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Department of Geodetic Science
Report No. 241

BASIC RESEARCH AND DATA ANALYSIS FOR THE
NATIONAL GEODETIC SATELLITE PROGRAM

by

Ivan I. Mueller

Final Report
Research Grant No. NGL 36-008-093
OSURF Project No. 2514

Prepared for
National Aeronautics and Space Administration,
Washington, D.C. 20546

The Ohio State University
Research Foundation
Columbus, Ohio 43212

July, 1976

This report is related to the work performed by the staff of the Department of geodetic science, The Ohio State University sponsored by NASA under the National Geodetic Satellite Program between August 1, 1967 - June 30, 1976. Grateful acknowledgement is given for the generous support given during the past nine years which not only made The Ohio State University's participation in this program possible but also provided over forty undergraduate and graduate students with assistantships of various lengths and types during their studies. On NASA's behalf the project was monitored by Jerome D. Rosenberg (currently Director, Technology Applications, Office of Applications, NASA Headquarters) through 1972, whose support and encouragement were felt and appreciated throughout. Due to a reorganization within NASA, his work was taken over with enthusiasm by James P. Murphy, Special Programs, Office of Applications, NASA Headquarters.

Project staff with significant contributions are listed in the table on the next page. The proportion of their individual contributions is reflected in a general way by the length of stay and/or by the issue numbers in the Report Series of the Department of Geodetic Science to which the individual contributed most. In a university environment where there are important interactions between the students themselves and the instructional staff, it is generally difficult to separate out individual contributions from the team work. Thus the Report Nos. listed reflect, in most cases, responsibilities in a given area rather than "individual" contributions. Exceptions to this are theoretical studies contained in Report Nos. 114, 147, 150, 177, 185, and 216 where very little input came from persons other than the authors.

Those students receiving financial assistance other than direct fellowships (travel, etc.) have asterisks next to their names. In addition to those listed in the table, fifteen students also carried short-term appointments for various generally nonprofessional responsibilities.

	1967		1968		1969		1970		1971		1972		1973		1974		1975		1976		Contribution in the Reports of the Department of Geodetic Science			Degrees Earned										
	II		I II		I II		I II		I II		I II		I II		I II		I II		I II					BS	MS	PhD								
<u>Student Assistants or Associates</u>																																		
Krakiwsky, E. J.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	86, 87, 88, 114			X	X	X								
Blaha, G.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	87, 140, 148, 150													
Reilly, J. P.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	88, 125, 140, 187, 190, 193, 199					X	X	X						
Schwarz, C. R.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	118, 125, 140, 147, 190					X	X	X						
Hornbarger, D. H. *	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	106					X	X	X						
Veach, J. P. *	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	110					X	X	X						
Gross, J. *	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100					X	X	X						
Arur, M. G.					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	139, 232					X	X	X						
Whiting, M.								X	X	X	X	X	X	X	X	X	X	X	X	X	188, 190, 199							X	X	X				
Kumar, M.								X	X	X	X	X	X	X	X	X	X	X	X	X	184, 193, 195, 196, 199, 228									X	X	X		
Soler, T.									X	X	X	X	X	X	X	X	X	X	X	X	187, 195, 199											X	X	X
Tsimis, E.									X	X	X	X	X	X	X	X	X	X	X	X	185, 191											X	X	X
Joshi, C. S. *											X	X	X	X	X	X	X	X	X	X	192											X	X	X
McLuskey, D.														X	X	X	X	X	X	X												X	X	X
Dermanis, A.																X	X	X	X	X												X	X	X
Leick, A.																	X	X	X	X												X	X	X
van Gelder, B. H. W.																	X	X	X	X												X	X	X
Gildengorin, M.																	X	X	X	X												X	X	X
<u>Administrative Assistants</u>																																		
Miller, J. R.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X														
Preston, J. C.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X														
Tesfai, I.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X														
Rist, E.								X	X	X	X	X	X	X	X	X	X	X	X	X														
Mason, A.																	X	X	X	X												X	X	X
<u>Research Associate</u>																																		
Saxena, N. K.					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	177, 193, 199, 216													

Graduate students on regular fellowships also received full tuition waivers from the University which is acknowledged here. Other University contributions came from the Computer Center, which provided a significant amount of free computer time and from the Department in the form of 6.1% cost sharing of the total research budget.

The achievements of this project are reported in the Reports of the Department of Geodetic Science listed on the following pages and in the 18 Semiannual Status Reports submitted to NASA Headquarters. Scientific papers presented at various national and international meetings sponsored under this grant are also listed.

Last but not least, grateful acknowledgement is given to Defense Mapping Agency (Aerospace and Topographic Centers), NASA (Goddard Space Flight Center and Wallops Island), National Geodetic Survey/NOS/NOAA, Smithsonian Astrophysical Observatory for supplying the observational and survey data, the basic ingredients of the work, and other information, always without reservations and delay. In this connection, the Computer Sciences Corporation and the National Space Science Data Center also played important roles.

Efforts under this grant were started on April 1, 1966 under NASA Grant NSR 36-008-003 and continue under NASA Grant NGR 36-008-204.

Submitted by:



Professor Ivan I. Mueller
Research Supervisor

July 1, 1976

List of Reports

OSU Department of Geodetic Science Reports published under
Grant No. NGR 36-008-093:

- | | | | |
|-----|---|----------------|-----------|
| 100 | Preprocessing Electronic Satellite Observations
by Joseph Gross
March, 1968 | NASA CR-1183 | N69-13470 |
| 106 | Comparison of Astrometric and Photogrammetric Plate Reduction Techniques
for a Wild BC-4 Camera
by Daniel H. Hornbarger
March, 1968 | | N68-28630 |
| 110 | Investigations into the Utilization of Passive Satellite Observational Data
by James P. Veach
June, 1968 | | N68-35610 |
| 114 | Sequential Least Squares Adjustment of Satellite Triangulation and
Trilateration in Combination with Terrestrial Data
by Edward J. Krakiwsky
October, 1968 | | N69-17336 |
| 118 | The Use of Short Arc Orbital Constraints in the Adjustment of Geodetic
Satellite Data
by Charles R. Schwarz
December, 1968 | | N69-26456 |
| 125 | The North American Datum in View of GEOS I Observations
by Ivan I. Mueller, James P. Reilly, Charles R. Schwarz
June, 1969 | | N70-12525 |
| 139 | Analysis of Latitude Observations for Crustal Movements
by M. G. Arur
June, 1970 | NASA CR-111567 | N71-13086 |
| 140 | SECOR Observations in the Pacific
by Ivan I. Mueller, James P. Reilly, Charles R. Schwarz, George Blaha
August, 1970 | | N71-19546 |
| 147 | Gravity Field Refinement by Satellite to Satellite Doppler Tracking
by Charles R. Schwarz
December, 1970 | | N71-21019 |
| 148 | Inner Adjustment Constraints with Emphasis on Range Observations
by Georges Blaha
January, 1971 | | |

- 150 Investigations of Critical Configurations for Fundamental Range Networks
by Georges Blaha
March, 1971 NASA CR-121445 N71-33310
- 177 Improvements of a Geodetic Triangulation through Control-Points
Established by Means of Satellite or Precision Traversing
by Narendra K. Saxena
June, 1972 NASA CR-128402 N73-10377
- 184 Coordinate Transformation by Minimizing Correlations Between Parameters
by Muneendra Kumar
July, 1972 N73-26621
- 185 On the Geometric Analysis and Adjustment of Optical Satellite Observations
by Emmanuel Tsimis
August, 1972 NASA CR-129516 N73-12891
- 187 Geodetic Satellite Observations in North America (Solution NA-9)
by Ivan I. Mueller, J. P. Reilly and Tomas Soler
September, 1972 NASA CR-131869 N73-23874
- 188 Free Adjustment of a Geometric Global Satellite Network (Solution
MPS-7)
by Ivan I. Mueller and M. C. Whiting
October, 1972 NASA CR-131535 N73-21823
- 190 The Ohio State University Geometric and Orbital (Adjustment) Program
(OSUGOP) for Satellite Observations
by James P. Reilly, Charles R. Schwarz and M. C. Whiting
December, 1972 NASA CR-131532 N73-21728
- 191 Critical Configurations (Determinantal Loci) for Range and Range-
Difference Satellite Networks
by E. Tsimis
January, 1973 NASA CR-136943 N74-17534
- 193 Free Geometric Adjustment of the DOC/DOD Cooperative Worldwide
Geodetic Satellite (BC-4) Network
by Ivan I. Mueller, M. Kumar, J. Reilly and N. Saxena
February, 1973 NASA CR-138598 N74-26773
- 195 Free Geometric Adjustment of the Secor Equatorial Network
(Solution SECOR-27)
by Ivan I. Mueller, M. Kumar and Tomas Soler
February, 1973 NASA CR-138597 N74-26771

- 196 Geometric Adjustment of the South American Satellite Densification
(PC-1000) Network
by Ivan I. Mueller and M. Kumar
February, 1973 NASA CR-138627 N74-26769
- 199 Global Satellite Triangulation and Trilateration for the National Geodetic
Satellite Program (Solutions WN 12, 14 and 16)
by Ivan I. Mueller and M. Kumar, J. P. Reilly, N. Saxena, T. Soler
May, 1973 NASA CR-138252 N74-22963
- 216 Marine Geodesy, A Multipurpose Approach to Solve Oceanic Problems
by Narendra K. Saxena
October, 1974 NASA CR-141011 N75-13495
- 228 The OSU 275 System of Satellite Tracking Station Coordinates
by Ivan I. Mueller and Muneendra Kumar
August, 1975 NASA CR-119099 N75-33156
- 232 Satellite Triangulation in Europe from WEST and ISAGEX Data
by Alfred Leick and Manohar G. Arur
November, 1975

The following papers were presented at various professional meetings:

"Report on OSU participation in the NGSP"

47th Annual meeting of the AGU, Washington, D. C. , April 1966

"Preprocessing Optical Satellite Observational Data"

3rd Meeting of the Western European Satellite Subcommission, IAG, Venice, Italy, May 1967.

"Global Satellite Triangulation and Trilateration"

XIVth General Assembly of the IUGG, Lucerne, Switzerland, September 1967, (Bulletin Geodesique, March 1968).

"Investigations in Connection with the Geometric Analysis of Geodetic Satellite Data"

GEOS Program Review Meeting, Washington, D. C. , Dec. 1967.

"Comparison of Photogrammetric and Astrometric Data Reduction Results for the Wild BC-4 Camera"

Conference on Photographic Astrometric Technique, Tampa, Fla. , March 1968.

"Geodetic Utilization of Satellite Photography"

7th National Fall Meeting, AGU, San Francisco, Cal. , Dec. 1968.

"Analyzing Passive-Satellite Photography for Geodetic Applications"

4th Meeting of the Western European Satellite Subcommission, IAG, Paris, Feb. 1969.

"Sequential Least Squares Adjustment of Satellite Trilateration"

50th Annual Meeting of the AGU, Washington, D. C. , April 1969.

"The North American Datum in View of GEOS-I Observations"

8th National Fall Meeting of the AGU, San Francisco, Cal. , Dec. 1969 and GEOS-2 Review Meeting, Greenbelt, Md. , June 1970 (Bulletin Geodesique, June 1970).

"Experiments with SECOR Observations on GEOS-I"

GEOS-2 Review Meeting, Greenbelt, Md. , June 1970.

"Experiments with Wild BC-4 Photographic Plates"

GEOS-2 Review Meeting, Greenbelt, Md. , June 1970.

"Experiments with the Use of Orbital Constraints in the Case of Satellite Trails on Wild BC-4 Photographic Plates"

GEOS-2 Review Meeting, Greenbelt, Md. , June 1970.

"GEOS-I SECOR Observations in the Pacific (Solution SP-7)"

National Fall Meeting of the American Geophysical Union, San Francisco, California, December 7-10, 1970.

"Investigations of Critical Configurations for Fundamental Range Networks"
Symposium on the Use of Artificial Satellites for Geodesy, Washington, D. C., April 15-17, 1971.

"Gravity Field Refinement by Satellite to Satellite Doppler Tracking"
Symposium on the Use of Artificial Satellites for Geodesy, Washington, D. C., April 15-17, 1971.

"GEOS-I SECOR Observations in the Pacific (Solution SP-7)"
Symposium on the Use of Artificial Satellites for Geodesy, Washington, D. C., April 15-17, 1971.

"Separating the Secular Motion of the Pole from Continental Drift - Where and What to Observe?"

IAU Symposium No. 48, "Rotation of the Earth," Morioka, Japan, May 9-15, 1971.

"Geodetic Satellite Observations in North America (Solution NA-8)"

Annual Fall Meeting of the American Geophysical Union, San Francisco, California, December 6-9, 1971.

"Scaling the SAO-69 Geometric Solution with C-Band Radar Data (Solution SC 11)"
Annual Fall Meeting of the American Geophysical Union, San Francisco, California, December 6-9, 1971.

"The Impact of Computers on Surveying and Mapping"

Annual Meeting of the Permanent Committee, International Federation of Surveyors, Tel Aviv, Israel, May 1972.

"Investigations on a Possible Improvement of Terrestrial Triangulation by Means of Super-Control Points"

IAG International Symposium - Satellite and Terrestrial Triangulation, Graz, Austria, June, 1972.

"Free Adjustment of a Geometric Global Satellite Network (Solution MPS7)"

IAG International Symposium - Satellite and Terrestrial Triangulation, Graz, Austria, June, 1972.

"Conjugate Gradient Method (Cg-Method) for Geodetic Adjustments"

Annual Fall Meeting of the American Geophysical Union, San Francisco, California, December 3-6, 1972.

"Preliminary Results of the Global Satellite Triangulation Related to the NGSP"
Journées Luxembourgeoises de Géodynamique, Luxembourg, February 19-21, 1973.

"Present Status of Global Geometric Satellite Triangulation and Trilateration"
54th Annual Spring Meeting of the American Geophysical Union, Washington, D.C.,
April 16-20, 1973.

"Free Geometric Adjustment of the OSU/NGSP Global Network (Solution WN4)"
First International Symposium on the Use of Artificial Satellites for Geodesy
and Geodynamics, Athens, Greece, May 14-21, 1973.

"Earth Parameters from Global Satellite Triangulation and Trilateration"
International Symposium on Earth's Gravitational Field and Secular Variations
in Position, Sydney, Australia, November 26-30, 1973.

"Review of Problems Associated with Geodetic Datums"
International Symposium on Problems related to the Redefinition of North
American Geodetic Networks, Fredericton, N.B., Canada, May 20-25, 1974.

"Marine Geodesy - Problem Areas and Solution Concepts"
International Symposium on Application of Marine Geodesy, Battelle Auditorium,
Columbus, Ohio, June 3-5, 1974.

"Station Coordinates and Geodetic Datum Positions from the National Geodetic
Satellite Program"
First Pan American Congress and the
Third National Congress of Photogrammetry, Photointerpretation and Geodesy,
Mexico City, Mexico, July 7-12, 1974.

"Review of Classical Methods for the Determination of Geodetic Datums"
International Colloquium on Reference Coordinate Systems for Earth Dynamics
(IAU Colloquium No. 26)
Torun, Poland, August 26-31, 1974.

"Global Satellite Triangulation and Trilateration Results"
Intercosmos Symposium on Results of Satellite Observations
Budapest, Hungary, October 21-24, 1974.

"Crustal Motion Monitoring with the Proposed Close Grid Geodynamics Satellite
Measurement System"
IUGG XVI General Assembly
Grenoble, France, August 16-31, 1975.

"Western European Satellite Triangulation (WEST) Station Coordinates in the OSU WN14 System"

IUGG XVI General Assembly

Grenoble, France, August 16-31, 1975.

"Aspects of Positioning Using Satellite Borne Laser or RF Systems"

Symposium on New Methods of Space Geodesy

Leningrad, USSR, November 24-30, 1975.

"Applications of Laser Satellite Ranging for Geodesy"

Plate Tectonics - LAGEOS Conference

Santa Maria, California, May 3-4, 1976