

N 66 - 17 480

FACILITY FORM 802

(ACCESSION NUMBER)

15

(THRU)

1

(PAGES)

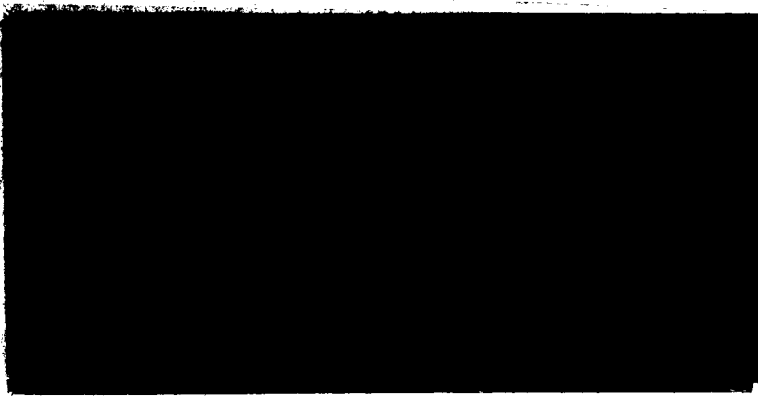
(CODE)

CR 70461

30

(NASA CR OR TMX OR AD NUMBER)

(CATEGORY)



ORBITAL OPERATIONS STUDIES

GPO PRICE \$

CFSTI PRICE(S) \$

Hard copy (HC) 1.00

Microfiche (MF) .50

ff 653 July 65

Natural Resources Research Institute
in association with the
National Aeronautics and Space Administration

College of Engineering
University of Wyoming
Laramie, Wyoming

THE UNIVERSITY OF WYOMING
COLLEGE OF ENGINEERING



NATURAL RESOURCES RESEARCH INSTITUTE

P. O. BOX 3038, UNIVERSITY STATION

LARAMIE, WYOMING 82071

December 28, 1965

ORBITAL OPERATIONS STUDY
Grant No. NsG-658

Third

Semi-Annual Progress Report

May 15, 1965 - Nov. 14, 1965

Office of Grants and Research Contracts
Attention: Code SC
National Aeronautics and Space Administration
Washington, D. C. 20546

Gentlemen:

This third semi-annual progress report describes the work accomplished under Grant No. NsG-658 from May 15, 1965 to November 15, 1965.

Indicative of progress during this period, it is being reported upon in five detailed technical reports, one of them has been accepted for publication in a national journal and one Master's thesis in Physics has resulted from this support. Greater than expected difficulty has been encountered, however, in the construction of experimental recording devices, thereby delaying the work of formulating samples of "real" orbital data in informatic form until after the end of this reporting period.

This grant continues to support a strong multidisciplinary effort of mutual advantage to the University of Wyoming and, we feel sure, the National Aeronautics and Space Administration.

Sincerely,

John C. Bellamy, Director

ORBITAL OPERATIONS STUDY
Grant No. NsG-658

Third Semi-Annual Progress Report
May 15, 1965 - November 14, 1965

1. Purposes

As established in our first "Plan of Study" report, the purposes of this Orbital Operations Study are "To help establish more productively effective ways of controlling orbital operations" and, specifically, to do so with Informatic Data Research:

"To establish the principles and practices of utilizing newly possible informatic ways of representing large sequences of numbers as concise complete 'pictures' or portrayals of information which can be acquired, processed, recorded and reprocessed in numerical detail only with appropriate automatic equipments in appropriately organized large scale operations."

In particular, the following tasks were established at the outset of this study and are discussed in turn in Sections 4-7 of this report.

- A. Formulating Illustrative Samples of Informatic Forms of Orbital Data;
- B. Fabricating Informatic Data Recorders;
- C. Developing Continuous Data Output Buffers; and
- D. Operational Engineering Research.

2. Personnel

The following personnel indicated by * participated in this study primarily during the period of June, July and August; those indicated by ** joined the research team in September; the others were part-time participants throughout this reporting period.

John C. Bellamy, Director, Professor of Civil Engineering

- * R. Kenneth Beach, Professor Electrical Engineering
- * Willis L. Everett, Associate Professor (Research) Resigned August 1965
- * Richard J. Jiacoletti, Assistant Professor Mechanical Engineering
Leave of Absence, August 1965
- C. Norman Rhodine, Associate Professor of Electrical Engineering
- * Donald L. Veal, Assistant Professor of Civil Engineering

- * Dennis J. Knowlton, Instructor (Research)
- * Dennis M. Kiser, Instructor (Research) Resigned August 1965
- * A. L. Riemenschneider, Instructor of Electrical Engineering
- * Carl V. Scott, Instructor of General Engineering

- ** Howard F. Guill, Mechanical Technician
Howard E. Roberts, Mechanical Technician

Graduate Research Assistants

- | | |
|-------------------------------|------------------------------|
| ** Larry N. Bruce (E.E.) | * Roland Lamberson (Physics) |
| * James W. Cady (E.E.) | * Ronald A. Stahla (E.E.) |
| ** Russell B. Chadwick (E.E.) | James W. Stugart (E.E.) |
| * Thomas C. Ensign (Physics) | ** Frank D. Terry (E.E.) |
| David Fjeld (Math) | |

Undergraduate Assistants

- | | |
|-------------------------------|--------------------------|
| ** Joseph P. Alibrandi (E.E.) | ** Robert O. Lamb (C.E.) |
|-------------------------------|--------------------------|

3. Publications

Progress to date toward the purposes of this study has been summarized largely in the following technical progress reports which have been completed by the time of this writing.

1. "Plan of Study," John C. Bellamy, August 1964, Mimeographed NRRI Information Circular No. 27, 30 pp.
2. "Proposed Nautical Units of Length and Time," John C. Bellamy, April 1965, Mimeographed NRRI Information Circular No. 28, 20 pp. Accepted for Publication in "Navigation."
3. "The Character of Gravispheres," Thomas C. Ensign and John C. Bellamy, October 1965. Mimeographed NRRI Information Circular No. 36, 35 pp. To be submitted for publication elsewhere. (Attached to this semi-annual progress report).
4. "1965 Status of TACOS, An Experimental Tabular Computing System," C. N. Rhodine, December 1965. Mimeographed NRRI Information Circular No. 29, 29 pp. To be submitted in part for publication elsewhere. (Attached to this semi-annual progress report).
5. "An Initial Use-Test of Triadic Decimal Digits," Richard J. Jiacoletti, and Donald L. Veal, December 1965. Mimeographed NRRI Information Circular No. 30, 14 pp. (Attached to this semi-annual progress report).
6. "A Triadic Decimal Digit Printer-Reader Unit, Preliminary Design Considerations," C. N. Rhodine, December 1965. Mimeographed NRRI Information Circular No. 31, 11 pp. (Attached to this semi-annual progress report).

In addition, the following two related papers were supported in part by this study and were published during this reporting period.

"'SIPLIC' Forms of Hourly Precipitation Data," Anton C. Munari and John C. Bellamy, August 1965. Mimeographed NRRI Information Circular No. 32, 25 pp. Accepted for publication in The Monthly Weather Review. (Attached to this semi-annual progress report).

"A Study of the Magnetohydrodynamic Behavior of the F Region of the Ionosphere," Roland H. Lamberson, August 1965. Thesis for M.S. degree in Physics, 61 pp.

Now being rewritten by Dr. Willis L. Everett as a report of this Orbital Operations Study and for publication elsewhere.

4. Illustrative Examples of Informatic Forms of Orbital Data

As described in Sections 5 and 6, unexpected difficulties in fabricating the prerequisite recording devices has delayed the planned-for formulation of illustrative examples of orbital data in informatic form. Nevertheless good research progress has been made toward this task with the following four test-trials of potentially useful forms of numerals.

4a, "SIPLIC" Forms of Data.

The development of the "SIPLIC" form of notation is deemed to be a major advance in the general field of informatic data research. Although its initial trial-use has been to portray the space-time distribution of hourly precipitation data, it clearly offers outstanding potentialities for portraying, especially, some of the scientific kinds of orbital data. In addition, participation by some of the Orbital Operations Study personnel in the formulation of this trial sample of data has provided them with valuable insight into the difficulties of using general purpose digital computers and currently available kinds of recorders to produce this kind of data.

4b. Incremental Forms of Orbital Position Data.

The report on the "Initial Use-Test of Triadic Decimal Digits" was based on a postulate that the newly conceived "Triadic Decimal Digits" might well be utilized for periodically labeling incremental forms of orbital position data. Consequently it included an initial use-test of an incremental notation to portray the values of time, longitude, latitude and elevation for a portion of an orbit of a TIROS satellite. The conclusions reached with this initial use-test were, in essence, that (1) the proportions of the incremental +1, 0 and -1 numerals used in this test were inappropriate for this purpose, (2) some other, probably "uadic", notation is needed to label this kind of incremental data and (3) the use of a general purpose digital computer such as the Philco 211 for formulating such data is not nearly as convenient and economical as was initially expected.

4c. Triadic Decimal Digits.

Although that initial use-test of "Triadic Decimal Digits" produced a negative result insofar as they might prove to be useful for periodically labeling incremental tallies, it also produced the positive result that they are readily recognizable after but limited experience with them. Consequently it is expected that they might well prove to be useful for purposes such as informatically labeling whole sheets or blocks of data.

4d. Uadic Numerals.

Although the unexpected difficulty of modifying a multistylus kind of recorder precluded the formulation of trial uadic forms of "real" orbital data during this period, it did prove to be possible to include an initial illustration of some uadic data in the "TACOS" report. The conclusions reached with this initial trial were that (1) the uadic kind of numerals offers very good potentialities for many kinds of orbital data, but that (2) additional work is required to obtain a better balance among their appearance, recordability and automatic readability.

4e. Portrayals of Scientific Orbital Data.

Work also continued during this reporting period toward formulating incremental portrayals of the distribution of infrared radiation as observed with TIROS. This work was held to a low level, however, by the diversion of effort required to overcome the unexpected difficulties encountered in the utilization of our large digital computer for, especially, the trial formulation of orbital position data.

5. Fabricating Informatic Data Recorders

As described in the report on "TACOS", the primary recorder-development effort during this period was expended upon the modification of a commercial multistylus, electrochemical type of recorder. This recorder became available for producing some initial samples of both incremental and uadic kinds of numerals near the end of this reporting period, and is now available for recording some trial samples of "real" orbital data.

Considerable effort was also expended upon modifying electric-typewriters for our experimental work. In particular, an old electric typewriter was equipped with stepping solenoids and worm gears to obtain about 72 paper and/or carriage steps per inch. This work was largely negated by the extreme difficulty of maintaining registry and striking forces of keys with compatibly small characters. An unsuccessful attempt was then made to overcome this difficulty by utilizing the ends of small music wires as an array of "tapper-bars" in fixed lateral positions. Those wires were to be driven against the typewriter ribbon individually by passing current through single drive wires in a strong magnetic field. It has not yet proven to be possible, however, to obtain sufficient striking force in this particular way.

In this respect, the Cook Electric Company of Chicago, Illinois donated some equipment to the University of Wyoming during this reporting period. It contained a fixed position tapper-bar type of recorder which had previously produced some very good quality incremental records. This recorder is now being modified to produce incremental tables for the tabular conversion technique of computation in TACOS, and a similar kind of "tapping" assembly is now being designed for use with appropriate paper carriages. In addition, a promising new kind of recorder for "uadic" numerals is now being developed for use in the University's Elk Mountain Water Resources Observatory which, if successful, will become available for use in this Orbital Operations Study.

6. Developing Continuous Data Output Buffers

The equipment developed under this Task C of the Plan of Study has been dubbed "TACOS" in short for the experimental "TABular COmputing System" with which this informatic data research is being conducted. As described in detail in the progress report on TACOS, its development has progressed very satisfactorily with the exception of its output recording devices. It has especially demonstrated good potentialities of the tabular conversion technique of computation for both (1) producing experimental samples of informatic data and (2) eventual real time use in orbital operations for, especially, rectifying observational data in terms of sensor-calibration data. The experimental use capabilities of TACOS were also greatly enhanced by receiving a different kind of tabular converting mechanism in the aforementioned gift from the Cook Electric Company.

7. Operational Engineering Research

A relatively small amount of effort on this Task D of the Plan of Study has produced one report and one Master's thesis during this period. The report on "The Character of Gravispheres" is meant primarily to help identify and define the characteristic regions of Orbital Operations. The resultant simple definitions of the extent of the "gravispheres" or "body-centered regions of space" associated with the planets and moons seem to provide a very useful perspective of present and future operations in space. The method used to evaluate the combined gravitational fields of such bodies in their transition regions is also expected to lead to some simplified methods of determining and describing orbits.

Mr. Lamberson's Master's thesis is concerned with some of the physical relationships upon which portrayals of the occurrences in the upper ionsphere can be based. The results of this work are apparently novel and offer good promise for continued development. A more complete report on this work is now being written by Dr. Everett, (who transferred to the University of New Mexico in September). This report is to be submitted for publication in some suitable journal and is to be preprinted as one of the mimeographed series of progress reports of this Orbital Operations Study.

8. Plans for the Next Period

8a. Formulating Illustrative Samples of Informatic Forms of Orbital Data.

Plans for the next semi-annual reporting period call for a major effort toward producing some informatic examples of "real" orbital data. Toward this end some sample Arabic digit tabulations of "housekeeping" data were obtained from each of the TIROS, NIMBUS and OSO control centers in the Goddard Space Flight Center. It was found while arranging in mid-November to obtain this data that similar data from OGO is not now available, and that special arrangements will have to be made with individual experimenters to obtain sample scientific data from OGO. Consequently primary attention will be directed during this next reporting period toward portraying the housekeeping kind of data from TIROS, NIMBUS and OSO.

Specifically, it is intended first to equip a manual typewriter with keys for a variety of differently proportioned uadic characters. This typewriter is to be used to transcribe as much of the housekeeping data on hand as proves to be practicable into trial uadic forms, and to photographically reduce the size of the resultant data by several experimental ratios. It does not now seem likely that the results of such initial trials will be obtainable much before the end of this next reporting period.

In addition, it is now planned to continue work on the portrayal of orbital position data and TIROS infrared data. In this case, it is planned to complete the debugging of a computer program to generate punched tape records of continuous orbital position data in a form suitable for input into a newly acquired electric typewriter. This typewriter is yet to be fitted with keys for (1) differently proportioned increments for portraying orbital position data, (2) labeling such positional data with a trial form of uadic numerals, and (3) incremental and scaling numerals appropriate for portraying the two-dimensional distributions of infrared data.

8b. Fabricating Informatic Data Recorders.

The development of mechanical recorders is to be continued during the next reporting period with emphasis on the "tapper-bar" method of obtaining the required small sizes of marks directly. Such mechanical recorders are needed for our experimental work as well as, ultimately, displaying the kinds of data in which successive values of each variable are received at only periodic intervals such as once each orbit.

In addition, a novel method has recently been conceived to record the kinds of data in which many successive values of each of the variables of interest become available at once. It is expected that this method of recording will utilize cathode-ray-tube flying-spot-scanners in a novel, exceptionally flexible and convenient, optical way of producing the desired small-size marks directly, rapidly and accurately. It is planned to start construction of an experimental recorder of this type during the next reporting period. This experimental recorder will require wet-processing of its photographic type of output record; this wet-processing could well be replaced in operational prototypes by dry xerographic processing.

8c. Developing Continuous Data Output Buffers.

As described in the report on "TACOS", it now needs to be provided primarily with automatic data-input and interpolative incrementation capabilities. Most of this work is to be accomplished during the next reporting period, however, with separately supported research on informatic forms of water resource data. It is expected that such parallel work will provide the experimental capability that this Orbital Operations Study will need about one year from now. By that time suitable output recorders should be available for the initiation of research on specific ways of realizing the potentialities of tabular conversion and incremental interpolation in orbital operations.

8d. Operational Engineering Research.

One of the primary results of informatic data research to date is the clear need it has highlighted to improve upon our understanding of what might be called the "Arithmetic of Physical Quantities". It has highlighted especially the need to develop better ways of defining and describing the concepts of things such as "operational units of resolution", "continuous data", "concordant functions", "tallie numerals", "tabular conversion", "incrementation", etc. It is thus planned to hold seminars throughout the next reporting period on this general subject. Initial emphasis is to be placed on ways of describing the concepts and electronic circuitry of the automatic kinds of "incremental arithmetic" which now seem likely to become most advantageous for use in various aspects of orbital operations.