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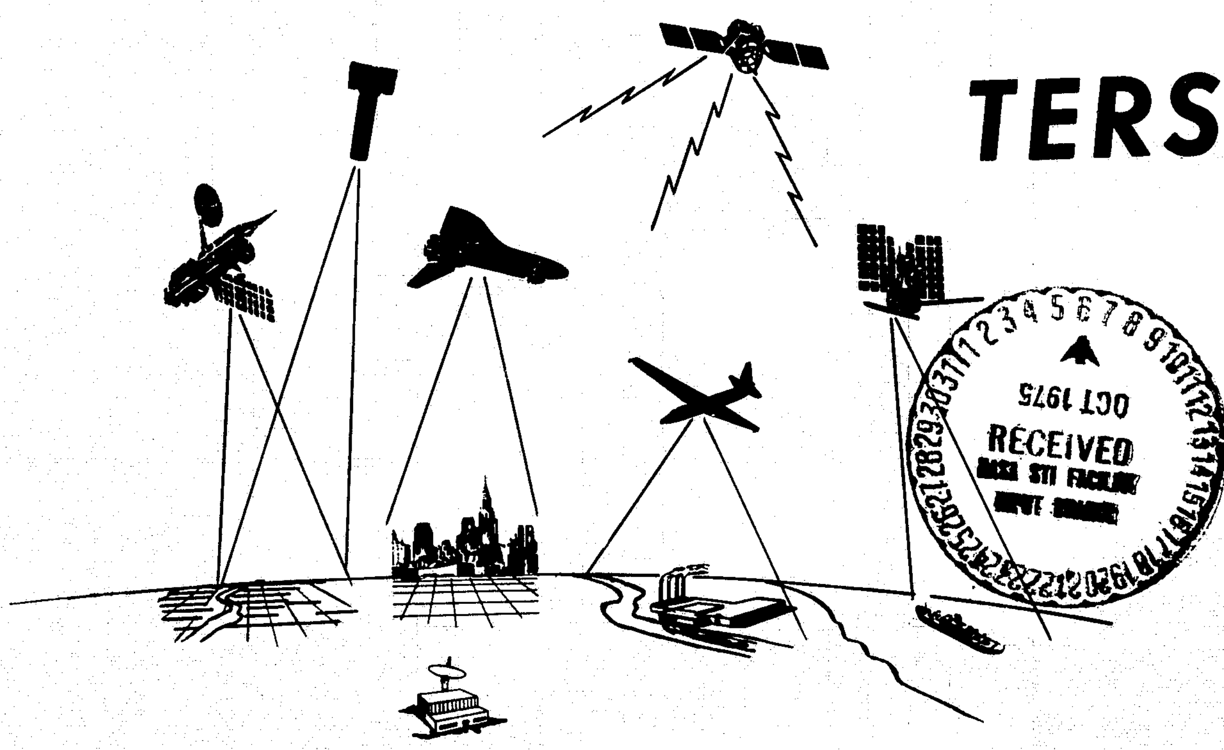
definition of the

Total Earth Resources System for the Shuttle Era

VOLUME 7
USER MODELS: A SYSTEM ASSESSMENT



TERSSE

GENERAL ELECTRIC
SPACE DIVISION

OCTOBER 1974

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TERSSE

DEFINITION OF THE
TOTAL EARTH RESOURCES SYSTEM
FOR THE
SHUTTLE ERA

VOLUME 7

USER MODELS: A SYSTEM ASSESSMENT

PREPARED FOR

EARTH RESOURCES PROGRAM OFFICE
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
JOHNSON SPACE CENTER
HOUSTON, TEXAS

PREPARED BY

GENERAL ELECTRIC
SPACE DIVISION
Valley Forge Space Center
P. O. Box 8555 • Philadelphia, Penna. 19101

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PRINCIPAL CONTRIBUTORS

DR. C. E. CHEESEMAN, TASK LEADER
JOSEPH WELCH
SURRENDRA RAJE
LYNN FUJII
DR. LOWELL KRAWITZ
FRED THOMSON, ERIM

APPROVALS:

DR. C. E. CHEESEMAN
TECHNICAL DIRECTOR

D. W. KELLER
PROGRAM MANAGER

Any questions or comments regarding this document should be addressed to:

Dr. C. E. Cheeseman,
Technical Director
General Electric Company
Valley Forge Space Center
P. O. Box 8555
Philadelphia, Penna. 19101

John Mitchell,
Technical Monitor
Earth Resources Program Office
National Aeronautic and Space Administration
Johnson Space Center, Code HD
Houston, Texas 77058

PREFACE

The pressing need to survey and manage the earth's resources and environment, to better understand remotely sensible phenomena, to continue technological development, and to improve management systems are all elements of a future Earth Resources System. The Space Shuttle brings a new capability to Earth Resources Survey including direct observation by experienced earth scientists, quick reaction capability, spaceborne facilities for experimentation and sensor evaluation, and more effective means for launching and servicing long mission life space systems.

The Space Shuttle is, however, only one element in a complex system of data gathering, translation, distribution and utilization functions. While the Shuttle most decidedly has a role in the total Earth Resources Program, the central question is the form of the future Earth Resources system itself. It is only by analyzing this form and accounting for all elements of the system that the proper role of the Shuttle in it can be made visible.

This study, entitled TERSSE, Total Earth Resources System for the Shuttle Era, was established to investigate the form of this future Earth Resources System. Most of the constituent system elements of the future ER system and the key issues which concern the future ER program are both complex and interrelated in nature. The purpose of this study has been to investigate these items in the context of the total system utilizing a rigorous, comprehensive, systems oriented methodology.

The results of this study are reported in eight separate volumes plus an Executive Summary; their titles are:

- Volume 1 Earth Resources Program Scope and Information Needs
- Volume 2 An Assessment of the Current State-of-the-Art
- Volume 3 Mission and System Requirements for the Total Earth Resources System
- Volume 4 The Role of the Shuttle in the Earth Resources Program
- Volume 5 Detailed System Requirements: Two Case Studies
- Volume 6 An Early Shuttle Pallet Concept for the Earth Resources Program
- Volume 7 User Models: A System Assessment
- Volume 8 User's Mission and System Requirement Data
- Executive Summary.

BACKGROUND

User models were identified early in the TERSSE study as a system element; the development of which was critical to system progress. The treatment of user models in the state-of-the-art assessment (reported in Volume 2) was necessarily brief and contextual. At the completion of that effort, several members of the study team refocussed on the user model question for four weeks in order to develop a greater understanding of the nature of this system element and the role that it plays in total system operation. A briefing on the results of this work was made to JSC personnel on 28 September 1973. The charts used in the briefing are reproduced in this volume as a stand-alone discussion of user models.

USER MODELS: A SYSTEM ASSESSMENT

We have chosen to include in the definition of user models any explicit process or procedure used to transform information extracted from remotely-sensed data into a form directly useful as a resource management information input. Merely reformatting or plotting information does not constitute user modelling, nor do all applications of remotely-sensed data require user models. But a significant fraction of applications do not permit the direct use of extracted information (such as acreage) but require the additional transformation of it, in conjunction with ancillary data to produce the final TERSSE output (such as a forecasted production level).

As such, user models form the interface between the TERSSE and the resource managers whom it serves. Models are not only the information interface but are also technological and operations interfaces. Technological because they are the "translator" between the system designer (who is accustomed to talking in terms of multispectral signatures or satellite characteristics) and the resource manager (who is accustomed to talking in terms of economics or his particular earth science). Models are the operations "translator" because they are the final functional step in the process of operating satellites and ground systems in synchronization with the resource manager's information needs schedule.

The current situation in user models is that, with a few exceptions, the remote-sensing community occasionally discusses the need for a model but it is so far downstream from his favorite or immediate problem that only the vaguest of definitions is provided. The resource management specialists, on the other hand, are conducting a truly amazing amount of research into mathematical models of a wide variety of resource management processes. Alas, this research for the most part does not acknowledge the existence much less exploit the technology of remote sensing.

The study team has recommended that the development of appropriate user models be given the same type (not to say level) of attention now afforded to sensors or any other system element. User model development requires focus and attention if applications systems are to become a mature reality.

The foregoing recommendation constitutes a management challenge. We know relatively well how to bring a new sensor into the inventory, but methodologies for developing user models are nonexistent. Questions arise such as "does the forcing function lie with the resource manager or NASA?" or "how should the steps of model development be synchronized with sensor or preprocessing system development?" We feel that the first steps to answer the challenge should be a joint NASA/user study of the problem with the specific objective of developing guidelines and management strategies for a systems approach to user model development.

USER MODELS

- WHAT ARE THEY ?
- HOW DO THEY RELATE TO THE TOTAL PROGRAM ?
- WHY ARE THEY IMPORTANT ?
- OBSERVATIONS ON THE CURRENT SITUATION
- AN ANALYSIS OF SOME CURRENT EXAMPLES
- PRELIMINARY RECOMMENDATIONS

AN UNDERSTANDING OF USER MODEL DEVELOPMENT IS KEY TO DEVELOPING THE TOTAL SYSTEM

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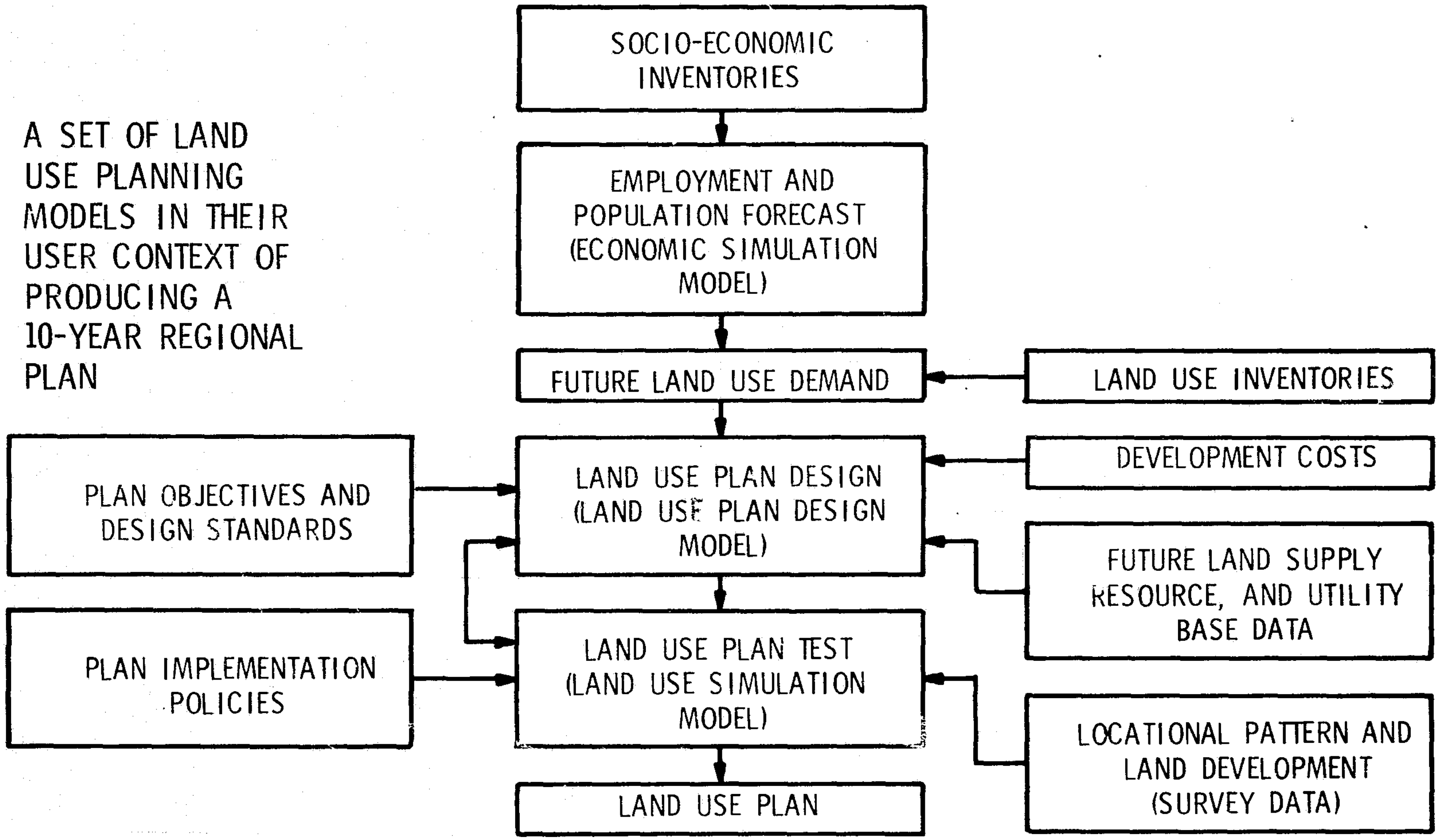
USER MODELS: AN EXAMPLE

ERTS USE

A SET OF LAND USE PLANNING MODELS IN THEIR USER CONTEXT OF PRODUCING A 10-YEAR REGIONAL PLAN



USER MODELS - WHAT ARE THEY?

- A TOOL FOR TRANSLATING A SET OF PARAMETERS INTO USEFUL INFORMATION
  - REMOTELY-SENSED INPUTS
  - ANCILLARY INPUTS
- A METHOD FOR DESCRIBING A DYNAMIC RESOURCE PROCESS OR CYCLE
  - PHYSICAL PROCESSES
  - BIOLOGICAL PROCESSES
- A STRUCTURED PROCEDURE FOR SOLVING A RESOURCE PROBLEM

USER MODELS: RANGE OF CHARACTERISTICS

TAILORED TO SPECIFIC SYSTEM/AREA	OR	USEFUL FOR MANY SYSTEMS/AREAS
RIGOROUS, EXPLICIT	OR	INTUITIVE, ABSTRACT
INPUT/OUTPUT ORIENTED	OR	PROCESS ORIENTED

MACHINE PROGRAMMABLE OR GRAPHICALLY SOLVED OR OPERATED "BY INSPECTION"

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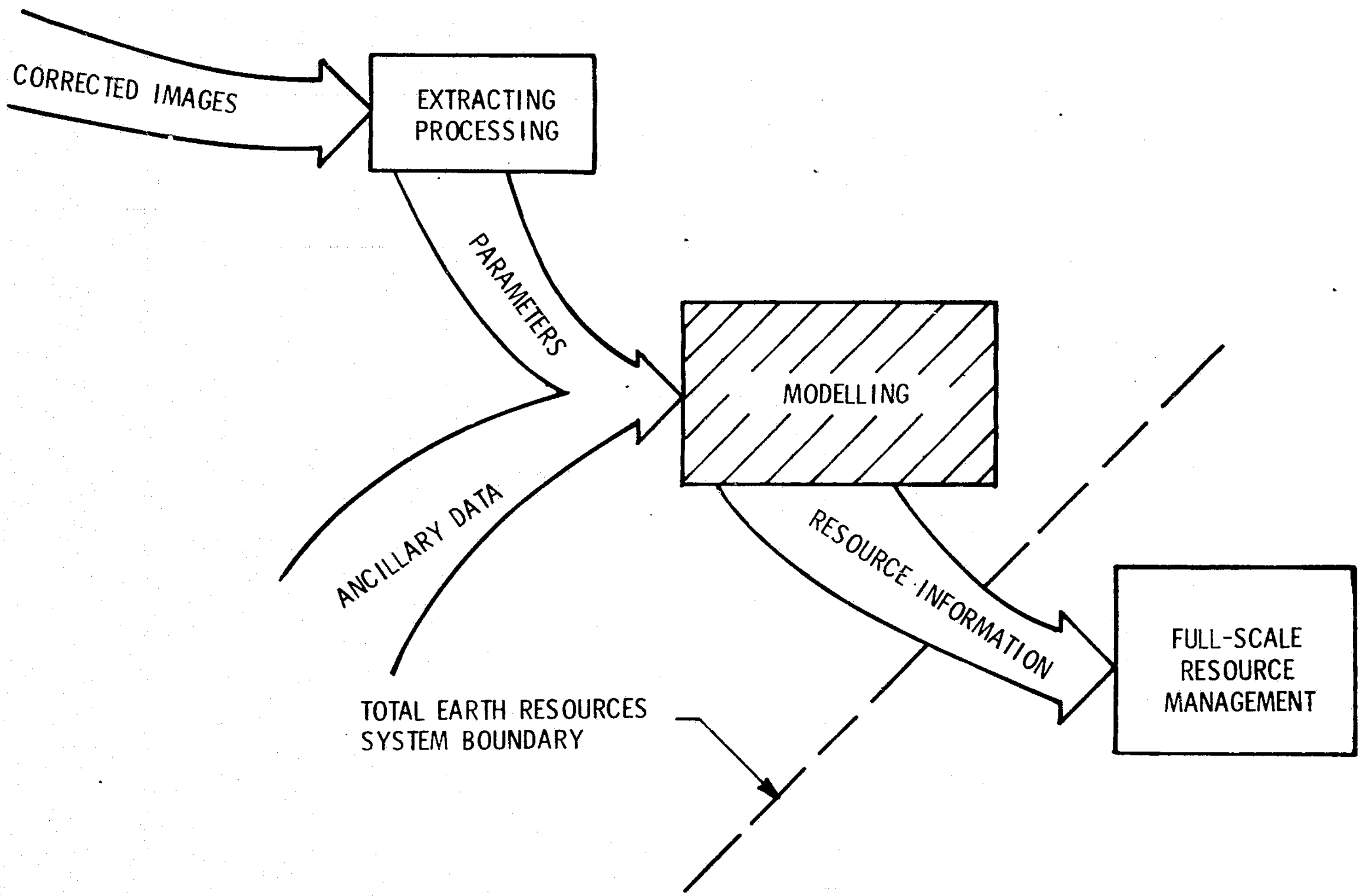
THE INFORMATION CASCADE

ERS TSE



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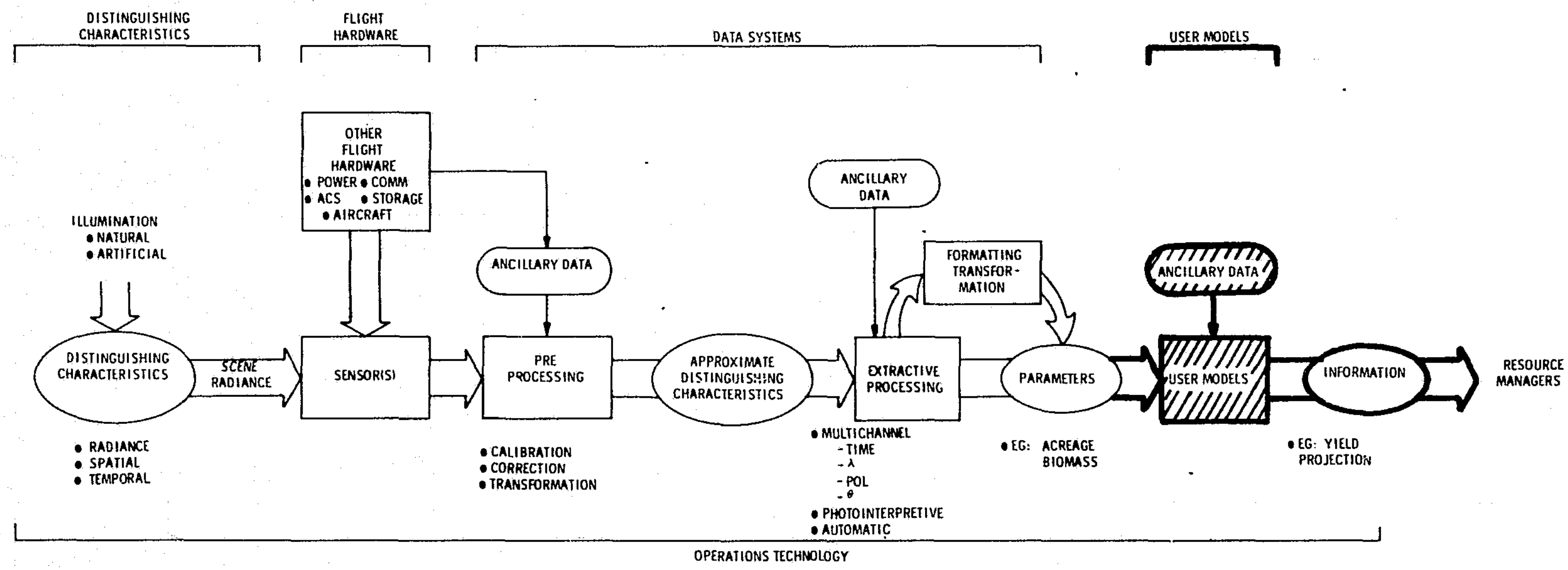
USER MODELS: SYSTEM CONTEXT



USER MODELS ARE THE "TRANSLATER" BETWEEN THE SYSTEM WHICH ACQUIRES INFORMATION AND THE RESOURCE MANAGERS WHO USE IT

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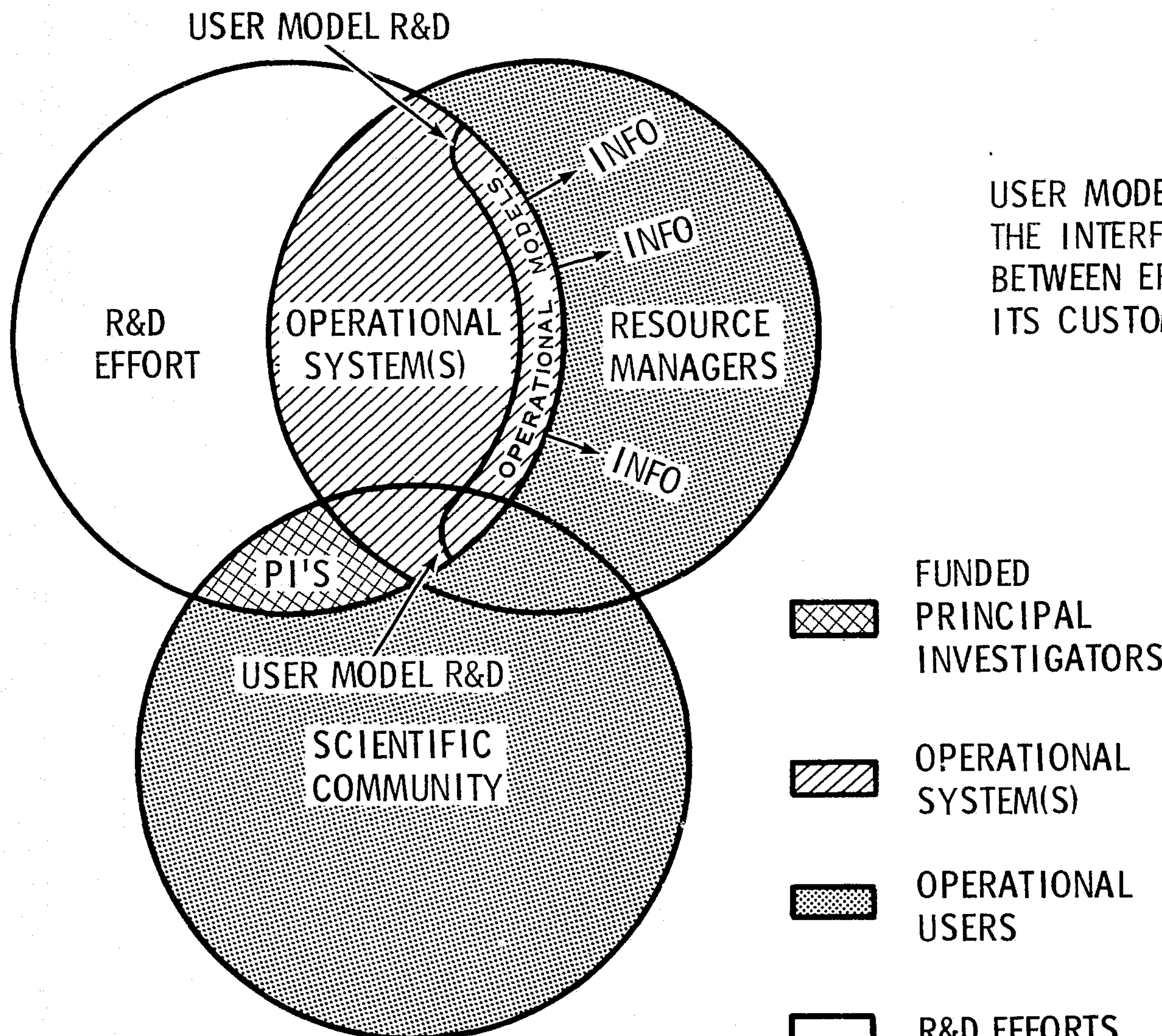
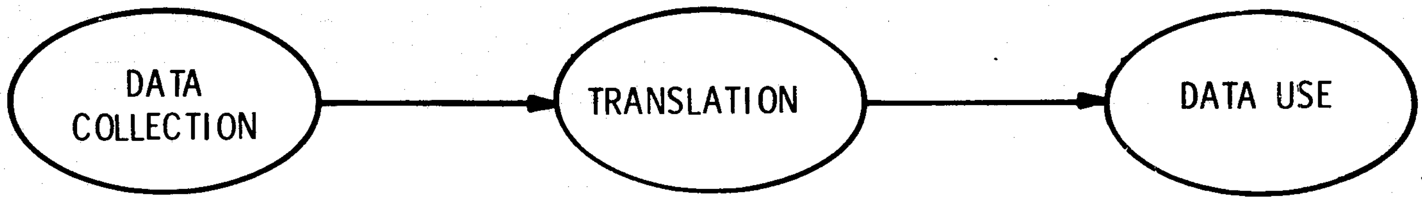
USER MODELS: PROGRAM CONTEXT

ERS SE

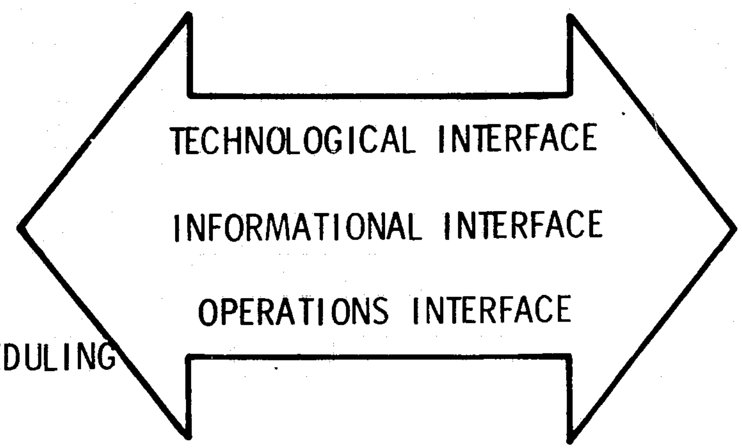


USER MODELS ARE THE INTERFACE BETWEEN ERS AND ITS CUSTOMERS

USER MODELS - WHY ARE THEY OF INTEREST?



- SIGNATURES
- SENSORS
- DATA SYSTEMS
- PLATFORMS
- CONTROL / SCHEDULING
- MANAGEMENT



- RESOURCE SCIENCES, ENGINEERING
- ECONOMICS, MARKET FACTORS
- DATA BASIS
- PLANNING, MONITORING, CONTROL ACTIVITIES
- RESOURCES MANAGEMENT

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USER MODELS: WHY ARE THEY OF INTEREST?

ERS SE

IN TOTAL SYSTEM DEVELOPMENT:

- TO VERIFY UTILITY OF REMOTE SENSING FOR SPECIFIC RESOURCE MANAGEMENT PROBLEMS
- TO DETERMINE OPERATIONAL ERS SYSTEM REQUIREMENTS
- TO ENCOURAGE USERS TO INTERFACE WITH R&D SYSTEM
    - REMOVES TECHNOLOGICAL MYSTIQUE
    - KEEPS USERS AWAY FROM UPSTREAM ENGINEERING

DEVELOPMENT OF USER MODELS IS A SEGMENT OF SYSTEM DEVELOPMENT

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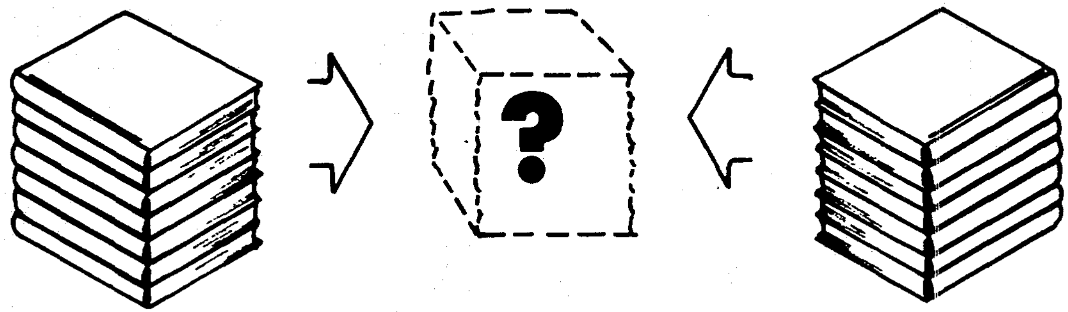
USER MODELS: A SUMMARY OF THE CURRENT SITUATION

ERS SE

MODELING WORK SORTS INTO TWO PILES:



THE AEROSPACE PILE

- BROAD, GENERAL, NON-QUANTITATIVE
- ALWAYS INCLUDES REMOTE SENSING
- USUALLY BENEFITS - ORIENTED
- RESOURCE MANAGEMENT NOT UNDERSTOOD
- NOT GENERALLY USEFUL TO RESOURCE MANAGER

THE RESOURCE SPECIALIST PILE

- DETAILED, RIGOROUS, EXPLICIT, NARROW
- ALMOST NEVER INCLUDES REMOTE SENSING
- SOMETIMES BENEFIT - ORIENTED
- REMOTE SENSING NOT UNDERSTOOD
- NOT GENERALLY USEFUL TO ERS DESIGNER

THERE ARE EXCEPTIONS -

SOME BRIDGES ARE BEING BUILT!

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ERTS-1 INVESTIGATOR MODELLING

ERTS SE

AG/FORESTRY/RANGE:	LANGLEY REFINING FORESTRY YIELD MODEL; DETHIER USING PHENOLOGY MODEL
MINERALS/GEOLOGY:	MORRISON/WOLEY LOOKING AT EROSION MODELLING; MANY REFERENCES TO INEXPLICIT, UNPROGRAMMABLE "MODELS"
WATER RESOURCES:	HOLLYDAY, SCHUMANN WORKING ON DCP MEASUREMENTS, BASIN AREAS AS INPUTS TO STREAM FLOW MODELS; COKER WORKING ON TAMPA BAY CIRCULATION MODEL FOR DREDGING
MARINE RESOURCES:	KEMMERER MODELLING MENHADEN LOCATION CORRELATIONS WITH IMAGE AND SEA TRUTH DATA
LAND RESOURCES:	RAJE AND OTHERS PROVIDING INPUTS FOR EXISTING REGIONAL PLANNING MODELS

ERTS-1 INVESTIGATIONS ARE IN THE "WHAT CAN WE SEE AND MAP" PHASE - A SMALL MINORITY ARE THINKING MODELS

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ANALYSIS OF ERTS-1 INVESTIGATIONS*

ERS SE

	NO. OF INVESTI-GATIONS REPORTED	INVESTIGATION USING (OLD) OR DEVELOPING (NEW) MODELS		INVESTIGATION IN EXTRACTIVE PROCESSING STAGE OR USING DATA DIRECTLY	SUBJECT AREAS WITH POTENTIAL FOR USER MODELS
		OLD	NEW		
AGRICULTURE/FORESTRY/RANGE	26	1	2	23	23
MINERALS/GEOLOGY/LANDFORMS	33	0	1	32	Unknown
ENVIRONMENT	14	0	0	14	14
WATER	20	2	1	17	17
LAND-USE/MAPPING	27	0	0	27	26
MARINE RESOURCES/OCEANOGRAPHY	21	0	1	19	20
MULTI-DISCIPLINARY/REGIONAL	6	0	0	6	6
UNCLASSIFIED	23	0	1	20	20

*AS REPORTED IN PROCEEDINGS OF NASA SYMPOSIUM ON SIGNIFICANT RESULTS OBTAINED FROM THE EARTH RESOURCES TECHNOLOGY SATELLITE-1 NASA SP-327

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SCIENTIFIC USER MODELS EXISTING OR IN DEVELOPMENT

ERTS SE

- GRASSLAND BIOME
- DECIDUOUS FOREST BIOME
- CONIFEROUS FOREST BIOME
- DESERT ECOLOGY
- TROPICAL FOREST BIOME
- TUNDRA BIOME

STATUS: LARGE SCALE DIGITAL SIMULATION SPONSORED BY NATIONAL SCIENCE FOUNDATION (PART OF "ANALYSIS OF ECOSYSTEMS RESEARCH PROGRAM OF INTERNATIONAL BIOLOGICAL PROGRAM)

IBP IS THE GARP OF ECOLOGY

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OBSERVATIONS ON USER MODEL UTILIZATION

ERS TSE

- OPERATIONAL MODELS ARE USED IN MANY RESOURCE MANAGEMENT AREAS - THE NECESSITIES OF THE REAL WORLD HAVE FOSTERED APPROPRIATE RESPONSES

- OPERATIONALLY, REMOTE SENSING PEOPLE ARE PRIMARILY ON THE OUTSIDE, LOOKING IN
  - REMOTE SENSING SYSTEMS NOT OPERATIONAL
  - MODELLING INTERFACES NOT DEVELOPED

NOT ONLY MUST DATA ACQUISITION BECOME OPERATIONAL - WE NEED PROVEN, INTERFACEABLE MODELS TOO

OBSERVATIONS ON USER MODEL DEVELOPMENT

- MODELS ARE INDEED THE POTENTIAL TRANSLATOR BETWEEN THE SYSTEM AND MANY OF ITS USERS
- THE FIELD OF MODELLING IS RICH WITH EFFORT BUT MOST MODEL DEVELOPMENT CURRENTLY INVOLVES RESOURCE SPECIALISTS WITH NO REMOTE SENSING SYSTEMS ORIENTATION
- NASA IS INVOLVED IN MODEL DEVELOPMENT, BUT THE EFFORT APPEARS TO BE CONCENTRATED IN DISCIPLINE AND CENTER NUCLEI

A SYSTEMS APPROACH TO REMOTE SENSING MODEL DEVELOPMENT IS NEEDED

WHAT NEXT?

POSTULATED NASA OBJECTIVE

- TO UNDERSTAND, THEN LEAD, WHERE APPROPRIATE THE USER MODEL DEVELOPMENT PROCESS AS A PORTION OF NASA'S TOTAL SYSTEM DEVELOPMENT RESPONSIBILITIES

PROPOSED ACTIVITY

- DEVELOP CASE STUDIES FOR EXAMINING SUCCESS FACTORS IN MODEL DEVELOPMENT
  - FORCING FUNCTION
  - TEAM SKILLS
  - ORGANIZATION/MANAGEMENT
  - FUNDING
  - DEVELOPMENT STAGING
  - RELATIONSHIP TO TOTAL R&D PICTURE
- USER MODEL WORKSHOP
  - TOTAL SYSTEM FOCUS
  - REPORTS FROM MODELERS
- DEFINE DEVELOPMENT GUIDELINES, MANAGEMENT STRATEGIES FOR TOTAL SYSTEM APPROACH TO MODEL DEVELOPMENT

USER MODELS:

ILLUSTRATIVE EXAMPLES

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ARID LAND EROSION

ERTS ESE

OUTPUT:	PREDICTION OF EROSION DUE TO ALTERNATIVE GRAZING, FLOOD CONTROL AND LAND DEVELOPMENT POLICIES
SOURCE:	USGS / ERTS INVESTIGATION (NO MODELING UNDERWAY)
REMOTE SENSING:	MEASUREMENT OF TOPOGRAPHY, EROSION, METEOROLOGY, LAND DEVELOPMENT

ARID LAND EROSION

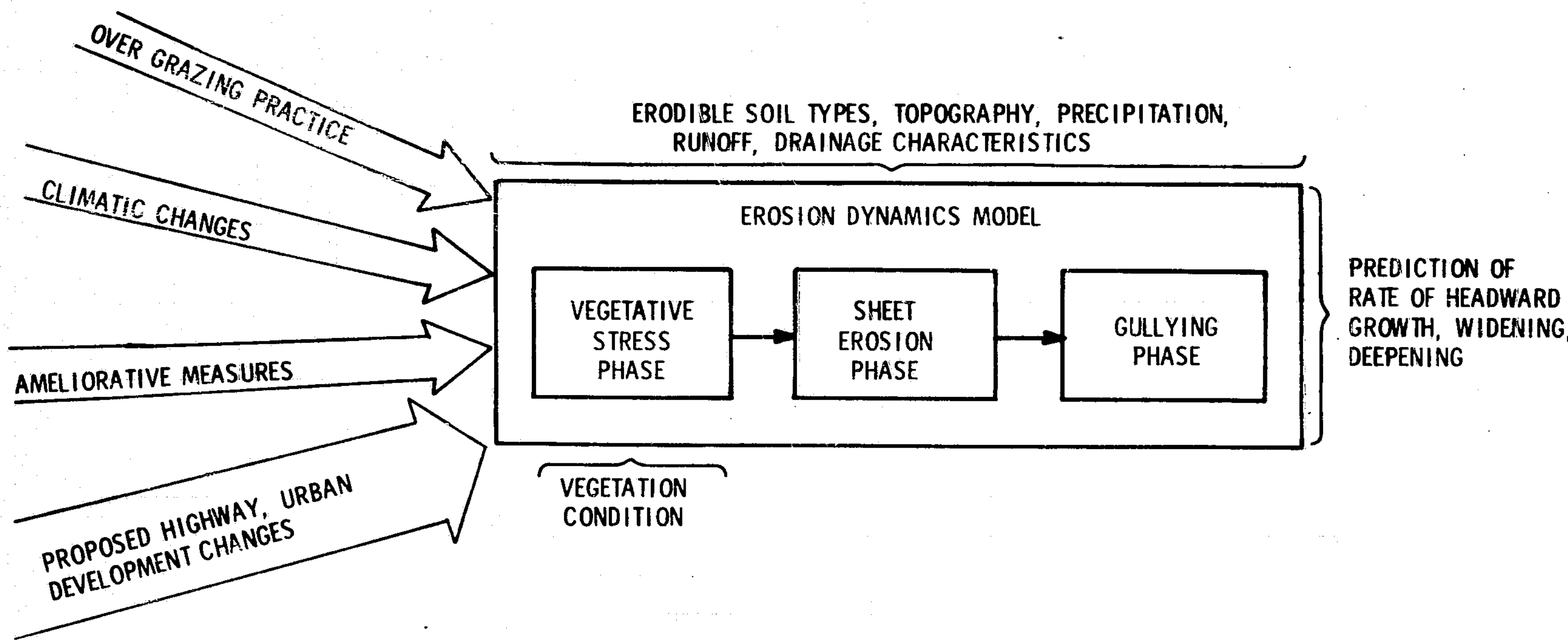
- Combination of climatic changes, grazing practices is causing loss of vegetation cover in arid regions (S. Arizona) which leads to major erosional changes of regional topography, land suitability.

- Model needed for translating measureable conditions of region into predictions to assess alternative regulation strategies for grazing, flood control facility construction, land development.

- Morrison/Cooley (USGS) in the investigative mode, under ERTS sponsorship. Currently mapping, developing understanding of contribution of remote sensing. Quantitative understanding stated as good, but no modelling effort under way.

- Remote sensing potential exists for measuring topology erosion, meteorology and land development.

ARID LAND EROSION



OPTIMUM SHIP ROUTING

OUTPUT:	BEST ROUTE TO MINIMIZE TRANSIT TIME, FUEL CONSUMPTION AND MAXIMIZE SAFETY FOR SEA CONDITIONS AND SHIP PERFORMANCE
SOURCE:	U.S. NAVY (et al.)
REMOTE SENSING:	HEIGHT AND DIRECTION OF WAVES, METEOROLOGY

OPTIMUM SHIP TRACK ROUTING

- The problem is to determine the optimum route for a ship between two ports. The optimum route is the one that minimizes transit time while maximizing the safety of the passengers and cargo.

- The Model is needed for derivation of necessary corrections to great circle (or minimum distance) route to account for projected sea surface roughness, direction of waves, and sailing characteristics of ship in question.

- Navy has implemented early model in the late 1950's. Many mathematical refinements for calculation of minimum transit route and for calculation of projected sea surface conditions have been and are still being introduced by several research groups.

- Remote Sensing has potential for:

  (1) Direct measurement of wave heights and direction. This potentially could obviate necessity for a large uncertain calculation of these parameters from surface wind data which suffer from many data sparse areas over the oceans.

  (2) Direct measurement of surface winds over ocean areas - particularly important in tropics.

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OPTIMUM SHIP TRACK ROUTING

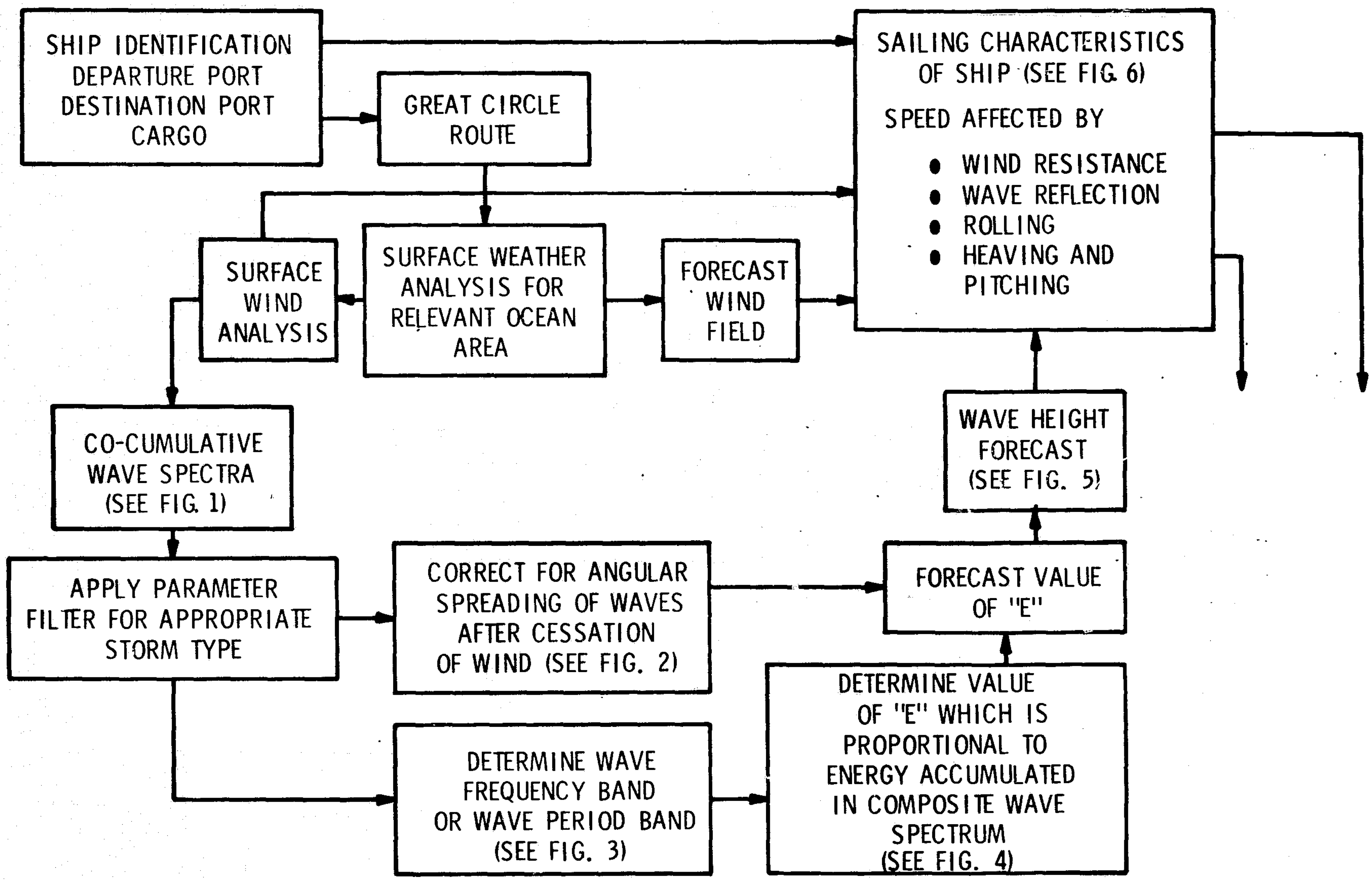

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FIGURE 1

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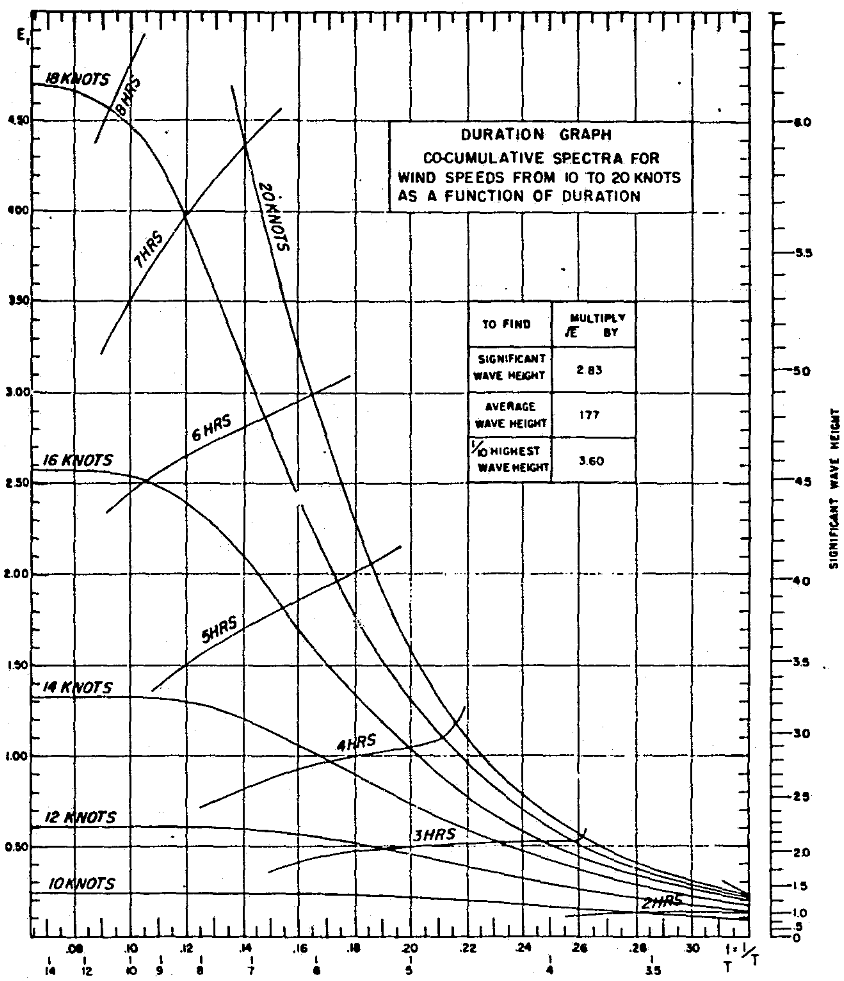

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FIGURE 2

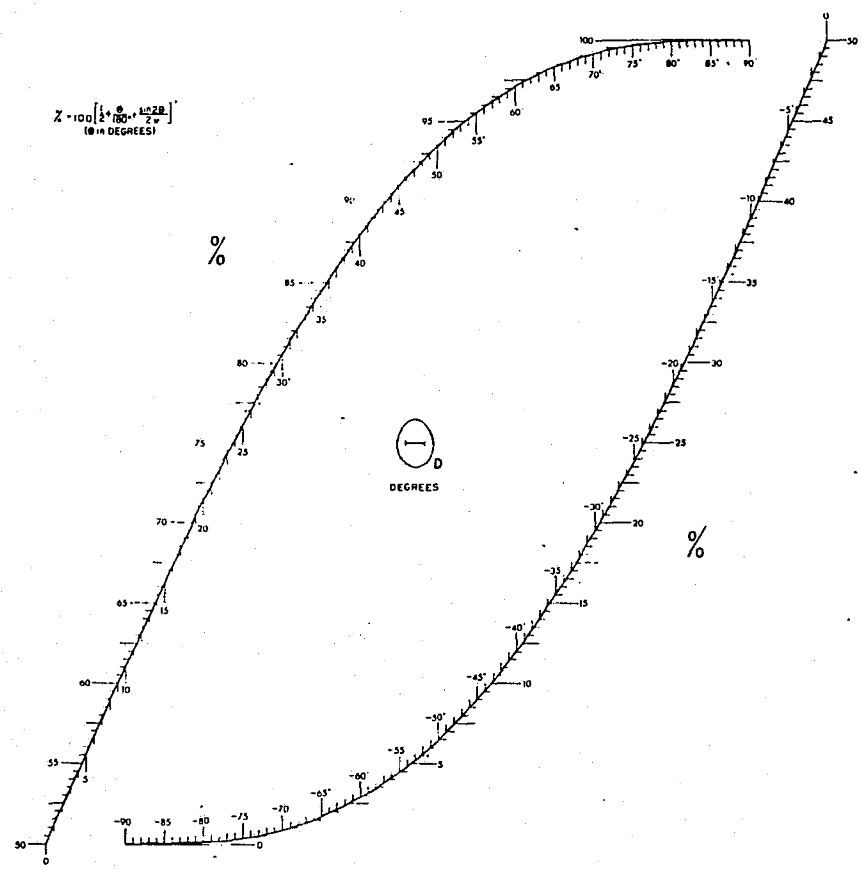

FIGURE 3

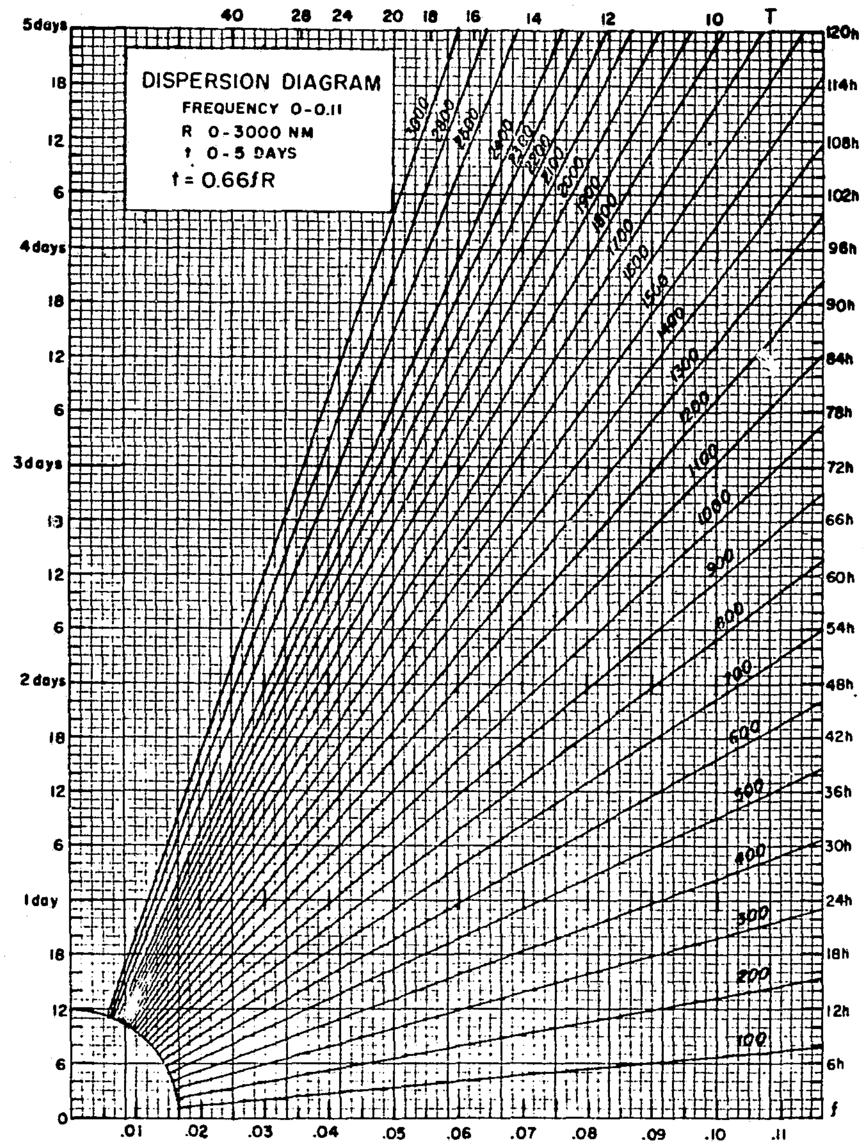
DISPERSION DIAGRAM
FREQUENCY 0-0.11
R 0-3000 NM
t 0-5 DAYS
t = 0.66 f R
40 28 24 20 18 16 14 12 10 T
5 days
4 days
3 days
2 days
1 day
120h 114h 108h 102h 96h 90h 84h 78h 72h 66h 60h 54h 48h 42h 36h 30h 24h 18h 12h 6h
f
.01 .02 .03 .04 .05 .06 .07 .08 .09 .10 .11
3000 2800 2600 2400 2300 2200 2100 2000 1900 1800 1700 1600 1500 1400 1300 1200 1100 1000 900 800 700 600 500 400 300 200 100

FIGURE 4

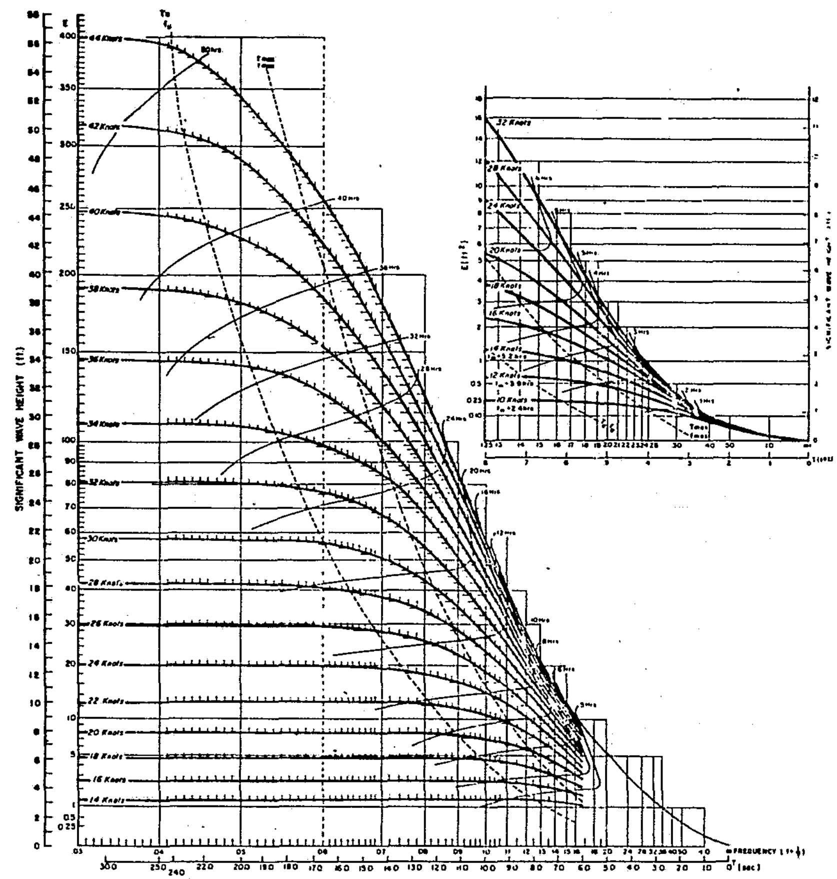
SIGNIFICANT WAVE HEIGHT (ft)
44 Knots
42 Knots
40 Knots
38 Knots
36 Knots
34 Knots
32 Knots
30 Knots
28 Knots
26 Knots
24 Knots
22 Knots
20 Knots
18 Knots
16 Knots
14 Knots
FREQUENCY
32 Knots
28 Knots
24 Knots
20 Knots
18 Knots
16 Knots
12 Knots
10 Knots

FIGURE 5
RANGE OF E FOR TYPICAL HEIGHT VALUES

Range of E	$\sqrt{E}$	E	Av. Ht.	Sig. Ht.	Av. 1/10 Ht.
.008–.06	.18	.03	.32	.5	.65
.06–.19	.35	.12	.62	1.0	1.26
.19–.38	.53	.28	.94	1.5	1.91
.38–.64	.71	.50	1.26	2.0	2.56
.64–.94	.88	.77	1.56	2.5	3.17
.94–1.54	1.06	1.12	1.88	3	3.82
1.54–2.53	1.41	1.99	2.50	4	5.08
2.53–3.76	1.77	3.13	3.13	5	6.37
3.76–5.29	2.12	4.49	3.75	6	7.63
5.29–7.02	2.47	6.10	4.37	7	8.89
7.02–9.00	2.83	8.01	5.01	8	10.2
9.00–11.3	3.18	10.1	5.63	9	11.4
11.3–15.1	3.53	12.5	6.25	10	12.7
15.1–21.1	4.24	18.0	7.50	12	15.3
21.1–28.1	4.95	24.5	8.76	14	17.8
28.1–36.1	5.65	31.9	10.1	16	20.3
36.1–45.0	6.36	40.4	11.3	18	22.9
45.0–60.4	7.08	50.1	12.5	20	25.5
60.4–84.5	8.48	71.9	15.0	24	30.5
84.5–112	9.89	97.8	17.8	28	35.6
112–144	11.3	128	20.0	32	40.7
144–180	12.7	161	22.5	36	45.7
180–225	14.1	199	25.0	40	50.8
225–282	15.9	253	28.1	45	57.2
282–346	17.7	313	31.3	50	63.7
346–412	19.4	376	34.3	55	69.8
412–488	21.2	449	38.8	60	76.3
488–571	23.0	529	40.7	65	82.8
571–702	24.7	610	43.7	70	88.9
702–900	28.3	801	50.1	80	102
900–1,129	31.8	1,010	56.3	90	114
1,129–1,376	35.3	1,250	62.5	100	127

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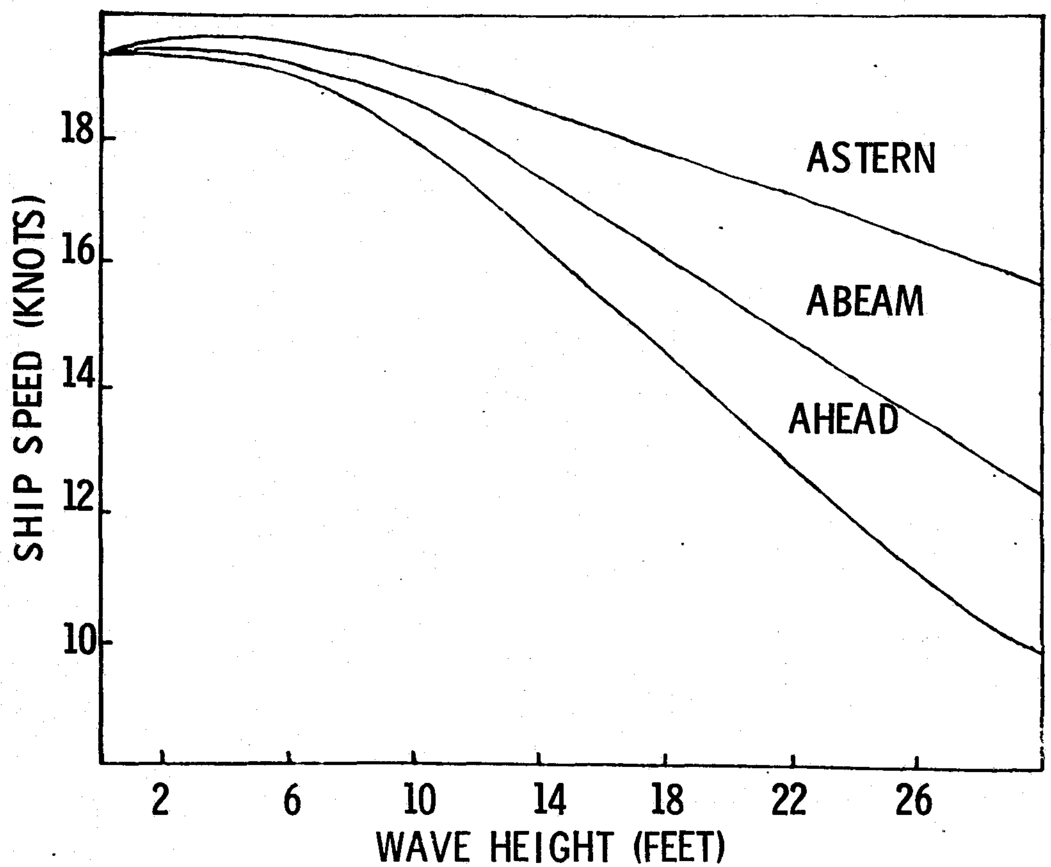
FIGURE 6

ERTS SE



AIR POLLUTION MODEL

OUTPUT:	FORECAST OF AIR POLLUTION DISTRIBUTION
SOURCE:	MODELS UNDER DEVELOPMENT CONSIDER MANY SOURCES AND WIND TRANSPORT
REMOTE SENSING:	MEASUREMENT OF DISTRIBUTION OF POLLUTION (RELIEVING REQUIREMENTS FOR DYNAMIC MODELING)

- The purpose is to forecast the concentration distribution of atmospheric pollution within an urban and/or industrial region.

- The Model is needed to account for the multitude of sources, source types, pollutant types, meso and micro-meteorological conditions that influence the future concentration of air pollution coinciding with population centers, impacting industrial facilities and activities, and affecting surrounding agricultural areas.

- Models are being developed to simulate observed pollutant dispersions giving some array of sources and source types. To simulate meso-meteorological processes in urban areas and pollutant transport; also air pollution control strategy modeling is under way.

- Potential exists for direct measurement by remote sensing of detailed 3-dimensional pollutant distributions, thus eliminating complicated atmospheric diffusion calculations.

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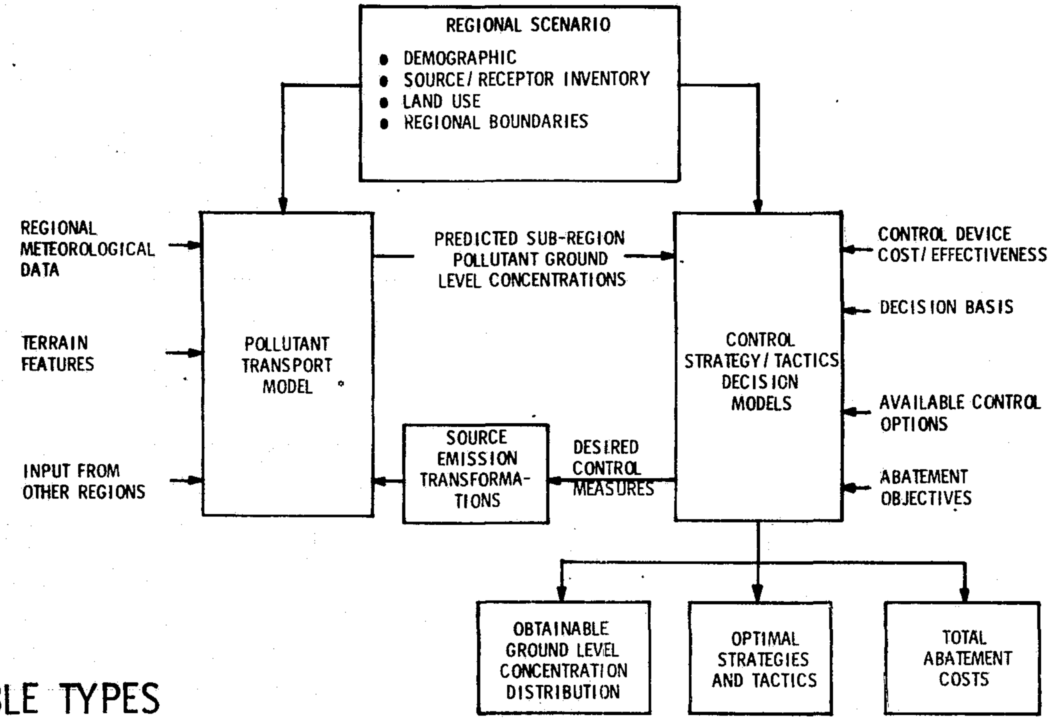
MAJOR ELEMENTS OF AN AIR-POLLUTION CONTROL DECISION MODEL SYSTEM



*POSSIBLE TYPES

- MULTIPLE SOURCE DISPENSION MODELS
- NUMERICAL ADVECTION - DIFFUSION SIMULATION MODELS

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GREAT LAKES ICE FORECASTS

ERS TSE

OUTPUT: DETERMINATION OF ACCESSIBILITY OF SHIPPING CHANNELS AND PORTS

SOURCE: IFYGL STUDY

REMOTE SENSING: ICE COVER AND THICKNESS, WATER AND GROUND TEMPERATURES, WATER CURRENTS AND ROUGHNESS

GREAT LAKES ICE FORECASTS

- The problem is to forecast the status of the ice cover on the Great Lakes in order to advise shipping interests as to the accessibility of a specified port or the navigability of the channels.

- The model provides a practical means to empirically integrate routine ice observations with meteorological measurements and measurements of the physical characteristics of the lakes and the near-lake shore to produce a forecast of the navigability of the shipping channels.

- The problem is being studied as part of IFYGL (International Field Year on The Great Lakes). Mechanical systems for prevention of ice formation are being developed.

- The Winter Navigation Board has been established (River - Harbor Act of 1970) to conduct a Winter Navigation Program to study and test the feasibility of extending the navigation season for the Great Lakes and the St. Lawrence Seaway.

  Program Features

  - Ship voyages beyond normal season
  - Observation and surveillance of ice conditions and ice forces.
  - Environmental and ecological investigations
  - Technical data on vessel design
  - Ice control facilities
  - Aids to navigation
  - Physical model studies
  - Coordinated collection and dissemination of key weather info to shippers.

- Measurement of ice cover thickness, water surface temperature, ground surface temperature, water surface roughness, currents can potentially be made by remote sensing.

SPACE DIVISION

FOREST YIELD MODELS

ERTS SE

OUTPUT: STATISTICAL ESTIMATE OF HARVESTABLE TIMBER VOLUME IN LARGE SCALE STANDS

USERS: USFS
TIMBER COMPANIES
(e.g., WEYERHAUSER)

TYPICAL MODEL: P.G. LANGLEY'S MULTISTAGE MODEL (DEPENDS ON REMOTE SENSING INPUTS TO PROPORTIONAL - PROBABILITY SAMPLING PROCESSES)

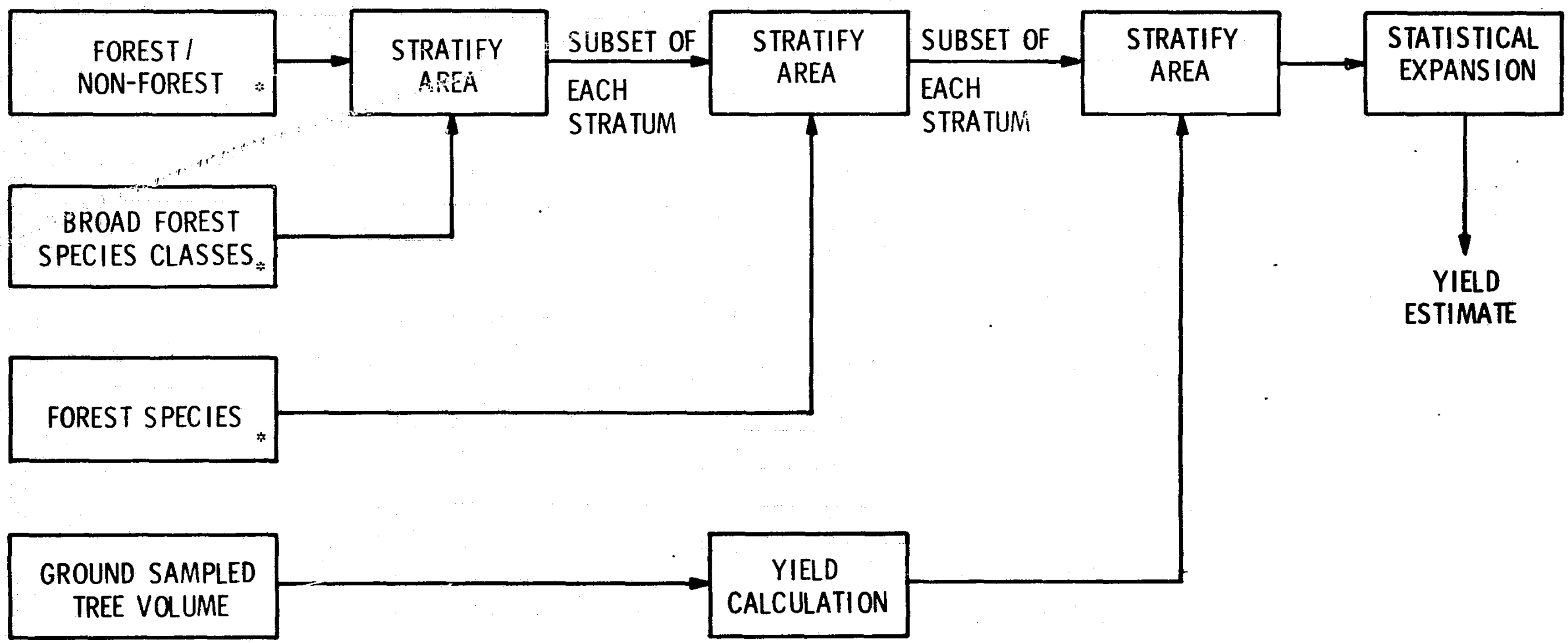
FOREST YIELD MODELS

- The problem is to predict or estimate the volume of merchantable timber in stands in forest areas. Both estimates of current timber volume and predictions of future volume are required. Both the U.S. Forest Service and lumber companies are interested in these yield estimates--the Forest Service because stand yield is a factor in U.S. forest management which the U.S. Forest Service is charged with and the lumber companies because of the impact of stand yield on harvesting plans and thus profits.

- A number of forest yield models, all designed for ground data input have been devised and are currently in use by both USFS and private companies. Langley's multistage forest yield model is unique in that it was designed specifically for remote sensing input and large area survey--it is currently being tested.

- Remote sensing plays a crucial role in providing inputs to Langley's multistage forest yield model. Acreages of species of trees and tree stands are used. Estimates of tree height and/or basal area may be obtained from remote sensing--research is currently underway to understand how to obtain these parameters.

LANGLEY'S MULTISTAGE SAMPLING FOREST YIELD MODEL



MIGRATORY FISH LOCATION

OUTPUT:	LOCATIONS OF FISHING AREAS WITH HIGH PROBABILITY OF FISH CONCENTRATIONS
USERS:	NMFS/NOAA (DEVELOPING CONCEPTUAL MODELS) COMMERCIAL FLEETS (USING EMPERICAL MODELS)
REMOTE SENSING:	POTENTIAL SOURCE FOR TEMPERATURE, WEATHER, SALINITY, WATER COLOR, SEA STATE, TURBIDITY, CURRENT, CHLOROPHYLL INPUTS

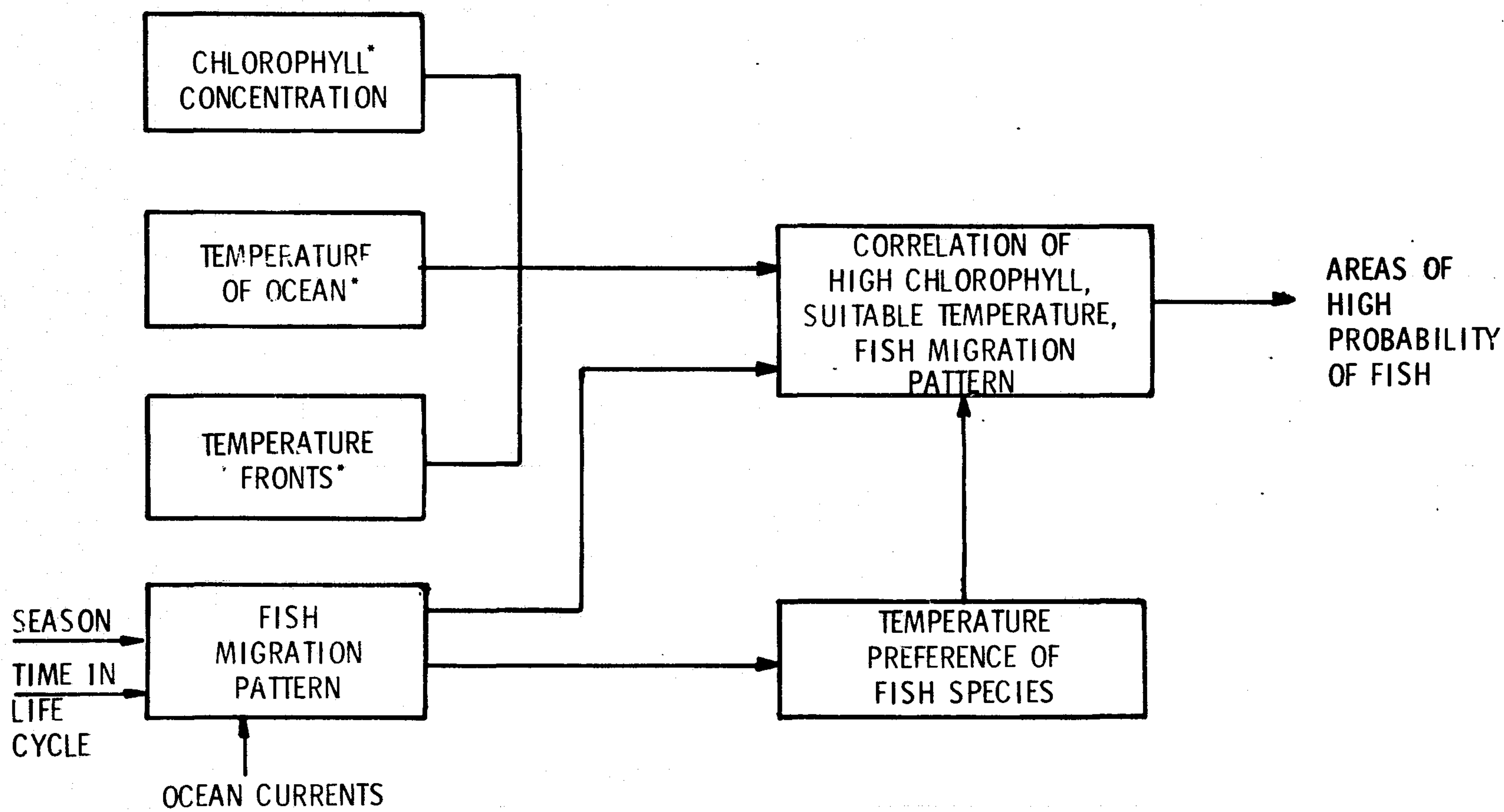
MIGRATORY FISH LOCATION

- Problem is to predict or delineate likely areas for fish in oceanic and coastal waters. Both NOAA and commercial fishing companies are interested in delineating likely areas so that the fishing fleet can be directed to areas where probability of success is maximized.

- Conceptual models were being developed under NOAA sponsorship. No operational use of models now except empirically by fishing fleet operators.

- Remote sensing ideally suited to delineation of temperatures and temperature fronts and of fronts in clear weather.

MIGRATORY FISH LOCATION



SPACE DIVISION

CROP YIELD MODELS

ERSTSE

OUTPUT:	STATISTICAL ESTIMATE OF HARVEST VOLUME BY CROP SPECIES
USERS:	AGRIBUSINESS - HARVEST STRATEGY PROCESSORS - BUYING STRATEGY USDA - POLICY AND STATUTORY
REMOTE SENSING:	TO ESTIMATE ACREAGES, BIOMASS, CATASTROPHIC FACTORS
TYPICAL MODEL WITH RS:	CALIFORNIA RAISIN MODEL

CROP YIELD MODELS

- Problem is to estimate the yield of important agricultural crops on a periodic basis or to obtain quick estimates of pre-harvest yield to plan harvesting strategy. Both USDA, agribusiness, and food processors are interested in the former, USDA for statutory reasons and agribusiness and food processor for determining marketing and buying strategy. Agribusiness interested in the latter.

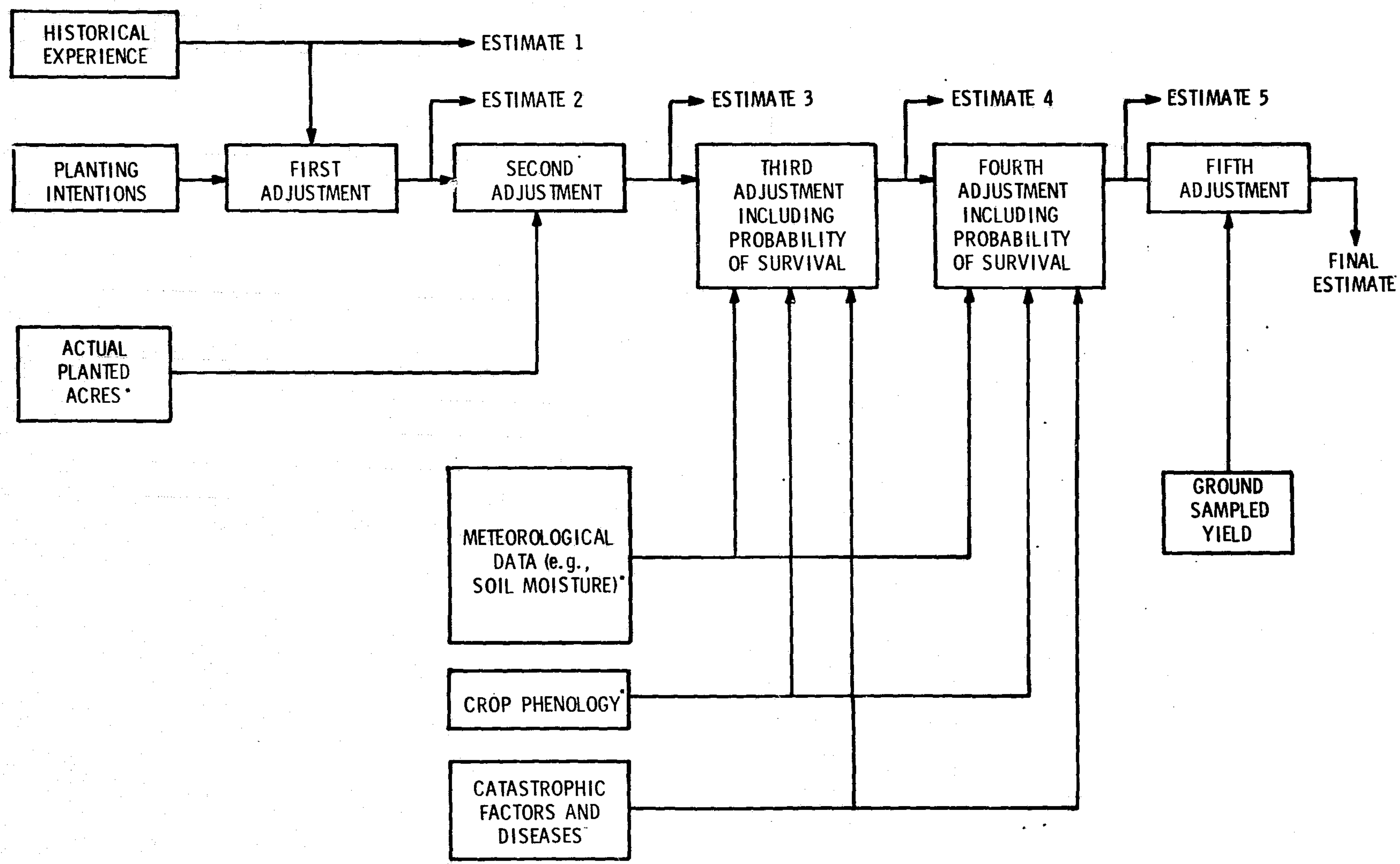
- Operational models based on stratified sampling and periodic introduction of more ground collected information are now in use at USDA-SRS for estimating monthly forecast crop yield. Some operational sampling models (e.g., California Raisin Survey) are currently conducted using remote sensing data and paid for by agribusiness. Research on new models being funded by USDA-SRS, and being studied by NASA-JSC (wheat).

- Remote sensing can impact yield models, especially to provide estimates of productive acreage of crops and catastrophic factor assessment (e.g., lodging, drought, hail damage).

SPACE DIVISION

CROP YIELD ESTIMATION

ERTS SE



SPACE DIVISION

CROP STRESS

ERS SE

OUTPUT: QUANTITATIVE PREDICTIONS OF PEST/ DISEASE STRESS INFLUENCES ON YIELD

USERS:
- USDA, STATE AGRICULTURAL DEPARTMENTS
- AGRIBUSINESS

TYPICAL APPLICATIONS:
- CORN - SOUTHERN LEAF CORN BLIGHT
- BRAZILIAN COFFEE

REMOTE SENSING: TO MEASURE STRESS, ASSESS EFFECT OF REMEDIES

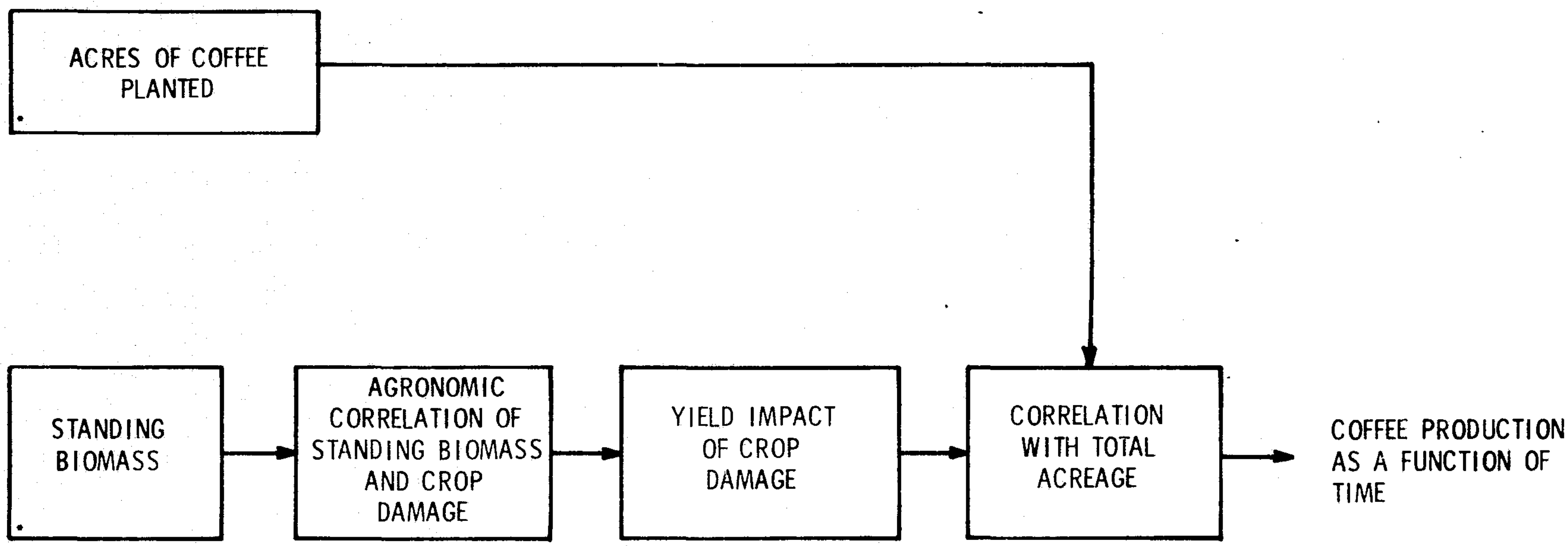
CROP STESS (BRAZILIAN COFFEE)

- The problems are: 1) to predict the spread of pests, disease, or other stress factors so that remedial action can be instituted, or 2) to estimate the impace of stresses on yield in cases where no remedial action is possible or feasible. Both USDA and agribusiness interests are concerned with this -- USDA because of the impact of stresses on yield predictions and the need to notify farmers of impending stresses (e.g., corn blight) and agribusiness because of the potential loss of profits.

- A number of empirical models exist for predicting stress (e.g., drought, where irrigation is a feasible remedy). USDA has sponsored work in house on the effects of stress on yield. Some work on this topic has also been done at Agriculture Experiment Stations. The Brazilians have constructed a model for the impace of frost on coffee production. The effects of corn blight on corn yield were being empirically studied at LARS.

- Remote sensing could have an impact on the assessment of degree of stress and on the previsual detection of stress. Also remote sensing could be used to assess the effects of remedial treatment.

CROP STRESS: BRAZILIAN COFFEE



SPACE DIVISION

WATER FOWL PRODUCTIVITY

ERS SE

OUTPUT: ESTIMATES OF FLOCK SIZES TO ESTABLISH HUNTING CONTROLS, LIMITS

TYPICAL MODELS: BSFW MODEL PREDICT MALLARD POPULATIONS

REMOTE SENSING: CAN DETERMINE HABITAT INFLUENCE OF FLOCK SIZE

WATERFOWL PRODUCTIVITY MODELS

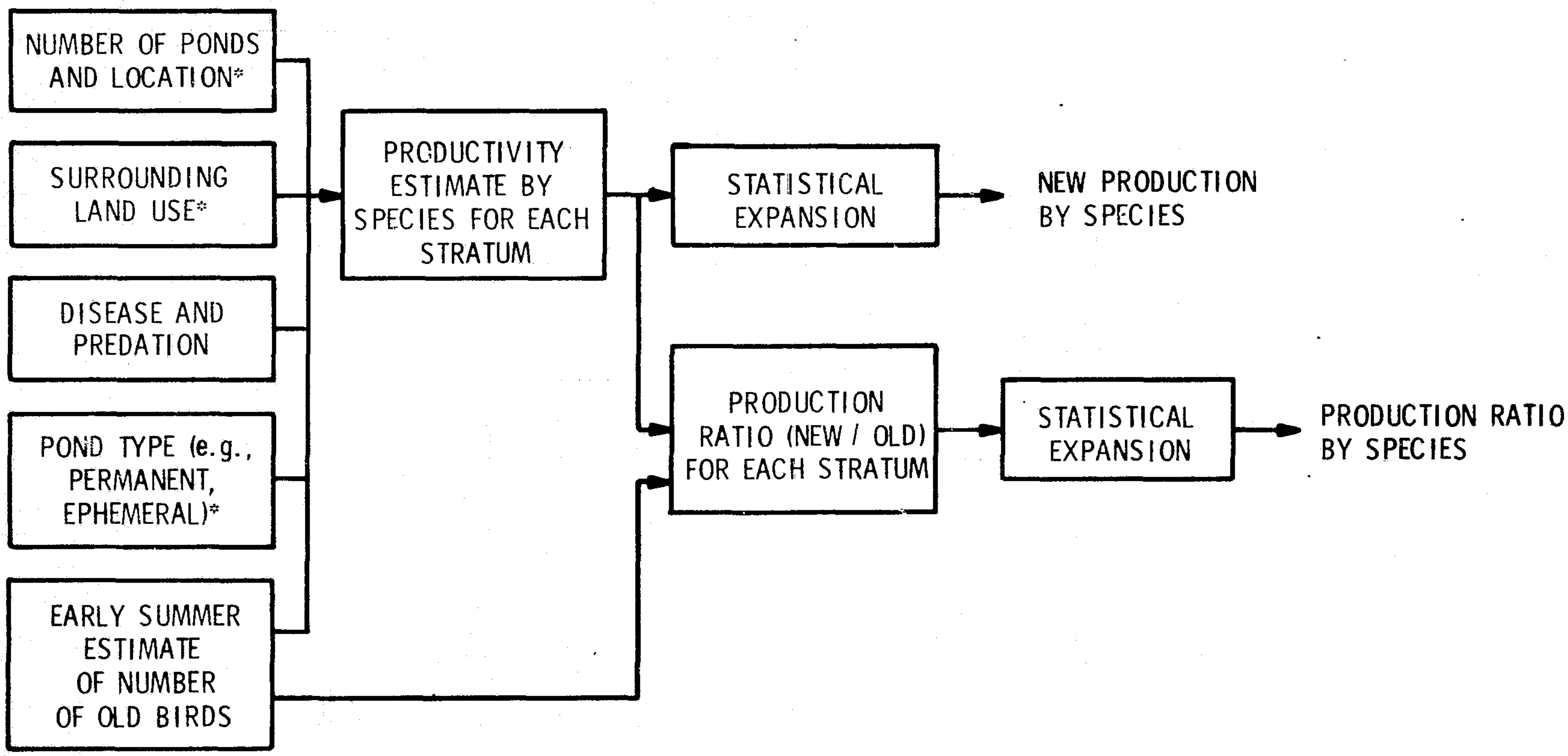
- Problem is to estimate the production of new migratory waterfowl, by species, for the U.S., Canada, and Alaska. An estimate of the ratio of new production to total population is desired. Both U.S. and Canadian Wildlife Services need this information to help set hunting limits each fall and to insure that enough birds survive to breed the next year.

- At present, some empirical models exist relating habitat quality to production of some species of ducks (e.g., Mallards). Current estimates of new production and total population are computed from stratified samples taken by serial observers. The current program and modeling research are funded by the Bureau of Sports Fisheries and Wildlife and the Canadian Wildlife Service.

- Remote sensing can impact the habitat assessment required as part of estimating new production.

SPACE DIVISION

A CONCEPTUAL WILD FOWL PRODUCTIVITY MODEL



*INDICATES EVENTUAL REMOTE SENSING IMPACT

SPACE DIVISION

PHYSICAL / BIOLOGICAL MODEL OF WATER BODY

ERS TSE

OUTPUT:	DUE TO BIOLOGICAL / MECHANICAL INTERACTIONS WITH IMPACT ON FISHING, NAVIGATION, RECREATION
SOURCE:	INSTITUTE FOR ENVIRONMENTAL STUDIES (UNIVERSITY OF WISCONSIN)
REMOTE SENSING:	CAN PROVIDE INPUTS ON ENERGY, NUTRIENTS, WATER INFLOW

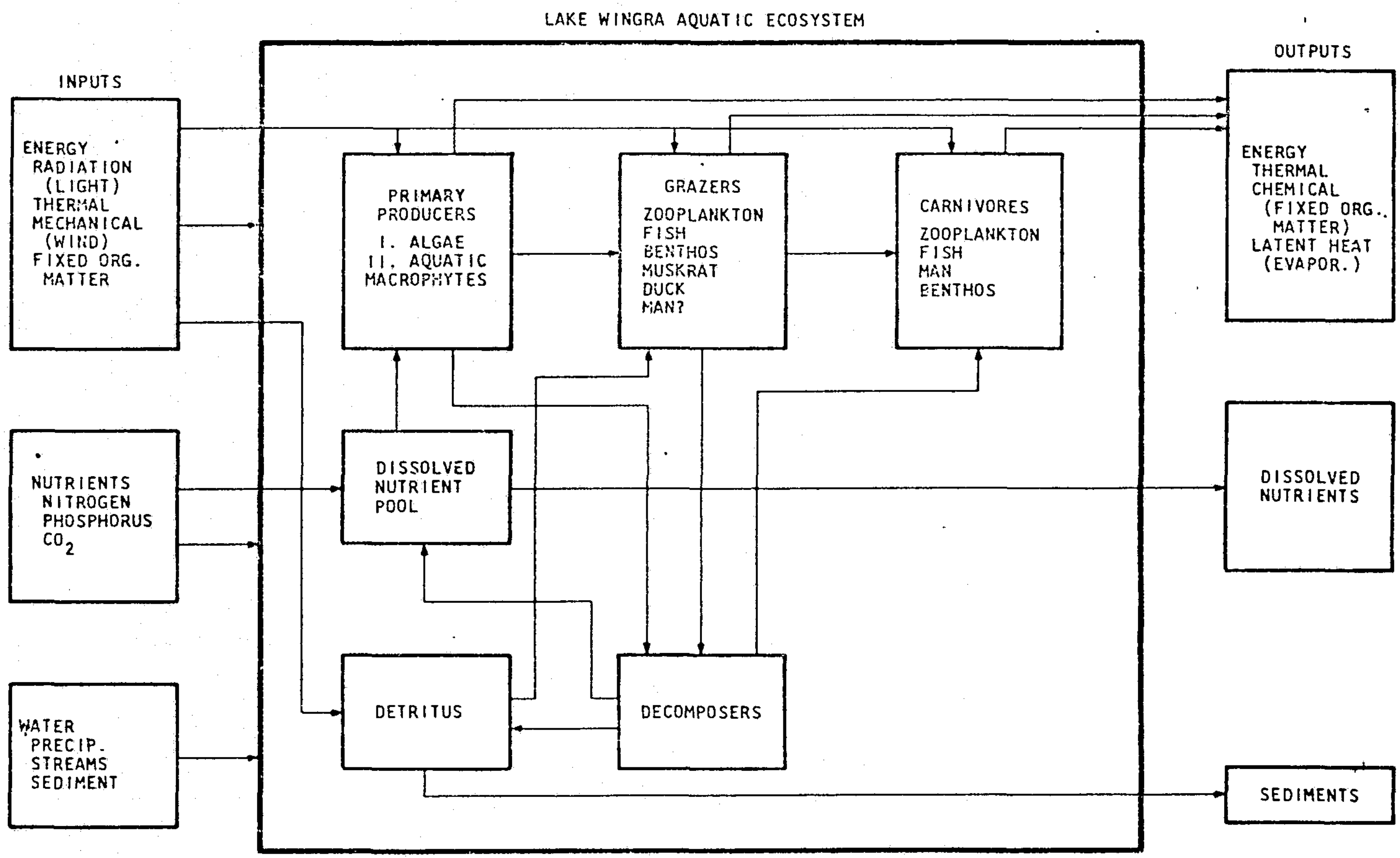
A PHYSICAL/BIOLOGICAL MODEL OF A WATER BODY

- The purpose of the model is to describe the transformations of a water body subject to complex mechanical and biological interactions.
- A typical source of a model is the Institute for Environmental Studies - University of Wisconsin - (Watt, K)
- This type of model has been used to explain transformations of water bodies.
- Potential contributions of remote sensing are inputs of various types of energy, inputs of nutrients and water inputs some of which can be obtained by remote sensing.
- Model inputs are Radiation, Thermal and Mechanical Energy, organic material and nutrient inflow and water inflow.
- Model outputs are energy outflow of water body (thermal, chemical, latent heat); change in nutrient and sediment levels in water body. These have potential impact on fish productivity, recreational and economic value of water body and surrounding land.

SPACE DIVISION

A COMPARTMENT MODEL SHOWING (1) THE MAJOR INPUTS (2) THE POOLS OF PLANTS, ANIMALS, DISSOLVED NUTRIENTS AND DETRITUS, AND (3) THE MAJOR OUTPUTS OF AN AQUATIC ECOSYSTEM. AFTER WATTS AND LOUCKS (1969)

ERS SE



SPACE DIVISION

ESTUARINE DYNAMICS

ERTS SE

TYPICAL OUTPUT: PREDICTION OF EFFECT OF STEAM PLANT ON MARINE LIFE

TYPICAL MODEL: PHYSICAL/DIGITAL MODEL OF GALVESTON/TRINITY BAY

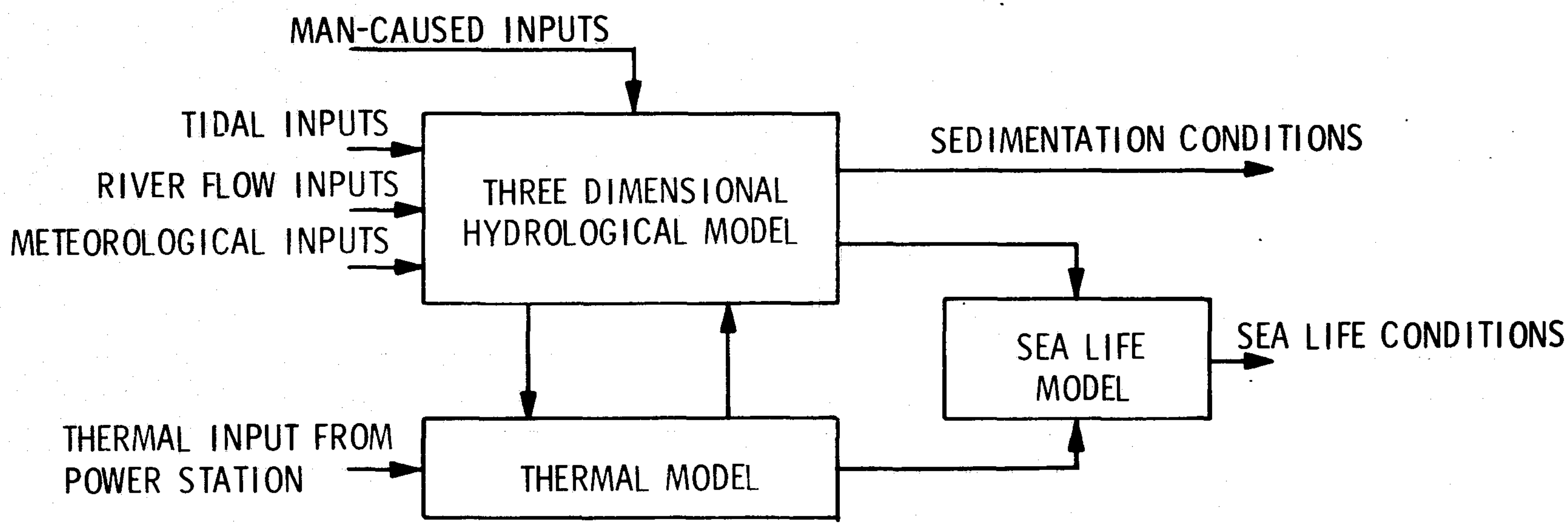
REMOTE SENSING: TIDAL PHASES, RIVER INFLOW, TEMPERATURE, SALINITIES, METEOROLOGY

ESTUARINE FLOW DYNAMICS

- Man-introduced substances and activities are threatening natural utility and productivity of coastlines. Better knowledge of near-shore circulation patterns are needed to better manage the sea/land resources for the long term benefit of man.
- Typical models used are the physical and digital hydrodynamic and thermal models of the Galveston-Trinity Bay System.
- Specific objectives are to determine heating effect of steam plant on small marine life and to corrolate spatial and temporal characteristics of estuarine effluents with other environment parameters.
- Model sensed inputs required are tidal phases in bays, meteorological parameters, river in-flow rates and temperatures, subsurface temperatures and salinities.
- Typical outputs are prediction of effects of man-induced activity such as thermo-electric plants on marine plant and animal life.

60

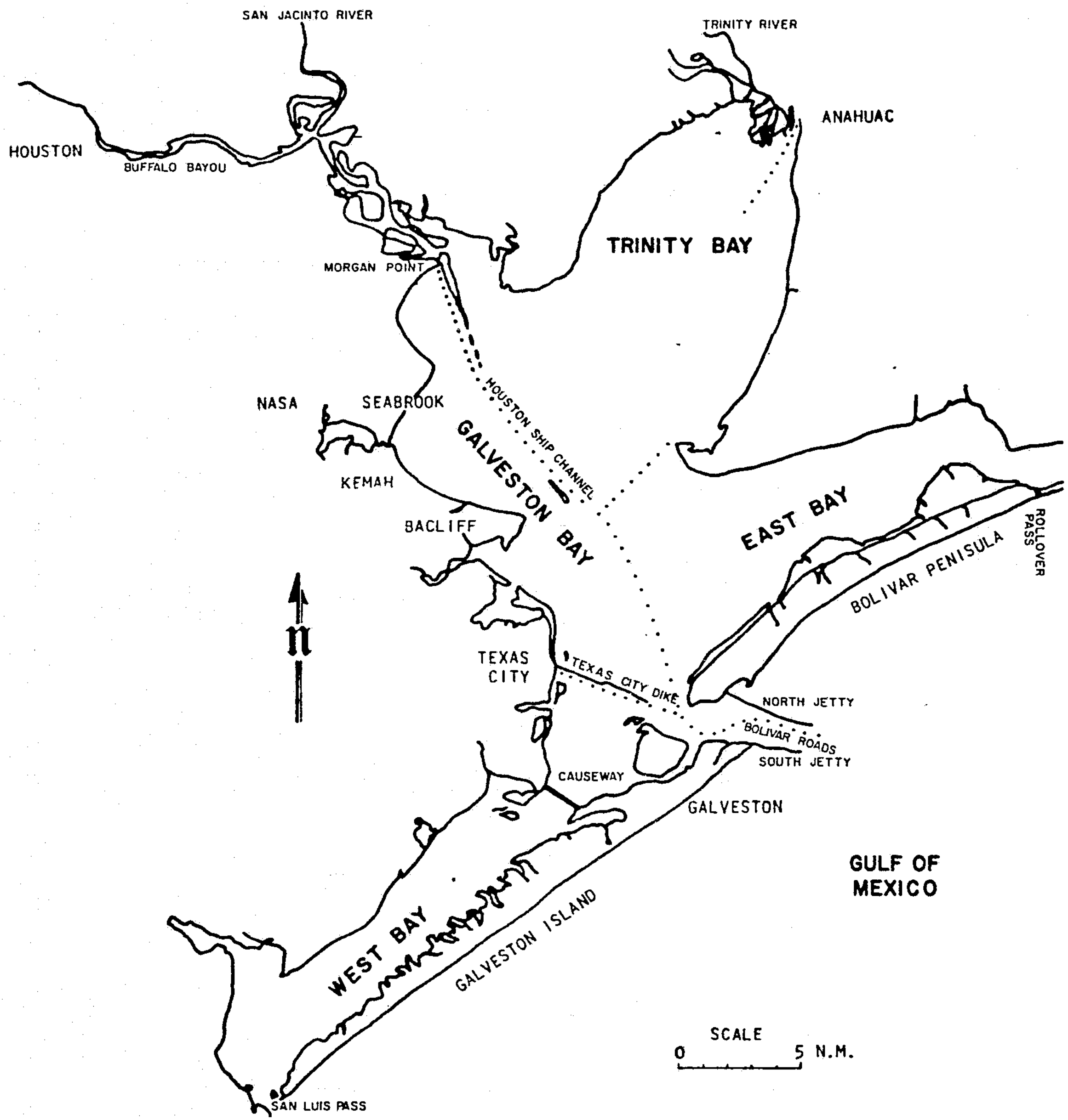
TYPICAL ESTUARINE USER MODEL



SPACE DIVISION

THE GALVESTON BAY SYSTEM

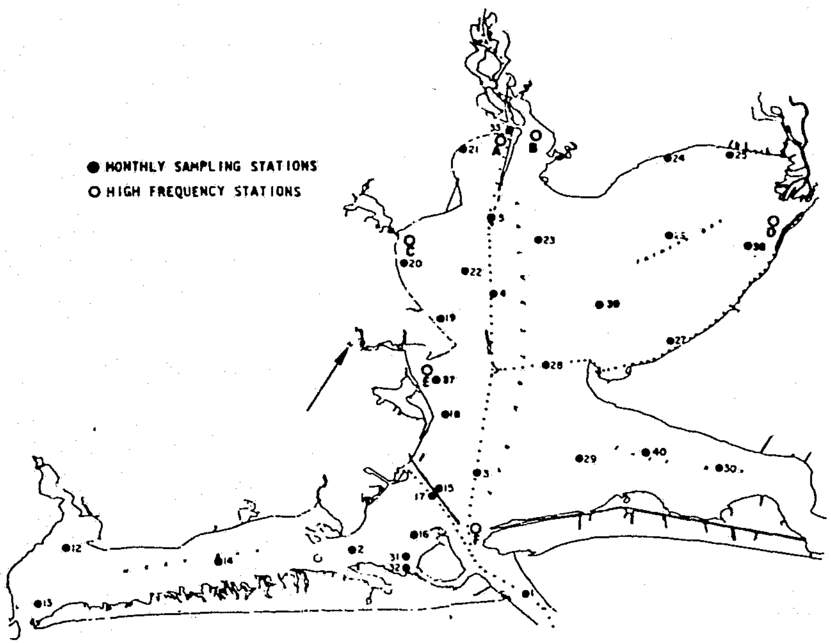
ERTS SE



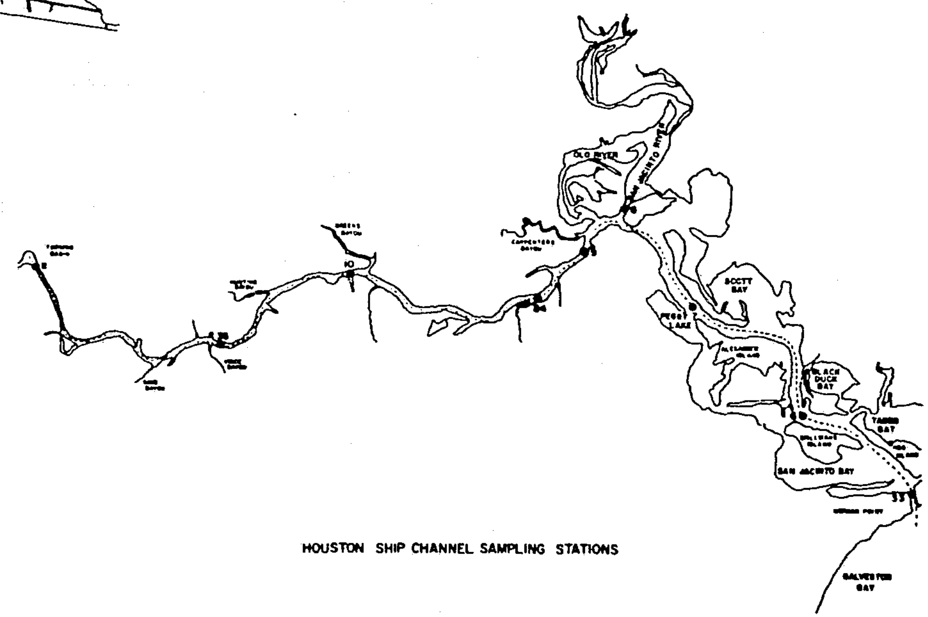
GE SPACE DIVISION

GALVESTON BAY PROJECT SAMPLING STATIONS

ERTS SE



GALVESTON BAY SAMPLING STATIONS

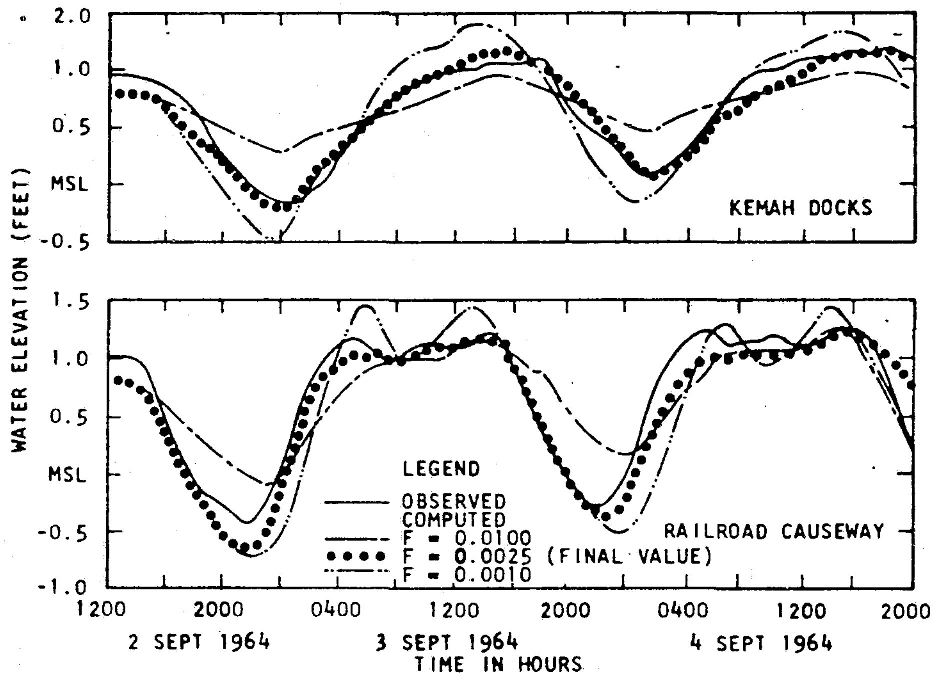


HOUSTON SHIP CHANNEL SAMPLING STATIONS

SPACE DIVISION

COMPUTED ASTRONOMICAL TIDE FOR TWO LOCATIONS IN GALVESTON BAY FOR THREE DIFFERENT FRICTION FACTORS: OBSERVED VALUE ALSO SHOWN. AFTER REID AND BODINE (1968).

ERTS SE

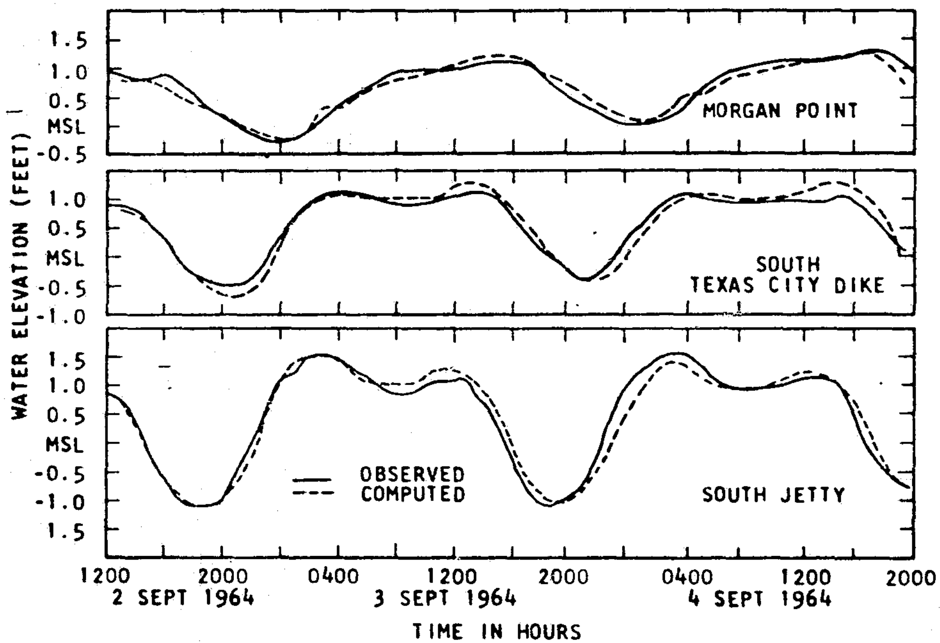


G4

SPACE DIVISION

COMPARISON OF OBSERVED AND COMPUTER ASTRONOMICAL TIDE FOR THREE LOCATIONS IN GALVESTON BAY USING FINAL FRICTION FACTOR. AFTER REID AND BODINE (1968).

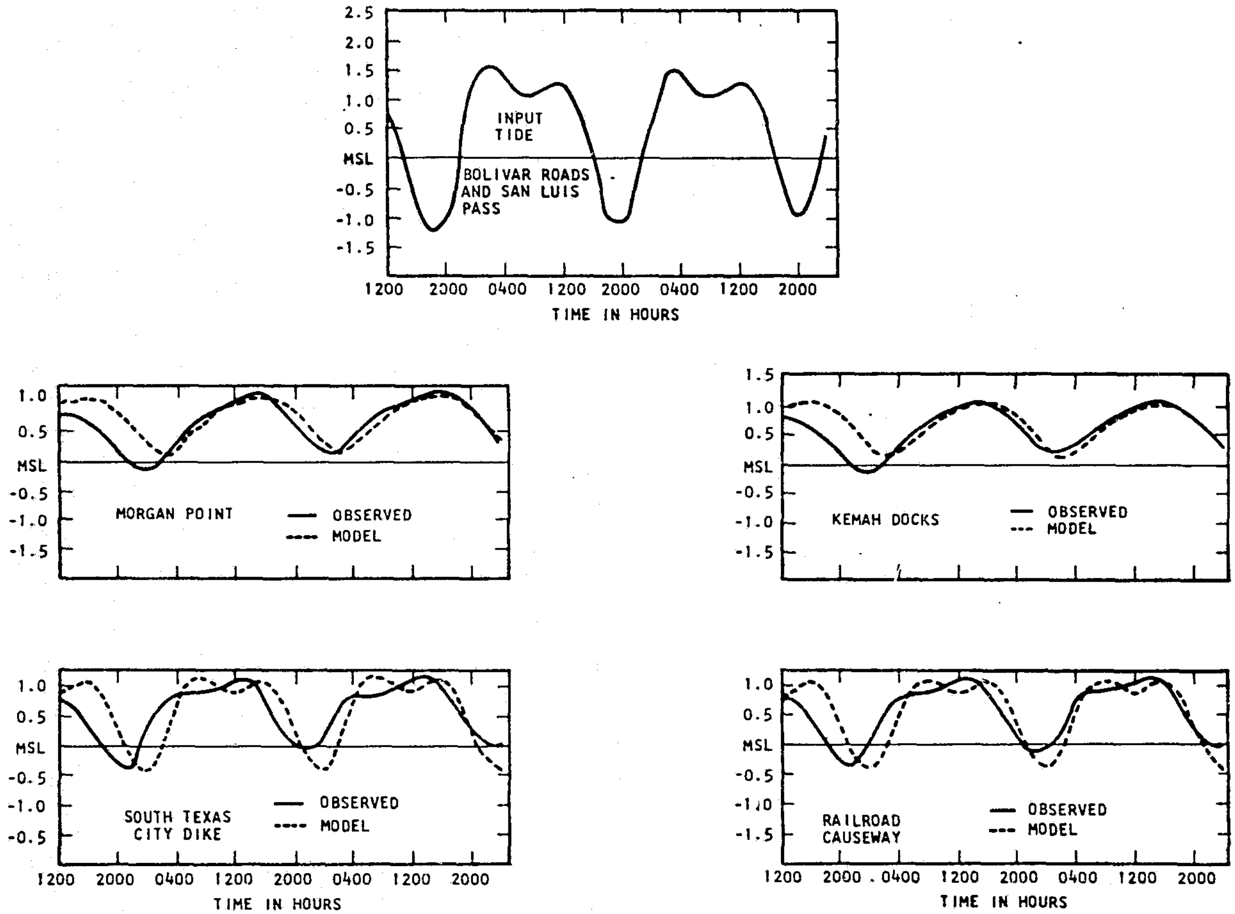
ERTS SE



SPACE DIVISION

COMPARISON OF MEASURED AND COMPUTED TIDAL ELEVATIONS IN GALVESTON BAY (STOVER et al. 1971).

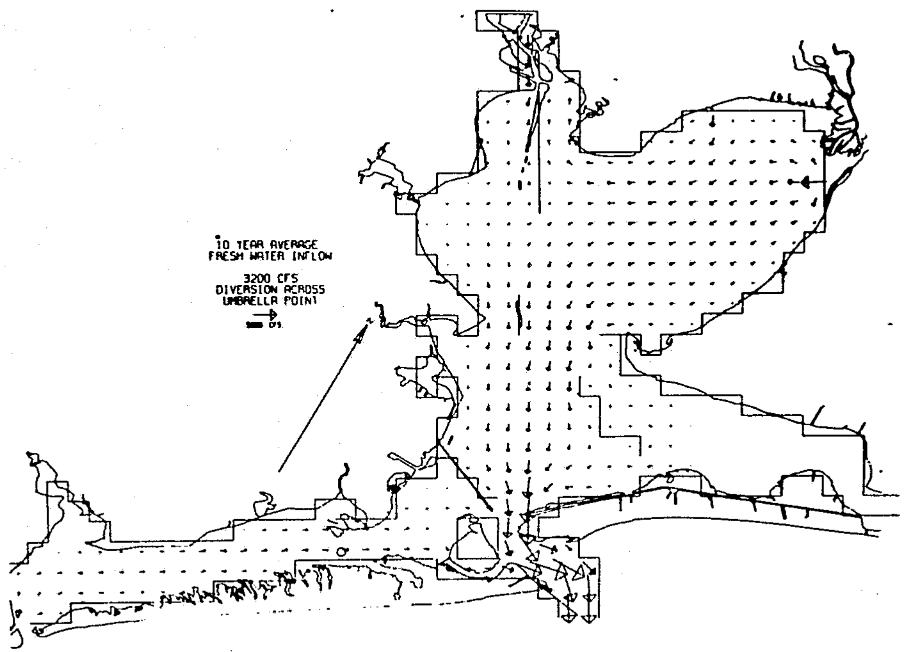
ERTS SE



SPACE DIVISION

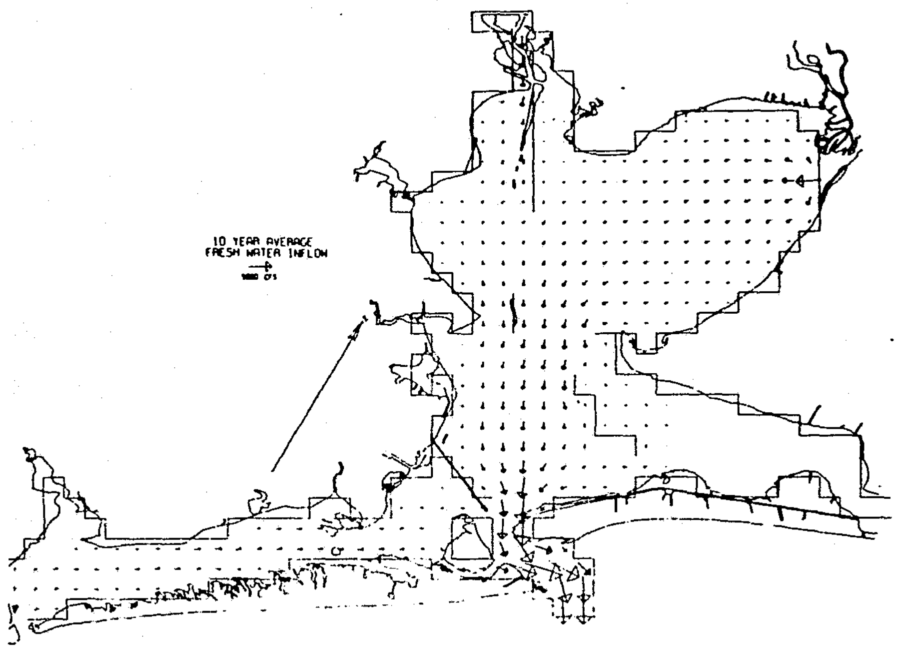
CALCULATED VELOCITIES FOR CONDITIONS OF PREVIOUS FIGURE WITH ADDED DIVERSION ACROSS UMBRELLA POINT (TOP RIGHT)

ERTS SE



SPACE DIVISION

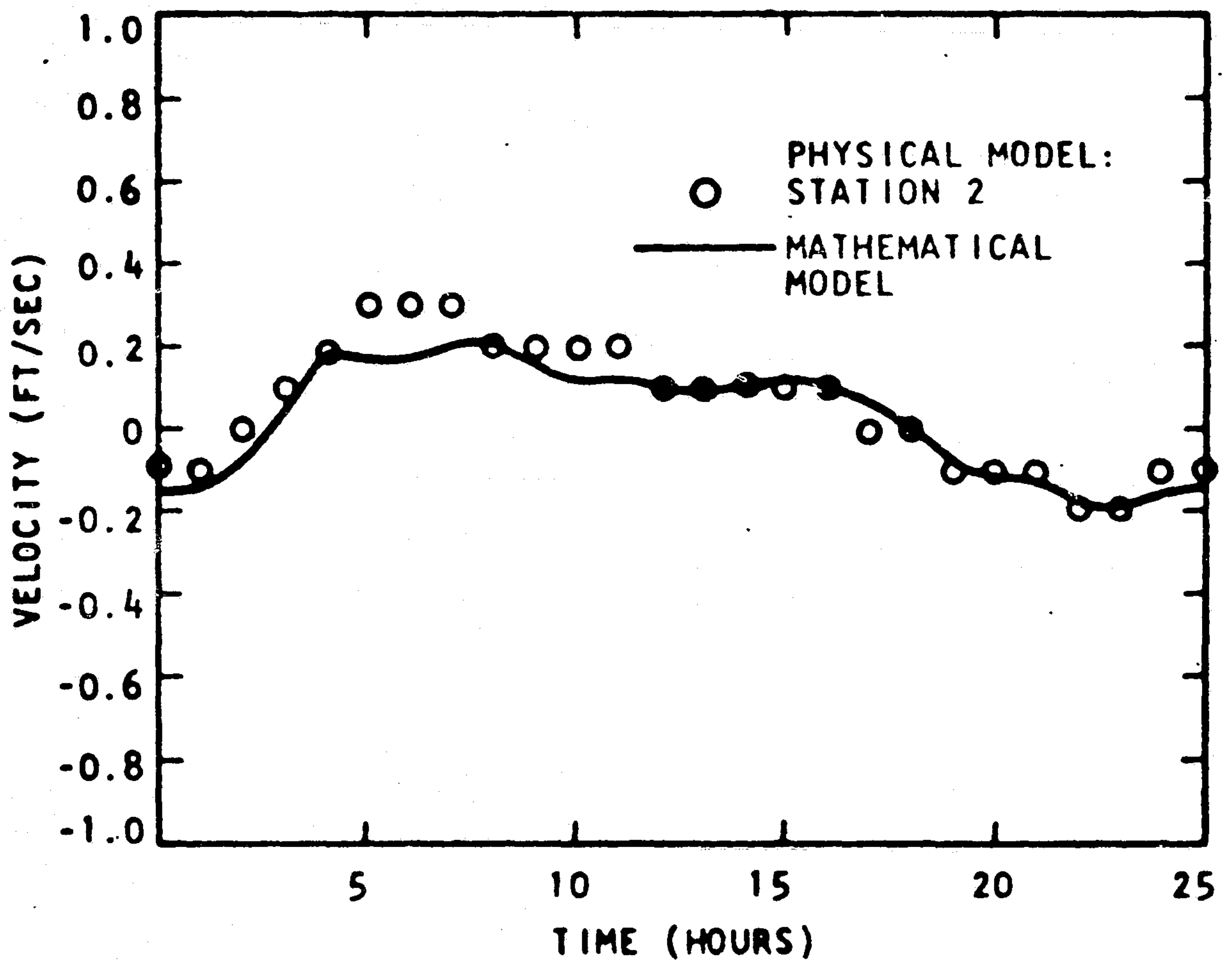
CALCULATED TIDAL-AVERAGE VELOCITIES FOR TEN-YEAR-MEAN INFLOW



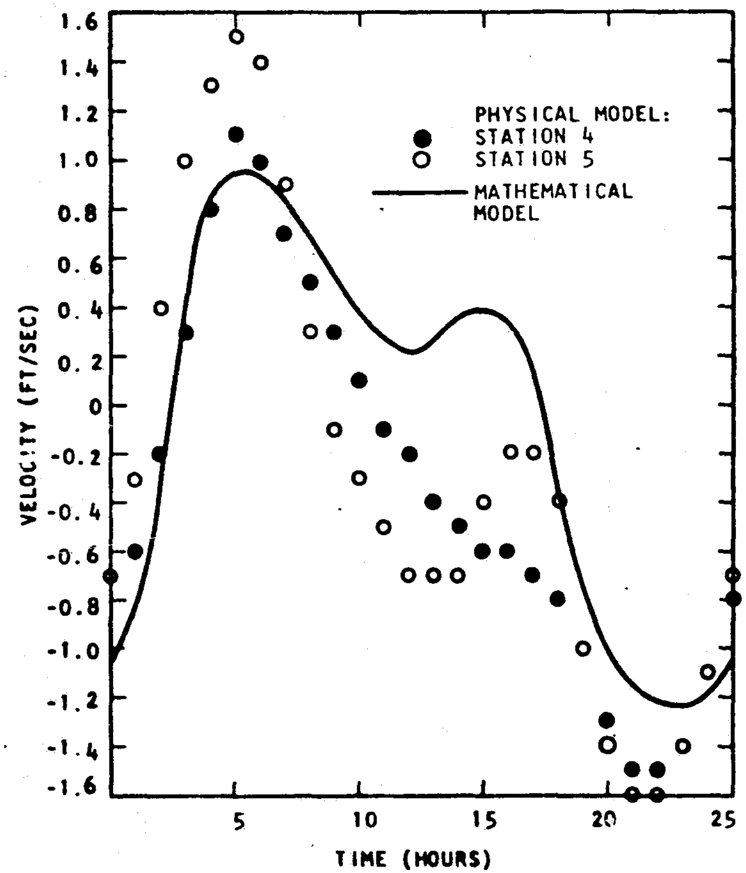
SPACE DIVISION

COMPARISON OF VELOCITIES FROM PHYSICAL MODEL AND MATHEMATICAL MODEL. RANGE 1, ATKINSON ISLAND TO MESQUITE KNOLL

ERTS SE



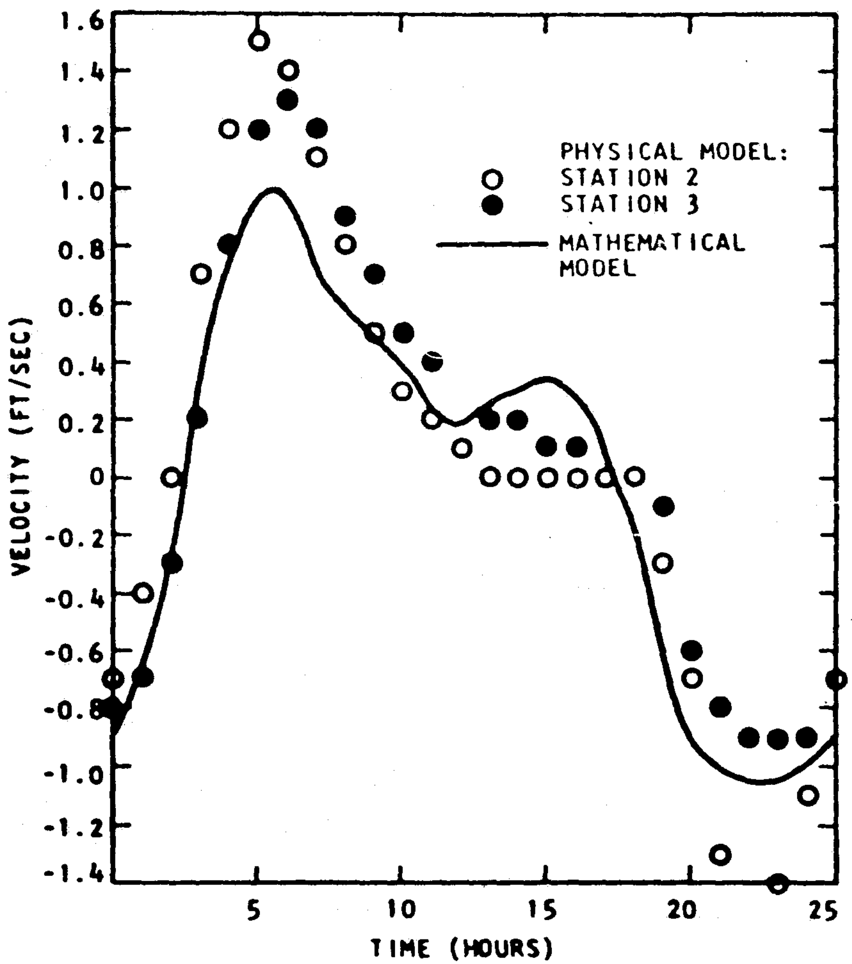
COMPARISON OF VELOCITIES FROM PHYSICAL MODEL AND MATHEMATICAL MODEL. RANGE 6, RED FISH ISLAND TO EAGLE POINT



SPACE DIVISION

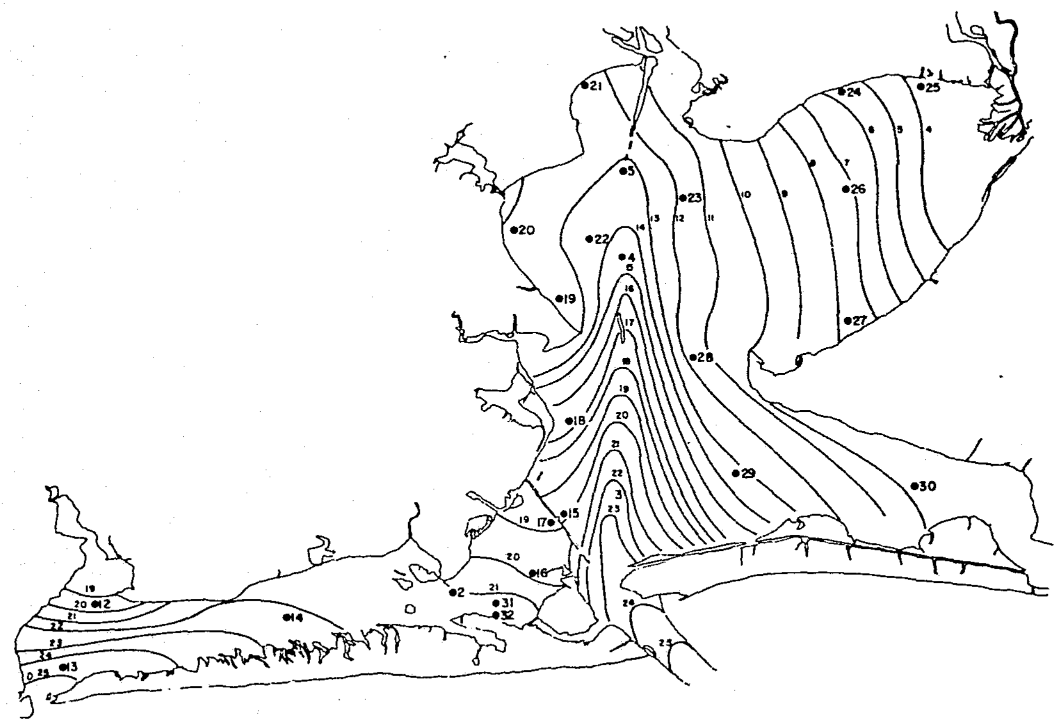
COMPARISON OF VELOCITIES FROM PHYSICAL MODEL AND MATHEMATICAL MODEL. RANGE 6, RED FISH ISLAND TO SMITH POINT

ERTS SE



SPACE DIVISION

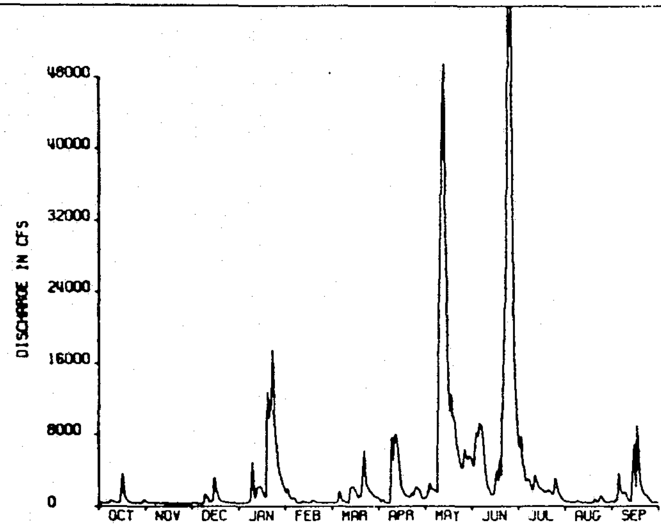
SALINITY CONTOURS FROM MEASUREMENTS OF 17 SEPTEMBER 1968 IN GALVESTON BAY



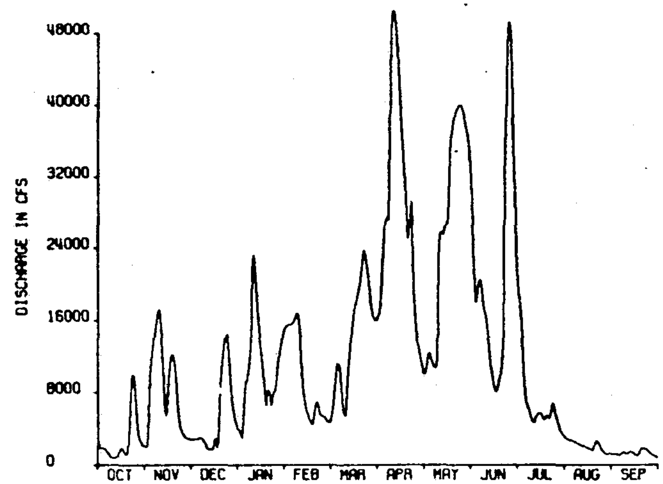
SPACE DIVISION

INFLOWS IN TRINITY RIVER AND HOUSTON SHIP CHANNEL (AT MORGAN POINT) FOR 1968 WATER YEAR

ERTS SE



DISCHARGE FOR 1968 WATER YEAR. HOUSTON SHIP CHANNEL

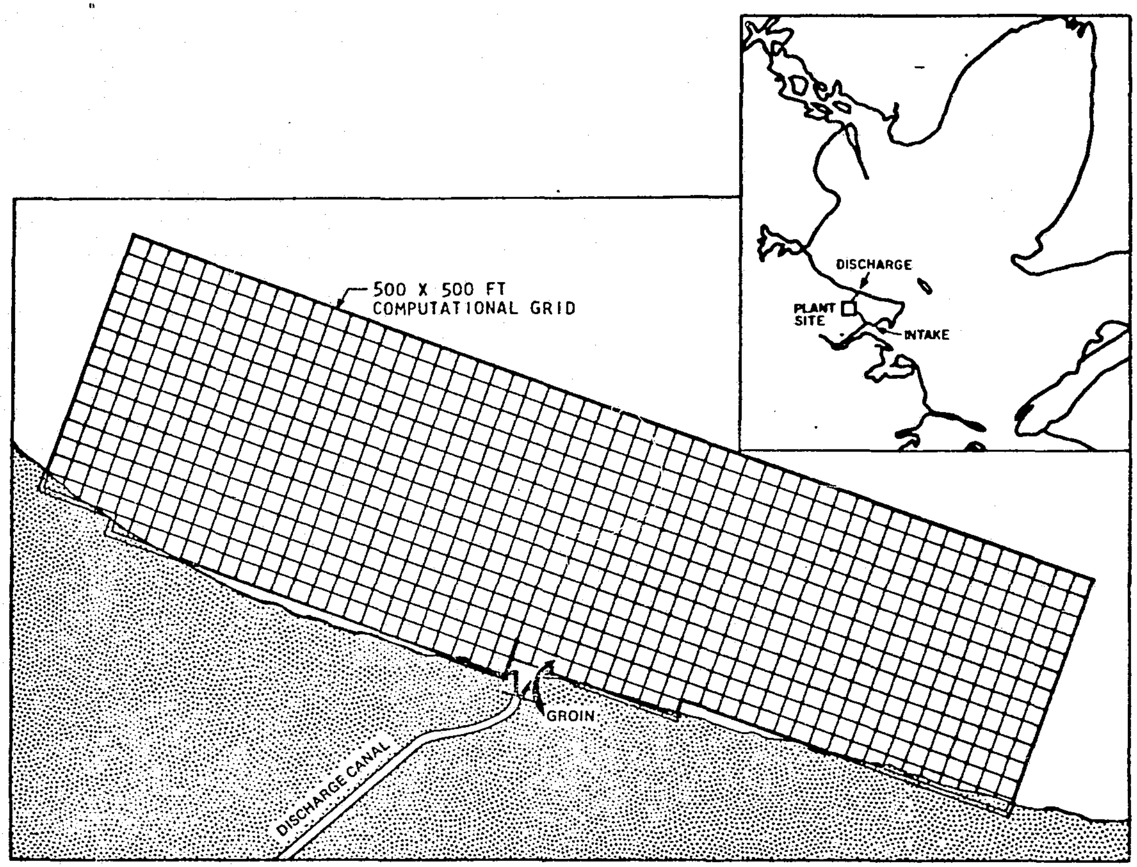


DISCHARGE FOR 1968 WATER YEAR. TRINITY RIVER AT ROMAYOR

SPACE DIVISION

LOCATION MAP AND COMPUTATIONAL GRID FOR THERMAL DISCHARGE MODEL

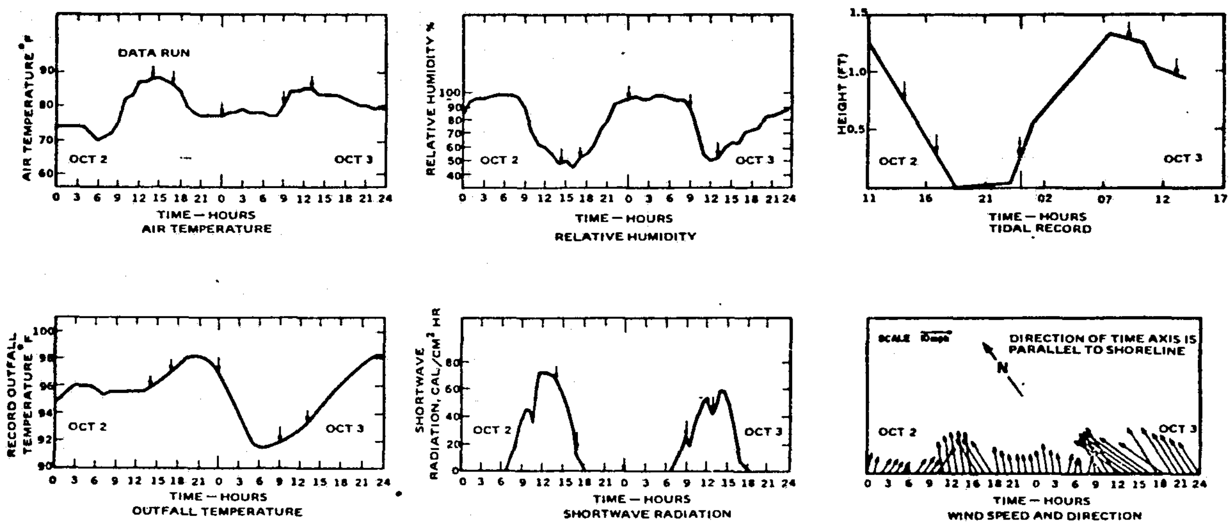
ERTS SE



SPACE DIVISION

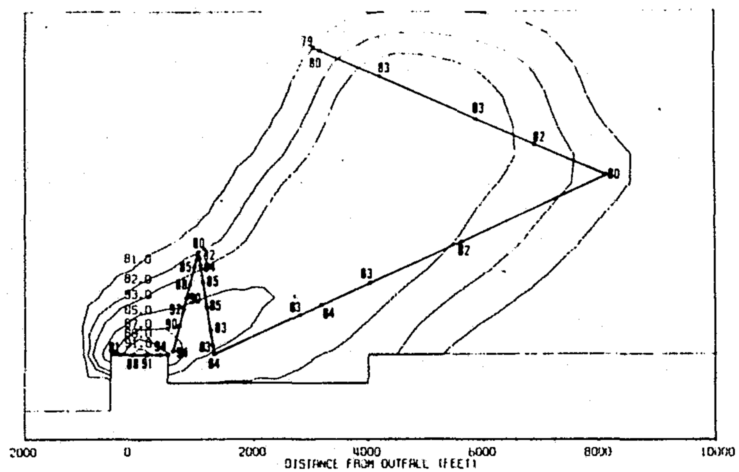
ENVIRONMENTAL CONDITIONS AT P. H. ROBINSON PLANT ON 2 - 3 OCTOBER

ERSTSE

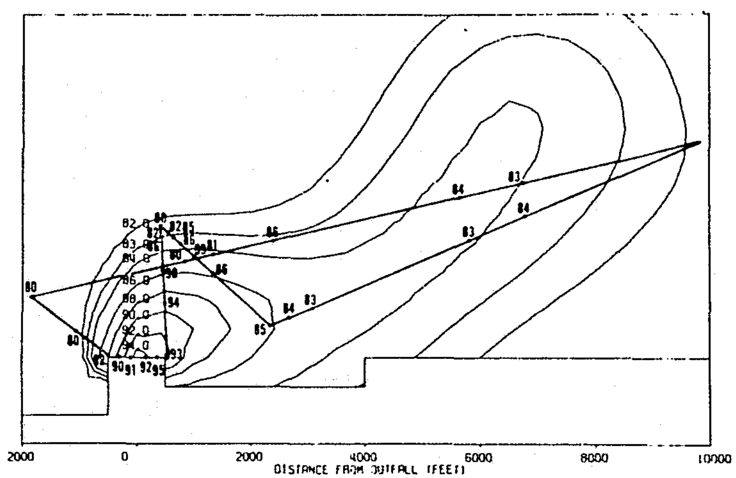


CALCULATED TEMPERATURE (°F) CONTOURS WITH MEASUREMENTS FROM BOAT TRAVERSES. P. H. ROBINSON DISCHARGE IN GALVESTON BAY. FROM STOVER et al. (1970).

SPACE DIVISION



(a) 2 October, 2:00 P.M.



(b) 2 October, 5:00 P.M.

SPACE DIVISION

COLUMBIA RIVER BASIN

ERS SE

OUTPUTS: EFFECTS OF ALTERNATE WATER STORAGE/RELEASE STRATEGIES TO IMPROVE OVERALL RIVER MANAGEMENT (HYDRO-POWER, IRRIGATION, FLOOD REDUCTION, NAVIGATION, RECREATION)

SOURCE: PLANNING RESEARCH CORP/NASA (CONCEPTUAL MODEL KNOWN TO EXIST)

REMOTE SENSING: DEPENDS ON MULTISPECTRAL SENSING AND SAR

A USER MODEL FOR WATER MANAGEMENT IN THE COLUMBIA RIVER BASIN

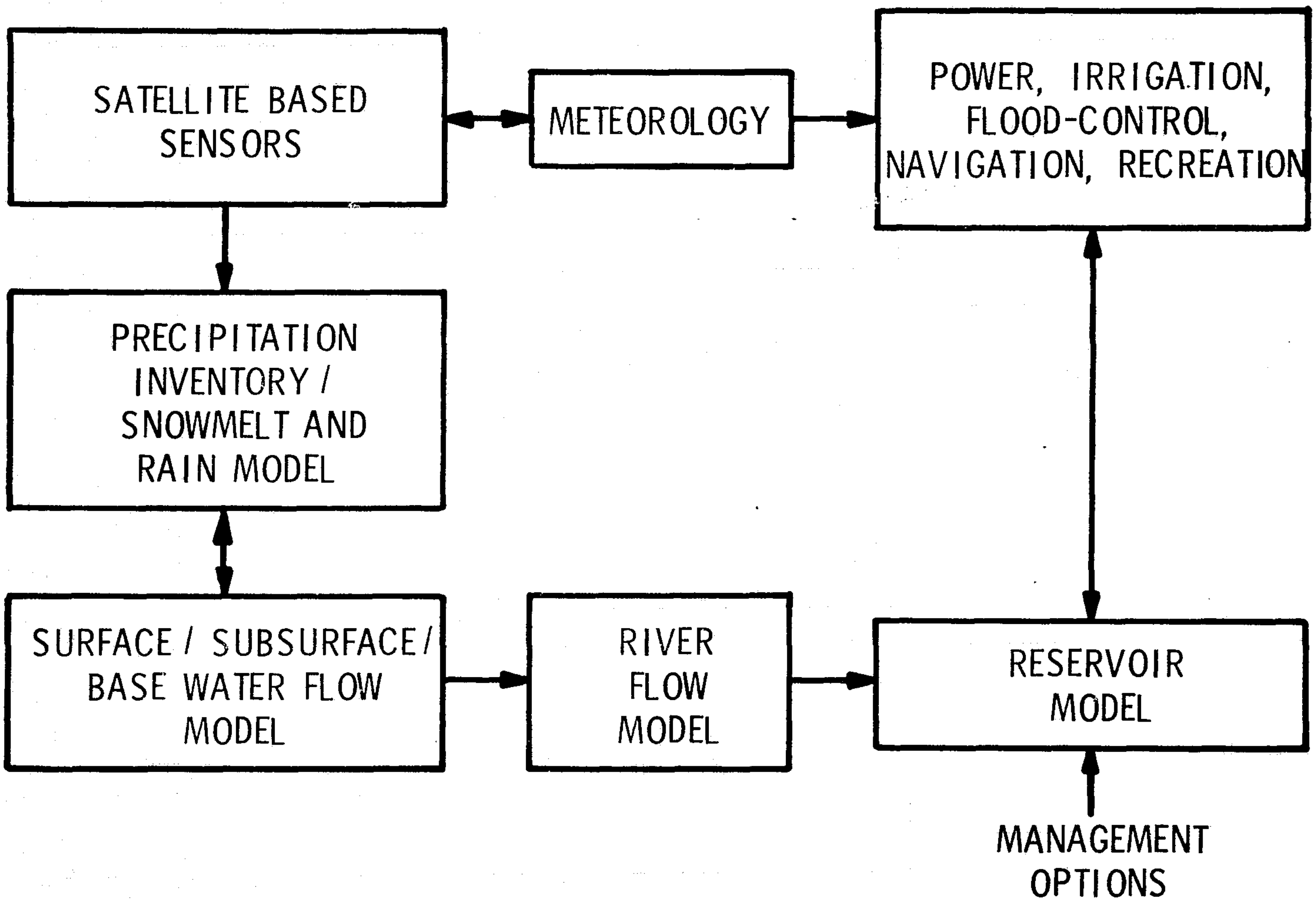
- The purpose of the Model is to specify sensing and system requirements needed to maximize benefits of hydropower output, recreational utilization and irrigation capability without incurring excessive flood risks.

- The source of the Model is Planning Research Corporation, under NASA Contract (NAS w-1816). Analysis of User Model has been made as part of Total River Basin Management Model. Model has not yet been used with remotely sensed data.

- The Model potentially can make use of satellite-mounted multi-spectral sensors and synthetic aperture radar.

- The Application of Model and to total management system projected to provide cost benefits to Pacific Northwest and the nation.

RIVER BASIN MODEL



SPACE DIVISION

MAJOR DIFFERENCES BETWEEN DOSAG-1 AND QUAL-1 MODELS

	Parameters	DOSAG-1	QUAL-1
Inputs	Water quality parameters	DO, BOD(C), BOD(N)	DO, BOD, Temperature, Conservative Minerals (3)
	Monthly flow and quality	Headwater stretches only	(Not available)
	Climatology	(Not required)	For temperature modeling
	Minimum DO targets	Specified for entire basin	Specified for each reach
	Stream temperature	Mean monthly value specified	Not required (computed)
Maxima	Monthly stream temperature	12	(Not available)
	Monthly headwater flow and quality	12	(Not available)
	Low flow augmentation sources	1 for each upstream headwater	6 per reach
	Minimum DO targets	4	1 per reach
	Headwater stretches	10	-
	Headwater sources	-	5
	Junctions	20	5
	Stretches	10 (including headwaters)	(Not included)
	Reaches	50	25
	Elements/reach	(Not available)	20
	Discharges and withdrawals	Each uses 1 reach	25
	Basin percent treatment	4 BOD(C); 4 BOD(N)	1 per waste load
	Waste load percent treatment	1 per reach	1 per element
Waste Inputs and Withdrawals	Location Parameters	Each uses 1 reach Flow, DO, BOD(C), BOD(N)	Element % Treatment, flow, temp, DO, BOD, CM(3)
Low Flow Augmentation	Minimum DO targets Allocation	Specified for whole basin Requirement divided equally between all headwaters	Specified for each reach Requirement divided equally between those headwaters specified as available for each reach
Runoff	Location quality	Each uses 1 reach Flow, DO, BOD	Distributed over any specified reach Flow, DO, BOD, Temp, CM(3)
Mathematical	Technique	Lagrangian	Eulerian
	Space interval	1 reach length (variable)	Specify length of computing element (miles)
	Time interval	(Steady-state)	Specify time increment (hours)
	Approximate time to solution	1 minute	10 minutes

SPACE DIVISION

PROJECTED BENEFITS - IMPROVED WATER MANAGEMENT IN MILLIONS OF DOLLARS *

	YEAR 1980	YEAR 1990
• BETTER UTILIZATION OF HYDRO-POWER	100	100
• BETTER UTILIZATION OF WATER FOR IRRIGATION	60	80
• REDUCED LOSSES FROM FLOODS	21	22
• INCREASED UTILIZATION FOR RECREATION AND NAVIGATION	0.5	1
TOTAL BENEFITS PROJECTED	181.5	203

*COLUMBIA RIVER BASIN ONLY

LAND USE PLANNING

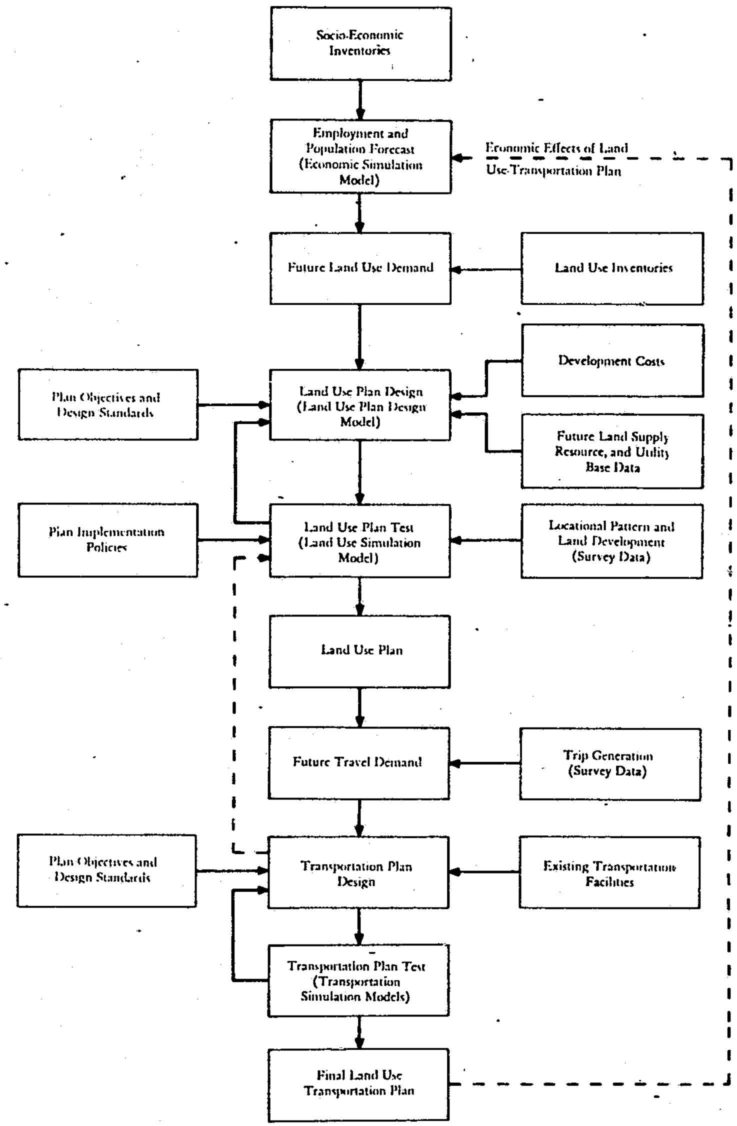
OUTPUTS:	LAND USE/TRANSPORTATION PLAN
SOURCE:	SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
REMOTE SENSING:	DATA ON PRESENT LAND USE, INVENTORY, DEVELOPMENT PATTERNS, TRANSPORTATION

A DESIGN MODEL FOR PLANNING LAND USE

- The purpose of model is to design a systematic plan for land use and transportation system for an urban area.
- Source of model is the Southeastern Wisconsin Regional Planning Commission. Plan has been designed but has not yet made use of remote sensing.
- Model depends on information on present land use and transportation facilities. These potentially can be obtained by remote sensing.
- The model inputs are land use and survey data, transportation data, land development costs and planning policies.
- The model outputs are a designed plan for use of urban areas and a transportation plan and evaluation of transportation plans by simulation.

SPACE DIVISION

LAND USE
TRANSPORTATION STUDY PLANNING SYSTEM DIAGRAM



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SPACE DIVISION

A "WEIGHTED VALUE" MODEL

ERTS SE

OUTPUT:	A MAP SHOWING PREFERRED LAND USE
TYPICAL SOURCE:	NEW YORK DEPARTMENT OF PARKS / STATEN ISLAND
APPROACH:	"PARALLEL PROCESSING" WEIGHTING MATRIX (OVERLAYS)
REMOTE SENSING:	CAN PROVIDE DATA ON GEOLOGY, PHYSIOGRAPHY, HYDROLOGY, ETC.

. A "WEIGHTED VALUE" USER MODEL FOR LAND USE PLANNING

- The problem is to determine how land can be allocated to best meet complex requirements of an urban area. The model is needed to provide a rational approach for applying weighted values in planning land use.

- The area is gridded and values assigned to each grid element for land suitability parameters such as drainage, scenic value, proximity to transportation. Overlays are made to provide a weighting matrix depicting overall land suitability for a specific set of functions.

- The model requires data on land characteristics (e.g., geology, physiography, hydrology, etc.) which potentially can be obtained by remote sensing.

- The model has been used by the New York Park Commission on Staten Island.

- Required inputs are distributed data on geology, land forms, vegetation, present land use, etc.

- Outputs are composite region maps of recommended land use.

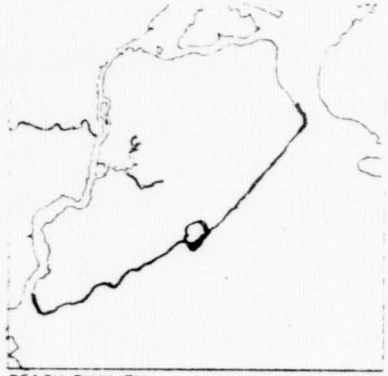
SPACE DIVISION

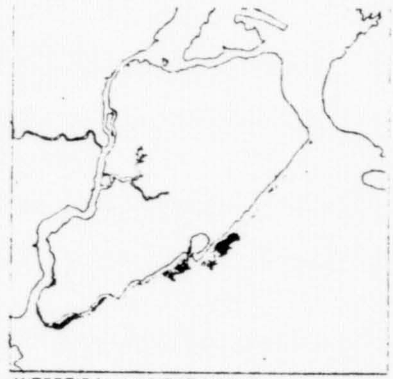
A "WEIGHTED VALUE" MODEL FOR LAND USE PLANNING

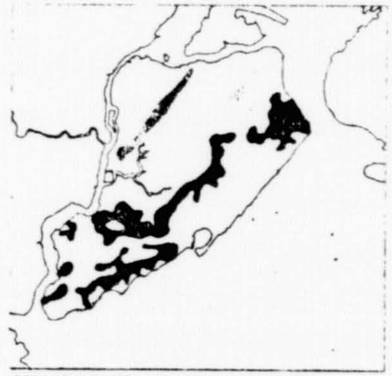
ERTS SE

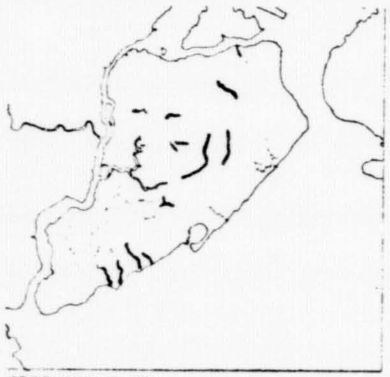
SPACE DIVISION

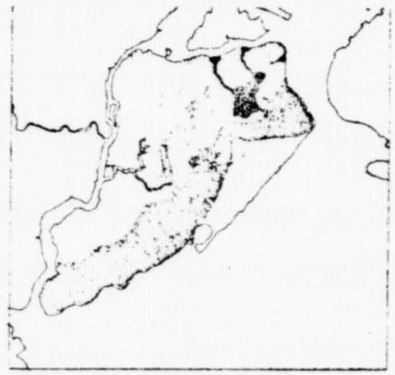
A "WEIGHTED VALUE" MODEL FOR LAND USE PLANNING

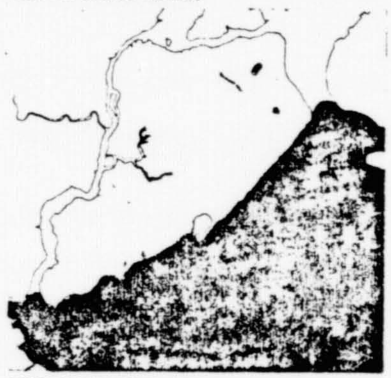

BEACH QUALITY


INTERTIDAL HABITAT VALUE


SCENIC VALUE (LAND)


STREAM QUALITY


GEOLOGIC FEATURES VALUE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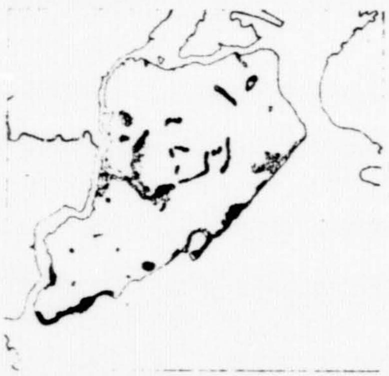
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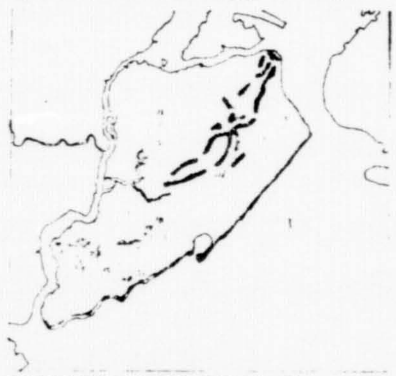
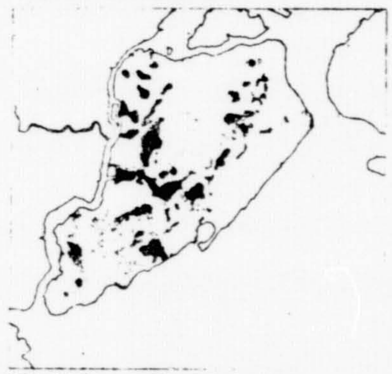

PHYSIOGRAPHIC FEATURES VALUE


ECOLOGICAL ASSOCIATIONS VALUE

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