre (NDC) reach DPS through IIMS when master scheduler is invoked. Individual DPSs invoke another scheduler called DPS scheduler (local to the particular DPS) which gives number of jobs for the session for that particular DPS. The next step in DPS-I and DPS-II is to ingest the raw data from HDT onto the hard disk connected on the APTEC I/O computer (IOC) via an inhouse developed hardware, called multifunction frontend processing hardware (MFPH). Radiometric and geometric corrections are applied by APTEC IOC and array processor using the data processing software.

In DPS-III, WiFS B/W and colour film products as well as digital products are generated by reading the raw data from optical disks (written at Level-0 system, Shadnagar). Apart from this, both radiometric and geometric quality evaluation of IRS-1C products, swath modelling of IRS-1C passes and Ground Control Points (GCPs) library updation are done in this system. Zonal VIM and full India VIM are obtained by processing the WiFS data of a few days.

Data processing software

Data processing software for IRS-1C data products is designed and developed on the basis of experiences gained from previous IRS missions and requirements of new types of products with the improved capabilities of sensors and platform.

Types of data products

Different types of data products for LISS-III, PAN and WiFS sensors have been categorized into three groups, viz. standard products, special products and stereo products.

Standard products. Standard products are corrected for the following errors to the extent possible through priority knowledge and orientation parameters which are updated using pseudo-orbit/attitude model – swath model. (i) Scene-related errors: It includes earth rotation, earth shape, earth curvature and map projection. (ii) Sensor-related errors: It includes mainly detector response non-uniformity, detector array alignment related and sensor tilt. (iii) Platform-related errors: These errors mainly include spacecraft altitude, spacecraft attitude, and sensor alignment.

Special products. IRS-1C data products with any one of the following characteristics are referred to as special products: Special radiometric data manipulation, registration between multiple data sets, usage of different data bases.

Stereo products. Stereo products for IRS-1C are defined to take advantage of the stereo data acquisition capability by tilting the PAN camera. These products are characterized by: Possibility to get a 3-D view of the area under consideration, capture of 3-D topographic data, removal of image distortions due to height variations.

Various types of data products and their specifications are given in Table 1.

Data corrections

Radiometric errors. Different sources for radiometric

Table 1. Types of data products and specifications

Name	Loc. accu. (m)	Int. dist. (pixel)	Anisomorphism (%)	Reg. accu. (pixel)	Radiom. accu. (%)
LISS-III scene (141 × 141 km)	50–500	± 1	0.01	0.5	0.5
LISS-III scene (Sat)	50–500	± 1	0.01	0.5	0.5
Quadrant	50–500	± 1/2	0.01	0.5	0.5
Geocoded (Map sheet based)	50–500	± 1/2	0.01	0.5	0.7
PAN scene (23 × 23 km)	50–500	± 1/2	0.01	NA	0.5
Basic stereo pair (23 × 23 km)	1500	NA	NA	NA	0.5
WiFS scene (810 × 810 km)	300–700	± 1	0.01	NA	0.5
District geocoded	50–500	± 2	0.02	0.5	1.0
PAN + LISS-III	50–500	± 1	0.02	1	NA
PAN mosaic	50–500	± 2	0.01	NA	0.7
Point geocoded	50–500	± 1/2	0.01	NA	0.5
Vegetation index map (Full India)	2000	± 5	0.05	NA	NA
Ortho image (Map sheet)	15–50	± 1/2	0.01%	0.5	0.5

distortions for IRS-1C sensors include: Non-uniformity response across detector arrays, non-uniformity response across multiple arrays, non-uniformity response over time, radiometric variation due to mosaicing of multiple scenes, and scanline losses.

Geometric correction. This is accomplished by using a dynamic imaging model which consists of a number of transformations involving payload co-ordinate system, spacecraft co-ordinate system, orbital co-ordinate system and earth centered inertial co-ordinate system.

Products generation

The output products are generated either in photographic or digital format. The digital data are supplied with various levels of processing such as raw, standard, special and stereo. The file formats and structures in User CCT (UCCT) are the same for all levels of processing. The formats in which the digital data are supplied include fast and super structure formats. Digital data details are given in User CCT Format.

Browsing facility

Data from IRS-1C are acquired daily and repeatedly on a regular basis from the same geographical region to enable the study of spatial and temporal behaviour of the data. The repetivity period is a characteristic of the specific satellite and is determined by the orbit in which it is placed. In order to pick the right data set from the archived data, it is essential to scan through the archives. A facility to meet the above requirement is initially set up at NDC and will be subsequently accessible by various user agencies across the country through network. The block diagram of this system is shown in Figure 5.

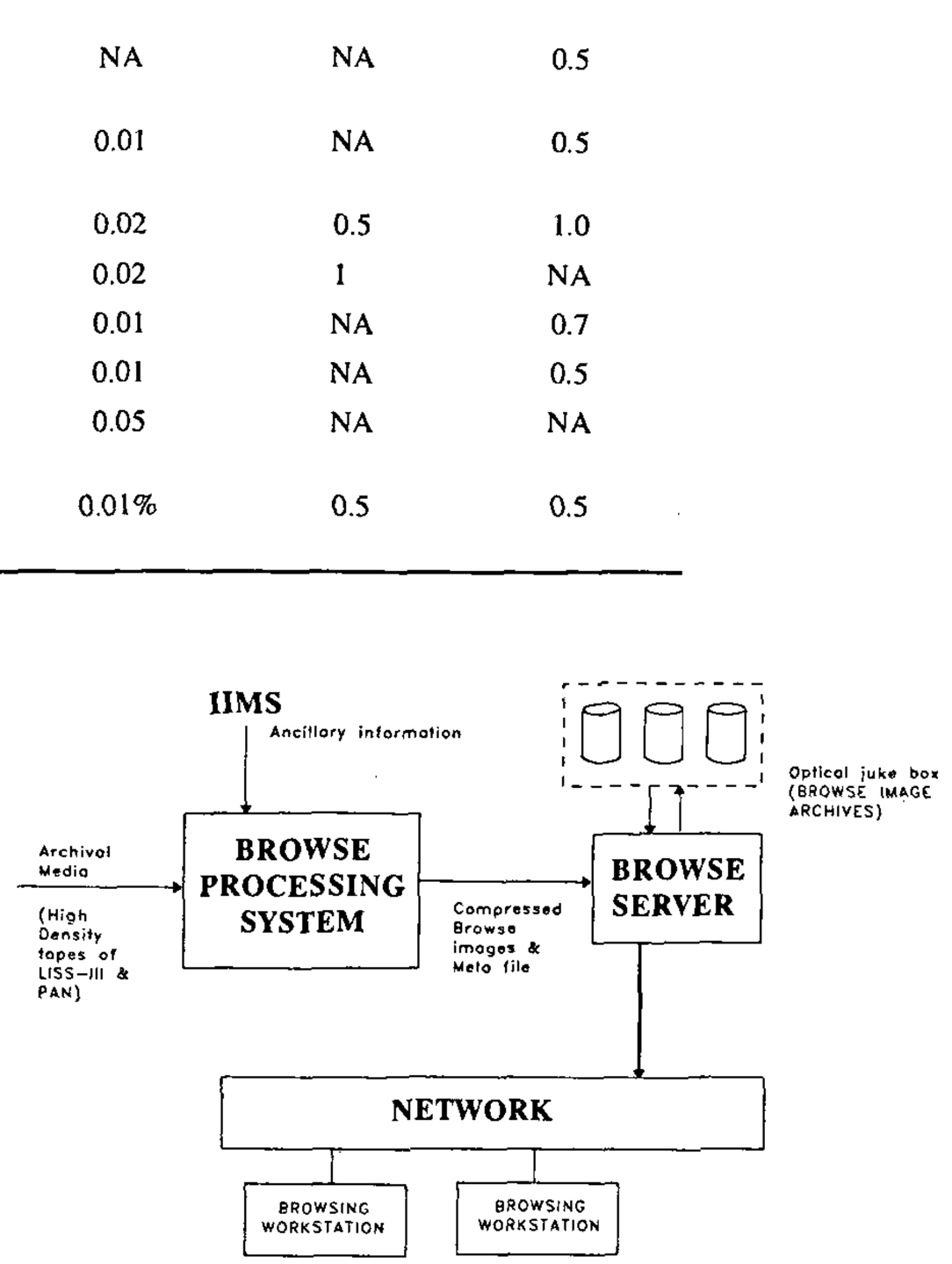


Figure 5. Browsing facility.

The browse facility consists of: (i) browse processing system, (ii) browse archival system, and (iii) browsing workstation(s).

Master film generation

Conversion of digital data to visual data is done using film recorder. In the film recorder, the digital data are converted into optical signals using light modulator. The output of the light modulator is proportional to the input digital data. This corresponds to the ground scene data from the tape.

In case of high resolution data received from panchromatic band the images are generated using Large Format Photowrite. In Large Format Film Recorder (LFFR), the large scale outputs are obtained by exposing 40" × 40" B/W film, B/W paper or colour negative film.

Photo Processing Facility

The sophisticated Photo Processing Facility (PPF) at NRSA is equipped with state-of-the-art technology systems such as photographic processors, contact printers, auto focus enlargers and quality evaluation and measuring devices, in addition to process monitoring and control systems, sensitometric lab, analytical lab, etc. The lab is specially designed and custom made for processing all types of satellite photo products. The facility was further augmented during 1995 with systems which are unique and capable of processing large format B/W and colour films as well as to generate large format B/W and colour contact films and prints.

Both small and large format photo products generation systems, as given in Tables 2 to 5, identified for IRS-1C task, are used for processing 36 types of B/W and colour master films and generating nearly 60 types of B/W and colour duplicate films and prints in the shortest possible turn around time, meeting the high quality and throughput requirements of the mission.

All the photographic products during the course of generation are subjected to a series of in-process control checks and extensive preliminary quality evaluation, prior to despatch to QC, for further inspection and dissemination to the users.

The products generated at the PPF are verified for quality at the QC work centre described in the next section.

Digital product quality check

All data products generated need to go through a quality check process in order to ensure the quality as per preset quality criteria. Digital product quality check system, checks the errors related to product media. This system extends a facility to check the media related errors in CCT, DAT, cartridge and floppy.

Photographic products quality

The photographic products are verified against established specifications. Any product deviating from the specifications is rejected at the quality control and is put through another cycle of generation till good quality product is generated, i.e. only those products which confirm to the specifications are accepted.

Table 2. Master film generation flow chart

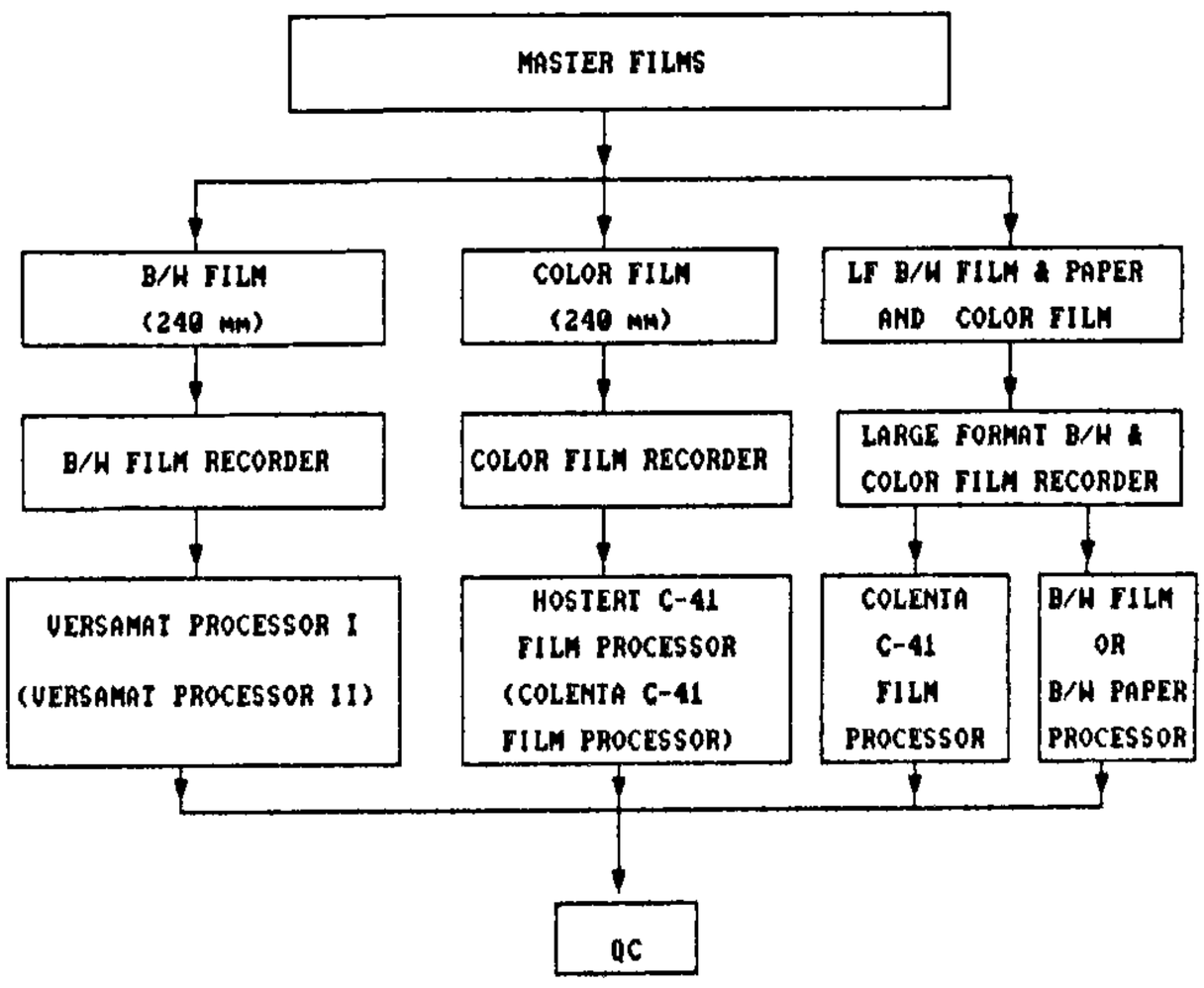


Table 3. Large format product generation flow chart

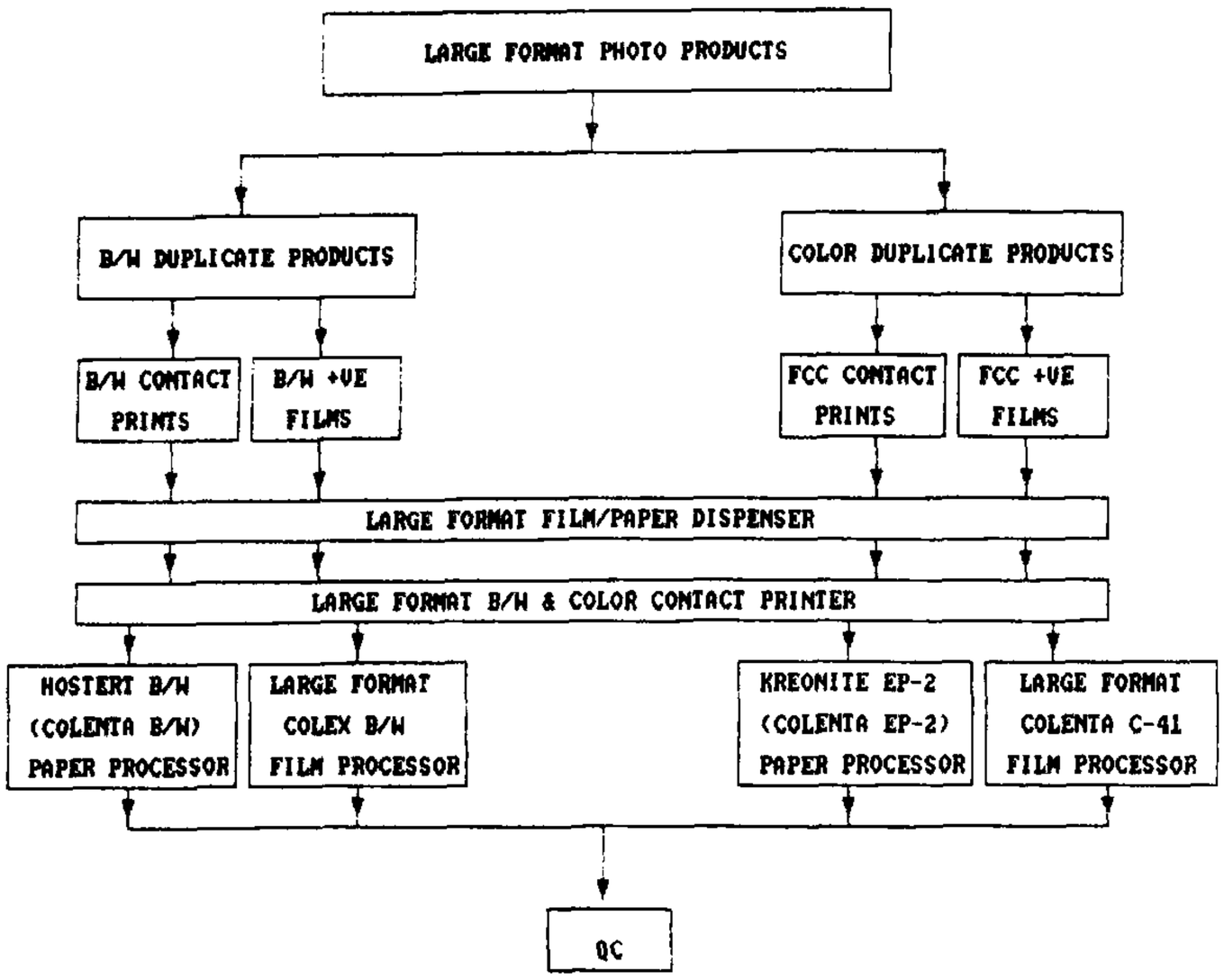
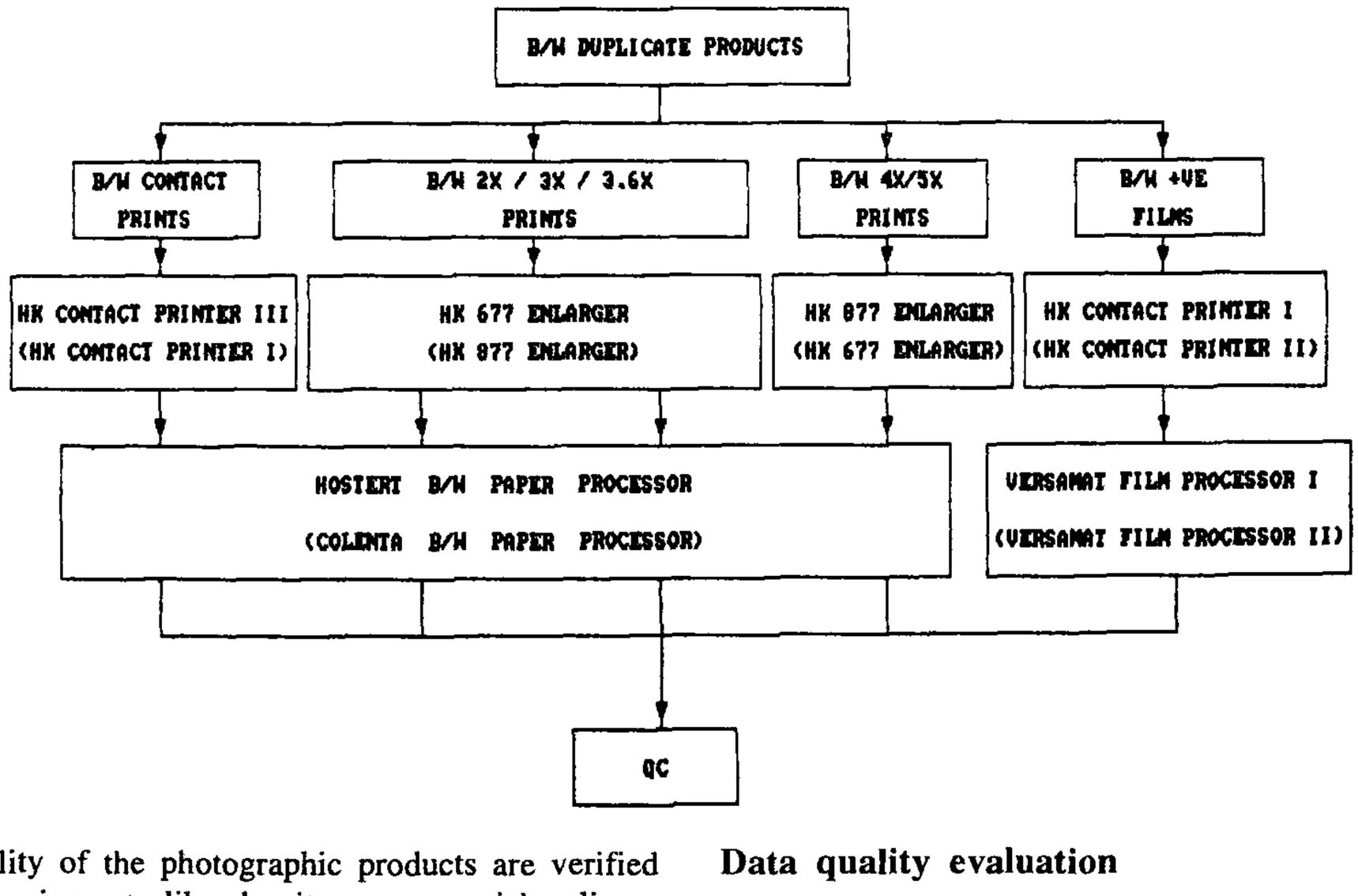


Table 4. IRS-1C duplicate photo products generation flow chart



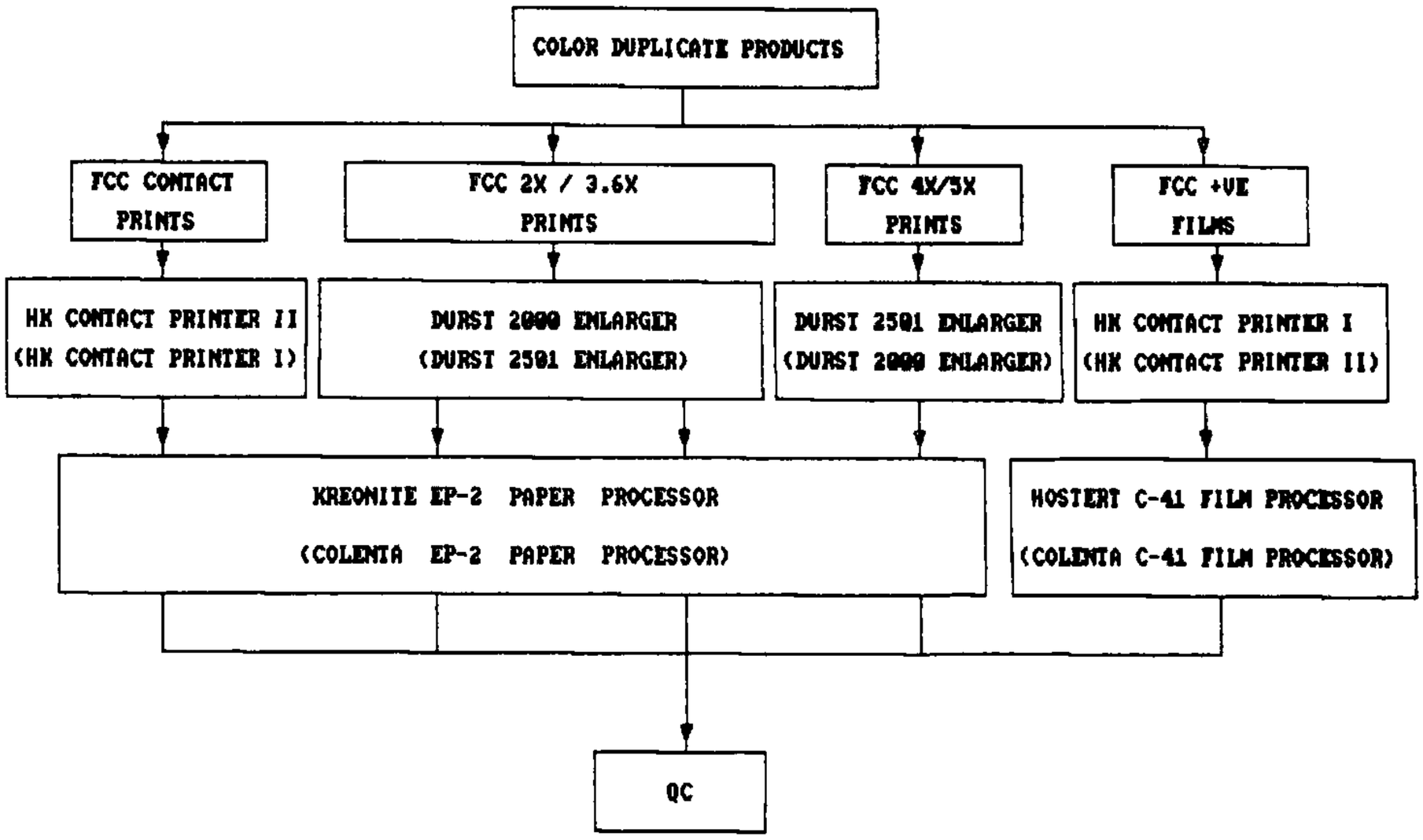
The quality of the photographic products are verified by using equipments like densitometer, precision linear measuring equipment, laminar air flow, light table, etc. Since the photo products go through the filming and photo processing systems, the parameters to be checked include density of master films, linearity of the gray scale, colour balance, dimension measurement, registration of tick marks and cosmetic defects like roller marks, scratches, fog, dust, finger prints, kinks, etc.

Data quality evaluation

The basic objective of data quality evaluation scheme for IRS-1C is to evaluate radiometric and geometric quality of data products. Radiometric quality is a measure of radiometric uniformity. Geometric quality is a measure of geometric inaccuracies caused due to platform attitude/orbit, sensor behaviour.

Prelaunch phase is used (a) to characterize detector

Table 5.



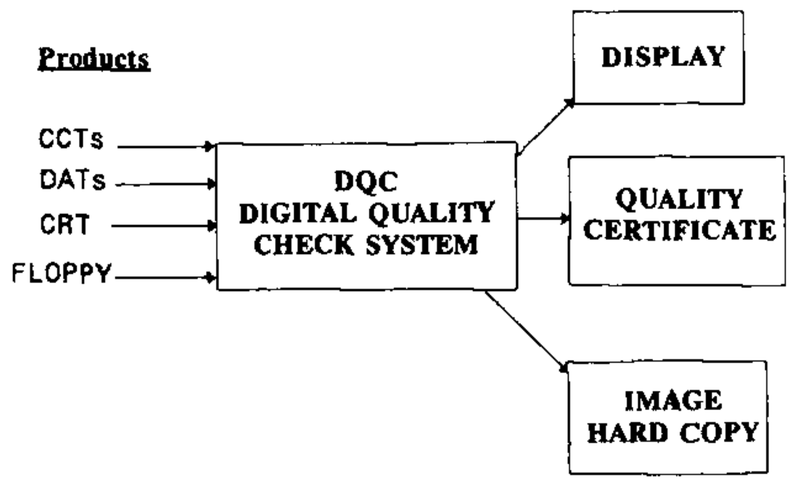


Figure 6. Digital quality check system.

performance on ground, in laboratory and thermovac chambers (b) to develop different algorithms/packages on identified systems which will be used to compare sensor/platform performance in various levels of data products.

Initial phase analyses sensor/platform performance at sub-system level and its impact on various levels of data products generated as user product. Radiometric quality is checked using raw/radiometric CCTs and geometric quality is checked using standard/geocoded products.

Operational phase is of longer duration where radiometric/geometric quality of data products are monitored routinely on sample scenes.

R&D phase is spread from initial phase to operational phase where accurate, detailed procedures for other radiometric/geometric aspect of sensor and data products are planned and developed to improve upon the current performances and providing feedback for improving future missions.

Radiometric parameters. Scene-based radiometric parameters are computed on target/scene. Histogram of the scene, target radiance to compare with other sensor's measured radiance values, dynamic range of scene and pass are a few parameters. The 'gain' and the sun angle also have an impact on these parameters.

Geometric parameters. These parameters quantify impact of (a) platform stability (orbit/attitude), (b) sensor/platform registration geometry [using RCPs (relative control points) and GCPs (geometric control points)], (c) Mapping accuracy of scene co-ordinates of a point on the image to a corresponding point on the ground.

The platform stability and mapping accuracy parameters are computed using GCP library. This library is a pre-defined database with latitude/longitude of known, measured ground control points. Video chip around GCPs of size 128×128 pixel area is stored. The parameters are location/tick mark accuracy, scale and internal distortion, sidelap/overlap of scene. The sidelap/overlap of two adjacent scenes of successive paths of the same cycle and same scene repeatability in two successive cycles is monitored.

Sensor-related registration parameters are band to band registration for LISS-III, WiFS and array registration for PAN. Results are stored in data bases to analyse the performance of the system and to monitor product accuracies.

R&D DQE parameters. These parameters include radiometric and geometric parameters. Radiometric parameters are modulation transfer function/effective resolution element (MTF/ERE) of sensors, intersensor calibration. Absolute calibration of sensors, which quantifies the error in detector-sensor characterization on ground, atmospheric characterization to remove atmospheric effect.