

778-34

256A
wmt

WOSSAC: 3966
631.4
(4)

EUROPEAN SPACE RESEARCH ORGANISATION

Page No.

SARSAT STUDY

- 2.1.1 "Standard" Product
- 2.1.2 Imagery for Enhancement
- 2.1.3 Selected Data Imagery

3. DIGITAL DATA

4. VIDEO DISPLAYS

5. USER DATA CATEGORIES

- 5.1 BASIC OPERATIONAL REPORT
- 5.2 DATA PROCESS MONITORING
- 5.3 DATA SEARCH RESULTS FOR

TASK 730

PRESENTATION OF RADAR RESULTS TO USERS

REFERENCES

- APPENDIX I SPECIFICITY
- APPENDIX II IMAGE DISPLAY COMBINATION SYSTEM

HUNTING TECHNICAL SERVICES
LIBRARY

June 1973

Table 1 Digital Data Specified by United Kingdom Potential Users

Table 2 Hunting Surveys and Consultants Limited
Elstree Way
Boreham Wood
Hertfordshire
England

256A

1942

REPORT ON THE PROGRESS OF THE WORK

1942

REPORT

FOR

1942

PRESENTATION OF THE RESULTS OF THE WORK

HUNTLEY & PALMER

1942

and the Survey and Manufacture of
Lithium
Compounds
Lithium
Lithium

CONTENTS

	Page No.
1. DATA FORMATS	1
2. HARDCOPY IMAGERY	1
2.1 IMAGERY OPTIONS	1
2.1.1 "Standard" Product	2
2.1.2 Imagery for Enhancement	2
2.1.3 Selected Data Imagery	3
3. DIGITAL DATA	3
4. VIDEO DISPLAYS	4
5. USER DATA CATEGORIES	5
5.1 BASIC INVENTORY TAKING	5
5.2 SLOW CHANGE MONITORING	6
5.3 RAPID CHANGE MONITORING	6
6. USER REQUIREMENTS	7
6.1 MAPPING SCALES AND RESOLUTION	7
6.2 DATA REQUIREMENTS FOR SELECTED MISSIONS	8
6.2.1 Basic Inventory Missions	8
6.2.2 Slow Change Monitoring	9
6.2.3 Rapid Change Monitoring	10
SELECTED REFERENCES	15

APPENDICES

APPENDIX I	SPECIFICATION OF PROJECT RADAM COVER	16
APPENDIX II	IMAGE DISCRIMINATION, ENHANCEMENT AND COMBINATION SYSTEM	17

LIST OF TABLES

Table 1	Digital Data Specified by United Kingdom Potential Users	13
Table 2	Mapping Scales and Imagery Resolutions Specified by Potential Users in the United Kingdom	14

CONTENTS

Page No.		
1		1. DATA FORMATS
1		2. MANEGERY TRACEY
1		2.1. TRACEY OPTIONS
2		2.1.1. "Standards" Product
2		2.1.2. Imagery for Enhancement
3		2.1.3. Selected Data Imagery
3		3. DIGITAL DATA
4		4. VIDEO DISPLAYS
2		5. USER DATA CATEGORIES
5		5.1. BASIC INVENTORY TAKING
6		5.2. SLOW CHANGE MONITORING
6		5.3. RAPID CHANGE MONITORING
7		6. USER REQUIREMENTS
7		6.1. MAPPING SCALES AND RESOLUTION
8		6.2. DATA REQUIREMENTS FOR SELECTED MISSIONS
8		6.2.1. Basic Inventory Missions
9		6.2.2. Slow Change Monitoring
10		6.2.3. Rapid Change Monitoring
12		SELECTED REFERENCES

APPENDICES

16		APPENDIX I SPECIFICATION OF PROJECT RADAM COVER
17		APPENDIX II IMAGE DISCRIMINATION, ENHANCEMENT AND COMBINATION SYSTEM

LIST OF TABLES

13		Table 1 Digital Data Specified by United Kingdom Potential Users
14		Table 2 Mapping Scales and Imagery Resolutions Specified by Potential Users in the United Kingdom

1. DATA FORMATS

Radar data can be presented in three ways. As:-

- (i) Photographically reproduced imagery (hardcopy).
- (ii) Digital tape data.
- (iii) Video display.

The first two are permanent records, the third is an ephemeral data form used mainly for data control and interpretation.

2. HARDCOPY IMAGERY

This is a film image format which may be a final product or a step in a more complex data processing sequence. Because of the limited density range registration of film, radar imagery contains less information than an original analog or derived digital record. The imagery may be generated by a compression of the full dynamic range of the recorded signals or a selected part of it.

Imagery rather than digital tape may be used for secondary data manipulation even though it does not comprise the full data record. This in part reflects the way in which side look radar systems have developed and has proved useful in comparison of separate spectral channel or polarity records, and in matching to base map material.

The great advantage of hardcopy imagery is that it provides a convenient and familiar data form to the interpreter and it constitutes a low cost data store.

Imagery derived directly from analog or digital data may be subjected to secondary processing, either by direct analog methods or by digitising or re-digitising.

Secondary processing not requiring digitising may be simple photographic processing involving scale correction, image dodging, etc. in preparation for mosaicing, or density slicing by photographic or micro-densitometry techniques giving simplified graphical outputs.

2.1 IMAGERY OPTIONS

There are basically three hardcopy imagery options.

1. DATA FORMATS

Radar data can be presented in three ways. As:

- (i) Photographically reproduced imagery (hardcopy).
- (ii) Digital tape data.
- (iii) Video display.

The first two are permanent records, the third is an ephemeral data form used mainly for data control and interpretation.

2. HARDCOPY IMAGERY

This is a film image format which may be a final product or a step in a more complex data processing sequence. Because of the limited density range registration of film, radar imagery contains less information than an original analog or derived digital record. The imagery may be generated by a compression of the full dynamic range of the recorded signals or a selected part of it.

Imagery rather than digital tape may be used for secondary data manipulation even though it does not comprise the full data record. This in part reflects the way in which side look radar systems have developed and has proved useful in comparison of separate spectral channels or polarity records, and in matching to base map material.

The great advantage of hardcopy imagery is that it provides a convenient and familiar data form to the interpreter and it constitutes a low cost store.

Imagery derived directly from analog or digital data may be subjected to secondary processing, either by direct analog methods or by digitizing or re-digitizing.

Secondary processing not requiring digitizing may be simple photographic processing involving scale correction, image bobbing, etc. in preparation for mosaicing, or density slicing by photographic or microdensitometry techniques giving amplified graphical outputs.

2.1 IMAGERY OPTIONS

There are basically three hardcopy imagery options.

2.1.1 "Standard" Product

High quality photographic products comprising spatially corrected and scaled imagery of a single channel record. They may be used for direct comparison with topographic base maps or for mosaicing as a map substitute. They provide an alternative to air photography and their prime use is for basic inventory mapping or reference purposes.

This imagery is normally printed down at the average dynamic range of the target area returns.

The interpretation of this form of imagery is by direct visual means, the most important criteria being spatial relationships of objects and their relative differences in brightness. For this reason processing techniques like dodging, (image density balancing), that alter absolute spectral response values are acceptable.

The specification in Appendix I is for the final mosaics for the Radam in Brazil and illustrates the standard generally expected from airborne side look radar systems at present in commercial operation.

2.1.2 Imagery for Enhancement

Single channel imagery may be simply enhanced by image density selection, (density slicing), by a number of techniques including direct photographic methods. Photographic methods, using Agfa contour materials for example, are imprecise compared to alternative optical-mechanical systems. More advanced techniques using these systems usually employ digital methods and are often specifically designed for dealing with multi-channel inputs.

With advanced data processing systems the analog/digital conversion from the film image input may be carried out by scanning micro-densitometer, flying spot scanner, laser beam scanner or video camera. The most convenient format for input into these systems is a positive transparency. This should be as fully rectified as possible as the systems in general have no image rectification capability apart from that necessary for multiple image registration, (congruencing). Precise image correction is best carried out at the pre-processing stage.

Requirements for input image characteristics vary between systems. Probably the most advanced hybrid radar data processor is the University

2.1.1 "Standard" Product

High quality photographic products comprising spatially corrected and scaled imagery of a single channel record. They may be used for direct comparison with topographic base maps or for mosaicing as a map substitute. They provide an alternative to air photography and their prime use is for basic inventory mapping or reference purposes. This imagery is normally printed down at the average dynamic range of the target area returns.

The interpretation of this form of imagery is by direct visual means, the most important criteria being spatial relationships of objects and their relative differences in brightness. For this reason processing techniques like dodging, (image density balancing), that alter absolute spectral response values are acceptable.

The specification in Appendix I is for the final mosaic for the Kadam in Brazil and illustrates the standard generally expected from airborne side look radar systems at present in commercial operation.

2.1.2 Imagery for Enhancement

Single channel imagery may be simply enhanced by image density selection (density slicing), by a number of techniques including direct photographic methods, photographic methods, using Agfa contour materials for example, are impracticable compared to alternative optical-mechanical systems. More advanced techniques using these systems usually employ digital methods and are often specifically designed for dealing with multi-channel inputs.

With advanced data processing systems the analog/digital conversion from the film image input may be carried out by scanning microdensitometer, flying spot scanner, laser beam scanner or video camera. The most convenient format for input into these systems is a positive transparency. This should be as fully rectified as possible as the systems in general have no image rectification capability apart from that necessary for multiple image registration (coregistration). Precise image correction is best carried out at the pre-processing stage. Requirements for input image characteristics vary between systems. Probably the most advanced hybrid radar data processor is the University

of Kansas IDECS (Image Discrimination and Enhancement System). In this system imagery for digital conversion by the flying spot scanner input subsystem should be dodged as too great a density range creates non-linear steps in the image dissection. A density spread of no greater than 1.3 is recommended.

The system's characteristics of IDECS are given in Appendix II.

2.1.3 Selected Data Imagery

The most obvious example of this is MTI - the moving target identification facility obtained by the matching of sequential lines of information. The identified target is enhanced and customarily printed as a bright spot on a dark background. The background may be black but in the case of terrestrial targets it has been found advantageous to allow a 'ghost' background of terrain information against which to position the target.

An MTI facility may not be feasible, (or necessary), for SARSAT but a simpler system of thresholding and enhancing high reflectance objects such as ships or fixed reflectors may be useful in some operational roles. This may be more practicable at a pre-processing stage rather than by later data manipulation.

3. DIGITAL DATA

This may be handled in a number of ways:

- (i) Input to a digital/analog conversion system producing a film image record. This could be a 'standard' hardcopy processor. Data can be manipulated against other input data - positional, systems correction, etc., - to generate planimetrically accurate and dynamically balanced high quality imagery.
- (ii) Input to a hybrid image processor like IDECS, by-passing the analog/digital conversion facility. As stated in Section 2.1.2 the data should preferably be systems- and scene-corrected though a degree of rectification is possible with some equipment.
- (iii) Input for computer-graphic generation. This gives a much lower information content than film image records but allows

of Kansas IDECS (Image Discrimination and Enhancement System). In this system imagery for digital conversion by the flying spot scanner input subsystem should be dodged as too great a density range creates non-linear steps in the image dissection. A density spread of no greater than 1.3 is recommended.

The system characteristics of IDECS are given in Appendix II.

2.1.3 Selected Data Imagery

The most obvious example of this is MTI - the moving target identification facility obtained by the matching of sequential lines of information. The identified target is enhanced and customarily printed as a bright spot on a dark background. The background may be black but in the case of terrestrial targets it has been found advantageous to allow a 'ghost' background of terrain information against which to position the target.

An MTI facility may not be feasible, (or necessary), for SAR/SARAT but a simpler system of thresholding and enhancing high reflectance objects such as ships or fixed reflectors may be useful in some operational roles. This may be more practicable as a pre-processing stage rather than by later data manipulation.

3. DIGITAL DATA

This may be handled in a number of ways:

- (i) Input to a digital/analog conversion system producing a film image record. This could be a 'standard' hardcopy processor. Data can be manipulated against other input data - positional, systems correction, etc. - to generate planimetrically accurate and dynamically balanced high quality imagery.
- (ii) Input to a hybrid image processor like IDECS, by-passing the analog/digital conversion facility. As stated in Section 2.1.2 the data should preferably be system- and scene-corrected though a degree of rectification is possible with some equipment at present.
- (iii) Input for computer-graphic generation. This gives a much lower information content than film image records but allows

a high degree of data selection particularly in the case of multi-channel inputs and time-lapse data.

- (iv) Numerical or graphical data. To reduce computation loads sampling techniques would normally be used in this case. Examples of information requirements particularly suited to this format are:

Point co-ordinates of small targets - shipping, structures, markers.

Areal co-ordinates of such targets as sea ice, snow cover, water bodies.

Codings associated with areal pattern recognition - crops, etc.

Histograms for pattern matching - sea state studies, etc.

4. VIDEO DISPLAYS

These are ephemeral displays of generally considerably lower resolution than photographic products. They are customarily used as an interface with the controller in hybrid processing systems, as data checks, or in an operational mode when real-time monitoring is required.

The video display is an essential component of advanced hybrid systems such as IDECS and the LARSYGT System at Purdue University. Their function in these systems is to allow interpreter interaction and process control.

The display is also the main element of simple single channel video image dissector systems.

Video displays can also be used for rapid data checks of hardcopy, analog or digital input. An example of this kind of system is the CCLS Quick-Look System for ERTS data. The normal role of such a system would be to vet low-grade, unrectified imagery or tape data, for selection for final processing.

Real-time video displays are a feature of some military airborne side-look radar systems. They are only necessary when a quick turn-round of data on rapidly changing situations is required. Such roles may not be feasible for SARSAT.

a high degree of data selection particularly in the case of multi-channel inputs and time-lapse data.

(iv) Numerical or graphical data. To reduce computer loads sampling techniques would normally be used in this case. Examples of information requirements particularly suited to this format are:

Point co-ordinates of small targets - shipping, structures, markers.

Area co-ordinates of such targets as sea ice, snow cover, water bodies.

Locations associated with aerial pattern recognition - crops, etc.

Histograms for pattern matching, sea state studies, etc.

4. VIDEO DISPLAYS

These are ephemeral displays of generally considerably lower resolution than photographic products. They are customarily used as an interface with the controller in hybrid processing systems, as data checks, or in an operational mode when real-time monitoring is required.

The video display is an essential component of advanced hybrid systems such as IDECS and the LARSYST System at Purdue University. Their function in these systems is to allow interpreter interaction and process control.

The display is also the main element of simple single channel video image director systems.

Video displays can also be used for rapid data checks of hardcopy, analog or digital input. An example of this kind of system is the CCL's Quick-look System for ERTS data. The normal role of such a system would be to vet low-grade, unclassified imagery or tape data, for selection for final processing.

Real-time video displays are a feature of some military airborne quick-look radar systems. They are only necessary when a quick turn-around of data on rapidly changing situations is required. Such roles may not be feasible for SARAI.

5. USER DATA CATEGORIES

For a satellite imaging radar system there are three categories of potential use. These are for basic inventory taking, low rate of change monitoring, and rapid rate of change monitoring. Each of these has ^{different} requirements for data and data handling.

5.1 BASIC INVENTORY TAKING

This requires once-off, comprehensive cover of a given area. Though there might be a demand to up-date any basic inventory, in this category the data base, when completed, is expected to remain unmodified for a considerable time. It is applicable to topographic mapping, geological mapping and other natural resources of a relatively stable nature.

As pointed out in other reports by Hunting, such roles are not regarded as the optimum use for SARSAT.

As the time factor is not critical in interpretation, a high data component over large areas is acceptable, and desirable if the maximum benefit is to be derived from the coverage.

The requirement for this type of work is high resolution, high quality, relatively large scale imagery. Imagery rectification and improvement by noise removal, tone matching and possibly more advanced techniques such as equalisation are expected to be carried out prior to delivery to the interpreter. In most applications average dynamic information level material will be required. Time saving data processing is not as justifiable as in cases where there is a pressing time element for data synthesis.

For certain specific uses secondary data processing will be an advantage using the original digital tapes or re-digitised imagery. This could include:

Selective data print-out (limited dynamic range recording, thresholding or density slicing.

Signature and pattern recognition.

Edge enhancement by derivative techniques.

These techniques are likely to be in greater demand if multi-channel information is available.

2. USER DATA CATEGORIES

For a satellite imaging radar system there are three categories of potential use. These are for basic inventory taking, low rate of change monitoring, and rapid rate of change monitoring. Each of these has requirements for data and data handling.

2.1 BASIC INVENTORY TAKING

This requires overall, comprehensive cover of a given area. Though there might be a demand to update any basic inventory, in this category the data base, when completed, is expected to remain unmodified for a considerable time. It is applicable to topographic mapping, geological mapping and other natural resources of a relatively stable nature.

As pointed out in other reports by Hunting, such roles are not regarded as the optimum use for SAR/SAT.

As the time factor is not critical in interpretation, a high data component over large areas is acceptable, and desirable if the maximum benefit is to be derived from the coverage.

The requirement for this type of work is high resolution, high quality, relatively large scale imagery. Imagery rectification and improvement by noise removal, tone matching and possibly more advanced techniques such as equalisation are expected to be carried out prior to delivery to the interpreter. In most applications average dynamic information level material will be required. Time saving data processing is not as justifiable as in cases where there is a pressing time element for data synthesis.

For certain specific uses secondary data processing will be an advantage using the original digital tapes or re-digitised imagery. This could include:

Selective data print-out (limited dynamic range recording, thresholding or density slicing,

Signature and pattern recognition,

Edge enhancement by derivative techniques.

These techniques are likely to be in greater demand if multi-channel information is available.

5.2 SLOW CHANGE MONITORING

Typical of tasks in this category are seasonal land-use mapping and comparisons of sea ice or snow-line extent. Changes are measured against a base-line and if operational decisions need to be taken, a reasonably fast data turn-round time is required.

Compared to basic inventory mapping the data of interest are limited. The limitations may be in the areal extent of data or in required resolution. This favours the use of automatic interpretation and mapping techniques.

With digital processing data quantity can be considerably reduced by a number of techniques including the following:

Variation in step quantization.

Resolution degradation by averaging.

Selective print-out of area or point targets, or edge enhancements.

Selection of pre-determined targets by:

simple spectral variance;

deviation from mean signal level;

areal rate of change - direct or derivative;

cluster analysis if there are multi-channel inputs.

If such techniques are employed direct digital tape inputs would be preferable to re-digitising imagery but, depending upon the particular task, a certain amount of interim image generation as hardcopy or video display for control purposes would be necessary.

5.3 RAPID CHANGE MONITORING

Rapidly changing phenomena monitorable by satellite systems vary from ephemeral weather effects or moving targets such as shipping, for which the most rapid repeat coverage is required, to slower changing situations such as crop condition.

The data handling requirements are essentially the same as for slow change monitoring applications but the data turn-round time required is much faster. In most applications at least partial data is required in real or near real-time.

2.2 SLOW CHANGE MONITORING

Typical of tasks in this category are seasonal land-use mapping and comparisons of sea ice or snow-line extent. Changes are measured against a base-line and if operational decisions need to be taken, a reasonably fast data turn-round time is required.

Compared to basic inventory mapping the data of interest are limited. The limitations may be in the total extent of data or in required resolution. This favours the use of automatic interpretation and mapping techniques.

With digital processing data quantity can be considerably reduced by a number of techniques including the following:

Variation in step quantization.

Resolution degradation by averaging.

Selective print-out of area or point targets, or edge enhancements.

Selection of pre-determined targets by:

simple spectral variance;

deviation from mean signal level;

areal rate of change - direct or derivative;

cluster analysis if there are multi-channel inputs.

If such techniques are employed direct digital tape inputs would be preferable to re-digitizing imagery but, depending upon the particular task, a certain amount of interim image generation as hardcopy or video display for control purposes would be necessary.

2.3 RAPID CHANGE MONITORING

Rapidly changing phenomena monitorable by satellite systems vary from ephemeral weather effects or moving targets such as shipping, for which the most rapid repeat coverage is required, to slower changing situations such as crop condition.

The data handling requirements are essentially the same as for slow change monitoring applications but the data turn-round time required is much faster. In most applications at least partial data is required in real or near real-time.



2.2 SLOW CHANGE MONITORING

Typical of tasks in this category are seasonal land-use mapping and comparisons of sea ice or snow-line extent. Changes are measured against a base-line and if operational decisions need to be taken, a reasonably fast data turn-round time is required.

Compared to basic inventory mapping the data of interest are limited. The limitations may be in the areal extent of data or in required resolution. This favours the use of automatic interpretation and mapping techniques.

With digital processing data quantity can be considerably reduced by a number of techniques including the following:

- Variation in step quantization.
- Resolution degradation by averaging.
- Selective print-out of area or point targets, or edge enhancements.

Selection of pre-determined targets by:

- simple spectral variance;
- deviation from mean signal level;
- areal rate of change - direct or derivative;
- cluster analysis if there are multi-channel inputs.

If such techniques are employed direct digital tape inputs would be preferable to re-digitising imagery but, depending upon the particular task, a certain amount of interim image generation as hardcopy or video display for control purposes would be necessary.

2.3 RAPID CHANGE MONITORING

Rapidly changing phenomena monitorable by satellite systems vary from ephemeral weather effects or moving targets such as shipping, for which the most rapid repeat coverage is required, to slower changing situations such as crop condition.

The data handling requirements are essentially the same as for slow change monitoring applications but the data turn-round time required is much faster. In most applications at least partial data is required in real or near real-time.

There is much greater justification for automatic processing to be undertaken in these applications but it is by no means essential in every application. At present, weather forecasting using satellite image data involves the near real-time visual interpretation of average dynamic range hardcopy without secondary processing.

In these roles data reduction may be achieved on an areal basis by the reduction of resolution occasioned by wide swath coverage to accommodate a comprehensive, high repeat performance.

For very short-term change monitoring time lapse super-imposition techniques are promising.

6. USER REQUIREMENTS

The general unfamiliarity with side-look radar systems is reflected by the limited response of potential United Kingdom users concerning their specific data requirements.* Only 14 potential users specify digital data, see Table 1. Most information is on the final mapping scales required for their studies.

Details of requirements are given in Tables 1-6 in the report on U.K. Potential Users.

This unfamiliarity leads to the very strong emphasis on high resolution imagery. This we feel is largely a false requirement as it tends to confine the SARSAT system to narrow swath coverage with low repeatability. This diverts the SARSAT concept away from what we feel are its most productive uses.

The only clear pattern of data preference that emerges from the disciplinary sub-division is that for the disciplines - meteorology, hydrology, oceanology - that are concerned with highly dynamic situations. For some applications their requirements can be satisfied with low resolution data provided high frequency repeat coverage can be obtained.

6.1 MAPPING SCALES AND RESOLUTION

Mapping scales specified for suggested projects using SARSAT data vary from 1:5,000 to 1:3,000,000, but most commonly the demand is for scales between 1:50,000 and 1:250,000.

It must be borne in mind that final map and working material scales do not directly relate to image acquisition or initial print-down

* Refer to report 'Review of Potential Users - United Kingdom Sources'.

There is such greater justification for automatic processing to be undertaken in these applications but they are by no means essential in every application. At present weather forecasting using satellite image data, involves the near real-time visual interpretation of average dynamic range hardcopy without secondary processing.

In these roles data reduction may be achieved on an areal basis by the reduction of resolution occasioned by wide swath coverage to accommodate a comprehensive, high repeat performance. For very short-term change monitoring time lapse super-impulsive techniques are promising.

6. USER REQUIREMENTS

The general unfamiliarity with side-look radar systems is reflected by the limited response of potential United Kingdom users concerning their specific data requirements. * Only 14 potential users specify digital data, see Table 1. Most information is on the final mapping scales required for their studies.

Details of requirements are given in Tables 1-6 in the report on U.K. Potential Users.

This unfamiliarity leads to the very strong emphasis on high resolution imagery. This we feel is largely a false requirement as it tends to confine the SAR/SAT system to narrow swath coverage with low repeatability. This diverts the SAR/SAT concept away from what we feel are its most productive uses.

The only clear pattern of data preference that emerges from the disciplinary sub-division is that for the disciplines - meteorology, hydrology, oceanology - that are concerned with highly dynamic situations. For some applications their requirements can be satisfied with low resolution data provided high frequency repeat coverage can be obtained.

6.1 MAPPING SCALES AND RESOLUTION

Mapping scales specified for suggested projects using SAR/SAT data vary from 1:5,000 to 1:3,000,000, but most commonly the demand is for scales between 1:50,000 and 1:250,000.

It must be borne in mind that final map and working material scales do not directly relate to image acquisition or initial print-down

* Refer to report 'Review of Potential Users - United Kingdom Sources'.

scales as radar imagery is very flexible in terms of enlargement. In our direct experience enlargements to 1:50,000 from 1:250,000 acquisition scale Westinghouse real aperture SLR are satisfactory as interpretation material, while 1:50,000 mosaics are a standard product of the RADAM Project Goodyear SLR material acquired at a scale of 1:400,000.

For air photo-interpretation it is commonly accepted that the image resolution should be at least a factor of 1:10,000 of scale, that is a resolution of at least 5 m is required of 1:50,000 photography. We have found a nominal resolution of 10 m adequate for most interpretation of SLR imagery at scales down to 1:50,000. If this is acceptable to other users the appropriate scale of imagery with a 20 m resolution system will be 1:100,000; for a 50 m resolution system, 1:250,000.

The specified scales and image resolutions under the different disciplinary categories are given in Table 2 with the appropriate scales and resolutions assessed on the above basis.

Final mapping scales are generally considerably smaller than the scales of the materials interpreted.

6.2 DATA REQUIREMENTS FOR SELECTED MISSIONS

The following are the specified and alternatively suggested data requirements for the missions selected in the Report for Task 250 - Review of Potential Users - United Kingdom Sources.

6.2.1 Basic Inventory Missions

(i) Survey of Peat-lands

Imagery required with a resolution of 50 m.

This would be satisfactory for interpretation at a scale of 1:250,000.

The product required would be high quality imagery with high planimetric rectification for transference of mapped detail.

(ii) Inter-tidal Information Up-dating

Resolutions of 50 m and better are specified for mapping at scales of 1:25,000. Even the best resolution obtainable is unlikely to be adequate at this scale of mapping and small scale information will have to be accepted.

scales as radar imagery is very flexible in terms of enlargement. In our direct experience enlargements to 1:20,000 from 1:250,000 reproduction scale Westinghouse real aperture SIR are satisfactory as interpretation material, while 1:50,000 mosaics are a standard product of the RADAM Project Goodyear SIR material acquired at a scale of 1:400,000.

For air photo-interpretation it is commonly accepted that the image resolution should be at least a factor of 1:10,000 of scale, that is a resolution of at least 5 m is required of 1:50,000 photography. We have found a nominal resolution of 10 m adequate for most interpretation of SIR imagery at scales down to 1:20,000. If this is acceptable to other users the appropriate scale of imagery with a 20 m resolution system will be 1:100,000; for a 50 m resolution system, 1:250,000.

The specified scales and image resolutions under the different disciplinary categories are given in Table 2 with the appropriate scales and resolutions assessed on the above basis.

Final mapping scales are generally considerably smaller than the scales of the materials interpreted.

6.2. DATA REQUIREMENTS FOR SELECTED MISSIONS

The following are the specified and alternatively suggested data requirements for the missions selected in the Report for Task 250 - Review of Potential Cases - United Kingdom Sources.

6.2.1. Basic Inventory Missions

(i) Surveys of Post-lands

Imagery required with a resolution of 20 m. This would be satisfactory for interpretation at a scale of 1:250,000. The product required would be high quality imagery with high planimetric rectification for transference of mapped detail.

(ii) Inter-tidal Information Updating

Resolutions of 20 m and better are specified for mapping at scales of 1:25,000. Even the best resolution obtainable is unlikely to be adequate at this scale of mapping and small scale information will have to be accepted.

The final product required for interpretation will be high quality imagery with high planimetric rectification for accurate plotting of detail. Edge enhancement techniques might give greater accuracy of detail for this role.

6.2.2 Slow Change Monitoring

(i) Global Water Resources Inventory

For maximum value, high resolution imagery is specified. A high quality hardcopy product is necessary with good planimetric accuracy. Over different areas different dynamic range or quantized steps may be necessary to locate most effectively different targets such as land/water interface, snow-line, sea ice limits. Edge enhancements on certain data should be of value for improved resolution.

(ii) Regional Crop Inventory

A high resolution of 10 to 50 m is specified with mapping scales varying between 1:10,000 and 1:250,000. The large scales do not seem appropriate to the potential resolution.

Only one potential user specifies digital data. However, as a variety of variable targets have to be resolved there is considerable scope for automatic pattern recognition. There is a very considerable body of work on this subject - mostly based on multi-spectral data.

The overall data requirement is likely to be a combination of high quality imagery acting as base-line material with digital data print-outs of identified crops. Hybrid data treatment systems such as IDECS and LARYSGT will be most important in this application.

(iii) Sea Ice Monitoring for Climatological Studies

The data requirement is similar to that for global water resources inventory.

(iv) Snow Mapping for Regional Situation

High resolutions are specified for this - 10 to 20 m for mapping at scales of 1:50,000 to 1:100,000.

The final product required for interpretation will be high quality imagery with high planimetric rectification for accurate plotting of details. Edge enhancement techniques might give greater accuracy of detail for this role.

6.2.2 Snow Change Monitoring

(i) Global Water Resources Inventory

For maximum value, high resolution imagery is specified. A high quality hardcopy product is necessary with good planimetric accuracy. Over different areas different dynamic range or quantized steps may be necessary to locate most effectively different targets such as land/water interface, snow-line, sea ice limits. Edge enhancements on certain data should be of value for improved resolution.

(ii) Regional Crop Inventory

A high resolution of 10 to 50 m is specified with mapping scales varying between 1:10,000 and 1:250,000. The large scales do not seem appropriate to the potential resolution. Only one potential user specifies digital data.

However, as a variety of variable targets have to be resolved there is considerable scope for automatic pattern recognition. There is a very considerable body of work on this subject - mostly based on multi-spectral data.

The overall data requirement is likely to be a combination of high quality imagery acting as base-line material with digital data print-outs of identified crops. Hybrid data treatment systems such as IDECS and LARYSCT will be most important in this application.

(iii) Sea Ice Monitoring for Climatological Studies

The data requirement is similar to that for global water resources inventory.

(iv) Snow Mapping for Regional Situation

High resolutions are specified for this - 10 to 30 m for mapping at scales of 1:50,000 to 1:100,000.

Again high quality imagery with good positional accuracy is likely to be the most satisfactory. Secondary processing requirements are likely to be simple - areal measurement, albedo, etc.

6.2.3 Rapid Change Monitoring

(i) Sea Ice Mapping for Operational Ship Routing

One user specifies the data requirement as 1 km resolution for 1:3,000,000 scale mapping. Better resolution than this would be welcomed by interpreters providing this still allows for a high rate repeat capability.

High quality imagery with accurate fiducials for position fixing is the basic requirement for this application. Extra processing of digital data may be required for edge enhancements and ice type discrimination by digital pattern recognition techniques.

(ii) Sea State Monitoring

Little is known about sea state assessment from satellites though considerable work has been done with airborne and ground-based radar. In view of this the specifications for high resolution imagery may be misleading. If this application is at all feasible it is possible that the most effective approach will be to utilise sampled lines of image data in digital format for pattern matching.

(iii) Balloon Tracking for Tropical Wind Monitoring,

(iv) Marine Traffic Monitoring and -

(v) Buoy Tracking for Ocean Current Monitoring

These present essentially the same problems. Providing the targets can be satisfactorily discriminated the most important requirement is accurate position location. Ideally two approaches are possible:

Enhanced target blips printed as in image format with accurate fiducials. A ghost background would be an advantage on any frames with shoreline or sea ice.

Again high quality imagery with good positional accuracy is likely to be the most satisfactory. Secondary processing requirements are likely to be simple - area measurement, albedo, etc.

6.2.2 Rapid Change Monitoring

(i) See Ice Mapping for Operational Ship Routing

One user specifies the data requirement as 1 km resolution for 1:3,000,000 scale mapping. Better resolution than this would be welcomed by interpreters providing this still allows for a high rate repeat capability.

High quality imagery with accurate fixings for position fixing is the basic requirement for this application. Extra processing of digital data may be required for edge enhancements and ice type discrimination by digital pattern recognition techniques.

(ii) See State Monitoring

Little is known about sea state assessment from satellites though considerable work has been done with airborne and ground based radar. In view of this the specifications for high resolution imagery may be misleading. If this application is at all feasible it is likely that the most effective approach would be to utilize sampled lines of image data in digital format for pattern matching.

(iii) Relion Tracking for Tropical Wind Monitoring

(iv) Marine Traffic Monitoring and -

(v) Buoy Tracking for Ocean Current Monitoring

These present essentially the same problems. Providing the targets can be satisfactorily discriminated the most important requirement is accurate position location. Ideally two approaches are possible

Enhanced target ships printed as in image format with accurate fixings. A good background would be an advantage on any frames with shoreline or sea ice.

Numerical positional print-outs generated from automatic target recognition programmes.

In the case of the image format a facility for displaying sequential time-lapse or real-time data, would be an advantage particularly in keeping track of individual targets.

(vi) Snow Monitoring - Dynamic Situation and

(vii) Soil Moisture Monitoring

For these purposes a high resolution is not required, a high repeat coverage being of greater importance.

Rapidly produced relatively low-grade imagery could form the basis for this application but selective edge enhancement or target print-out could greatly reduce the data load of rapidly repeated cover. An alternative could be real or near real-time video display with digital storage of selected data such as interpreter delineation by light pen on a computer-graphic display.

Snow-moisture equivalent assessments may be possible using automatic digital processing.

(viii) Tidal Flood Monitoring and

(ix) Water Body Monitoring - Europe

These have perhaps the most stringent data requirements. Frequently repeated high resolution cover requires to be assessed in near real-time. This demands very high quality imagery to be generated in near real-time for immediate interpretation. Alternatively very high quality video display is required.

As the land/water interface target is likely to be basically a simple dynamic contrast with a complex spatial expression it is unlikely that secondary processing will be of value, particularly in view of the time constraint.

(x) Water Body Monitoring - Ex-Europe

Data requirements are essentially the same as for tidal flood monitoring except that the data turn-round time is not so

Numerical positional print-outs generated from automatic target recognition programmes.

In the case of the image format a facility for displaying sequential time-lapse or real-time data, would be an advantage particularly in keeping track of individual targets.

(vi) Snow Monitoring - Dynamic Situation and

(vii) Soil Moisture Monitoring

For these purposes a high resolution is not required, a high repeat coverage being of greater importance.

Rapidly produced relatively low-grade imagery could form the basis for this application but selective edge enhancement or target print-out could greatly reduce the data load of rapidly repeated cover. An alternative could be real or near real-time video display with digital storage of selected data - simple interpreter delineation by light pen on a computer graphic display.

Snow-moisture equivalent assessments may be possible using automatic digital processing.

(viii) Tidal Flood Monitoring and

(ix) Water Body Monitoring - Europe

These have perhaps the most stringent data requirements. Frequently repeated high resolution cover requires to be assessed in near real-time. This demands very high quality imagery to be generated in near real-time for immediate interpretation. Alternatively very high quality video display is required.

As the land/water interface target is likely to be basically a simple dynamic contrast with a complex spatial expression it is unlikely that secondary processing will be of value, particularly in view of the time constraint.

(x) Water Body Monitoring - Ex-Europe

Data requirements are essentially the same as for tidal flood monitoring except that the data turn-round time is not so

critical. Rapidly produced high quality imagery should suffice but as the target is relatively simple, automatic computer-graphic up-dating of the situation is possible.

(xi) Locust Breeding Ground Detection

Similar to ex-European water body monitoring but rapidly produced high quality imagery will suffice.

(xii) Oil Slick Detection

Provided this is feasible for a SRSAT system, high resolution data might not be necessary. Rapid data assessment and plotting is essential in this context and relatively low grade imagery or video display should suffice. As the target is in fact located by sea surface condition, computer-graphic print-out onto base maps of sample image line data might offer an alternative.

University Geography and Environmental Departments

Nys College

Countryside planning

National College of Agricultural Engineering

Rural resources

University of Aberdeen

General inventory

Bedford College

Terrain evaluation

University of Leeds

Soil moisture

University of East Anglia

Land use and settlement

University College, London

Theoretical geodetic

(Survey Department)

studies

Geology

Selection Trust

Regional structural

analysis

Oceanology

Institute of Coastal Oceanology and Tides

Sea state,

Inter-tidal monitoring

Unit of Coastal Sedimentation

Wave studies,

Inter-tidal monitoring

University of Southampton

Sea state

(Oceanology Department)

critical. Rapidly produced high quality imagery should suffice but as the target is relatively simple, automatic computer-graphic up-dating of the situation is possible.

(xi) Locust Breeding Ground Detection

Similar to ex-European water body monitoring but rapidly produced high quality imagery will suffice.

(xii) Oil Spill Detection

Provided this is feasible for a SARCAT system, high resolution data might not be necessary. Rapid data assessment and plotting is essential in this context and relatively low grade imagery or video display should suffice. As the target is in fact located by sea surface condition, computer-graphic print-out onto base maps of sample image line data might offer an alternative.

TABLE 1

Digital Data Specified
by United Kingdom Potential Users

<u>Government Planning Organisations and Services</u>	<u>Use</u>
Department of the Environment (Planning Development, Planning Systems Department)	Regional planning
Ministry of Agriculture, Fisheries and Food (ADAS)	Rural resources
Meteorological Office (High Atmospheric Division)	Atmospheric phenomena
<u>University Geography and Environmental Departments</u>	
Wye College	Countryside planning
National College of Agricultural Engineering	Rural resources
University of Aberdeen	General inventory
Bedford College	Terrain evaluation
University of Leeds	Soil moisture
University of East Anglia	Land use and settlement
University College, London (Survey Department)	Theoretical geodetic studies
<u>Geology</u>	
Selection Trust	Regional structural trends
<u>Oceanology</u>	
Institute of Coastal Oceanology and Tides	Sea state, Inter-tidal monitoring
Unit of Coastal Sedimentation	Wave studies, Inter-tidal monitoring
University of Southampton (Oceanology Department)	Sea state

TABLE I

Digital Data Specified
by United Kingdom Potential Users

Use	Government Planning Organizations and Services
Regional planning	Department of the Environment (Planning Development, Planning Systems Department)
Rural resources	Ministry of Agriculture, Fisheries and Food (ADAS)
Atmospheric phenomena	Meteorological Office (High Atmospheric Division)
	<u>University Geography and Environmental Departments</u>
Countrywide planning	Wye College
Rural resources	National College of Agricultural Engineering
General inventory	University of Aberdeen
Terrain evaluation	Bedford College
Soil moisture	University of Leeds
Land Use and settlement	University of East Anglia
Theoretical geodetic studies	University College, London (Survey Department)
	<u>Geology</u>
Regional structural trends	Selection Trust
	<u>Oceanology</u>
Sea state, inter-tidal monitoring	Institute of Coastal Oceanology and Tides
Wave studies, inter-tidal monitoring	Institute of Coastal Sedimentation
Sea state	University of Southampton (Oceanology Department)

TABLE 2

Mapping Scales and Imagery Resolutions Specified by
Potential Users in the United Kingdom

With appropriate scales and resolutions assessed on current SLR imagery usage

User Specified Scales and Resolutions		Appropriate Scale and Resolution	
<u>Agriculture, Forestry and Vegetation</u>			
1:10,000	Finer than 10 m	Larger than 1:50,000	2 m
1:50,000	10 m	1:50,000	10 m
	20 m	1:100,000	
	50 m	1:250,000	
	100 m	1:500,000	
1:625,000			125 m
<u>Environment, Planning and Allied</u>			
1:10,000	Finer than 10 m	Larger than 1:50,000	2 m
1:50,000	10 m	1:50,000	10 m
1:100,000			20 m
1:200,000			40 m
<u>Geography, Cartography</u>			
1:5,000	1 m	1:5,000	1 m
1:10,000			2 m
1:50,000	10 m	1:50,000	10 m
1:100,000	20 m	1:100,000	20 m
1:250,000	50 m	1:250,000	50 m
1:1,000,000			200 m
1:5,000,000			1,000 m
<u>Geology</u>			
1:50,000	10 m	1:50,000	10 m
1:100,000	20 m	1:100,000	20 m
1:250,000	50 m	1:250,000	50 m
<u>Hydrology and Meteorology</u>			
-	Finer than 100 m	Larger than 1:500,000	
<u>Oceanology and Allied</u>			
	1 m	1:5,000	
1:10,000			2 m
1:25,000			5 m
	10 m	1:50,000	
	20 m	1:100,000	
	50 m	1:250,000	
	100 m	1:500,000	
1:3,000,000			600 m
	1,000 km	1:5,000,000	

TABLE 2

Mapping Scales and Imagery Resolutions Specified by Potential Users in the United Kingdom

With appropriate scales and resolutions assessed on current SLM imagery usage

User Specified Scales and Resolutions		Appropriate Scale and Resolution	
<u>Agriculture, Forestry and Vegetation</u>			
1:10,000	Finer than 10 m	Larger than 1:50,000	2 m
1:50,000	10 m	1:50,000	10 m
	20 m	1:100,000	
	50 m	1:250,000	
	100 m	1:500,000	1:25 m
1:625,000			
<u>Environment, Planning and Allied</u>			
1:10,000	Finer than 10 m	Larger than 1:50,000	2 m
1:50,000	10 m	1:50,000	10 m
1:100,000			20 m
1:200,000			40 m
<u>Geography, Cartography</u>			
1:2,000	1 m	1:2,000	1 m
1:10,000			2 m
1:50,000	10 m	1:50,000	10 m
1:100,000	20 m	1:100,000	20 m
1:250,000	50 m	1:250,000	50 m
1:1,000,000			200 m
1:2,000,000			1,000 m
<u>Geology</u>			
1:50,000	10 m	1:50,000	10 m
1:100,000	20 m	1:100,000	20 m
1:250,000	50 m	1:250,000	50 m
<u>Hydrology and Meteorology</u>			
-	Finer than 100 m	Larger than 1:500,000	
<u>Oceanology and Allied</u>			
1:10,000	1 m	1:2,000	2 m
1:10,000			2 m
1:25,000	10 m	1:50,000	
	20 m	1:100,000	
	50 m	1:250,000	
	100 m	1:500,000	600 m
1:3,000,000	1,000 km	1:2,000,000	

SELECTED REFERENCES

- ANDERSON, P.N. et al. 1972 Image Processing with a Hybrid System:
The IDECS. Bull. of Engineering, No.64.
(After R. de Godoy) University of Kansas Publications.
- ANDREWS, H.C., TESCHER, A.G. 1972 Image Processing by Digital Computer
and KRUGER, R.P. Spectrum. July 1972. IEEE.
- de GODOY, R.C. and 1973 Semi-Controlled Mosaics for Project
van RESSEL, J.W. Radam. Proc.Am.Soc. Photogrammetry.
39th Annual Meeting.
- INNES, R.B. 1972 Controlled Quality Images for Synthetic
Radar Data. Seminar on Operational
Remote Sensing. Am.Soc.Photogrammetry.
Houston 1972.
- JOHNSON, C.W. 1971 Computerised Land Pattern Mapping from
Mono-Imagery. Proc. 7th Int.Symp. on
Remote Sensing of the Environment.
Vol.III. Institute of Science and
Technology. University of Michigan.
- ROUSE, J.W. 1969 Arctic Ice Type Identification by Radar.
Proc.IEEE. Vol.57. No.4.
- SWANLUND, G. 1972 Hybrid Techniques for Automatic Imagery
Interpretation. Proc.Seminar on
Operational Remote Sensing. Am.Soc.
Photogrammetry. Houston 1972.

SELECTED REFERENCES

ANDERSON, F.N. et al. 1972 Image Processing with a Hybrid System
The DMCS, Bull. of Engineering, No. 64.
University of Kansas Publications.

ANDREWS, H.C., TESCHER, A.C., 1972 Image Processing by Digital Computer
and KEMER, R.P. Spectrum, July 1972, IEEE.

de GODOY, R.G. and 1973 Semi-Controlled Mosaics for Project
van RESELT, J.W. Radam, Proc. Am. Soc. Photogrammetry,
35th Annual Meeting.

IMMS, R.B. 1972 Controlled Quality Images for Synthetic
Radar Data. Seminar on Operational
Remote Sensing. Am. Soc. Photogrammetry,
Houston 1972.

JOHNSON, C.W. 1971 Computerized Land Pattern Mapping from
Mono-Imagery. Proc. 7th Int. Symp. on
Remote Sensing of the Environment,
Vol. III. Institute of Science and
Technology, University of Michigan.

ROUSE, J.W. 1969 Arctic Ice Type Identification by Radar.
Proc. IEEE, Vol. 57, No. 4.

SWANLUND, G. 1972 Hybrid Techniques for Automatic Imagery
Interpretation. Proc. Seminar on
Operational Remote Sensing. Am. Soc.
Photogrammetry, Houston 1972.

APPENDIX I

SPECIFICATION OF PROJECT RADAM COVER

(After R. de Godoy, 1973)

Each sheet comprises	1 degree of latitude by 1.5 degree of longitude
Dynamic range of recording	20 dB
System resolution	16 m

Geometric Fidelity of Image Strips

Along and across track scale	to 1%
Along track scale of adjacent strips	to 1%
Angular distortion in one swath	Not more than 10 m rads.
Image side-lap	Average 25%
	Not less than 10%

Geometric Fidelity of Semi-controlled Mosaics

Cumulative scale discrepancy in any direction not to exceed 1 km.
Angular distortion in any one mosaic not to exceed 10 m rads.
Corner positions - accurate to 1 km with 95% probability - accurate to 0.5 km with 50% probability
Tick mark grid orientation correct to 10 m rads.

APPENDIX I

SPECIFICATION OF PROJECT RADAM COVER

(After R. de Loooy, 1975)

1 degree of latitude by 1.2 degree
of longitude

30 kb

10 m

Each sheet comprises

Dynamic range of recording

System resolution

Geometric Fidelity of Image Strips

to 1%

to 1%

Not more than 10 m rads.

Average 25%

Not less than 10%

Along and across track scale

Along track scale of adjacent strips

Angular distortion in one swath

Image side-lap

Geometric Fidelity of Semi-controlled Mosaic

Cumulative scale discrepancy in any direction not to exceed 1 km.

Angular distortion in any one mosaic not to exceed 10 m rads.

Corner positions - accurate to 1 km with 95% probability

- accurate to 0.5 km with 50% probability

Tick mark grid orientation correct to 10 m rads.

