EUROPEAN SPACE AGENCY
8-10 RUE MARIO-NIKIS
757348 PARIS 15

ERS-1 PILOT PROJECTS

DEMONSTRATION OF ERS-1

AS AN OPERATIONAL TOOL IN MALAYSIA

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in association with

MACRES - The Malaysian Centre for Remote Sensing
PRI - The Petroleum Research Institute of Petronas
FRIM - The Forestry Research Institute of Malaysia

1.0 SCOPE

Following correspondance between Hunting Technical Services Limited (HTS); the Malaysian Centre for Remote Sensing (MACRES); the Petroleum Research Institute of Petronas (PRI), funding and support has been granted to HTS to carry out a Pilot Project to demonstrate some operational applications of ERS-1. This work is to carried out with data provided by ESA under the ESA programme of Pilot Projects. This document will describe the work that is to be carried out and present a workplan with suggested responsibilities.

2.0 PROJECT TEAM AND OULINE PLAN

2.1 Proposed Study Team

The project team will be composed of personnel from Hunting Technical Services Limited who will supervise the work; Macres - The Malaysian Centre for Remote Sensing; PRI - the Petroleum Research Institute of Petronal and FRIM - Forest Research Institute of Malaysia.

A total of thirteen scientists will be available to the project.

HTS - 3 (remote sensing and application specialists)
MACRES - 4 (remote sensing specialists)
PRI - 4 (geologists)
FRIM - 2 (foresters)

It is proposed that the project be located in Malaysia with some elements carried out at the offices of HTS. It is envisaged that overall supervision and responsibility for the project (in accordance with ESA requirements) will be vested in HTS but a local Project Manager will be assigned.

2.2 Proposed Outline of the Project

A proposed project outline, covering the main elements of interest has already been suggested; further more detailed work will be presented in Section 4 of this document. It is intended therefore that this section briefly reviews the main aims and objectives of the project. Figures 1 and 2 illustrate the proposed study areas. The final study areas will, of course, be limited by the availability of imagery.

The proposed study will cover aspects of three potential operational applications: forestry, wetland studies and geology. Each of these application areas is presented below together with a rationale for its inclusion as a potential operational application of ERS-1.

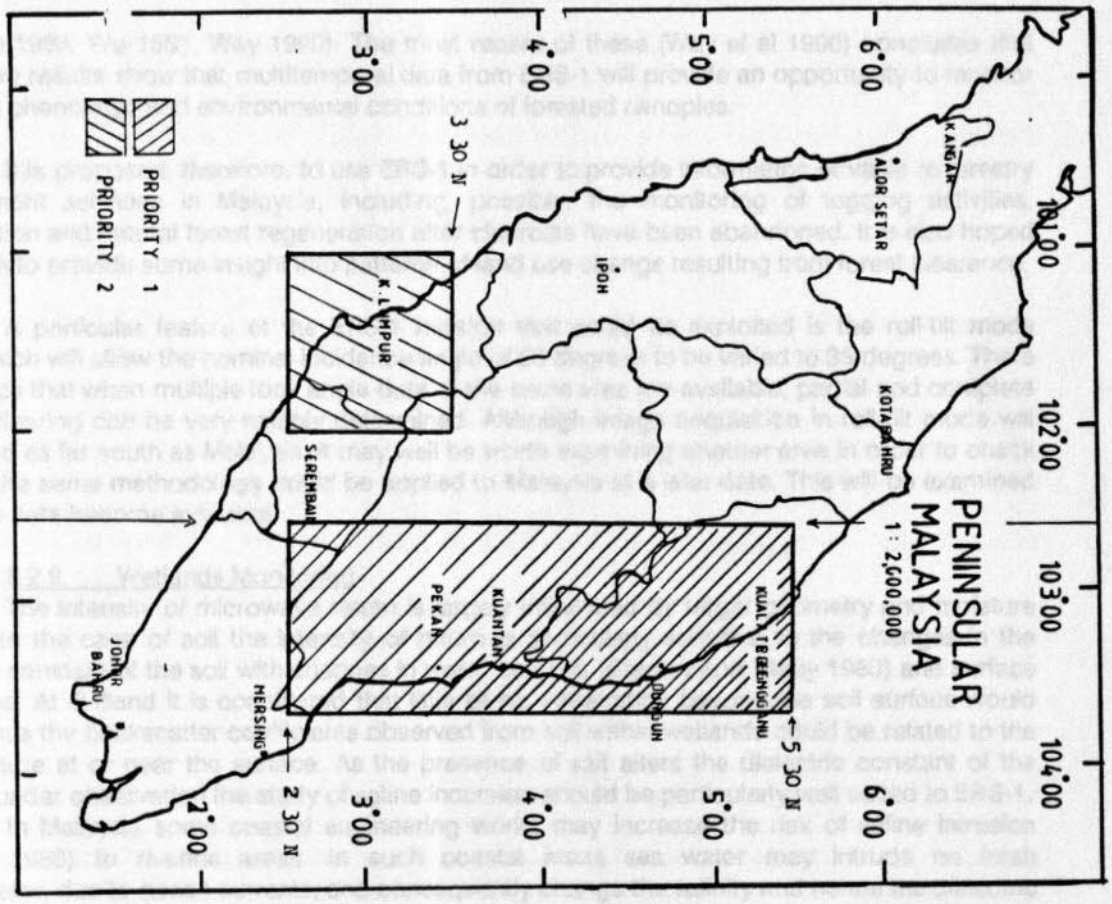
The whole study is intended to show how ERS-1 can be used as an opearational tool in areas which are not appropriate for operational use of other sources of imagery. The study will be a joint project with overall supervision and direction being given by HTS and the majority of the work being carried out locally. It is forseen that data will be provided to the consultants by ESA. The work programme will be preceded by a workshop intended to introduce the study team to ERS-1 data. It is also intended to conclude the study with a workshop in which the potential of ERS-1 will be critically assessed and recommendations for future studies made.

2.2.1 Forestry Studies

ERS-1 has potential as an instrument particularly suited to forestry studies. The SAR instrument on board ERS-1 images at 5.3GHz (C-band). At this frequency much of the backscatter will be from the canopy and only a limited amount of penetration to the ground will occur. This will allow measurements of tone and texture to be related to forest cover. In addition, observation of pattern and context can give some insight in possible logging or land use change activities.

A number of studies have indicated that measurements of forest biomass, canopy structure and species composition can be made using SAR data (Sader 1987, Ford 1985,

FIGURE 1



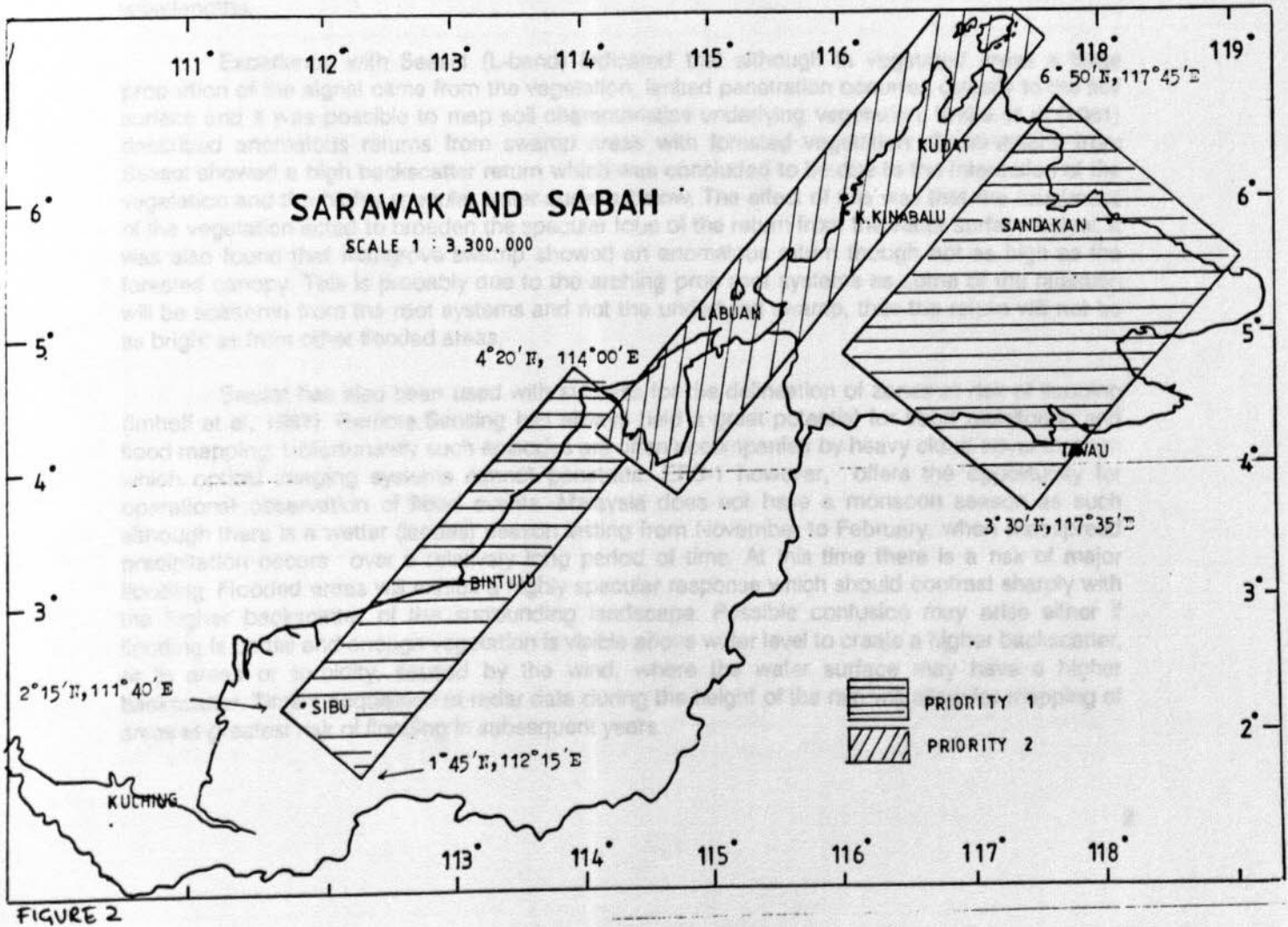


FIGURE 2

Hoekman 1985, Wu 1985, Way 1990). The most recent of these (Way et al 1990) concludes that preliminary results show that multitemporal data from ERS-1 will provide an opportunity to monitor changing phenologic and environmental conditions of forested canopies.

It is proposed, therefore, to use ERS-1 in order to provide information of value to forestry management activities in Malaysia, including, possibly, the monitoring of logging activities, reforestation and natural forest regeneration after clearcuts have been abandoned. It is also hoped to be able to provide some insight into patterns of land use change resulting from forest clearance.

A particular feature of the ERS-1 mission that could be exploited is the roll-tilt mode phase which will allow the nominal incidence angle of 23 degrees to be varied to 35 degrees. There is evidence that when multiple look angle data of the same area are available, partial and complete canopy clearing can be very reliably determined. Although image acquisition in roll-tilt mode will not extend as far south as Malaysia, it may well be worth examining another area in order to check whether the same methodology could be applied to Malaysia at a later date. This will be examined if suitable data become available.

2.2.2 Wetlands Monitoring

The intensity of microwave return is largely influenced by target geometry and moisture content. In the case of soil the intensity of return is particularly sensitive to the changes in the dielectric constant of the soil with changes in water content, (Bradley and Ulaby 1980) and surface roughness. At C-Band it is considered that little or no penetration beyond the soil surface would occur. Thus the backscatter coefficients observed from soil within wetlands could be related to the soil moisture at or near the surface. As the presence of salt alters the dielectric constant of the material under observation the study of saline incursion should be particularly well suited to ERS-1.

In Malaysia some coastal engineering works may increase the risk of saline intrusion (Ibrahim 1988) to riverine areas. In such coastal areas sea water may intrude on fresh groundwater, due to ocean currents, and consequently change the salinity and hence the dielectric constant of the ground water. Such processes may become visible in imagery at microwave wavelengths.

Experience with Seasat (L-band) indicated that although in vegetated areas a large proportion of the signal came from the vegetation, limited penetration occurred directly to the soil surface and it was possible to map soil characteristics underlying vegetation. Waite et al (1981) described anomalous returns from swamp areas with forested vegetation. Observations from Seasat showed a high backscatter return which was concluded to be due to the interaction of the vegetation and the highly specular water surface below. The effect of this was that the roughness of the vegetation acted to broaden the specular lobe of the return from the water surface below. It was also found that mangrove swamp showed an anomalous return though not as high as the forested canopy. This is probably due to the arching prop root systems as some of the radiation will be scattered from the root systems and not the underlying swamp, thus the return will not be as bright as from other flooded areas.

Seasat has also been used with success for the delineation of zones at risk of flooding (Imhoff et al, 1987). Remote Sensing has always held a great potential for flood monitoring and flood mapping. Unfortunately such episodes are often accompanied by heavy cloud cover through which optical imaging systems cannot penetrate. ERS-1 however, offers the opportunity for operational observation of flood events. Malaysia does not have a monsoon season as such although there is a wetter (landas) season lasting from November to February, when widespread precipitation occurs over a relatively long period of time. At this time there is a risk of major flooding. Flooded areas will exhibit a highly specular response which should contrast sharply with the higher backscatter of the surrounding landscape. Possible confusion may arise either if flooding is partial and enough vegetation is visible above water level to create a higher backscatter, or in areas or turbidity, caused by the wind, where the water surface may have a higher backscatter. Timely acquisition of radar data during the height of the rain will allow for mapping of areas at greatest risk of flooding in subsequent years.

If such a study were complemented with ground data it could be possible to model the effects of rises in mean water level and predict the nature and extent of flooding.

It is proposed that ERS-1 could be used as a tool to aid flood prediction, monitoring and mapping. An attempt will be made to monitor flooded forests. In addition it is proposed to look at the wetland areas of Malaysia where the primary concern is that of saline intrusion and an assessment made as to the extent and effects of any saline intrusion.

2.2.3 Geological Studies

The first Shuttle Imaging Radar mission (SIR-A) was intended principally for geologic use. In common with the majority of radar sensors the SAR on board the SIR-A shuttle was L-band. It was found that the majority of rock units could be distinguished simply by appropriately enhancing the imagery. In the majority of Malaysia there is little rock exposure apart from coastal areas. The majority of the land is thickly forested and therefore, there is no direct indication of lithology. Discrimination of rock type and structure will therefore be have to be based on morphological and textural variations of the cover types present. For example variations of vegetation may be indicative of changes in the mineralogical composition of the soil supporting the vegetation and thus of the underlying rock type.

The most striking feature of geological radar images is the way in which surface morphology is accentuated. This is due to the fact that the amount of energy backscattered is partly related to the attitude of the slopes and therefore causes topographic features to appear more clearly than in any other form of imagery.

As a result of continuous cloud cover it is not feasible to acquire optical images over much of Malaysia. Consequently in order to carry out geological surveys airborne radar campaigns have to be made. This is both costly and time consuming. It would therefore be very useful to ascertain to what extent ERS-1 could fulfil the role of a survey instrument. In terms of resolution it is equivalent to TM which is often used for such surveys where conditions permit. We believe that airborne X-band SAR has recently been flown over Sarawak and Sabah for geological interpretation; a useful exercise would be to compare this directly with ERS-1 C-band data which should exhibit a deeper penetration through vegetation.

It is proposed therefore to use ERS-1 in an examination of its potential usefulness to geological studies in Malaysia. Two aspects will be considered; firstly an examination of potentially hydrocarbon-bearing sedimentary basins in Sabah and Sarawak; secondly the examination of the tin-bearing granites in Peninsular Malaysia.

3.0 PROPOSED WORKSHOP PLAN

It is suggested to hold two workshops within the duration of the project.

An initial worshop is proposed to introduce the Project Team and other interested members of MACRES, PRI and FRIM to ERS-1 data and its potential uses. The proposed preliminary program for this 5 day workshop is presented below. It is intended that on the final day of this workshop a precise definition of the further work to be carried out will be made. This is intended to outline a precise workprogramme against which progress can be monitored.

Day 1 - ERS-1 - instruments, orbit, data and products
Day 2 - Introduction to the Malaysian Datasets
Day 3 - Geological applications
Day 4 - Forestry Applications
Day 5 - am: Other applications
Day 5 - pm: Definition of workplan

A second workshop is foreseen at the conclusion of the work. This workshop will aim to consider and review the results of using ERS-1 in an operational application and to propose a rationale for using ERS-1 (and later ERS-2) data routinely in operational applications in Malaysia. It

is intended that each research group present its' results and recommendations for the future. The foreseen outcome would be a workplan for the use of ERS-1 in a cost effective and efficient way.

It is intended that in conjunction with the preliminary workshop a more detailed training course on the use of remote sensing and particularly radar imagery for geological applications be available for the staff of PRI and Petronas Exploration Department. This course has been described separately in a proposal from HTS to Mr Ho Wang Kin of the Petronas Exploration Department.

4.0 PROPOSED TECHNICAL WORK PLAN

A brief outline technical workplan has already been proposed. The project will look at three applications of potential interest. Geology, forestry and wetlands studies. These applicatiuons have been described in broad detail in section 2.2 above. This section considers the proposed work in more detail. It is intended that the project be divided into workpackages each covering a discrete area of the planned work. For each workpackage its aims, methods and expected results are described. It is now also possible to locate, more precisely, the areas of interest for the study.

WP1000 - INTRODUCTION OF ERS-1

Workpackage will be led by HTS with attendance by the whole of the study team.

Aims: To introduce ERS-1 and its instruments to the study team. To examine the basic characteristics of the data.To define exactly the work programme.

Methods: Workshop (see programme above).
Task 1: Attendance at Workshop
Task 2: Production of a workplan
Results: Workplan for remaining period

WP2000 - FORESTRY STUDIES

The aim of this workpackage is to evaluate ERS-1 as a tool suitable for forest studies and in particular as an aid to management.

Direct identification of natural forest species is most unlikely as there can occur up to 100 species per hectare. However, phytogeomorphology (the relationship between landforms and plant or forest cover) leading to land unit classification may be an initial aim.

From previous studies using Seasat, SIR A and SIR B, experience, it is expected that accurate results will be achieved for the estimation of deforestation, however, abandoned agricultural areas returning to forestry will not be reliably recognised. This is due to the fact that forest regrowth is rapid and appears to have a surface roughness similar to that of unlogged forest. Good results should be acheived for the identification of water surfaces under forest cover with accurate identification obtained.

Forest damage takes place over three different scales of time; a) sudden - such as fire damage, mass clearing; b) gradual over a short period of time - such as disease and c) gradual over a long period of time - forest decline. It is hoped that some aspects of this will be clearly illustrated within the Pilot project.

Malaysia is of significant international importance in the timber trade. However, this must be managed if it is to be sustainable in the long term. Using ERS-1 it will be possible to monitor the deforestation that occurs within the country and to examine the associated changes in land use. The ability, potentially provided by ERS-1, to monitor Malaysia's forest on a synoptic and regular basis will allow predictive models to be developed which would aid in the management of

Malaysia's forest resources and models which could be used to predict the impact of other developments such as the Bakun dam, on forest resources.

Aims: To demonstrate the use of ERS-1 as an operational tool in forestry management in Malaysia.

Methods:

ERS-1 is a single frequency, single polarisation instrument, it can be described as having only a single band and thus the imagery produced by ERS-1 can in many ways be treated as analogous to an air photograph. The methods used for identifying various features will therefore be similar to those used in air-photo interpretation. For example examination of features such as tone, texture, size, shape, pattern, and association will provide much of the information necessary for interpretation.

The major components of backscatter of the signals towards the sensor will be canopy volume (biomass), scattering from the canopy towards the ground and reflection back (as a dihedral reflector); and scattering from the crown with a diffuse reflection from the ground.

WP3000 - GEOLOGICAL STUDIES

This workpackage will consist of two subpackages, one concerned with the use of ERS-1 for geology and a second which will examine and compare ERS-1 to the recently acquired airborne data over Sarawak and Sabah. It is hoped that this will demonstrate ERS-1 as a useful and cost effective survey tool for geological studies.

The priority site in Sabah is underlain by a wide variety of rock types, ranging from tectonised ophiolite to Late Paleogene to Neogene deltaic-fluvial clastic sediments. The complex deformation of older predominately deepwater facies strata and occurence of deltaic facies with formation of possible structural as well as stratigraphic traps in late Tertiary strata make this a priority area for hydrocarbon exploration.

In the secondary area along the north coast of Borneo deformed terbidites, part of an accretionary wedge complex, of Late Cretaceous to Early Eocene age outcrop in the north and east. To the south and west exposed strata are predominately Early to Middle Miocene to late Miocene in age. Environments of deposition of the Neogene strata change from fluvial and deltaic inland to nearshore towards present coastline. Oil accumulations are associated with transitional facies. There is a pronounced northeast-southwest structural grain imposed on Miocene and older strata. There are also significant westerly to northeasterly trending structures which were formed during the Pliocene which may control the formation of structural traps and localised depositional basins.

Peninsular Malaysia has a rather different geological structure in that it is dominated by a central mountainous spine of raised marine sediments with granitic intrusions noe deeply eroded. It is surrounded by lower undulating land with coastal plains and alluvial terraces spreading inland. The tectonic history of Peninsular Malaysia can be traced through to the Middle and Upper Triassic when the Malay Peninsula underwent a tectonic event involving deformation, granite intrusion, greenschist and amphibolite facies metamorphism and considerable associated uplift. Granite intrusion extended from the upper Carboniferous to the Tertiary with emplacement of the granites in the existing metasediments.

The known mineralisation in the area is related to the granite bodies, with pegmatitic and hydrothermal mineral deposits being of greatest importance. As much of the area under investigation is covered by vegetation, mineralisation may be indicated by geobotanical changes observable in the imagery. For example the presence of aluminium is known to stress vegetation and this should be seen by changes in the vegetation cover. Fracturing and alteration associated with the mineralisation may also be expressed by the surface morphology.

Aims: **1.)To demonstrate the use of ERS-1 as an operational tool in geology.**
2.)To demostrate ERS-1 as a survey tool.

Task 1: In the demonstration of ERS-1 as a tool for geological applications it is proposed to consider the area in the east of Sabah. Two specific tasks will be carried out. Firstly an identification of the main structural trends and the subdivision of the region into its main structural provinces. Interpretation of lithostratigraphy, structure and morphology will limited to large scale features.

Secondly a single basin or part of one will be identified and features of importance in the evolution of the basin including the position and trend of structures that may control hydrocarbon accumulation will be identified. For example anomalous vegetation which may imply a change in lithology or hydrocarbon leakage; drainage anomalies which may indicate neo-tectonic movements.

Within Peninsular Malaysia the imagery will be examined for evidence of mineral deposits underlying the vegetation. A geological interpretation will be undertaken to evaluate the extent to which lithospheric units can be differentiated from the landforms. Particular attention will be paid to areas of known bedrock mineralisation to evaluate the extent to which the morphological expression of faults, fractures, veins and dykes and of more general attention aides in the search for mineral deposits. Regions of anomolous backscatter will be thouroughly investigated against available ground-based information to determine the extent to which they might be associated with vegetation stress related to anomolous concentrations of minerals or associated bedrock alteration.

Task 2: This task is concerned with the comparison of airborne (Intera STAR-1) and spaceborne SAR (ERS-1). The ERS-1 data will be examined in detail to see how the reduced resolution between ERS-1 and SAR affects the quality of geological interpretation. It is hoped that this may serve to illustrate that ERS-1 can be used efficiently as a survey tool and that airborne data need only be flown for specific areas of interest where the increased resolution will merit the cost. A caveat will, however, need to be made; this concerns the different frequencies of the two SAR instruments. The airborne SAR was flown at X-band, whereas the spaceborne ERS-1 SAR is C-band. This difference in frequency may affect the quality of one or other sensor where interpretation of specific features is required.

It is envisaged that this task would be carried out by the staff of HTS at the offices of Petronas in Kuala Lumpur.

WP4000 - WETLANDS STUDIES

No imagery will be acquired specifically for this application, however, several of Malaysia's main wetland areas fall within the priority areas for forestry and geological studies and these will be examined. Figure 4.1 illustrates the main wetland areas in Malaysia which fall within the priority areas for geological study. Each of these is briefly described below. It is suggested that the ERS-1 Pilot project selects one or two of the selected wetland areas and carries out a detailed case study.

PENINSULAR MALAYSIA

(1) SE Pahang Swamp Forest - swamp forest lying on organic soils. There is also a limited amount of freshwater alluvial swamp forest. This area is proposed for conservation however there exist threats from reclamation of land for agriculture and non-sustainable logging.

(2) Pulau - Mangrove islands in the estuaries of the Sungei Klang and Sungei Langat with adjoining mudflats and sandflats. The main problems encountered are associated with land reclamation for agriculture.

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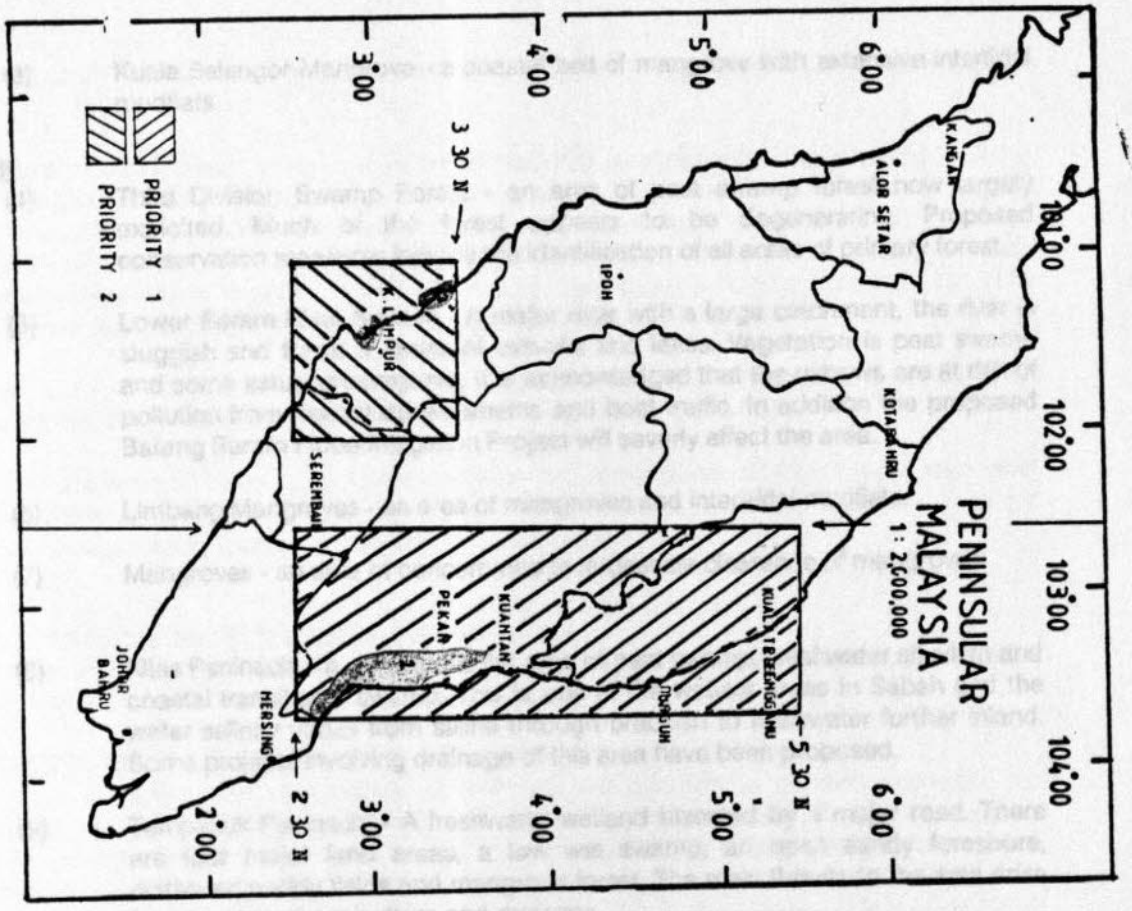
PRIORITY 1
PRIORITY 2
PENINSULAR MALAYSIA
1 : 2,500,000
K. LUMPUR
IPOH
ALOR SETAR
KANGAN
KOTA BHARU
SEREMBAN
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KUALA TERENGGANU
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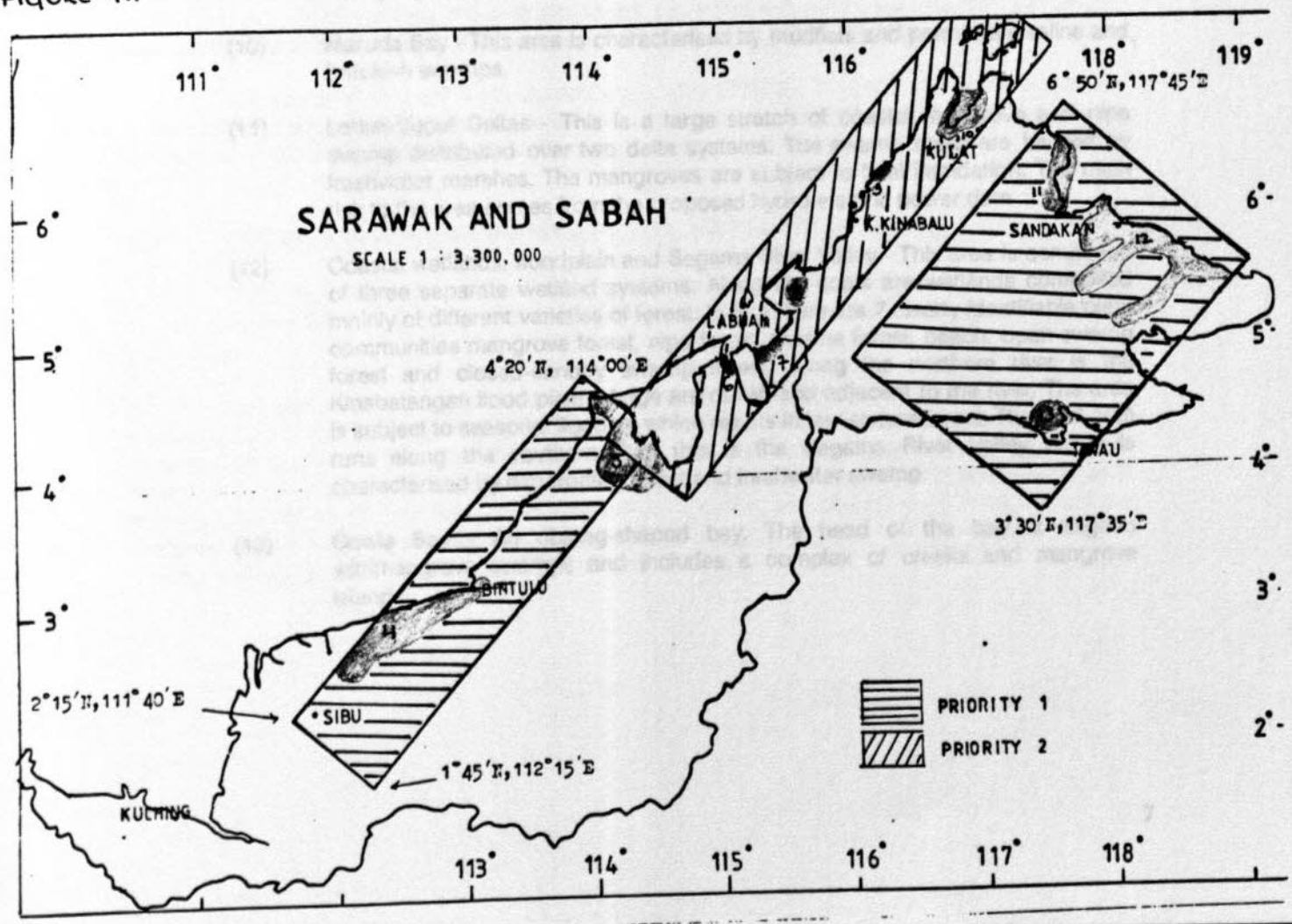
FIGURE 4.1


SARAWAK AND SABAH
SCALE 1 : 3,300,000
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4°20'N, 114°00'E
3°30'N, 117°35'E
2°15'N, 111°40'E
1°45'N, 112°15'E
KUDAT
K.KINABALU
SANDAKAN
LABUAN
BINTULU
SIBU
KUCHING
TAWAU
PRIORITY 1
PRIORITY 2
111°
112°
113°
114°
115°
116°
117°
118°
119°
6°
5°
4°
3°
2°

(3) Kuala Selangor Mangrove - a coastal belt of mangrove with extensive intertidal mudflats.

SARAWAK

(4) Third Division Swamp Forest - an area of peat swamp forest now largely exploited. Much of the forest appears to be degenerating. Proposed conservation measures include the identification of all areas of primary forest.

(5) Lower Baram River System - A major river with a large catchment, the river is sluggish and forms a series of oxbows and lakes. Vegetation is peat swamp and some esturine mangrove. It is acknowledged that the oxbows are at risk of pollution from nearby developments and boat traffic. In addition the proposed Batang Baram Flood Mitigation Project will severly affect the area.

(6) Limbang Mangroves - an area of mangroves and inter-tidal mudflats.

(7) Mangroves - an area of concern due to largescale clearence of mangroves.

SABAH

(8) Klias Peninsula - a continuous flat area of peat swamp, freshwater alluvium and coastal transitional swamp. This is one of the wettest areas in Sabah and the water salinity varies from saline through brackish to freshwater further inland. Some projects involving drainage of this area have been proposed.

(9) Tempasuk Peninsula - A freshwater wetland bisected by a major road. There are four major land areas, a low wet swamp, an open sandy foreshore, cultivated paddy fields and mangrove forest. The main threats to the area arise from proposed aquiculture and drainage.

(10) Maruda Bay - This area is characterised by mudflats and permanent saline and brackish swamps.

(11) Labuk-Sugut Deltas - This is a large stretch of coastal mangrove and nipa swamp distributed over two delta systems. The swamp areas are backed by freshwater marshes. The mangroves are subject to tidal inundation. The main risk to the area comes from the proposed hydro-electric power dam

(12) Coastal wetlands, floodplain and Segema River Valley - This area is composed of three separate wetland systems. Along the coast are wetlands composed mainly of different varieties of forest. In fact there are 7 clearly identifiable plant communities mangrove forest, nipa forest, riverine forest, beach, open swamp forest and closed-canopy swamp forest. Along the northern river is the Kinabatangan flood plain a large are of flat land adjacent to the river. The area is subject to seasonal flooding which results in low-stature forest. The third area runs along the southern river this is the Segama River Valley which is characterised by dipterocarp forest and freshwater swamp.

(13) Cowie Bay - An oblong-shaped bay. The head of the bay is alligned withmangrove swamps and includes a complex of creeks and mangrove islands.

Aims: To demonstrate the use of ERS-1 as a tool for wetland monitoring.

Methods:

Acquisition of Seasat imagery over forest wetlands suggests that swamp forest is better delineated on SAR imagery than any other spaceborne source and in addition information may be extracted about the associated water regimes. It is envisaged that one or more of the areas described above will be selected and studied. Initially the precise boundaries of the wetlands would be delineated and its features described. Of particular interest would be the areas that have been highlighted as being at risk from particular developments.

By extension of areas which are easily accessible it is also intended to examine small areas of wetlands that are inaccessible on grounds either of difficulty or of cost.

If multitemporal imagery is made available the observation of tidal innundation, and seasonal variation of the wetlands would aim to aid in the prediction of floods. A methodology for routine monitoring of wetland areas would also be established.

WP5000 - A DEMONSTRATION OF ERS-1 IN MALAYSIA

This workpackage will be carried out in the form of a workshop at which the results of all the project areas will be presented and discussed.

5.0 RESULTS

It is expected that the results of WP1000 will provide a detailed workplan for workpackages WP2000, WP3000 and WP4000. It is aimed that the work carried out under each of these workpackages will be based on or around projects currently being carried out. The aim of the workpackage WP1000, therefore, it to introduce ERS-1 and to examine how best ERS-1 may be used in a operational way within each of the three chosen application areas. Precise goals and methodologies will be defined, it is also envisaged that some sub-workpackages may be defined. The results of the three major workpackages will be presented within WP5000.

It is intended that the work carried out under WP2000, WP3000 and WP4000 can be integrated with other operational work at the present time being carried out in each of the subject areas. Thus ERS-1 will immediately be able to prove its' worth as an operational tool.

6.0 COSTS OF HTS PARTICIPATION, ESTIMATED DURATION OF THE PROJECT

HTS intends to put three staff members at the disposal of the project. Mr G. Deane, Dr M.W.C Barr and Miss A. Wielogorska. Their Curricula Vitae are attatched in an appendix to this document.

It is intended that 2 members will organise and attend the workshop, 2 members will carry out the comparison of airborne and spaceborne SAR under WP3000 and two members will organise and attend the final workshop. In addition to this the three staff members will be available throughout the duration of the project to give advice and generally supervise the workpackages. It is envisaged that regular contact will be maintained by telefax and telephone. In order to facilitate the provision of advice copies of the imagery will be available both at HTS and within Malaysia which will allow identical procedures to be carried out at either location.

The costs for HTS participation are envisaged to be as follows:

Labour - 2 man months £10000

(this represents the time for:
2 persons x 1 week WP1000
2 persons x 2 weeks WP3000
2 persons x 1 week WP5000)

It is our understanding that travel and subsistence will be provided by Petronas or Macres.

It is also our intention that for any additional time devoted to the project either locally or in Malaysia the costs will be borne by HTS. That is any time necessary to supervise the project components will represent the HTS input to the project.

It is estimated that the total duration of the project will be between 6 to 9 calendar months.

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APPENDIX A
CV'S OF PROPOSED PERSONNEL

BARR, Michael William Craig

B.A. (Natural Sciences), Cambridge, 1965
M.A. Cambridge, 1969
Ph. D. Leeds, 1974

BORN: **1943**

NATIONALITY: **British**

BACKGROUND AND EXPERIENCE:
Dr Barr is a geologist with 23 years experience principally in Africa and the Middle East but also in SE Asia, S. America and laterly Europe. He is manager of the Geology Section of Hunting Technical Services Limited with responsibility for marketing and supervision of services in geological mapping and interpretation, minerals and hydrocarbons exploration, geotechnical investigations and non-renewable resource appraisal and inventory. Dr Barr joined the Hunting group of companies in 1974.

BRAZIL	1974	Geologist Gold Exploration, Amazon Basin
EAST ASIA	1990	Consultant Geologist
ETHIOPIA	1975	Geologist NASA Landsat Project
EUROPE	1989-	Supervision MuSIP Project
THE GAMBIA	1975-76	Geologist Mineral Resources of Beach Deposits
INDONESIA	1981	Geologist Geothermal Resources, Java and Sumatra
KUWAIT	1980-81	Project Manager/Geologist Geol. Mapping and Hydrocarbon Exploration
LIBYA	1974	Geologist Mineral Exploration Project
MOZAMBIQUE	1981-84	Chief Geologist Minerals Inventory Project
PERU	1974-75	Geologist Radar Interpretation of S. Oriente Province
QATAR	1981	Team Leader/Geologist Geological Map of Qatar
SPAIN	1985	Project Supervision Mineral Exploration using ATM Imagery
SUDAN	1977	Geologist Recce. of Basement Complex, S. Region
SYRIA	1990	Consultant Geologist
UAE	1989-1991	Project Manager/Geologist Mineral Exploration
	1978-79	Team Leader/Geologist
and	1976-77	Mineral Exploration Project
UNITED KINGDOM	1987-	Team Leader Geologist Dev. of Explor. Criteria for Buried Mineralisation
	1986	Team Leader Coal Exploration, Brit. Coal Opencast Exec.
	1986	Team Leader BNSC, GIS Project
	1984-85,1988	Project Manager Teal Ruby Project
ZAMBIA	1984	Consultant Geologist UNESCO Geotraverse 2
	1965-71	Geologist Geol. Survey Department, Zambia

DEANE, Graham C

B.A. Geography (Oxon) 1974
M.Sc. Forestry and Land Management (Oxon) 1975
M.A. (Oxon) 1979

BORN: **1953**

NATIONALITY: **British**

BACKGROUND AND EXPERIENCE:
Mr Deane, who joined Hunting Technical Services in 1976, is a remote sensing expert and forestry specialist with experience in the Middle East, Africa, Europe and China. He is an Associate Director and Manager of the Remote Sensing Unit with responsibility for all remote sensing projects involving renewable natural resources. He has managed numerous projects using computer aided image processing to analyse satellite imagery at the Company's UK laboratories, and has co-authored a number of papers on the subject.

HEAD OFFICE:

1986-1987	Assessment of Storm Damage to Non-woodland Trees in SE England
1986	Imaging Radar Research
1984-1986	Monitoring Landscape Change in England and Wales
1983-1984	Analysis of Airborne Multi-spectral Scanner Data
1982-1983	Digital Image Processing and Analysis
1981	Evaluation of SAR-580
1980	Development & Application of the Company's Image Processing System
1979	Assessing Seasat Satellite Imagery Data

OVERSEAS PROJECT WORK:

BANGLADESH	1991	Remote Sensing Consultant Adviser to the Deep Tubwells II Project
CHINA	1986-1990	Deputy TL/Remote Sensing Specialist Soil & Water Conservation, Sichuan Province
INDONESIA	1989	Remote Sensing Specialist Land Use Inventory Applications
IRAQ	1982	Remote Sensing Training Specialist Govt. Earth Scientists Training
MALAWI	1983	Remote Sensing Specialist Salima Lakeshore Land Use Plan
NIGERIA	1979	Forester/API Specialist Third Cocoa Project, Pilot Study
	1976-1978	Forest Inventory Specialist Side Looking Airborne Radar Study
SAUDI ARABIA	1978	Vegetation Mapping Umm Er Radhuma Project
SPAIN	1988-90	Team Leader/Remote Sensing Specialist Regional Crop Inventory, Castilla-Leon
SUDAN	1976	Forest Inventory Specialist Inventory of the Imatong Mountains.
UNITED KINGDOM	1990	Remote Sensing Training
ZIMBABWE	1983	Remote Sensing Specialist Landsat Study of Mazoe Valley

LANGUAGES: Spanish - basic
French - basic

WIELOGORSKI, Anna Ludwika

B.Sc. Hons. Geography, (London), 1986
M.Sc. Remote Sensing, (London), 1988

BORN: **1965**

NATIONALITY: **British**

BACKGROUND AND EXPERIENCE

Miss Wielogorski gained an Honours degree in Geography from King's College, London University in 1986. The main subjects studied included geomorphology, environmental change, cartography and remote sensing. Her final year project was entitled: 'Delineating Saline Soils in NW India with the aid of LANDSAT' and involved fieldwork in India.

During her M.Sc. course she specialised in the Geological Applications of Remote Sensing, which involved fieldwork in Spain for a project entitled 'Detecting lineaments using RBV imagery'. The title of her M.Sc. thesis was 'Selection of Desert Test Sites for the ERS-1 and SIR-C Radar Altimeters'.

At HTS Miss Wielogorski specialises in the development of microwave remote sensing for land applications and the role of knowledge based automated image processing in remote sensing.

UK	1991	Remote Sensing Specialist Site preparation for Ground Survey Document Production
	1989	Ground-Data Collection Coordinator NASA/JRL SAR overflights, Maestro-1 Campaign.
	1989	Remote Sensing Specialist ESA Study into Microwave Interaction with the Earths Surface
	1988	Spain: Castilla-Leon Regional Crop Inventory from Satellite Imagery
	1988	Applications of Remote Sensing to Land Use Studies
	ESPRIT	1989-1991 Remote Sensing Specialist Multi Sensor Image Processing
ITALY	1989	Technical Manager Design and Implementation of a European Radar Cross Section (EURACS) Database
SPAIN	1988-1989	Image Processing Specialist EBRO Valley Classification

LANGUAGES: Polish - fluent
French - fair
German - fair
Italian - basic