# Plan for Economic Evaluation of Products from the Remote Sensing Information Subsystem (RSIS)

prepared by

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TABLE OF CONTENTS



TABLES

# 1.0 INTRODUCTION

## 1.1 Objective

The objective of this proposed analysis is to compare the cost and accuracy of map production using existing methods with map production using the Remote Sensing Information Subsystem (RSIS). Both methods require surface visits in order to control the validity of interpretations. Existing methods imply the use of aerial photography at appropriate scales with conventional photo interpretation techniques. Map units are delineated directly on the photograph, on an overlay, or a map base and, through the process of scribing and other cartographic techniques, a final map product is produced. Use of the RSIS implies use of Landsat or airborne multispectral scanner data in a digital processing system which will operate in an interactive manner with the interpreter, supplemented by aerial photography. A keyboard cathode ray tube (KCRT) will be the primary means for data display and for the interpreter to direct further data analysis. During the TNRIS/NASA Joint Project, hard-copy output from digital data is dependent upon use of a Matrix Color Camera to produce Polaroid prints and film transparencies. The RSIS will accept hard-copy input (maps and aerial photographs) for use with overlay production but will not digitize photography.

## 1.2 Scope of the Analysis

The analysis of RSIS products and comparison with products derived from other methods will be based on: (1) cost of data acquisition; (2) cost of map production; (3) accuracy as determined by a comparison with other data, and (4) utility as determined by the User Advisory Group and other agency participants (Applications Coordinators, etc). The latter step is significant in that it reflects the user's assessment of remote sensing techniques and the resulting products. These products are aimed at supporting the management responsibilities of state agencies concerned with natural resources. The products are to be evaluated in an operational environment wherein the remote sensing techniques and resulting products become part of the decision-making processes of the state agencies.

Because remote sensing techniques are to be evaluated in an operational environment, the time involved from definition of an information need to preparation of a working map must be considered. Familiarity with image interpretation procedures, whether using aerial photography or Landsat hard-copy imagery, may offer advantages in the speed with which a product can be produced. The tradeoff of speed vs. accuracy should be evaluated in terms of the best combination of procedures to apply to a particular mapping need.

The specific map products to be prepared for use in this economic evaluation will depend on the availability of data, the time alloted for generating the conventional products, and the ability to control those elements of the production effort which contribute to the validity of the comparison. Attention will be given to developing conventional and RSIS-derived map products which are intended to convey similar levels of detail and types of information, which will cover the same geographic area, and which require a similar general background in resource interpretation. (Note: Some background will be the same but skills and training will be quite different. Understanding Landsat, digital data manipulation, and RSIS will be a step beyond photo interpretation). The RSIS Project Team Leader will develop a recommended set of products, which will be submitted to the Project Manager, the Deputy Project Manager, the User Advisory Group, and the Applications Coordinators for review and consideration. Once the selection of map products has been made and the technical approach approved, the

RSIS Team Leader will be responsible for preparing the maps, accumulating the cost data, conducting the cost and accuracy analyses, and coordinating with the Applications Coordinators and User Advisory Group, as needed, to obtain their evaluations of product utility, and documenting the results of the economic evaluation.

## 2.0 AN ECONOMIC ANALYSIS

This plan for the economic analysis of RSIS and conventional map products has been prepared under Interagency Contracts IAC (78-79) - 1418 and (80-81) - 1676 between the Texas Department of Water Resources/Texas Natural Resources Information System and the Bureau of Economic Geology, The University of Texas at Austin. Specific tasks call for the development of the program design and for the appropriate documentation, which is contained herein. The cost, accuracy, and utility assessments each comprise a separate segment of the overall economic analysis.

### 2.1 Cost Analysis

The two primary cost components involve acquisition of the raw data and preparation of map products from that data. The data costs considered should be the direct purchase cost to the user of hard copies or tapes of imagery and of photography. For Landsat data, these costs will be based on the current price schedule of the Earth Resources Observations System (EROS) Data Center. For aerial photography, acquisition costs can be assessed from (1) EROS Data Center prices for photographic reproductions; (2) prices of the U.S. Soil Conservation Service and other agencies which routinely duplicate photography, and (3) prevailing prices for photographic laboratory processing. The latter is applicable in that one agency can often acquire data from another agency for the cost of reproduction. Commercial rates should be applied and not the costs of processing at a laboratory housed within a state agency where overhead costs are, in effect, subsidized.

Costs of data acquisition considered by Malin (in Harwood and others, 1977) include labor, equipment, and the purchase price itself. Labor is involved in reviewing data printouts and, possibly, in reviewing microfilms. A viewer, light table, and keyboard terminal are equipment which may be used, and associated costs would be computed on the basis of an hourly rate. Labor costs include the interpreter/scientist and support personnel. The unit of cost for data acquisition (cost per scene, cost per frame, cost per unit area, etc.) will be defined before operational data analysis begins. These costs (table 1) will be collected for RSIS operations and for photo interpretation during the preparation of selected products (see Test Plan for each test site) (table 2).

The price of conventional map preparation involves labor costs for the interpreter and assistant, labor costs for drafting support, the cost of materials such as stable-base films, and equipment costs such as the use of a light table and steroscope or a Zoom Transfer Scope. The cost of some initial amount of field checking may be included in the cost of map preparation, while the price of a detailed test of map accuracy should be included in the cost of an accuracy assessment.

Within the RSIS, the cost per hour of system operation will depend on the components involved and how they are interconnected. Costs for the display device (Ramtek), the minicomputer (Interdata) and the main computer (Univac) will be involved, as will be the data transfer mechanism between the Univac and the Interdata. Labor costs for the interpreter and system operator and the cost of materials used must also be included. As in the conventional approach, use of supporting materials and a limited amount of field checking should be part of the preparation process.

Table 1. Costs which may be evaluated in a comparison of the interpretation of aerial photography and the digital processing of Landsat imagery.

| Aerial Photography | Landsat Imagery |
| --- | --- |
| **Materials** | |
| photographs | digital tape (CCT) |
| stable-base film | transparencies, bands 5 & 7 |
| scribe-coat and matte print | Polaroid film (for Matrix) |
| topographic maps | topographic maps |
| supplies | supplies |
| **Equipment Use** | |
| Zoom Transfer Scope | Univac 1100 |
| Richards Film Table and Stereoscope | Interdata 7/32 |
| | Ramtek Color Graphics Display |
| | Matrix Camera |
| | disc pack |
| | computer tapes |
| | 35 mm camera |
| **Labor** | |
| interpreter | programmer/analyst |
| interpreter (checking) | operator |
| cartographer | interpreter |
| photo technician | interpreter (checking) |
| **Other Costs** | |
| field checking | field checking |
| interpreter | interpreter |
| plane/pilot | plane/pilot |
| travel | travel |
| reports (labor and materials) | reports (labor and materials) |

Table 2. Form for recording time for each step in development of land cover/land use maps from aerial photography.

MAPPING TIME SHEET

Name________________________ Position________________________

Monday________________________ through Friday________________________

Area________________________ Level: I II III (circle one) Scale:________________

| | Task | Hours | Task | Hours | Task | Hours |
|---|---|---|---|---|---|---|
| MONDAY | | | | | | |
| TUESDAY | | | | | | |
| WEDNESDAY | | | | | | |
| THURSDAY | | | | | | |
| FRIDAY | | | | | | |

Task Code

0: Map base preparation

1: Study of supporting materials

2: Interpretation

3: Checking interpretation

4: Map clean-up and annotation

5: Checking scribe sheet

6: Preparing final work copy, including color out

For both RSIS and conventional products, costs will be based on the production of a limited number of working copies to meet agency needs (see Test Plan for each test site). The price of printing multiple copies of a map is excluded from this analysis.

## 2.2 Accuracy Analysis

The accuracy of both conventional and RSIS products will likely be evaluated in a similar manner. A combination of (1) photography at a scale larger than that utilized in the initial analysis, (2) field checking on the ground and from an aircraft at low altitude, and (3) published information, can be applied to determine map accuracy. A stratified random sample of points was used in the previous Landsat investigation (Finley, 1979) for accuracy analyses (Appendix A). Evaluation of total area within categories along a transect and the degree to which boundaries between units are reliably resolved are other types of accuracy assessments which may be appropriate. These analyses assume that the most accurate data available for land cover/land use is that derived from the largest scale photography and from the use of multiple data sources. An example of the latter would consist of a combination of large-scale photography, field checking on the ground or from an aircraft at low altitude, and the use of published maps.

Fitzpatrick (1975) sampled 1 percent of a test site using larger samples (25 sq km) in non-urban areas and smaller areas (4 sq km) for intensely developed areas. Accuracy analyses were concentrated within the subsampled areas. A procedure which potentially involves any part of a mapped area (Finley, 1979) involves placing a grid of randomly selected points (Berry and Baker, 1968; Wood, 1955) over the mapped area and investigating the land cover/land use at each point location. Disadvantages of this procedure are (1) some categories may not be adequately sampled because of their small areal extent, (2) the accuracy of boundary placement between categories is not adequately tested, and (3) the accuracy of the final map is only as good as the checker's prior knowledge of the land cover/land use in the mapped area, when no field checking is done. A combination of random point sampling and intensive study of particular areas may be the best approach to accuracy analysis of land cover/land use maps within the ASVT project.

The accuracy of a map derived from Landsat imagery which depicts variable parameters, such as water turbidity or chemical water quality, can only be evaluated on the basis of surface data collected concurrently with the imagery. Seasonal studies within Test Site 1 (Coastal) during the ASVT Project provide some background data for evaluating the correlation between reflectance characteristics and bay water parameters. Current literature suggests, however, that a thorough knowledge of local conditions is required to use remote sensing techniques for water quality evaluation, and that this is one of the more difficult applications of such techniques.

## 2.3 Utility Analysis

The User Advisory Group, as specified in the ASVT Project Plan and the Applications Coodinator will make an evaluation of product utility and value which will serve as the basis for refining or modifying the RSIS. This evaluation should be made in light of the requirements provided to the Project Team for the development of specific RSIS output products. The cost and accuracy analyses which have been completed by the Project Team should be provided to the User Advisory Group and Applications Coordinators for their use in evaluating the map products.

The utility evaluation process should help to direct the further development of specific RSIS products. If certain products appear to be most valuable, from among those originally suggested by the User Advisory Group and Applications Coordinators, then further development of RSIS procedures may include emphasis on development of those particular products.

## 3.0 SOURCES OF COST DATA

Accounting mechanisms will be established and utilized to document (1) the type and level of support provided to the Project and (2) the cost of generating each product from RSIS and the other Subsystems. These same mechanisms can be used to document costs associated with the generation of products from conventional methods for comparison with those derived from RSIS. Appendix B includes a listing of accountable areas which, if properly recorded, should provide the sources for cost data needed to conduct this economic evaluation of RSIS generated products. Not all items listed apply to all phases of the project.

## 4.0 SUMMARY

The economic evaluation of Remote Sensing Information Subsystem products should be based on a comparison with products developed using conventional interpretation procedures. The comparison should include assessments of (1) data acquisition and product development costs, (2) accuracy of the map products, and (3) utility of the product to the user carrying out state agency responsibilities. Various accounting mechanisms will be utilized to record the cost data needed for this study. Analyses of product cost and accuracy should be carried out by the ASVT Project Team and provided to the User Advisory Group and Applications Coordinators for use in utility evaluations. Product evaluations by these individuals will be a measure of the direction which RSIS should take to meet the specific information needs of TNRIS member agencies.

## 5.0 REFERENCES


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# Appendix A

# ACCURACY ANALYSIS PROCEDURES

Land cover/land use mapping based on Landsat imagery or the interpretation of aerial photographs may be evaluated for accuracy by comparison with large-scale aerial photographs and existing map data and by field checking. To initiate analysis, a dot grid was prepared using paper divided into 1 inch squares, such as Crystalene cross section tracing paper. The 1/10-inch subdivisions of each 1 x 1-inch square permit the selection of 100 possible points in each square. The point selection is accomplished by entering a random number table and using successive pairs of entries as x and y coordinates within each 1-inch square. Two points are selected within each square and for enough squares to produce a dot grid covering the largest map to be analyzed. The dots are color coded and one set or both may be utilized depending upon the density of points which are desired for checking, relative to the scale of the map. At a map scale of 1:125,000, for example, the 1-inch major grid divisions corresponding to a 2 x 2-mi (3.2 x 3.2-km) spacing.

The entire dot grid is placed randomly on the annotated line boundary map interpreted from the imagery or photography. The points from the dot grid are transferred to the map and the points reinterpreted from larger scale remote sensing data and from published maps. The points may also be checked from an aircraft at low altitude or by comparison with large scale (1:5,000, for example) aerial photography flown in strips to cover a series of points to be evaluated. The latter procedure may require a tighter grid (i.e., more dots per unit area) in order to select points within a single flight path or pair of adjacent flight paths. Field checking on the ground may also be utilized but is likely to be difficult and time-consuming for a large number of points, many of which may be difficult to access.

Each location picked for checking using the dot grid may be considered to represent a circle of specified diameter on the ground. In a past use of this technique (Finley, 1979) a circle 3 pixels (0.24 km) in diameter was chosen. For those locations falling over land cover/land use boundaries the lesser part of the circle which extends into another unit may be ignored.

At least 100 and as many as 300 points may be checked on a map such as a single 1:24,000 scale quadrangle. The analysis is performed by an interpreter who had not been involved in developing the map being checked. The accuracy of the map is determined by dividing the number of correct points by the total number of points checked. Points considered to be questionable may be held separately and may require field investigation for complete confirmation. One approach to computing an accuracy statement for a map considered that one-half of the questionable points might ultimately be considered correct (Finley, 1979). Anderson and others (1976) suggested an 85 percent minimum level of accuracy as acceptable.

Appendix B

TNRIS/NASA JOINT PROJECT (ASVT)

ACCOUNTING AREAS

A. OBJECTIVES

1. To document the type and level of support to the Project.
2. To document the cost of generating each product from the RSIS, GIS, and NRAS.

B. ACCOUNTABLE AREAS

1. NASA (Proposed)

   a. Staff (Contract Support/Consultation)
   b. Hardware Procurement
   c. Software Procurement
   d. Remote Sensing Data (By Data Set)
      (1) Aircraft Data
      (2) Landsat Data
   e. Ground Truth Data (By Data Set)
   f. Civil Service Support
   g. SR & T
   h. Travel
   i. Other (Specify)

2. TNRIS/TDWR

   a. Hardware Procurement/Rental/Usage (and related Software)
   b. Facilities Use (Building/Utilities/other)
   c. Remote Sensing Data (By Data Set)
      (1) Aircraft
         (a) Air Photos
         (b) Other
      (2) Satellite
         (a) Landsat
         (b) Other
   d. Ground Truth Data (By Data Set)
   e. Cartographic Data (By Data Set)
   f. Reports/ Documents/Misc. Data and Information (By Data Set)
   g. Computer Time (By Product/Task)
      (1) Univac
      (2) Interdata
   h. Supplies
   i. Photo/Litho/Xerox/Matrix Reproduction (non-personnel) (by product where appropriate)
   j. Consultation (Specify Tasks Performed)
   k. Staff Time
      (1) Project Team
         (a) Data Collection (By Data Set)
            (1) Ground
            (2) Aircraft
            (3) Satellite

(b) Data Handling (Index/Store/Retrieve) (By Data Set)
    (1) Ground
    (2) Aircraft
    (3) Satellite
(c) Data Analysis (By Product/Task)
    (1) Computer-assisted
    (2) Image Interpretation
(d) Documentation
(e) Training
(f) Travel

(2) User Advisory Group/Applications Coordinators
(3) Steering Committee
(4) TDWR (Library/Graphic Arts/Motor Pool/Secretarial/Others)
(5) TNRIS Task Force/RS & C Committee
    (l) Software Procurement
    (m) Training (non-personnel)
    (n) Travel (non-personnel)

3. UNIVERSITY

a. Consultation (By Task)
b. Data Analysis (By product)
c. Data Collection (By Data Set)
d. Training

4. INDUSTRY

a. Hardware
b. Software
c. Consultation
d. Data Collection
e. Training
f. Reproduction

C. REPORTING

1. Monthly (In Detail)
2. Quarterly (Major Categories)
3. Annually (Total)
4. Costs Per Product (As Needed)
5. Costs Per Task/Source (As Needed)
6. Other Cost Data (As Needed/Available)