7.9 - 10.287
CR-162274

(E79-10287) SATELLITE MONITORING OF SEA SURFACE POLLUTION Progress Report, period ending 31 Aug. 1979 (Lancaster Univ.) 35 p HC A03/MF A01 CSCL 13B

N79-32611

Unclas
G3/43 00287

CONTRACT RD 1182/03 Identification Number HCM-023

Satellite Monitoring of Sea Surface Pollution

Authors: Gilbert Fielder (P.I.) and Duncan John Telfer (Co-I)

Sponsoring Organisations: Department of Industry, London, and University of Lancaster, England.

First Progress Report Number 2-13/P5 for the period ending 31st August, 1979.

2-13/P5-1 Objectives of Investigation

The overall aim of this research is to investigate the feasibility of the use of data drawn from the visible and near-IR (0.5 to 1.1 μm) and from the thermal IR (10.5 to 12.5 μm) bands of NASA's Heat Capacity Mapping Mission (Explorer-A satellite), as applied to the sea surfaces centring on the North Sea, to study marine pollutants, particularly oil.

2-13/P5-2 Historical Review

An overview of the development and achievements of the current research programme is given in Section 2-13/P5-14, appended to this Report.

2-13/P5-3 Principal Accomplishments

The most important attainment was the design, construction and refinement of an eight level colour video black and white slicer, the refinement stage including the incorporation of an automatic brightness compensation circuit. This equipment allowed us to survey large oceanic areas represented on either transparencies or prints.

Prints were difficult to view because of the problems of achieving uniform illumination across the whole of a print, so we normally chose transparencies for synoptic studies. The transparencies were illuminated by fluorescent strip lights diffused by a ground glass screen. A good approximation to flat illumination was achieved by the examination of a sufficiently small area within a given transparency, while TV camera shading was minimised by using a silicon diode camera tube.

Detailed line profiles were examined, where the synoptic view showed some interest, using a storage oscilloscope video-densitometer. Quantitative video line processing with corrections for camera shading and uneven illumination was readily achieved through the use of a PET microprocessor and floppy disk system. The system configuration was developed by the Co-Investigator, who also evolved the suite of software for operating the system.

An outdoor simulator using two, one-metre diameter tanks to hold, respectively, water and oil-on-water, those tanks being viewed by IR and visible sensors held aloft by means of a gantry capable of rotation in the plane of the daytime HCMM satellite passes, was designed by the P.I. and constructed by his technical support to test the capability of selected instruments to discriminate between the water, and the oily, surface. A real temperature difference was determined, the oil surface presenting the higher temperature in daytime conditions.

Because of the need to control the immediate environment around the tanks a small-scale version of the simulator was developed for use in the laboratory. Here, surface temperature measurements were taken at times of different ambient (room) temperature and humidity.

Computer routines for the preparation of maps of oil slicks from geographical data such as the map co-ordinates of recognisable coastline features on a HCMM image were prepared by a Consultant.

Routines for the simulation of heat balance regimes in oil slicks have been developed by the Co-I. for use with the microcomputer. Results suggest that the transition from laminar to turbulent airflow over the slicks could give rise to sharp changes in slick surface temperature.

A survey of sources of sea truth was made by the P.I. who concluded that, although there were a number of special organisations willing to provide a variety of data relating to limited sea areas, the most generally useful data would derive from the Meteorological Office at Bracknell. These data may be split into (a) Ice Chart five-day means (which, tests have shown, are more numerous than all other data); (b) data from ships using Code FM21-V; (c) bathymetric data (Code FM63-V) and (d) British Light Vessels data. The data provided range through parameters such as sea surface temperature, cloud amount and type, weather, visibility, surface wind speed and direction, and wave height and frequency. In a test case of one sea area, surface temperatures, measured in situ, were found to correlate well with the HCMM thermal infra-red brightness data even though the temperatures were five-day means.

2-13/P5-4 Satellite Data

Positive and negative HCMM transparencies covering 32 areas close to the UK have been received since the official data of first receipt of HCMM data by investigators (30th April, 1979). These transparencies have been coded, catalogued and filed. Starting on 8th June, 1979, "quick look" (QL) positive and/or negative HCMM prints have arrived from Lannion Centre for Space Meteorology. These data have been supplemented by various prints from the satellites LANDSAT, NOAA 5 and TIROS N; and by one CCT from Lannion.

The Lannion QL prints cover a larger range of latitude than the NASA transparencies and provide relatively rapid means of assessing, visually, the usefulness of a given pass of the HCMM satellite in regard to the sea areas around the UK. The NASA transparencies have proved best for false colour synopses and for detailed regional work of a more quantitative nature. Of the transparencies, the D thermal IR images have proved to be the most useful, particularly the positive transparences.

2-13/P5-5 Sea Truth

The measurement of sea truth is not part of the present programme: sea truth will instead be gathered by other organisations and will be ordered retrospectively, by us, as required. Although other sources of regional sea truth have been noted, the principle source lies in Department METO 12c of the Meteorological Office at Bracknell, England.

2-13/P5-6 Methodology used in Performing the Investigation

QL prints are scanned visually, sorted and catalogued in the P.I.'s office prior to being passed to the Co-I for visual identification of "useful" imagery.

Transparencies received are scanned visually, sorted and catalogued in the P.I.'s office prior to being passed to the Co-I for semi-quantitative synoptic viewing of "useful" imagery. Taking note of any points of optical interest (such as known oil spills) covered by an image, the Co-I then proceeds to process theimagery quantiatively. In the first test case, the P.I. and

Co-I have compared the given sea truth temperatures with a false colour distribution and a histogram of a line scan through the corresponding thermal IR data.

No oil spills in the area of investigation have been confirmed in the data received up to the present. However, we are simulating oil spills, in a parallel line of research, so as to be aware of the possible responses from the instruments on board the HCMM when encountering oil.

Following any future discovery and analysis of image events corresponding to an oil spill, it is intended to make use of further facilities offered for image analysis and interpretation. The Co-I has visited the R.A.E., Farnborough, and also Plessey to discuss the possibility of using the Plessey IDP 3000 advanced image processing computer as and when the need arises.

2-13/P5-7 Accomplishments Based on Data Use

In the first test case, in which measured sea surface temperatures off the west coast of Scotland were compared with the HCMM output, a remarkably good correlation was found.

2-13/P5-8 Significant Results

In addition to the sea truth/HCMM comparison of 2-13/P5-7. experiments with the simulators (2-13/P5-3) have shown that temperature differences of 0.25 K are attained using a solid state pyroelectric sensor with a chopper and phase-sensitive detector. Oil slick thickness over the range 2 mm to 2 cm does not have as significant an effect as does the relative humidity (RH) of the air above the experimental tanks: as the RH increases towards 100% the surface temperature difference between the tanks tends to zero. These daytime measurements , made using carefully placed PRT elements, indicated that the oil layer temperature (under ambient conditions in the laboratory) achieved a consistently higher temperature than the exposed water surface.

2-13/P5-9 Publications

The following in-house reports have been issued to the Department of Industry, as required, and to a limited number of persons from whom data have been, or are likely to be, exchanged:

> Satellite Monitoring of Sea Surface Pollution (G. Fielder and D. Telfer) Monthly Reports No's 1 and 2 (1977); Quarterly Reports No's 3, 4, 5 and 6 (1977); Quarterly Reports No's 7, 8, 9 and 10 (1978); and Quarterly Reports No's 11 and 12 (1979).

As a result of local and national publicity through the Information Office of the University of Lancaster, the BBC has broadcast one programme item dealing in very general terms with the problems of oil detection in marine areas based on future (then) satellite data. This programme featured both P.I. and Co-I.

2-13/P5-10 Problems

Up to date, no major problems are impeding the progress of the investigation.

2-13/P5-11 Data Quality and Delivery

The best HCMM imagery from NASA virtually attains the predicted resolution. Drop-outs (principally pixels, rarely whole lines) are minimal, particularly in the more recent data. By comparison, drop-outs appear to be more numerous on the hard copy, QL imagery received from Lannion. We have yet to see an encouraging degree of thermal IR contrast stretching in the sea areas.

2-13/P5-12 Recommendations

Better contrast sketching in the positive transparencies covering the marine areas would greatly assist our densitometric analyses and subsequent interpretation.

2-13/P5-13 Concluding Remark

It will be appreciated that the bulk of our data has been received during the third quarter of 1979: the first use of data is therefore largely relegated to subsequent reports.

CONTRACT RD 1182/03 Identification Number HCM-023

Satellite Monitoring of Sea Surface Pollution

Authors: Gilbert Fielder (P.I.) and Duncan John Telfer (Co-I)

Sponsoring Organisations: Department of Industry, London, and University of Lancaster, England.

First Progress Report Number 2-13/P5 for the period ending 31st August, 1979.

2-13/P5-14

HISTORICAL RESUME

(Giving Details of Work Done to Date)

YEAR BEGINNING 1ST JANUARY, 1977

Cartography from Satellite Photographs

During the first quarter of 1977, Dr. R. J. Fryer was appointed as Consultant to the Lunar and Planetary Unit (LPU) to advise on the handling, and the making compatible with the mainframe computer needs, of map and support data to be used in the programme, following receipt of CCT's.

The Consultant made a start on the development of routines on the mainframe computer (ICL 1905 F) for the preparation of maps from geographical data. The following graphical routines were prepared:-

MERC a subroutine to compute the cartesian co-ordinates, on a Mercator projection, of geographical points supplied as radian latitude/longitude pairs.

ØTLN a subroutine which draws a rectangular map outline for the final plot and simultaneously initialises some important variables. This subroutine is an essential preliminary to the use of DRSCN, CØAST or GRDTH (see below). Additionally ØTLN enables the user, optionally, to draw a labelled latitude/longitude grid on the map at specified intervals from a specified geographical origin.

DRSCN a subroutine which draws digitised outlines ('scans') on the base-grid prepared by ØTLN by joining successive map positions by straight lines. The subroutine uses EDGPT (see below) to ensure that only those parts of the scan which lie within the map boundaries are drawn.

CØAST this routine is identical to DRSCN with the exception that its data source is from a supplied file rather than from the digitised data derived from the image being analysed. Its purpose is to enable the user to insert, optionally, a stylised coastline on a map when there is no desire to digitise the coastline in an image or where, for various reasons (e.g. cloudover or coastline not in image area), digitised measures of the coastline position are not available.

EDGPT a subroutine to halt drawing of a scan at a map boundary where the scan would otherwise extend out of the map being prepared.

GRDTH a subroutine to enable the annotation of a map with ground-truth data if so required. Geographical positions and alphameric labels are read from computer cards and the labels inserted on the map beside a symbol drawn at the supplied geographical position. Positions outside the map boundary are ignored, and for each position a choice may be made from fourteen available symbols.

These routines are combined, under the control of a master programme, in a single package and stored in a computer file. The file may then be utilised as desired, implementation of the various subroutines being controlled by the values of parameters punched in a single control card.

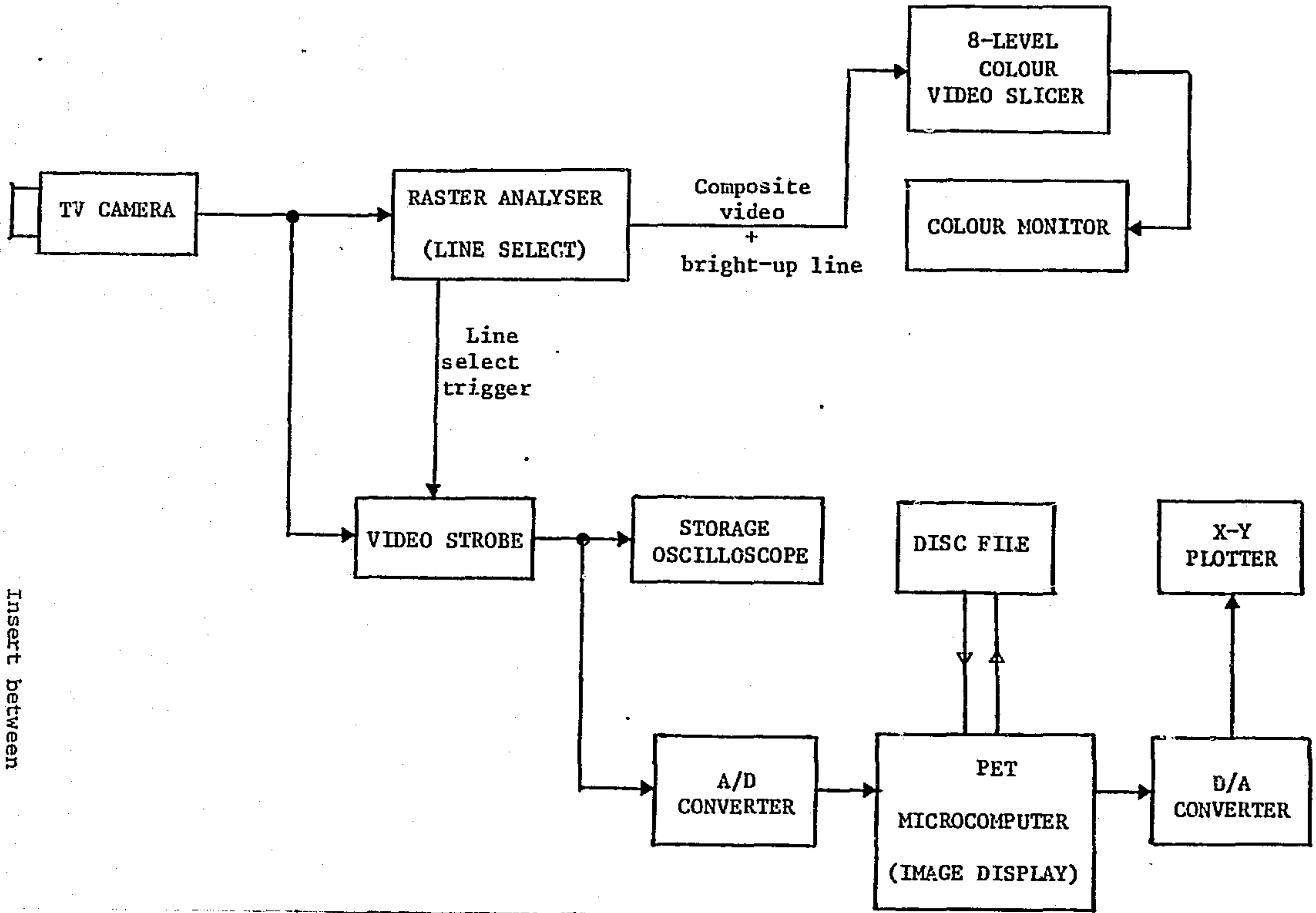
A sufficient understanding of the orbit and imaging system of the HCMM was gleaned for a start to be made on routines for the transformation of 'image' co-ordinates into 'geographical' co-ordinates.

Technical Developments

By March 1977 D. Telfer completed the design and construction of a low cost 8-level colour video (CCTV) black and white slicer for enhancement and recognition of grey level variations in monochrome printsand transparencies. In trials, the equipment yielded promising results when applied to NOAA-5 imagery obtained from Dundee University. The B/W video camera was a Sony AVC 3250 CE loaned by the Media Services Unit of Lancaster University. A secondhand Bush CTV-25 was employed for display of the false-colour images. Some trials were also conducted using a suite of LANDSAT images of the UK purchased from Nigel Press Associates.

A block diagram of the basic video processor is shown in Fig. 1. The black and white video signal is divided into eight grey levels, each of which may be displayed as a false colour. Three primary colours are added to black until white is produced at the fourth level. Primary colours are then subtracted from white to yield two additional colours at levels five and six. Finally, the colours corresponding to levels seven and eight are obtained by further subtraction operations not confined to white. The main part of the processor uses seven 527 fast comparators with TTL outputs as digital RGB (+ or -).

Subject plane



Insert between

pages -3- and -4-

Fig.1

Block diagram showing microcomputer processing of strobed video signal from TV camera.

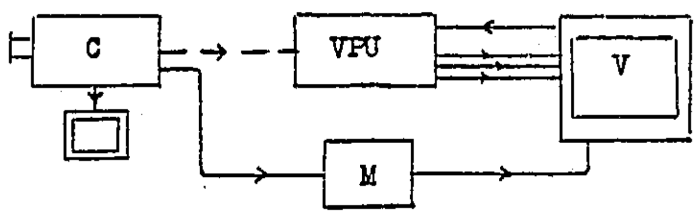
Grey level range (SPAN) and threshold (SHIFT) are provided, along with variable input (GAIN) and output (SATURATION) levels. The device worked satisfactorily in conjunction with the Bush CTV-25 receiver, which was suitably modified to permit injection of digital RGB signals to the grids of the chrominance output tubes. Delay between chrominance and luminance at the CTR was not significant.

The Sony black and white CCTV camera was equipped with a view finder display which served as a black and white monitor.

During the test runs with NOAA-5 Thermal IR imagery, modifications were made to the processor to improve the quality of the display. The most benefit was achieved from adjustment of the comparator series input resistors. These were decreased from 4.7 kΩ to 470 Ω. The capability limits of both the CCTV camera and the domestic monitor receiver were reached and further modifications could not be tried until purchase of better quality camera and monitor systems.

Regarding needs to maximise the video processing capability (synoptic fast processing) with the L.P.U. video processor, we considered the possibilities as summarised in the following schemes:

1. <u>Configuration up to March 1977</u>



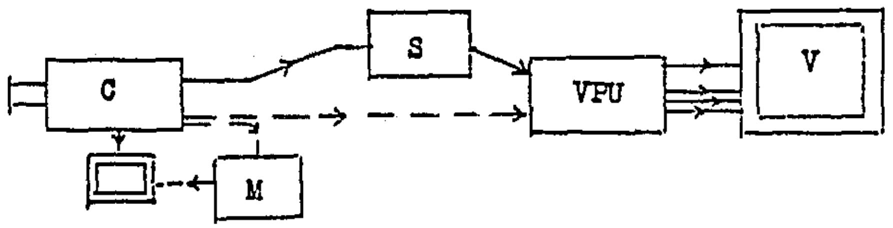
C Black-and-white CCTV camera, Sony, on loan from Media Services Unit.

M Video modulator (nominal cost excluding power supply) built by D. Telfer.

V CTV 25 Bush T/V receiver (cost, S/H £20).

VPU L.P.U. video processor.

2. Analogue shading correction with improved camera and monitor

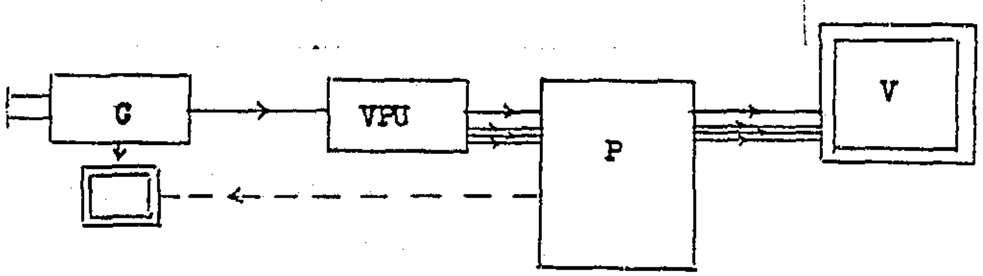


C CCTV camera with low shade vidicon, Link Electronics Limited (£550).

S Analogue shading corrector, Cox Electronics (£650). Alternatively built at L.P.U. Est. cost < £100.

V Colour video display monitor. Crow Electronics; as recommended by Plessey (£3 000).

3. Digital correction with improved camera and monitor



C CCTV camera, b/w, as in 2C above.

V Colour monitor, as in 2V above.

P Plessey image processing console with minimum requirements for storage and digital correction for shading. This includes only the necessary stores, viz., 3 bit output, 8 waveband for 640 x 480 picture elements; store and waveband controllers, and ratio unit with modification for real-time control override. Estimated cost (Plessey) £50 000.

N.B. Shading effects were apparent in displayed imagery on the IDP 3000 during a visit to Plessey (see below). It was noted that a relatively inexpensive CCTV camera was being used.

For synoptic fast processing, we favoured Option 2 above. We compared this type of scheme with the IPD 3000 and concluded that Option 2 would provide a cost-effective solution of fast processing NOAA and HCMM imagery, in preference to Option 3.

We felt justified in claiming that a better camera/tube unit was required because:

a) The camera shading effects using a vidicon were found to change with image brightness, contrast and structure. This makes electronic (anologue of digital) correction of the video wave form difficult. However, improved results could be obtained by having minimal need for a shading correction in the first place. Link Electronics market a camera-tube combination which was effectively demonstrated at Imperial College. No electronic shading corrector was used on that occasion.

b) At a visit to Plessey, made on 3rd June by D. Telfer, critical examination of NOAA imagery (Ekofisk oil slick area) included ratio-taking for camera shading corrections, but even with the digital technique spurious colour rings were evident in the display. It was felt that the IPD 3000 could benefit from improvements at the camera end of the system.

In addition, the visits made to Plessey demonstrated that a good quality monitor is an essential part of a video processing system. Plessey strongly recommended to us the Crow Electronics model used in the IDP 3000; this had been chosen following assessment of alternative monitors. Although at £3 000 this would be the most costly item in Option 2 above, the indications were that this colour monitor could improve image definition by at least an order of magnitude.

D. Telfer also designed circuitry for a colour-selective area integrator to be used in conjunction with the L.P.U. video processor. Following discussions with the Department of Industry, a provisional patent was applied for in connection with the video processor. Microwave Modules Ltd., Liverpool, were approached regarding the possibility of marketing the device should sufficient interest be shown. A further set of experiments was undertaken to evaluate the usefulness of optical diffraction filtering in conjunction with the video processor and results were promising for the test image used, which was an Orbiter picture of the lunar surface containing raster lines. These were successfully removed.

As an alternative to the rather more expensive Crow Electronics (Barco) colour monitor, the Sony Trinitron was evaluated.

Delivery was taken on the D.O.T. Products, Incorporated, "Compo 2" additive viewer with a projection facility. This is being used in the synoptic fast processing of HCMM and support imagery. The viewer was first set up and tested by Mr. N. Press of Nigel Press Associates in October 1977.

Visit to the USA by D. Telfer, 7th-16th November 1977

This visit was arranged primarily in response to a communication from the D.O.I. concerning recent developments in remote sensing of oil pollution by the United States Coast Guard

(U.S.C.G.) although the opportunity was taken to visit other relevant establishments in the eastern United States. Contributions to the U.S.C.G. research programme on oil detection were being managed by Lt. Cdr. J. C. R. White, and D. Telfer visited him at the Washington headquarters of the U.S.C.G. on 7th November 1977.

The current activities of the U.S.C.G. were found to be yielding useful results derived from day/night aircraft overflights of oil spills using side-looking radar, an IR/UV line scanner, an aerial reconnaissance camera and a passive microwave imager. Operations with this system have already logged several oil spills, and the results were discussed in detail. Clear images of oil slicks were produced by the IR line scanner: the results were comparable to those gained by the French organisation G.C.T.A. (Groupement pour le developpment de la teledection aerospatiale) over the Ekofisk blow-out in the North Sea, and show that thermal IR detection of oil is a most promising technique.

A second important visit was made to NASA (MD) to contact as many as practicable of the staff who were involved in HCMM and to exchange information about progress in the present project and matters arising therefrom. The principal personnel contacts were with the Investigations Manager, Mr. Locke Stuart, who, following a discussion of our data requests, pointed out that thermal inertia maps will not now be supplied unless specifically requested for areas of extreme interest within the scene under investigation; the Technical Officer, Mr. H. Oseroff, with whom the data mailing arrangements were discussed and clarified; Dr. J. Vette, Director of the World Data Centre A for Rockets and Satellites; and HCMM Project Scientist Dr. J. Price. Possible points of relevance concerning NASA's proposed contribution to the Climate Program were investigated in discussions with Mr. L. Hogarth and Dr. W. Bandeen. Use of satellite imagery other than that from HCMM was considered both as possible accessory material to the HCMM data and in the context of contingency plans should there be a launch failure, or other difficulties in connection with the Explorer A satellite.

At NOAA (World Weather Building, Washington) the technical aspects and acquisition of NOAA imagery were discussed with Dr. W. Jaeger and Mr. L. Berry, respectively. The NASA and NOAA visits were made during the period 8th to 9th November and concluded the business in the Washington D.C. area, while Thursday 10th November was used to travel from Washington D.C. to Rhode Island as well as for collection of information received and for further itinerary planning.

The Marine Station at Woods Hole was visited on Friday 11th November, when D. Telfer met Dr. D. Butman to discuss and exchange information about sea-data measurements. As a result of this visit, we expect to receive a copy of the report appertaining to the portable sensing platform which has been developed at Woods Hole for measuring sea-surface parameters including temperature, salinity, turbidity and current.

The weekend, Saturday 12th and Sunday 13th November, was spent with Dr. S. Sparks, currently at the Graduate School of Oceanography, University of Rhode Island, and was used for planning the remaining visits - those to establishments in the NE U.S.A. - in more detail.

On 14th November, D. Telfer visited M.I.T., Boston, and discussed applications of "whole-Earth" synoptic imagery, and infrared and radar techniques, with P. Rosencrantz. Back-up meteorological imagery of 1 km resolution from NOAA was considered to be of some value in the HCMM work.

At the University of Massachusetts, Amherst, D. Telfer was able to discuss the remote sensing of planetary surfaces in the visible, UV and near-IR, with Professor R. Huguenin. Another discussion with Dr. K. Beechis centred on the usefulness of passive microwave radiometry in thermal and textural investigations of water surfaces, and on the possible application of this technique to complement IR measurements in our simulator experiments at Lancaster.

D. Telfer rounded off his visit to the U.S.A. on Wednesday 16th November by having discussions, at the Graduate School of Oceanography (University of Rhode Island), with W. Mosher on aerosols and trace element enrichment in the atmosphere and on the subject of the generation of these particles from natural sources; and by noting the results of Dr. T. Huang's studies of marine sediments.

Other Visits (in the UK)

On 3rd October 1977 D. Telfer visited Dr. Alison Cook and Mr. T. Welch to view the remote sensing equipment in the Department of Geography of the University of Sheffield.

G. Fielder and D. Telfer travelled to Aberdeen on 10th October 1977 and, on 11th October, entered profitable discussions on North Sea truth with Dr. H. Dooley of the Marine Laboratory of the Department of Agriculture and Fisheries for Scotland. The team leader in pollution, Dr. MacIntyre, and a specialist in the chemical aspects of oil pollution, Dr. W. Johnston, were also involved in the discussions, which covered other points of contact, specific problems (such as fog) likely to arise in HCMM remote sensing of the North Sea surface (based partly on NOAA data), the nature and temperature of effluents currently discharged into home waters, and other factors (such as chlorophyll, dredging effects and jellyfish shoals) which might complicate the interpretation of remote sensing data relating to the North and Irish Seas.

Ground Truth

A survey of existing sources of ground and sea-level data was initiated. Informal plans were laid for the acquisition of temperature, salinity and plankton bloom data from a part of the

Irish Sea (which will be used to provide control data), and for the acquisition of temperature and sea current data from parts of the North Sea.

In preparation for the ready identification of marine features on satellite pictures, maps having a 1:500 000 scale were purchased in the second quarter of 1977 to provide a definition of the coast lines of Britain and the west European continent. This scale was selected to provide map positions to an apparent accuracy only slightly less than the expected resolution to be provided by the HCMM. In those instances in which Ordnance maps were out-of-print and unobtainable, Aeronautical maps were procured in their place. Both series of maps were prepared on the Lambert Conformal Conic projection. One wall of a cartographic room was covered with Sundeala board to receive the map mosaic.

The geographical co-ordinates of oil rigs in the North Sea were received, with rig identifications, from M. Sturgeon of the Department of Energy.

G. Fielder continued the survey of sources of sea truth relevant to the present programme and received informative letters from Dr. L. E. J. Roberts, A.E.R.E. (Harwell); R. K. Webster, A.E.R.E.; Dr. V. Essex, S.R.C.; Dr. B. Jamieson, N.E.R.C.; E. A. Stephens, I.G.S. (London); D. A. Ardus, I.G.S. (Edinburgh); Dr. T. C. O'Connor, University College Galway; and J. Smythe, Occidental. All these responses were positive only in that they referred to potentially useful points of contact. However, it was clear that some sea truth could be provided through Dr. P. Diver, Lancashire and Western Sea Fisheries and through Dr. E. Monahan, University College, Galway. Dr. Monahan's Irish Sea programme collects temperature, salinity, chlorophyl, nutrient and other data.

A mosaic of the 1:500 000 Aeronautical maps of the North Sea area was prepared during the third quarter and mounted on Sundeala board in an Operations Room, this series of maps being found more suitable than the Ordnance maps of the same scale and projection for defining the area under investigation. A second set of relatively undistorted Aeronautical maps was bought for the purpose of the definition of coastline data to an accuracy adequate to feed to the computer's subroutine ØTLN.

G. Fielder continued to survey sources of sea truth and received replies from the following organisations:-

Continental Shelf Institute, Trondheim (J. O. Klepsvik).

Department of Agriculture and Fisheries for Scotland, Marine Laboraboty, Aberdeen (B. B. Parrish).

Department of the Environment, London (J. M. Williams).

Harwell, Nuclear Physics Division H8 (J. A. Cookson).

Institute of Hydrology, Wallingford (J. S. G. McCulloch and K. Blyth).

Institute of Oceanographic Sciences, Birkenhead (D. E. Cartwright).

Institute of Oceanographic Sciences, Wormley (Mrs. P. M. D. Hargreaves).

Meteorological Office, Bracknell (J. L. Brownscombe).

Ministry of Defence, Hydrographic Department, London (Lt/Cdr. T. McAndrew).

Ministry of Public Health and Family, Brussels (M. J. P. Monnaerts).

Of these organisations, the Scientific Attache of the Brussels Ministry offered to provide us with all the sea truth data which may be of interest to us, in excahnge for remote sensing data and our own, or our joint (collaborative), interpretation of those data. Again, D.A.A.F.S. (Aberdeen) wish to explore the possibility of their supplying relevant sea truth data to us.

Enquiries about certain lines of application of the present research programme were received from the Central Office of Information, London, the Liberal Whip's Office, London, Norpipe Petroleum U.K. Ltd., Middlesbrough, and Tioxide International Ltd., Stockton-on-Tees.

Methods of measuring sea surface temperature have been researched by D. Telfer. In a visit to E.G. and G. Geophysical Ltd., Bracknell, in late June, D. Telfer learned that they could be in a position to obtain sea surface data to special order but at a cost of the order of £3 000 per day.

Further research on the sources and acquisition of sea surface data was completed in December 1977 by G. Fielder and the following organisations should be in a position to provide relevant data during Phase 2 of the programme.

Fleet Weather and Oceanographic Centre
Meteorological Office
Department of Agriculture and Fisheries for Scotland
Ministry of Agriculture, Fisheries and Food
Deutsches Hydrographisches Institut
Institut Francais de Petrole
Lancashire and Western Sea Fisheries
Dept. Physical Oceanography, Univ. Coll. N. Wales
Hydrographic Department, Ministry of Defense
Marine Information and Advisory Service, I.O.S.
British Aircraft Corporation
Brussels Ministry of Public Health and the Family
Water Research Centre
Tioxide International Ltd.
University College Galway
E. G. and G. Geophysical Ltd.

The data derive chiefly from a variety of vessles but also from sea platforms and bouys. One major problem over the rapid interpretation of synoptic satellite data in association with sea truth lies in the delay commonly experienced between the acquisition of the sea data and their release to the scientific community.

Satellite Data

NOAA pictures of the region including the Ekofisk slick were obtained through Dundee and examined using both the video processor and the Plessey IDP 3000 Digital Image Processor. Cloud cover prevented effective interpretation of the data.

Simulation Equipment

In order to test and develop pollution detection and monitoring technqiues under controlled conditions, plans were laid for an outdoor simulator consisting essentially of two 100 gallon capacity water tanks, with filling and emptying facilities, viewed by a battery of optical and infra-red sensors riding on an overhead gantry. A site for this equipment was selected, and delivery taken of the polyurethane tanks. A mount for two reflex cameras was designed and built. In addition, two Eltec infra-red sensors were ordered.

By September 1977, the gantry of the outdoor simulator had been assembled and erected on a specially constructed reinforced concrete pad in the grounds of the University of Lancaster close to the offices of the Lunar and Planetary Unit. In the first instance the gantry, which rotates in a vertical plane which is itself inclined at 45°W of geographical north, is designed to carry two optical cameras and one of two Eltec IR sensors. The orientation of the plane of rotation of the gantry was set by map measurements and checked using a magnetic compass and taking a variation of 8°W. The orientation error was estimated to be not more than $\pm 1^{\circ}$ of azimuth. Thus the plane in which the simulator sensors rotate is identified with the orbital plane of the HCMM satellite.

A 20 mm O/D outdoor water tap was fitted close to the simulator pad and plastic hoses for filling and emptying the polyurethane tanks were bought. Oil contaminating the water which is being put to waste is removed by special filters in the drainage system.

YEAR BEGINNING 1ST JANUARY, 1978

Mapping from HCMM Images

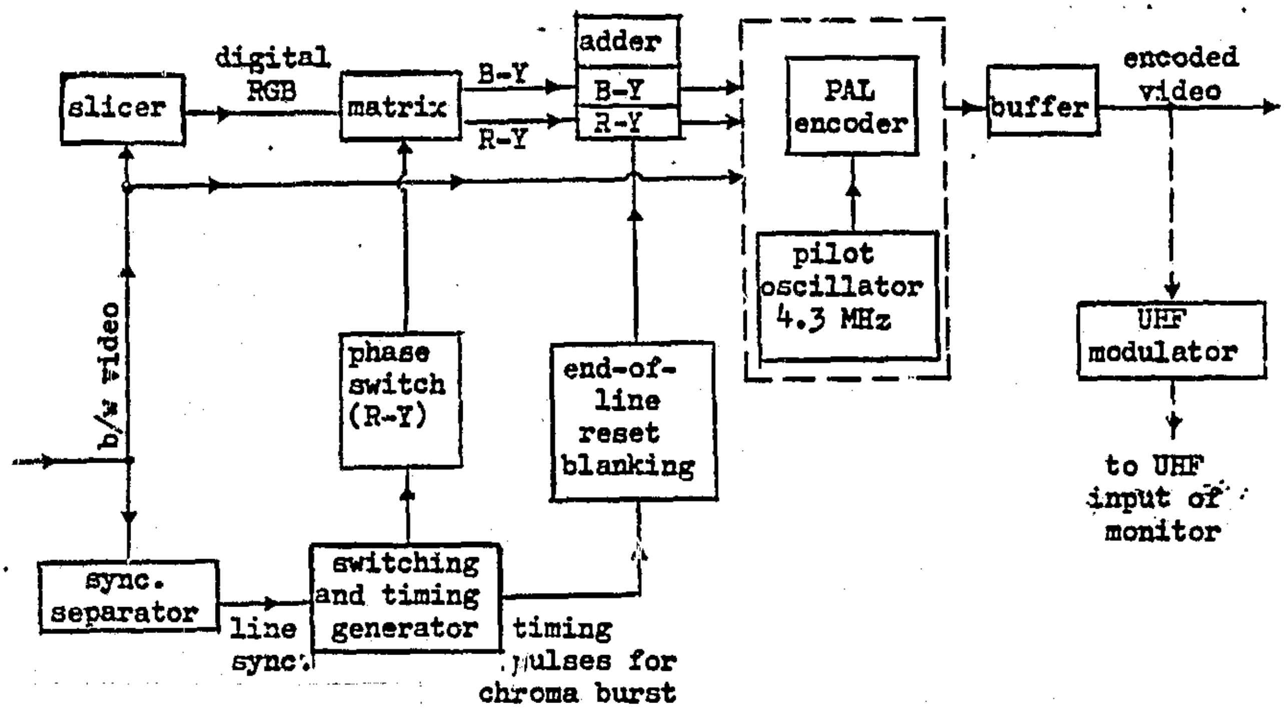
R. J. Fryer reported usefully on the problems likely to be encountered in the work of relating points in HCMM imagery to fixed co-ordinates on the Earth's surface.

PAL-encoder and matrix

Equipment for performing first-look operations on the basis of the use of colour video presentation of grey-level, sliced black and white images using a CCTV camera was developed further.

To enable acceptance of colour video information through the composite video input or into the UHF aerial of a TV monitor, a PAL system encoder interface was designed and assembled for use with the grey-level slicer. The latter provides digital red, green and blue colour information which must be converted via a suitable matrix circuit to colour-difference signals, namely, red-minus luminance (R-Y) and blue-minus luminance (B-Y). These are injected into the encoder along with timing pulses for the chroma-burst signals appropriate for acceptance of the total video information, by the decoding circuits of a PAL receiver/monitor. In the PAL system it is necessary to switch the phase of the (R-Y) signal every alternative line; provision for this is included in the matrix before the encoder.

A block schematic of the PAL interface is given below:



Colour Monitor

It was decided to purchase a SONY model, CUM-1801 UB, which gave pictures of acceptable definition during trials with LANDSAT and NOAA imagery, and compared favourably in performance with the more expensive available monitors.

CCTV Black and White Camera

A different B/W camera was tried: this was a S/H ITC model with a silicon diode tube. This model however, was then replaced by a Link Electronics Model 109, a camera specially selected for its high grade vidicon tube of low shading characteristics, but which was later also fitted with a silicon diode tube.

Videodensitrometry

Single line selection, using a purpose-built raster analyser from Video Electronics Ltd., Manchester, enabled us to display density profiles of black and white imagery on a storage osilloscope. Positive LANDSAT and NOAA prints were examined in this way, and grey-scales were used for calibration runs. Using video signals from the camera output, amplitude resolution attained by the method exceeded our expectations.

Optical Filtering

A samll He/Ne laser and its accessories were ordered, following the successful trials using equipment borrowed from the Department of Physics, University of Lancaster.

Compo-2 Additive Viewer

The high quality optics, the projection facility, and the ease of operation (using the convenient control panel) of this instrument make it particularly suitable for our pruposes. As D. Telfer discovered during his visit to NASA, the necessity for hand-registration of day/night HCMM imagery has precluded the possibility of NASA's supplying thermal inertia maps as a routine procedure. However, following some tests with the Compo-2, we considered that we could effectively assess the usefulness of day/night data, and extract other information directly, using the instrument's projection facility in conjunction with our video processing equipment.

Quantitative Processing

Results with a storage oscilloscope type of display of selected lines of satellite imagery encouraged us to consider the profitability of storing and processing parts of the video output obtained from the CCTV camera. In addition to plans to make use of existing University facilities, we considered the incorporation of a dedicated microcomputer system into our video processing facility. A number of hardware, and associated software, options were reviewed. These included mini- and micro-computer systems.

On 27th January 1978, D. J. Telfer visited Dr. C. Taylor at the Medical Biophysics Unit, University of Manchester, to see a Joyce-Loebl Magiscan digital image analyser demonstrated. This programmable system is based on a Nova minicomputer with the additional hardware and software developed at Manchester University. It is intended, we understand, to make the equipment available for solving external users' problems; an opportunity in which we have expressed interest should the need arise. A Quantimet image analyser was also seen on display at a Royal Society exhibition in London.

Analysis

Following further trials using the additive viewer, grey-level slicer and video densitometer, purchase of a Telequipment DM63 storage oscilloscope enabled us to implement tests of quantitative intensity determinations on LANDSAT imagery, using grey-scale calibration. The results confirmed that this technique would be of invaluable assistance in our assessment of HCMM imagery. We also experimented with Explorer-A scans of the eastern seaboard of the U.S.A. received from NASA.

A Commodore PET 200 microcomputer was purchased with a view to video line processing in the quantitative analysis of images. The method was planned by Dr. Telfer according to the following scheme: a stored portion of the image to be analysed (part of a raster line) is combined in a chosen way (e.g., subtraction, division) with the video image data to give an image profile plot corrected for the TV camera shading at an XY plotter. The peripheral hardware was initially committed to our electronics workshop, but D. Telfer designed and built the video strobe interface for use with the CCTV camera.

Programs were evolved for image correction and these were stored initially on cassette tape. Up to this time a reliable floppy disk drive was not available in the UK for use with the Commodore PET microcomputer (but see page 24).

Improvements to the sharpness and degree of edge enhancement of the CCTV imagery were effected electronically. Further improvements were gained by mounting transparencies on the stage of a low-power microscope, illuminating them by means of a projector lamp arranged to back-light the condenser lens. The image was viewed with our TV camera receiving light through the eyepiece of the microscope. This arrangement is useful for the examination of picture data at high resolution. Furthermore, the system has been found to produce a noticeably flatter effective illumination field that in the case of front-illuminated prints viewed directly by the TV camera.

Trials with the test imagery of the U.K. coastal regions again demonstrated the usefulness of the videodensitometric technique. Steps were then taken to interface the signals with the PET microprocessor system so that the quantitative measurements, incorporating a camera shading correction, could be implemented. A printer for providing hard copy of numerical data held in the microprocessor was ordered. This was the Commodore PET printer. As yet, it is unavailable.

Data Handling

In order to facilitate the conversion of data from the digital to the analogue form, and vice versa, for the generation of hard copy of data on an XY plotter, and for the CCTV display of data, we commissioned the Psychology Department of Lancaster University to construct D to A and A to D converters for use with the microprocessor.

Software for Data Processing

D. Telfer continued to develop further microprocessor routines for use in processing a given HCMM image, in which picture elements are sampled at video frame frequency. TV camera shading corrections were evolved. Refinements to the routines forimage rectification were also prepared by D. Telfer, using polar co-ordinates.

The Explorer-AEM-A satellite was launched on 26th April, 1978, and, thereafter, the regular orbital adjustments were completed. We received the first test data in the form of three pictures of the eastern coastline of N. America in June, but we awaited the first of our own set of data from the North and Irish Sea areas.

On 20th June 1978 Dr. R. J. Gurney and Dr. S. F. Jagger of the Institute of Hydrology, Wallingford, and Mr. K. Blyth of the University of Leeds, visited the LPU to discuss points of mutual interest on the HCMM project. The principle discussions centred on correction procedures and cartographic problems.

On 21st September 1978, D. Telfer visited Dr. J. Hardy in the Department of Geography of Reading University to discuss the status of our respective projects. D. Telfer was able to view a demonstration of the Image Science colour video slicer applied to the recent Explorer A imagery and he found that the results were comparable to ours.

In a visit to the Transport and Road Research Laboratory at Crowthorne, on 21st September, D. Telfer discussed sources of good quality supplementary imagery and current developments in image processing and analysis with Warren Heath.

At the Microcomputer Exhibition (sponsored by 'Personal Computer World') held in London on 22nd September, D. Telfer was able to make an appreciation of the present technical and market status of microprocessors and microcomputers. Associated peripheral instrumentation was also examined. Some printers were examined but most were considered unsuitable for our purposes.

Imagery Received

By September 1978, this Research Unit received three HCMM pictures of the eastern coastline of N. America in June and two test-data images (one in the visible band and one night-time IR photograph), showing parts of the U.K. coastline. NASA reported that these latter images were substandard in several respects. Tests on the IR image with the grey-level slicer showed clear differences, on the synoptic scale, between exposed estuarine deposits and a part of the North Sea. Contrasts away from coasts were less conspicuous but, although complicated by the superimposed raster, could be detected using the video line-scan densitometer. We awaited arrival of the first standard data relating to the North and Irish Seas.

Further picture data (test) arrived at the LPU on 3rd November 1978. Up to that time we had received a total of 12 images of 8 areas in the North Sea and 1 area in the Irish Sea/ North Atlantic Ocean.

For "vertical" images composed from 620 km altitude the predicted resolution in either of the channels was about 600 x 600 m^2. Measurements made by G. Fielder on a night IR image of the west coast of the U.K. showed that this resolution was essentially attained. Many thermal fronts in the marine areas were sharply delineated on the images provided by NASA. D-MAC card-print-outs of positions were obtained on prints received, for survey purposes in the first instance.

For test purposes, using the unenlarged hard copy HCMM positive prints in conjunction with the D-MAC plotter, it has been possible to develop a microprocessor data filing and handling system for processing cassette data tapes for each HCMM image for rectifying co-ordinates in terms of any given map projection, using known coastline features for calibration. Tests carried out on HCMM IR imagery for 1st June 1978 showed that image features can be plotted in terms of map-co-ordinates by this technique to within a few minutes of arc. Refinements to the program are continually in progress and are expected to improve the plotting accuracy.

Other Contacts

D. Telfer visited NORSG/Swindon (N.E.R.C. Oceanographic Remote Sensing Group) on 9th November 1978 for an interesting and useful meeting at which contacts were made with 17 other people in the U.K. directly concerned with remote sensing of the marine environment.

Sea surface temperature data were obtained for the Liverpool Bay area at the beginning of June 1978, corresponding to IR imagery from NASA for that period.

The Chairman, Dr. J. Simpson, of the UCNW Marine Research Unit, Anglesey, showed particular interest in our requirements and image processing facilities at Lancaster, which he has also seen during a recent visit.

Tiros N imagery from Dundee University (P. Bayliss) was shown and considered to be of potential use in the HCMM work.

Indoor Simulation Equipment

The two gallons of crude oil for use in experiments with the simulation equipment were received gratis from Norpipe Petroleum Limited (U.K.).

Laboratory tests were carried out with an IR sensor to compare the emissivity of water and oil-on-water. In the case of a film of North Sea oil covering an equal volume of water, and in which the equipment had been left to attain thermal equilibrium, the measured responses of the systems were mutually different, with a general tendency of the oil surface to be warmer by an estimated 1 or 2 K.

Outdoor Simulation Equipment

Two 35mm cameras and an Eltec IR sensor were mounted in such a way that they could be carried, singly or together, by the rotating gantry of the simulator. In addition, a chopper assembly was mounted in front of the IR sensitive surface in order to introduce the capability of distinguishing the response from the water, or oil-on-water, from the overall response including background noise. The detector/chopper system was tested with the aid of a recently acquired Ortec-Brookdeal phase sensitive detector. In the high positions of the gantry, the IR sensor and cameras are out of reach. Furthermore, the solar radiation incident on the tank fluids would be interrupted by an operator near to the battery of sensors. Hence the latter must be actuated by remote control. To this end, cables were run to the Eltec sensor and chopper, and air tubes were connected to the shutter mechanisms of the respective cameras. The whole sensor assembly can be moved along the gantry by means of a cord and pulley system: in this way the sensors can be directed at each tank in rapid succession before the conditions of solar illumination change. A water-powered extractor pump was incorporated in the plastic water hose system for the rapid exchange of tank fluids.

Sea Truth

The locations of foreign oil and gas platforms in the North Sea were noted using the Offshore Promotional Services Ltd., North Sea Concession Map. A principal source of sea truth, through Phase 2, will be the Meteorological Office (METO). Data from vessels, platforms and buoys will be made available to us through METO 12c. The potential of deriving subsidiary data from ASSFS, MAFF, LAWSF, and the previously mentioned organisations was established.

YEAR BEGINNING 1ST JANUARY, 1979

Extension of Hardware

Purchase of a Computhink Floppy disk system and memory expansion for the PET microcomputer (27 K) greatly increased the speed and flexibility of the small systems data handling facility.

Data

By March 1979, we had recieved images covering a total of sixteen scenes of marine areas in the vicinity of the British Isles. Apparently, no data have been degraded by loss of performance of the power system of HCMM; but routine data acquisition from the statllite was terminated on 1st March, 1979 (telex, NASA to G. Fielder, 16th March 1979). Apart from the backlog of HCMM data expected to arrive at the LPU we understood that alternative data may also be made available to us should the need arise.

Further Software Development

Advantage was taken of the continuing delay in the receipt of standard data to develop further the methods of handling both analogue and digital data-formats. Fuller use was made of the synoptic fast-processing facility already in operation by permitting the camera waveform to be digitised.
This introduced the option of further processing of the imagery in blocks. First, an area of interest of a colour density-sliced image seen on the colour video monitor is selected by inspection. In this way, the choice of block is settled and the relevant brightness data presented in digitised form. In order to achieve this result, various items of software were developed:

(a) Data strobing program. With the aid of an interface constructed by D. Telfer the camera wave-form is digitised and strobed in to the PET microprocessor. The PET then creates a data file in blocks of 225 x 25 data points, each of which is an 8-bit byte giving a maximum of 256 density levels. In practice, the upper limit is fixed at 250 levels.

(b) File handling programs. These programs are used to select blocks of data from a master file created in program (a). Thus, a 40 x 25 array of data points can be presented on the video display unit of the PET. The blocks of data points can then be re-filed on floppy disc.

(c) File reading program. These programs enable one to read the contents of any named file for a block of imagery and to present the results of processing that file on the PET screen. The processing can take the form of (i) camera correction (shading, and electronic, errors) and (ii) illumination correction.

NOTE: In programs (a) and (c) there is the option for the output of the digitised and corrected video wave-forms on an XY plotter.

A number of successful trials were completed by D. Telfer. In particular, in the case of an area measuring some 100 x 20 km^2 to the west of Stavanger (Norway) a daytime, IR positive print recorded on 28th May 1978 was contrast-stretched to clarify the apparent 1:1 correspondence between the gross features on the print, on the one hand, and the data block, on the other.

Visits

In the first quarter of the year, D. Telfer undertook visits to the following establishments:-

Department of Geography, Sheffield University, 2nd February: the acquisition and processing of radar imagery (SLR) was discussed with Dr. Alison Cooke.

NERC Oceanographic Remote Sensing Group, Alhambra House, 9th February: at the MORSG meeting, an update on the status of projects involving experimentation, and the processing of imagery and other data, in relation to the marine and oceanographic research activities in the UK was assimilated; and the opportunity was taken to make, and renew,contacts with scientists in the field.

Farnborough (NPOC), 22nd February: this was a meeting at the UK National Point of Contact with Earthnet (the European Remote Sensing Group) arranged in conjunction with the Remote Sensing Society. An overview was taken of the reported data and image processing facilities. Contact was made with Keith Bagot and his colleagues with a view to acquiring high quality data/image products as and when required; and the opportunity was taken to assess the usefulness of the IDP 3000 in its present form.

The Warren Spring Laboratory, 23rd February: in a meeting with Dr. D. Cormack and his colleagues the Eleni-V and the Amoco Cadiz events were reviewed, and the results of the appropriate aircraft overflights (in which IR-sensors were employed) were examined. As in the case of earlier US Coastguard experiments of a similar nature, the thicker parts of a slick of oil showed warmer, and the thinner parts cooler, than the surrounding water surface.

The possibility of collaboration over the question of synchronism of data acquisition (viz HCMM and further marine overflight experiments) was also discussed.

University College, London, 23rd February: a meeting was held with T. Fountain, to discuss "cellular logic" image processing. The concept of intelligent data points was explored and there was a demonstration of pattern recognition equipment.

NERC (Tidal Institute, Bidston Observatory), 10th August: Dr. Cartwright's group was visited to discuss sea truth in the context of the forthcoming MARSEN experiment in the German Bight.

Data

The official date of first receipt of data was 30th April, 1979. Transparencies covering a total of 32 areas close to the UK have been received since that date and have been coded, catalogued and filed for ready access. Also since 30th April, 1979 33 photographic scenes copied from "quick look" HCMM imagery arrived from the Lannion Centre for Space Meteorology, France.