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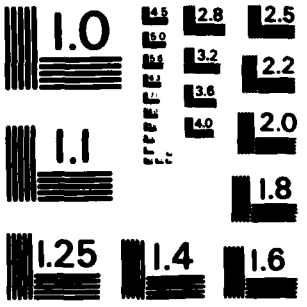

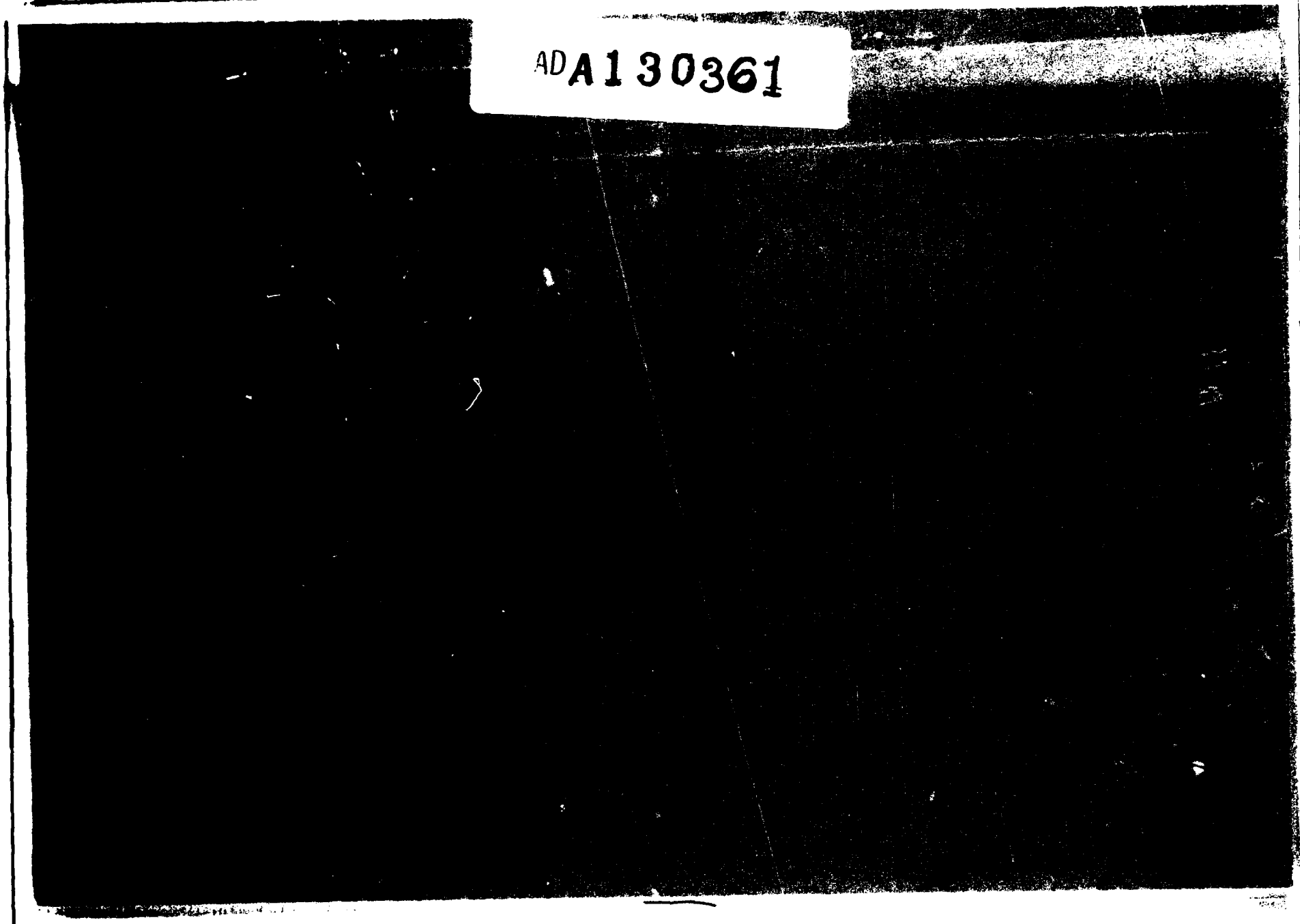

ROYAL AIRCRAFT ESTABLISHMENT

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SPINE - A PAPER PRESENTED TO THE INTERNATIONAL SOCIETY OF PHOTOGRAMMETRY AND REMOTE SENSING (AUGUST 1982, OTTAWA) ON THE APPLICATION AGRISPINE

by

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SUMMARY

The Memorandum reproduces a paper entitled "AGRISPINE: A Demonstration of the Rapid Dissemination of Remote Sensing Data" presented at the Ottawa meeting of the ISPRS (August 1982). This paper describes a long term data collection and dissemination campaign which was, at the time, being undertaken by RAE, in cooperation with a number of European agencies.

LIST OF CONTENTS

1 INTRODUCTION

During 1978 the UK Space Technology Programme gave support to the development of a low cost earth station which the European Space Agency (ESA) had specified[1] to be compatible with the data transmission tests envisaged for the Orbital Test Satellite (OTS). This satellite is the forerunner of the European Communications Satellite (ECS) which is shortly to come into service for pan-European communications under the administration of Interim EUTELSAT. It is probably due to the ongoing successful operation of the data transmission tests[2], and the growing need for high data rate transmissions, that has persuaded the European PTT administrations to provide a satellite multi-service system (SMS) on the ECS flight model 2. SMS will offer facilities for the transmission of data, text, images and voice.

The Royal Aircraft Establishment has been actively involved in the data transmission tests authorised to use OTS facilities and is a participant in the international Space Informatics Network Experiment (SPINE). This project has reached a pre-operational stage in which network nodes (four stations at present) regularly transmit LANDSAT remote sensing data for onward processing at the receiving stations. A further project, AGRISPINE, has been conceived as a suitable application, using the SPINE infrastructure, to demonstrate the advantages of satellite communications in the transfer of bulk digital data for fields of research where rapid delivery of data is essential. A number of time-dependent tasks have been chosen to take part in this experiment; these include, the long-term monitoring of crops and forest growth at test sites within the UK (hence the name AGRISPINE), glacier movement in Greenland and sea ice characteristics in the Gulf of Finland. The principal investigators for these applications, under the leadership of the RAE, have formed an agreement to participate in AGRISPINE over the UK growing season - March until November 1982.

2 THE SPACE INFORMATICS NETWORK EXPERIMENT (SPINE)

SPINE is an ongoing international cooperative project which seeks to investigate the suitability of the satellite link for transferring bulk digital data at megabit rates between small customer-located earth stations. Responsibility for the coordination of the experiment lies with ESA, whereas the authorising body for scheduled use of the space segment (OTS) is Interim EUTELSAT.

SPINE has been allocated operating frequencies within the channel bandwidth of the OTS module B transponder. The repeaters of this transponder have a receive bandwidth of 5 MHz centred on 14.4575 GHz; this is translated by satellite circuitry to a transmit centre frequency of 11.7950 GHz. Module B is designed to receive circularly polarised signals, the sense of this polarisation is also transposed by the repeaters.

Thus the earth segment for SPINE was required to have characteristics compatible with the facilities offered by OTS; namely, to provide circular polarized transmission at fixed frequencies within the 11 and 14 GHz bands and at suitable power levels. The digital transmission rate through the satellite was chosen to be 2 Mbit/s, so as to match the input/output speeds of earth terminal peripheral equipment. Error correcting facilities were to be included in the terminal design, such that the satellite link would not

introduce a degradation, in terms of bit error rate, compared with those normally achievable with computer "back-to-back" communications. A rate-½ convolutional encoding and Viterbi decoding system was specified; this meant that for a satellite channel rate of 2 Mb/s, the lower rate of 1 Mb/s would be achievable for the source data. The earth terminal elements are shown in Fig 1, where it can be seen that the earth station installation includes a channel synchronizer, which provides data scrambling/descrambling and data burst timing; a computer interface module, which packages the serialized data coming from the link driving mini-computer (LDC) into high level link control (HDLC) frames (and the inverse) and, finally, the LDC which provides the high level link control and input/output functions for media peripherals and operator's console. Thus, once a link is established between two SPINE terminals, data from, say, a magnetic tape unit is written into HDLC frames which are then packaged as data bursts for transmission over the satellite link. The burst structure is introduced to enable acknowledgements, that data has been received at the remote receiving terminal, to be interleaved with the transmitted data bursts. In fact, the LDC buffers transmitted data until this acknowledgement is received, at which time the buffer is cleared and more data is read from the magnetic tape for onward transmission. Receipt of a non-acknowledgement means that errors have been detected in the received data and a request for retransmission is initiated. Whilst operating at optimum conditions, terminal design precludes the occurrence of requests for retransmission during the transfer of a full computer compatible tape (CCT).

The modular nature of the SPINE earth station allows for the possibility of investigating information coding, signal modulation, access and capacity assignment techniques; as well as to demonstrate a range of different transmission and operational requirements.

3 RELAY OF REMOTE SENSING DATA VIA OTS

One of the original applications to be proposed[3] for SPINE was the demonstration of the rapid relay of remote sensing data between the ESA central Earthnet facility at ESRIN (Frascati) and Earthnet National Point of Contact (NPOC) offices in Sweden (SSC/Solna) and the UK (RAE Farnborough). This application is now operational.

A SPINE station has been installed at each of the proposed network nodes (see Fig 2), except that, in the case of Solna, the RF terminal equipment is remotely located at Farsta (21 km range) and linked to the LDC via a 2.048 Mbit/s PCM circuit.

Currently, SPINE is allocated 2 h transmission time daily and staff at the Earthnet Programme Office (EPO) coordinate a schedule to suit the participant's requirements. Much of the traffic is LANDSAT imagery (multi-spectral scanner full resolution or quick-look, or Return Beam Vidicon) that has been ordered by NPOC customers. Briefly, the operational procedure is for the NPOC to interrogate the LEDA catalogue at ESRIN using the online interactive QUEST[4] system maintained by Earthnet. After a successful research, an order for the required imagery is placed via the QUEST terminal. The system responds with the allocation of a SPINE time slot, during which the NPOC can expect to receive the data. Typical transfer times at the 1 Mbit/s data rate for the full MSS image is less than 7 min; this includes system overheads which are difficult to estimate, because they relate to

the type of data being transmitted, nevertheless this represents a throughput in excess of 650 kbit/s. Having achieved these high data rates it became apparent that a further demonstration, using the SPINE infrastructure, could be undertaken to disseminate data for time-dependent applications, where near real time acquisition of satellite remote sensing data by end users was essential. The Royal Aircraft Establishment has undertaken the management of such a demonstration, which, because of its interest to agricultural investigation has been named AGRISPINE.

4 AGRISPINE OBJECTIVES

(a) To demonstrate the use of communication satellite links in a particular example of the "special services" field.

(b) To investigate the utility of LANDSAT data for a variety of time-dependent applications, and compare this with aerial photography and the ground truth measurements hitherto relied upon.

(c) To construct a model or prototype of rapid delivery networks for remotely sensed data from future sensing systems, *eg* LANDSAT-4, SPOT, ERS-1.

5 PRINCIPAL INVESTIGATORS

The following UK research centres have designated principal investigators:

(a) The Forestry Commission Research Development Division (FCRDD), Field Survey Section, Alice Holt, Farnham, Surrey.

(b) The Ministry of Agriculture, Fisheries and Food (MAFF), Cambridge.

(c) The Macauley Institute for Soil Research (MISR), Remote Sensing Unit, Aberdeen.

(d) The National College of Agricultural Engineering (NCAE), Silsoe, Bedford.

(e) Space and New Concepts Department, Space Systems and Applications Division, RAE Farnborough.

6 TEST SITE INVESTIGATION

The principal investigators have agreed a list of test sites for which they require data rapidly and over a long period of time (*eg* a full growing season).

6.1 *East Grampians, Scotland*

The test area selected is an existing Macauley test terrain transect in the Eastern Grampian region. LANDSAT MSS data will be evaluated in respect to the monitoring of change in crops and cropping procedures, terrain and land types throughout the growing season of 1982. This transect covers a variety of crops, soil types, vegetation, peat land and forestry, and a large historical database of terrain information already exists. Ancillary ground data will be collected from farmers on cropping practices, and from Agricultural Colleges' Advisers on the state of crops during the growing season.

6.2 West Coast, Greenland

The main objective is to test the value of high speed SPINE relay of LANDSAT data for monitoring the calving of icebergs from glaciers on the west coast of Greenland for

the oil industry. A Newfoundland-based survey aircraft will be used to survey the test sites during LANDSAT passes when suitable weather conditions prevail. Ancillary ground surveys will also be conducted for at least two dates through the ice season of interest to the oil industry, to measure rates of glacier flow and calving of icebergs and to monitor the residence time of icebergs in the receiving zone.

6.3 Gulf of Finland

This test site will be monitored to investigate the melting and formation of ice in open and confined waters.

6.4 Thetford Forest, England

This area includes the Thetford Forest for which extensive ground truth, aerial photography and Synthetic Aperture Radar (SAR) coverage are already available for monitoring coniferous and deciduous woodlands. Adjacent to the forest are a number of agricultural test sites which are to be monitored for crop growth and stress detection during the 1982 season in medium (European) scale agriculture.

The AGRISPINE principal investigators have requested LANDSAT-3 MSS images, either as CCTs or off-screen photographs from an analysis procedure, of the areas which contain the test sites associated with their particular research fields. These scenes are identified in Fig 2 and listed in Table 1.

Table 1

Test site locations

Principal investigator	LANDSAT scene reference	LANDSAT predicted overpass time (GMT)	Approximate coordinates of test site centre	Site description
MISR/FCRDD	221/20 222/20 (alternative)	1030	56° 45'N, 2° 15'W	East Grampians, Scotland
MISR	11/11 12/11 (alternative)	1420	69° 12'N, 50° 0'W	West Coast, Greenland
RAE/MISR	199/18	0825	60° 0'N, 30° 30'E	Gulf of Finland
MAFF/ NCAE/ FCRDD	217/23½ 218/23½ (alternative)	1005	52° 45'N, 0° 35'E	Thetford Forest, England

7 OPERATIONAL PROCEDURES

7.1 Product standing orders

As each scene of interest is known, and the period of the campaign is defined, it has been possible to place a standing order for the LANDSAT-3 products through the EPO.

For each AGRISPINE scene the acquisition centre at Kiruna monitors the quality of Band 7* online and only prepares the system corrected MSS CCT when the scene is not fully cloud covered - tape preparation takes less than 2 h. These CCTs are then transferred to the SPINE terminal for direct transmission to the NPOC at RAE.

7.2 SPINE transmission

The SPINE earth station nodes at ESRANGE, Kiruna, and RAE Farnborough, are ideally situated to form an integral part of the AGRISPINE campaign. As seen in Fig 2, the Kiruna acquisition area for LANDSAT data encompasses all the designated test sites. An assessment of the predicted LANDSAT overpass times for the test sites has enabled a full time-table of required SPINE time slots for AGRISPINE transfer to be defined. In general, they fall conveniently within the normal SPINE scheduled times; where this is not the case, Interim EUTELSAT has allocated sufficient OTS time. Thus it is that the Gulf of Finland scenes are transmitted at 1200 GMT (a delay from acquisition of 3½ h), the UK scenes are transmitted at 1230 GMT (a delay of 2-2½ h) and the Greenland scenes are transmitted at 0900 GMT the day following acquisition (a delay of 18½ h). In this latter case, operational procedures at Kiruna preclude SPINE transmission after 1430 h GMT.

7.3 CCT post processing

LANDSAT CCTs received at the RAE SPINE terminal are transferred to the NPOC archive facility, where they are prepared for subsequent analysis on the co-located National Remote Sensing Centre (NRSC) GEMS image processing system. A further assessment is made as to the usefulness of the data for the principal investigators. If the data is deemed satisfactory, CCT copies and unprocessed off-screen photographic products are prepared and distributed by the NPOC by the most rapid means possible. Normally this involves using the Post Office Special Delivery service which guarantees next day delivery within the UK; although, in some cases, advantage is made of the RAE air ferry facilities, which means same day delivery is possible. In all cases the interactive GEMS analysis procedure should take no longer than 3 h to complete, so that same day dissemination of image products will be possible from the NPOC, with the investigating institutions receiving this part processed data less than 24 h after LANDSAT acquisition. For investigators within easy access of the NPOC, analysis of the image data is possible on the GEMS system within 1 h of data receipt at the SPINE terminal.

7.4 Aerial photography and ground truth

In parallel with the decision making exercise that will determine whether suitable LANDSAT data is available, preparation for overflying the UK test sites to undertake aerial photography will be initiated on the basis of meteorological forecasts. The intention is to overfly the test areas at as near the time of the predicted LANDSAT overpass as is possible - thereby establishing good data correlation. This task, and an accompanying ground truth measurement exercise, will be entirely under the direction of the principal investigators for their respective test sites. In support of this

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* The multi-spectral-scanner in LANDSAT-3 accepts earth reflected solar radiation in four spectral bands: Band 4 (0.5 to 0.6 μm), Band 5 (0.6 to 0.7 μm), Band 6 (0.7 to 0.8 μm) and Band 7 (0.8 to 1.1 μm).

exercise, the Department of Electrical Engineering and Electronics at Dundee University and the Meteorological Research Flight, RAE have agreed to monitor NOAA 6 and 7 satellite visual and IR facsimile data at the time of LANDSAT overpass. This data will be collected as part of the AGRISPINE campaign.

8 EXPERIMENT ASSESSMENT

An interim assessment of the experimental procedures and data quality will be made during September 1982. It will be decided at that stage if the experiment is to be expanded to gather LANDSAT-3 RBV data for the test sites. This will not involve the Kiruna station as all data, in this case, will be transferred between ESRIN and RAE. A review of operating procedures will be made in this circumstance.

The principal investigators will evaluate the performance of the dissemination system and the utility of the data for their various applications. They will issue preliminary reports within 6 months of the end of the data acquisition period and a final report will be issued by November 1983.

The AGRISPINE campaign may be seen as a prototype for evaluation of data from future satellites. The participants have agreed to support such future activities by making their test sites, facilities and expertise available for investigations of interest to ESA and the European remote sensing community.

Acknowledgments

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Swedish Space Corporation
University of Dundee, Department of Electrical Engineering and Electronics
NPOC and NRSC facilities at RAE Farnborough
Meteorological Research Flight, RAE Farnborough
Interim EUTELSAT, Paris
Principal investigators

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Reports quoted are not necessarily available to members of the public or to commercial organisations.

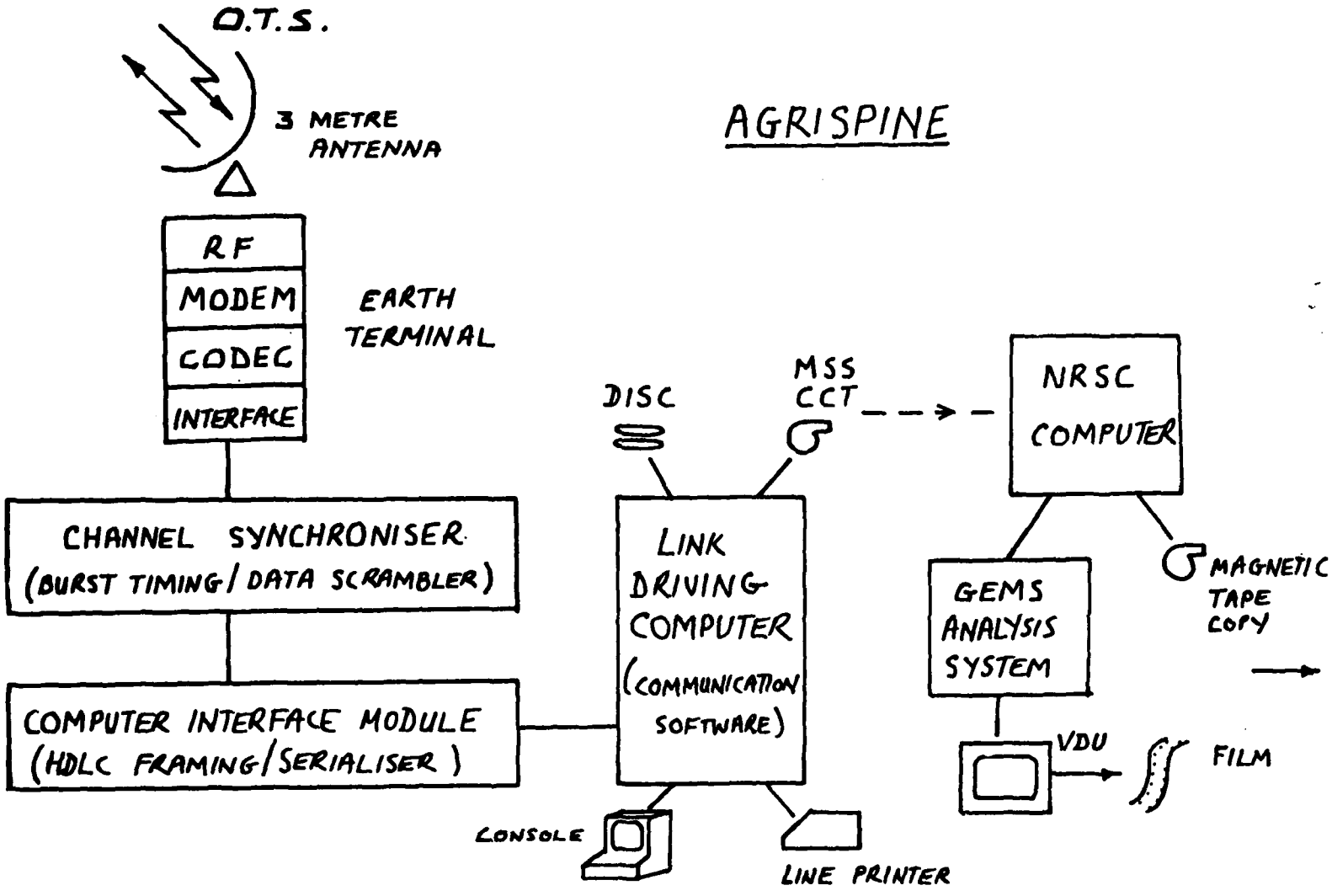

Fig 1 RAE facility

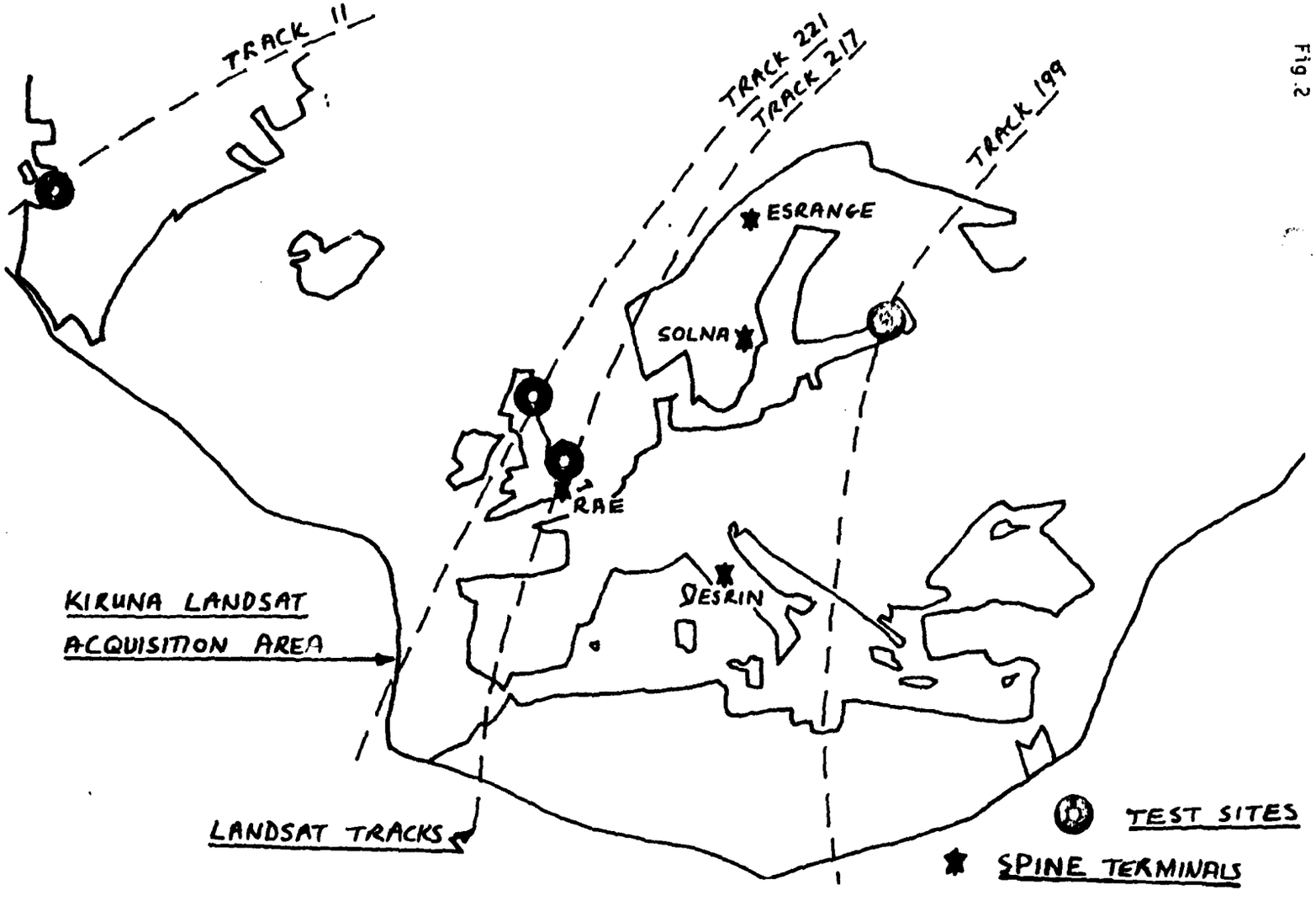

Fig 2 AGRISPINE test sites

Fig. 2

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