Title:/Titre:/Titel: LA QUALITE DES IMAGES ISSUES DU SYSTEME SPOT ET SON CONTROLE APRES LE ~~LANCEMENT~~ DU LANCEMENT.

Author (s)/Auteur (s)/Autor (en): G. BEGNI

Abstract:/Sommaire:/Zusammenfassung:

L'objet de l'exposé est double.

D'une part, il présente les principales spécifications et performances prévisibles de qualité des images issues du système SPOT (satellite + pré-traitement sol). Telles qu'elles ont été conçues pour rendre ces données aussi adaptées que possible aux besoins des utilisateurs. Les aspects radiométriques et géométriques sont présentés.

D'autre part, il montre comment les deux premiers mois après le lancement du satellite seront consacrés en priorité à évaluer les performances réelles du système sur l'ensemble de ces points (méthodes, plans d'opérations, résultats attendus).

Title:/Titre:/Titel:

"SPOT, a new generation of land remote sensing satellites"

Author (s)/Auteur (s)/Autor (en):
Gérard BRACHET, Chairman and Chief executive Officer, SPOT IMAGE, Toulouse, France

Abstract:/Sommaire:/Zusammenfassung:

With the launch of the SPOT 1 satellite in April 1985 followed by SPOT 2, planned for 1987, a new generation of operationnal land remote sensing satellites will begin. SPOT carries two identical High Resolution Visible (HRV) optoelectronics cameras operating in the visible and near infrared part of the spectrum. Each instrument, using CCD linear array detectors, can operate in either the panchromatic mode with a 10 meters ground sampling interval or the multispectral mode with a 20 meters sampling interval. The swadth is 60 km and the field of view can be oriented either along the vertical or at an angle up to + 27 degrees from vertical.

The image data are transmitted at a rate of 50 Mbits/second at 8 GHz either in real time or in a play back recorded mode.

The ground system will be briefly described as well as the image taking scheduling established at the Mission Control Center

Title:/Titre:/Titel: Results of the Test of the Commission C/OEEPE "Optimal Emulsions for Large Scale Mapping"

Author (s)/Auteur (s)/Autor (en):

Dr.-Ing. W. Brindöpke

Abstract:/Sommaire:/Zusammenfassung. The paper deals with the test programme of the Commission C/OEEPE which has been carried out 1982-1983.
A test field of 400 x 600 metres with varied topographical features and over more than one hundred signalized ground control or check points was photographed. Altogether 17 flights were performed under 2 different light conditions and using 9 different emulsions so that there were in total 57 models at the disposal of the test work. In the study an attempt has been made to determine whether or not there are significant over all differences, advantages or disadvantages in the use of different emulsions for the purpose of large scale mapping. The analysis deals with the photographic image quality and both accuracy and reliability of the restitution.

Title:/Titre:/Titel:

PRINCIPES DE REALISATION
DE LA COUVERTURE D'UNE ZONE GEOGRAPHIQUE
PAR LE SATELLITE SPOT

Author (s)/Auteur (s)/Autor (en): B. CABRIERES
A. CARIOU
G. PONCE

Abstract:/Sommaire:/Zusammenfassung:

Afin de raccourcir au maximum les délais de réalisation des couvertures de zones géographiques par des images SPOT, une méthode originale a été élaborée au Centre National d'Etudes Spatiales.

Cette méthode tient compte de l'orbite réelle et de la géométrie des instruments.

Elle permet :

- d'obtenir une couverture exhaustive et "sans trous" de la zone désirée
- de minimiser les recouvrements entre scènes
- d'optimiser la programmation des prises de vues.

Title/Titre/Titel: Kern Aerial Triangulation Package AETRI

Author(s)/Auteur(s)/Autor(en): Louis Cogan
Kern & Co. Ltd. - Aarau
Switzerland

Abstract/Sommaire/Zusammenfassung

This paper outlines the KERN AERIAL TRIANGULATION PACKAGE, AETRI for use with the KERN STEREO RESTITUTION INSTRUMENTS DSR-11 and DSR1.

An explanation is given of the concepts and theory behind the formation of the package, which includes: DATA COLLECTION, STRIP FORMATION, STRIP TO GROUND AND STRIP TO STRIP ADJUSTMENT, BLOCK ADJUSTMENT.

A description of the inputs, outputs and use of the software highlights the ease of operation of the Aerial Triangulation programs. The user is guided through all the procedures by the Kern Menu System. Features such as digital transfer, on-line checking of results, on-line editing of points etc. are explained, and examples of the menus and results are given.

All the output files are ASCII coded and thus compatible with block adjustment programs.

The output files may be used directly as input to bundle or model block adjustment programs e.g. BLUH, or may be easily processed to obtain the desired input.

Title:/Titre:/Titel:

Photographic Systems for Space

Author(s)/Auteur(s)/Autor(en):

Frederick J. Doyle

Abstract:/Sommaire:/Zusammenfassung: Since the Soyuz 22 mission in 1976, the USSR has been operating the MKF-6 multi-spectral film camera built by Zeiss Jena. The camera is now carried on the manned spacecraft Salyut 7 with film retrieval and supply by the Soyuz missions which transfer crews. The USSR also operates film return cameras for Earth resources observation in the Cosmos series.

The European Space Agency has supplied a 3023 Zeiss camera for operation from the manned module of Spacelab-1 scheduled for Space Shuttle mission STS-9. The camera will produce ground resolution of about 20m/line pair and will be used for topographic mapping at scale 1:50,000.

NASA has built the Large Format Camera with stellar Attitude Reference System for use on Shuttle Missions STS-14 and STS-17. Studies have been conducted for mounting the camera on a free flying spacecraft together with panoramic cameras which would provide data adequate for 1:25,000 mapping.

Title:/Titre:/Titel:

The Shuttle Imaging Spectrometer Experiment

Author (s)/Auteur (s)/Autor (en):

Alexander F. H. Goetz

Abstract:/Sommaire:/Zusammenfassung:

A new instrument concept for collecting image data in many spectral bands simultaneously has been proposed for a Shuttle flight. The Shuttle Imaging Spectrometer Experiment (SISEX) will acquire images in 128 spectral bands simultaneously over the region 0.4-2.5 µm. The purpose is to acquire a complete reflectance spectrum of the surface in each picture element in order to identify cover materials.

With data from existing remote sensing systems such as the Landsat Thematic Mapper, in which data in only seven spectral bands are acquired, direct indentification of materials is possible in only a few cases. The SISEX will open a new era in orbital remote sensing of the Earth's surface.

This research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

Title:/Titre:/Titel:

Imaging Spectrometry: Results in Remote Identification of Vegetation Species and Minerals

Author (s)/Auteur (s)/Autor (en):

Alexander F. H. Goetz, Barrett N. Rock

Abstract:/Sommaire:/Zusammenfassung:

Recent developments in dectector technology have allowed the development of imaging instruments that acquire data in a large number of contiguous spectral bands simultaneously. The first instrument developed at JPL, the Airborne Imaging Spectrometer (AIS), has been used to acquire data over vegetated and bare soil surfaces in 128 spectral bands in the 1.2-2.4 µm region. Results show that, unlike broad band imaging systems, the AIS can be used for identification of vegetation species and minerals based on the continuous reflectance spectrum acquired for each picture element. For instance, in the Cuprite mining district, Nevada, direct identification of kaolinite and alunite were possible in images acquired in 32 categories bands 9.6 nm wide in the region 2.03-2.32 µm. The AIS is the first sensor in a series to be constructed, ultimately leading to an orbital capability.

This research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

"PROCESSING OF AERIAL PHOTOGRAPHY"

by: Ron Graham AIC Ltd, U.K.
Rolf Lorenz, ITC, Holland.
Mahmud Hassan, MSD, Syria.

Abstract:

Despite a history of more than 60 years of continuous improvement to the physical and chemical properties of aerial films it is surprising to find that, by comparison, relatively little change has attended the attitudes to their processing. By their nature, mapping films have always required special attention in terms of their length and size, with processing methods traditionally divided into (i) Rewind Spool, or (ii) Continuous Processing Machines, according to either operational constraints, economics, or logistical demands.

Whereas special processing formulation, replenishment-rates, and temperature are controls readily accepted with expensive installations, it would seem that Rewind Spool processing is generally carried out in a relatively arbitrary fashion without resort to any special developers or sensitometric control.

In this paper the authors' compare general processing methods, formulae, and the standards of quality to be expected with modern materials available to the world of aerial survey. The ideal developer for survey is defined, and special reference is made to the authors' recently formulated IRD-3 two-bath developer for Rewind Spool processing of mapping films.

Title:/Titre:/Titel:

SOME INVESTIGATIONS INTO OMTIMIZING EXPOSURE AND PROCESSING FOR AERIAL PHOTOGRAPHY

Author (s)/Auteur (s)/Autor (en):

J. HORN & J. TUGWOOD

Abstract:/Sommaire:/Zusammenfassung:

In order to ensure the optimum reproduction of terrain information in the final aerial photographic product, it is essential that the scene luminance values are initially recorded on the negative at the required density levels. This may only be achieved when a) the shape of the aerial film characteristic curve is chosen to suit the particular ground scene and atmospheric conditions, b) an appropriate camera exposure is chosen. In order to satisfy these conditions, information is needed on a) characteristic curve shapes for all available film and development combinations, b) maximum and minimum scene luminance values measured at the time of the mission.

Experimental work has been carried out to produce characteristic curves (from which effective aerial film speed and average gradient values were derived), for 6 different aerial films developed at a range of speeds in a Versamat 11C using Agfa G74C developer. Attempts were made to use a digital spot luminance meter in flight to measure the maximum and minimum scene luminance values, from which the required film contrast and exposure were calculated using a programmable pocket calculator.

Title:/Titre:/Titel:

Progress in Improving Performance of Zeiss Aerial Cameras

Author (s)/Auteur (s)/Autor (en):

Prof. Dr.-Ing. H.-K. Meier

Abstract:/Sommaire:/Zusammenfassung:

The quality of the photographic results is of decisive importance for the subsequent photogrammetric evaluation processes. This applies to the accuracy and interpretability in plotting on the one hand and to cost-effectiveness and, quite generally, to the choice of working methods on the other hand.

Improvements of performance may therefore not only lead to increased cost-effectiveness but also to a clearly extended field of application.

Making use of the most up-to-date technological developments, Carl Zeiss Oberkochen has always been able to attain a remarkable standard in this sector. The line of camera lenses, for example, is characterized by superior image quality and freedom from distortion.

The paper presents the lastest progress made in the RMK system and its effects on practical photogrammetry.

Title:/Titre:/Titel:

A Study on Simulation of Three Dimensional Measurement with Use of Stereo Linear Array Sensors

Author (s)/Auteur (s)/Autor (en):

Shunji Murai, Institute of Industrial Science, University of Tokyo
and Ryosuke Shibasaki, Research Institute of Public Works

Abstract:/Sommaire:/Zusammenfassung:

The study deals with simulation woth respect of accuracy of orientation for stereo linear array sensors of fore and aft mode and side looking mode.

Automated mapping with image matching for two dimensional window has been developed.

Simulation has been done for two cases of B/H ratio, 0.5 and 1.0 for checking the accuracy of three dimensional measurement.

some new results will be added to the papers submitted to Com.I and Com.IV Symposium in 1982.

Title:/Titre:/Titel:

Image and Geometry Effects of Operational Environments on Aerial Cameras

Author (s)/Auteur (s)/Autor (en):

Clarice L. Norton/Lorin C. Peck

Abstract:/Sommaire:/Zusammenfassung:

Aerial cameras frequently perform their missions in unfriendly environments which have degrading effects on the recorded image. In many cases there is a big difference between the well-defined image produced by the camera in the environmentally controlled laboratory, and the image obtained from the aerial platform. There is a need to better understand the sensitive characteristics of aerial cameras, so that their image response to the harsh operational environments may be prevented, or at least reduced. These are discussed with references to previous studies.

Title:/Titre:/Titel:

Automated Scanning an Digitizing of multilayered cartographic Map information

Author (s)/Auteur (s)/Autor (en):

Dr.Gunter Oesterhelt

Abstract:/Sommaire:/Zusammenfassung:

Experiences are described with an automated scanning and digitizing system for multilayered cartographic,cadastral and cultural maps to create a structured computercompatible geometry database together with the structuring feature codes.
Quality and achieved accuracy of map data capturing related to geometry and structure logic are analyzed and a complete system application approach is presented for an automated cartographic database systeem.

Title:/Titre:/Titel:
OPTICAL-HOLOGRAPHICAL PHOTOGRAMMETRIC DATA PROCESSING AND STORAGE

Author (s)/Auteur (s)/Autor (en):
Dr.eng.Nicolae Răducanu

Abstract:/Sommaire:/Zusammenfassung:
Some aspects and results regarding both the filtering of remote sensing recordings obtained by optical-electronic investigating systems within the space frequency,and optical-holographical storage of the topographic and photogrammetric data referring to visualized photograph,maps,and texts,finally to be presented using photographic means are discussed in the paper.

A device for optical filtering in coherent light, hologram making and plotting has been developed to be used in practical experiments.

Title:/Titre:/Titel:

The equipment system of VEB Carl Zeiss JENA for the remote sensing of the earth

Author (s)/Auteur (s)/Autor (en):

Prof. Dr. Klaus Szangolies, VEB Carl Zeiss JENA, 6900 Jena, DDR

Abstract:/Sommaire:/Zusammenfassung:

On the basis of available practical experience in the production of photographs of the earth's surface from satellites the various techniques can be subdivided into two fundamentally different groups: 1. Scanner technique and digital image transmission to ground stations and 2. photographic exposure technique with transportation of the films back to earth by landing modules.
The advantages of the ist group lie especially in the low expense of time for image transmission to earth and the flexible adaptation to desired spectral ranges. Disadvantages are the limited resolving power (detail recognizability: 20-80m referred to the erarth's surface) and the restricted geometric accuracy.

Title:/Titre:/Titel:

Measures of Data Quality for Photographic, Electro-optical and SAR Imaging Systems

Author (s)/Auteur (s)/Autor (en):

Trinder, J. C., Welch, R.

Abstract:/Sommaire:/Zusammenfassung:

Imaging sensor systems designed to acquire data from aircraft and satellites include: 1) photographic; 2) electro-optical; and 3) synthetic aperture radar (SAR). Performance parameters such as modulation transfer functions (MTF), spatial resolution, radiometric resolution and signal-to-noise ratio are examined in relation to data quality requirements for topographic, thematic and image maps. Particular emphasis is placed on recent and planned satellite missions.

Title:/Titre:/Titel:

Comparison of Calibration Procedures

Author (s)/Auteur (s)/Autor (en):

H. Ziemann

Abstract:/Sommaire:/Zusammenfassung:

The project Comparison of Calibration Procedures is summarized. This project commenced in 1974. The agencies participated and provided input data for fifteen different calibrations of the same two reseau cameras. The efforts of the last four year period were directed primarily towards the development of a standard model for the treatment of the data. The majority of the data have now been processed using the developed model. The results have been proven to be quite similar for the different procedures.

Invited paper.

Title:/Titre:/Titel:

The interrelationship between calibration parameters determined by system calibration and self-calibration

Author (s)/Auteur (s)/Autor (en):

H. Ziemann, S.F. El-Hakim

Abstract:/Sommaire:/Zusammenfassung:

Several sets of aerial photography forming 3x3 blocks were analyzed to determine the effectiveness of self-calibration models to recover known but uncorrected effects of image deformation consisting of film deformation and lens distortion. The photographs were flown simultaneously with two different reseau cameras; several photogrammetric test fields were used for the project. All available targeted points were used as control.

Invited paper.

SAR Calibration Techniques

D.Corr *

A.Woode **

S.Bruzzi ***

* Systems Designers Limited

** ESA/ESTEC

*** ESA/Earthnet

Commission II

1. INTRODUCTION

This poster session intends to outline with examples how the back-scattering coefficient of a given area can be restituted, and to which degree of accuracy. It is acknowledged that there is a requirement to calibrate other measurements than the back-scattering coefficients (see sect.2) but, at this stage, the straight system monitoring requirements, as outlined in section 3, seem to lead to a calibration scheme which allows only restitution of the back-scattering coefficient.

2. Objectives of Calibration for a Spaceborne Synthetic Aperture Radar:

1. to restitute accurate information on an absolute scale of the backscattering coefficient of the sensed area.
2. to restitute an accurate estimate, on an absolute scale, of geophysical parameters which can be derived from the radar data. Examples are :
   - soil moisture
   - wave spectra and direction
   - wind speed
   - etc.
3. to allow multitemporal comparisons of measurements/estimates both of the backscattering coefficient and of derived geophysical parameters.

General Approach :

The radar equation can be represented in a "simplified" form like :

$$S = F\ (T, \quad , \quad , R, P_t, P_i)$$

T = Time

= Depression angle

= Transmitted wavelength

R = Range

P_t= Transmitted power

P_i= Power derived from the scene being analyzed

S = A geophysical parameter of interest on the radar cross-section, depending on the requirements.

F = the global transfer function of the system

If the required output is a geophysical parameter of interest, to be restituted and calibrated, the function F will include the required modeling parameters.

If an assumption of time invariance of the main parameters is made (P_t, , etc.) the function F is no longer time dependent and its identification fully characterizes the system.

Therefore, if the function F is known, the parameter S, being investigated can be derived from the image data themselves.

$$S = F'\ (P_i)$$

where F' is a modified F for a given set of all variables, except P_i.

The identification of F, or F', is the objective of the calibration in this approach.

Two cases are easily distinguished :

- relative calibration
- absolute calibration

In this approach, even if the absolute calibration may be difficult to achieve, the relative calibration of the parameter S can be achieved if the function F can be determined to within some constants.

Assumptions:

- The function F must have a "manageable" degree of complexity.
- The measurements required in order to characterize the function itself are to be performed on the resulting image. The identification of the parameters to be measured and their accuracy is a major task.

Limitations:

- The function F may result as extremely complex and therefore :
  - be difficult to define
  - be difficult to be applied to the data

3. SYSTEM MONITORING REQUIREMENTS

Before considering the practical details of SAR calibration, in connection with the SAR-580 and the ERS-1, we extend the fundamental ideas of calibration already described.

The idea behind relative calibration is that any variation in the overall system is compensated for in order to make inter-comparison of measurements. The overall system includes both the satellite (or airborne) system and the image processor: Fig. 1 shows a simplified system block diagram. The principle system elements which may potentially be subject to variations are:-

a) Chirp waveform generator (SAW).

b) High power amplifier.

c) Receiver.

d) SAR antenna.

e) Miscellaneous system components e.g. circulators.

f) SAR processor.

Items a) to e) are all sensitive to temperature variations; component aging and variations in supply voltages can be other factors. The gain of the SAR processor can vary through range compression waveform mismatch and (principally for airborne systems) inaccurate azimuth compression due to the effects of random motion.

Monitoring of the systems can have several different applications:

a) Direct application. For example, transmitter power monitoring.

b) Application to the processing strategy. For example, chirp replicas could be obtained to be used directly as the range compression replica in the SAR processor.

c) Reliability assessment of calibration. For example, there could be mechanical sensors monitoring the alignment of the antenna structure. In the event that only insignificant changes were measured then calibration would not be affected by the antenna.

4. CALIBRATION PHILOSOPHY

End to end calibration is the only way in which complete confidence in the system can be obtained. If relative calibration is desired, accurate standard targets must be used. Corner reflectors can be both accurately made and absolutely calibrated. Therefore when high accuracy is required absolute calibration can be performed as easily as relative calibration.

It is not practical to have worldwide distribution of calibration sites. It may be several days between observation of standard targets. As well as random system variations, for a satellite system there may also be cyclical effects correlated with the position of the satellite within its orbit. Monitoring the system parameters will show what changes are taking place.

It is possible to use a processing strategy which directly eliminates all of the principle system variations except for variations in the antenna gain. It might be possible to compensate for variations in the antenna structure by using a theoretical model; this is desirable because measurements using a large number of calibrated targets would be vastly expensive.

The SAR processor is an important element of the overall system, however its operation cannot be measured unless the input data has both the chirp FM, doppler FM and data range walk necessary for its operation. Obviously, passive external targets provide this data but echo data can be simulated (using a chirp replica) to have the necessary doppler and range characteristics for focussing by the SAR processor. This simulation does not necessarily have to take place on board, or in real time; providing the replicas are available it can be performed off line on the ground.

By using simulation end-to-end monitoring of the complete system, except the antenna and connecting microwave systems, can be performed. If cyclical antenna effects are found to be negligible, then end-to-end relative calibration is achievable. This means that simulation would effectively allow a standard for relative calibration to be available worldwide. Further, calibration could be made absolute by the use of a single calibration site.

When external targets are used for end-to-end calibration, it is desirable to use targets which are as large as is practicable; this overcomes measurement error caused by ground clutter. However, it is also necessary to verify the system linearity so that calibration can confidently be predicted for other operating levels. This can be achieved by measuring replicas which have passed through the system, but have been subjected to different amounts of accurate attenuation. Range compression can be used to facilitate this measurement.

5. SAR-580

The European Space Agency, and the Joint Research Centre of the European Community have recently performed an extensive experimental campaign using the SAR-580 airborne SAR system. Part of this campaign was concerned with calibration. Two test sites were used, one at DFVLR and one at RAE Bedford, on which a large number of accurately made corner reflectors were sited.

The corner reflectors used were accurate absolute standards. It would therefore be possible, by repeated viewing, to verify if both relative and absolute calibration were achievable.

It was found that there were several practical difficulties which would have to be overcome if calibration was to be achieved; these were:-

a) Unpredictable FM chirp variations.

b) Random aircraft motion due to turbulance.

c) Unknown SAR antenna characteristics.

d) Unknown aircraft attitude.

Items a) and b) caused changes in the focus of the SAR processor in range and azimuth respectively. These variations were largely overcome by the use of an integration method of energy measurement. This method is much less sensitive to system focus than the peak method of energy measurement.

The determination of the antenna profile across track (item c) was one of the main outcomes of the data analysis.

The aircraft attitude was not known because of indadequate instrumentation. It was possible to overcome this, and to determine the antenna profile, as a result of both a large number of passes and a large number of reflectors on each site (53 reflectors over the two sites, and selected best 20 passes).

The benefit of the SAR-580 campaign was that the experience gained highlighted all of the potential difficulties of calibration. The techniques used have been described in ESA SP-193 p119-132, in the next section we summarise these techniques in the context of ERS-1.

6. ERS-1

Figure 2 shows a simplified block diagram for the system.

There are several possible calibration strategies, the choice of which depends on the calibration requirements, funds available, and the system performance (i.e. stability). As an example we could suppose that cyclical antenna variations are negligible and that the antenna characteristics are as designed or have been measured. The following strategy shows the principles which could achieve worldwide absoulte calibration.

Absolute Calibration

Accurate trihedral corner reflectors will be imaged. The energy for the reflectors is measured by summing the squares of pixel values in the vicinity of a target. A correction can be made for the energy contribution from the background; this correction can be determined from the image away from the target (see Fig.3).

The actual cross section of the reflectors can be determined from calibration data for the appropriate viewing angle. The effect of range and the two-way antenna gain can be equalised.

The target cross section σ_T is related to the measurements in the following way:-

$$F_T = \frac{R_T^4}{A_T^2} \left(\sum_N \phi_i^2 \, dA - \frac{N}{M} \sum_M \phi_i^2 \, dA \right) \cos \theta_T \quad (1)$$

where

ϕ_i are the pixel values taken from a plan range "amplitude" - type image product of a corner reflector

N = the number pixels taken in the region of a target.

M = the number pixels taken in the surrounding region.

dA = area of pixel grid (i.e. along track pixel spacing x across track pixel spacing)

R_T= slant range from satellite to target.

θ_T= surface grazing angle at the target.

A_T= antenna gain in the direction of the target.

All of these parameters are known.

(When several reflectors are used average values can be determined in the manner described).

Whence $$\sigma_T = \frac{C_A \, k \, F_T}{G_p \, G_s \, P_T}$$

where P_t= transmitter power level.

G_s= Receiver and other variable system gains or losses.

G_p= SAR processor gain.

K = Constant: static system gains or losses, numerical constants etc.

C_A= Constant related to the size of the integration area.

With the measurement strategy to be described these quantities do not need to be measured directly.

The constant C_A arises because a finite rather than an infinite area is used in the surface integration over the point target region (this account could typically be about 1.02).

A simulated image of point targets is measured in a similar way. The noise contribution to this measurement is negligible and can be omitted. The important factor in simulation is that the replicas used are obtained using an accurately set attenuation. (If it is necessary to use different attenuation for simulation on other occasions, the difference in attenuation must be known and allowed for). The simulation target's cross section is related to the measurements as follows:

$$F_x = \left(\sum_N \phi_i^2 \, dA \right) \cos \theta_x \qquad (3)$$

where

ϕ_i are pixel values in an image of a simulated point target.

θ_x = surface grazing angle at the target.

Whence the target's cross section σ_x is given by:

$$\sigma_x = \frac{k \, F_x \, G_A \, C_A}{G_p \, G_s \, P_T} \qquad (4)$$

where

G_A = an accurate attenuation used in deriving the replicas for simulation.

The parameters G_p, G_s and P_t are the same as in Eq. 2 because the replicas are obtained close to the time of imaging the targets.

On another occasion when it is desired to make a measurement, say of the scattering cross section of a uniform surface, then a simulation is made using data obtained at this time, and the image is measured.

The simulation targets cross section is related to the measurments as follows:-

$$F_x' = \left(\sum_N \phi_i^2 \, dA \right) \cos \theta_x' \qquad (5)$$

whence (6)

$$\sigma_x = \frac{k \, F_x' \, G_A \, C_A'}{G_p' \, G_s' \, P_t'}$$

The quantities C_A', θ_x', G_p', G_s', P_t' have the same significance as before but refer to the system operating on a different occasion. The factor C_A' must be determined either from the simulated image or theoretically.

The scattering cross section σ_o per unit surface area would be determined by measurement of the image as follows:

$$F_o = \frac{R_o^4}{A_o^2} \frac{\left(\sum_Q \phi_i^2 \, dA\right) \cos \theta_o}{\sum_Q dA} \tag{7}$$

where ϕ_i are pixels from the region which is being measured.
Q is the number of these pixels.
θ_c =surface grazing angle at the centre of region.
R_o =slant range to the centre of the region.
A_o =antenna gain at the centre of the region.

Whence

$$\sigma_o = \frac{k F_o}{G_p' \, G_s' \, P_t'} \tag{8}$$

Using Eq. 2,4,6,8 the desired calibrated measurement is obtained:

$$\sigma_o = \sigma_T \frac{F_o \, F_x}{F_T \, F_x' \, C_A'} \tag{9}$$

The principle sources of error are:

i) image measurement

ii) corner reflector accuracy

iii) antenna gain equalisation error due to attitude uncertainty.

The predicted calibration error is

- Random
- Bias

Using a calibration site containing - corner reflectors whose side length is - cm.

There are several benefits of this strategy:

(1) The users processor can be different to the processor used for calibration.

(2) There is no need for a large number of auxiliary measurements or parameters describing the system operating gains used.

Calibration is a detailed subject; within the scope of this poster it has only been possible to state the most important factors. Under certain circumstances simplification of the strategy is possible.

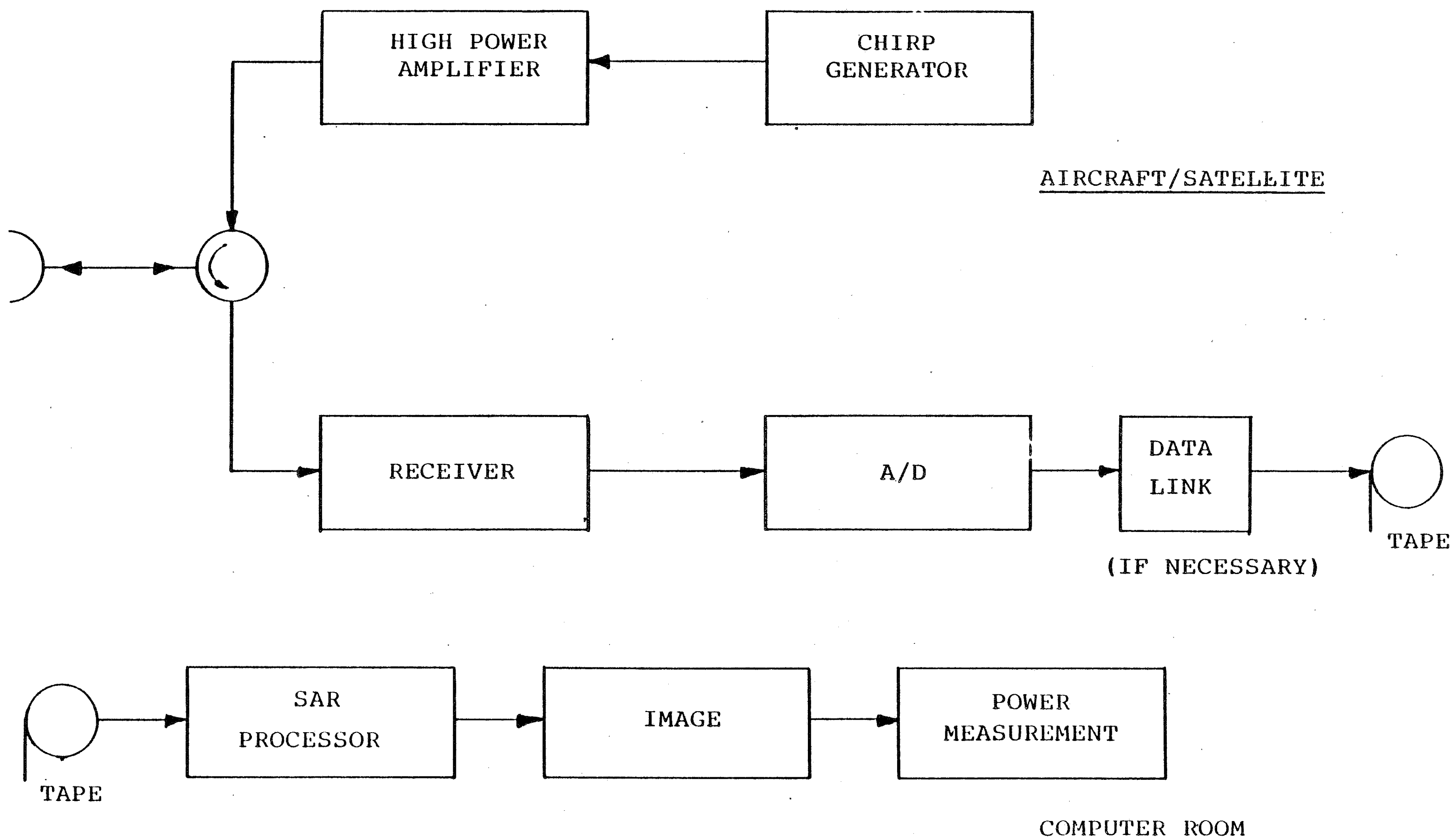

FIGURE 1: SIMPLIFIED OVERALL SAR SYSTEM

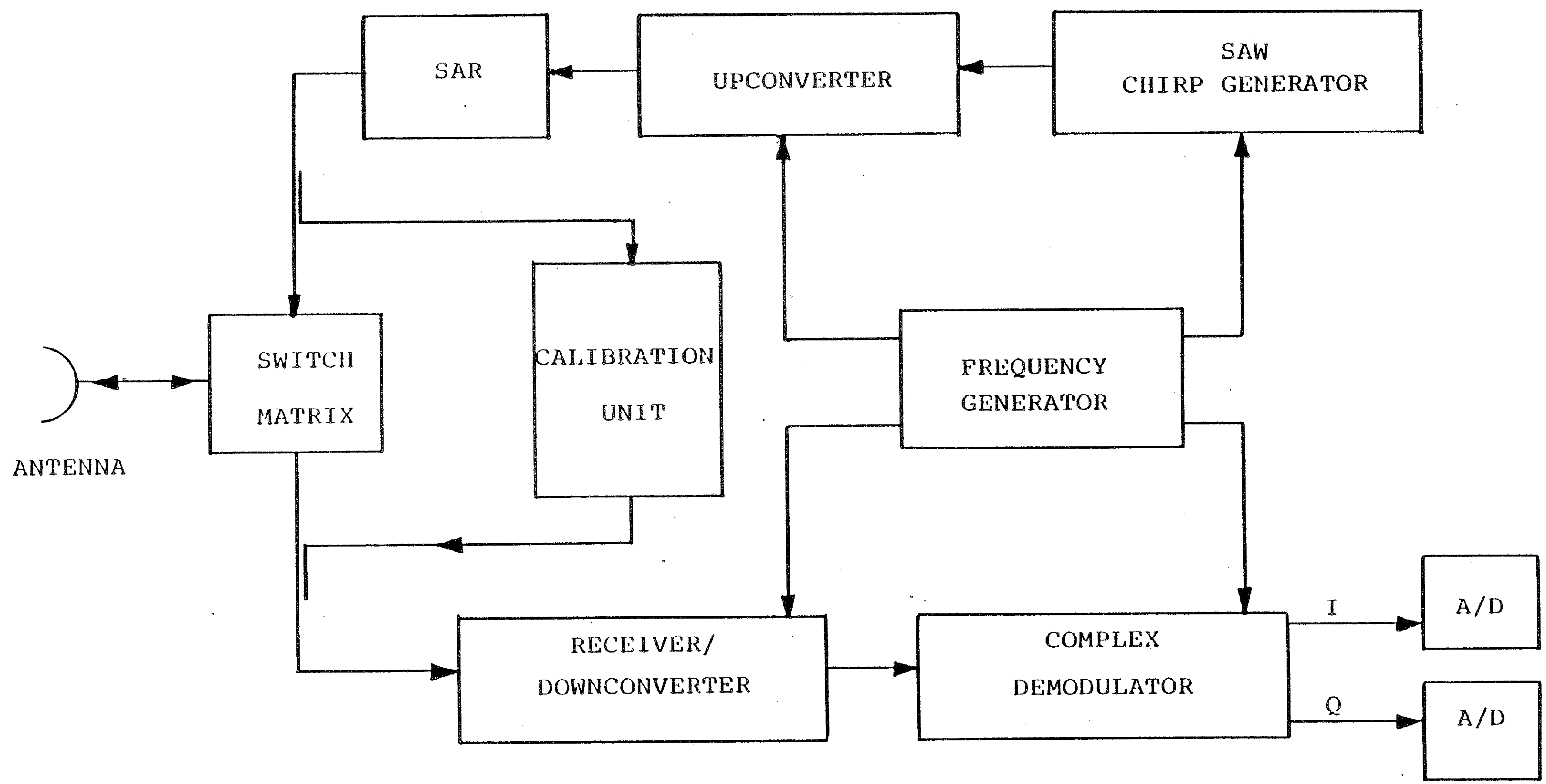

FIGURE 2: SIMPLIFIED ERS-1 SAR SYSTEM

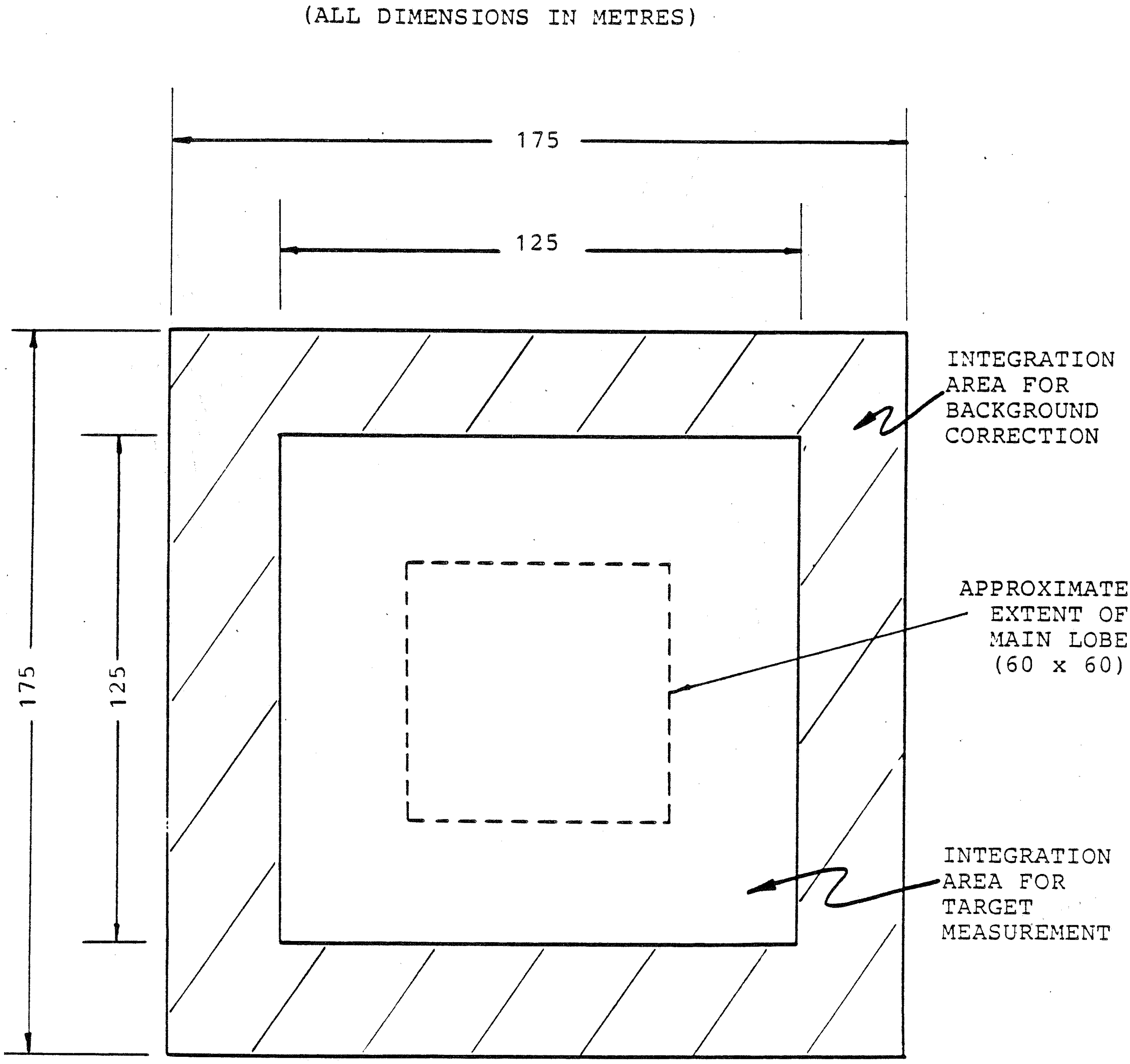

FIGURE 3: TYPICAL AREAS FOR INTEGRATION METHOD