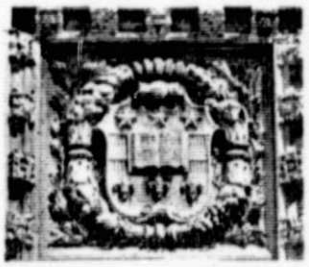

WASHINGTON UNIVERSITY

APPLICATION OF COMMUNICATIONS SATELLITES TO EDUCATIONAL DEVELOPMENT

FINAL TECHNICAL REPORT
SEPTEMBER 1, 1969 - AUGUST 31, 1975

NASA GRANT NO. NGR-26-008-054

Robert P. Morgan, Principal Investigator

Center for Development Technology
Washington University
St. Louis, Missouri 63130

APPLICATION OF COMMUNICATIONS SATELLITES TO EDUCATIONAL DEVELOPMENT

Final Technical Report
September 1, 1969 - August 31, 1975

NASA Grant No. NGR-26-008-054*

Robert P. Morgan, Principal Investigator

This brief final technical report represents a summary of research undertaken by the Center for Development Technology, Washington University on applications of communications satellites to educational development. The broad objectives of this NASA-supported interdisciplinary research effort, as stated in the original proposal to NASA, were 1) to assess the role of satellite communications as a means of improving education in the United States, as well as in less-developed areas of the world; 2) to generate basic knowledge which will aid in making rational decisions about satellite application in the field of education in the years ahead; 3) to devise systems and strategies for improving education; and 4) to educate individuals who will be knowledgeable about aspects of satellite communications policy which transcend any single discipline. The duration of the grant, which included a final, eight-month no-cost extension was from September 1, 1969 through August 31, 1975. Total funding over this six year period was $645,000.

---

*The current NASA Technical Officer for the Grant is Wasyl Lew, User Support Officer (Code ECS), Applications Technology Satellites, Communication Programs, Office of Applications, National Aeronautics and Space Administration, Washington, D. C. 20546.

At the time this research effort was initiated, there was very little research in this field underway, either at universities or elsewhere. What has emerged is a series of documents which taken as a whole, provides a comprehensive base for considering future educational satellite utilization, with almost total focus on use within the United States. All the documents which were supported at least in part on this grant are listed in the bibliography in this report.

Rather than attempt a comprehensive summary of all research undertaken in the program, this final report will be built around the Bibliography which is divided into four sections. Section A, entitled Of General Interest, contains listings of periodic progress reports (Items A1 - A7), and articles which provide an overview of the program and educational satellite utilization in general (Items A8 - A20). It also contains a listing of published articles which pertain primarily to educational as opposed to technical aspects of satellite utilization. Item A3, which is available from ERIC and NTIS, provides a comprehensive overview of the first two years of the program. Items A11 and A12 perform a similar function as of early, 1972. Item A20 represents an initial attempt at identifying impacts of large-scale educational telecommunications systems, a subject in which additional work is desirable in the future.

Section B lists the theses which were carried out. Of these, two (B4 and B18) were PhD dissertations and the rest master's theses. Three of the latter (B8, B11 and B12) received no support from the NASA grant but are closely related to the field in question. Theses supported were in the fields of electrical engineering, computer science, economics, and technology and human affairs. Eight theses (B2, B3, B5, B7, B9, B13, B15, B16) were primarily technical in nature, focusing on such subjects

as microwave receiver design (B3, B5, B9) and communication satellite system analysis and optimization (B7, B15). Several others focused upon potential educational satellite system users (B6, B10, B14, B17).

Section C lists in order of their issuance, the CDT memoranda released in connection with the grant program. The memoranda proved to be a useful, rapid way to disseminate results. Memoranda topics can be roughly divided into three categories which were used as a means of organizing the project: 1) Needs Analysis (Items C1, C3, C4, C7, C8, C12, C13, C15, C18, C19, C21, C22, C23, C26); 2) Communications Technology Studies, (Items C9, C10, C11, C14, C16, C25); 3) Systems Synthesis (Items C2, C5, C6, C17, C20, C24, C27). Memorandum C26, "Large-Scale Educational Telecommunications Systems for the U.S.: An Analysis of Educational Needs and Technological Opportunities" represents a major program output. Memorandum C27, "Market Scenarios and Alternative Administrative Frameworks for U.S. Educational Satellite Systems" represents a pulling together of work in the systems synthesis area. Item C15 has been brought together in one volume entitled "Communications Technology for Education and Health Care Delivery in Appalachia." This work, although not supported by NASA, is listed because we believe that it was useful to the Appalachian Regional Commission in their participation in the ATS-6 satellite experiment and because it built upon expertise developed in the course of the NASA-sponsored research effort.

A final section, Section D, lists articles of primarily a technical nature which were published in connection with the NASA sponsored effort.

As with all research efforts, there is usually much that remains undone and new research opportunities to pursue in the future. This program is no exception. It was our original intention to synthesize

technical, economic and organizational factors to develop a set of educational satellite system alternatives. This effort, although partially attempted in several reports, (see in particular C27) was not completed. Many of the elements to perform such an analysis exist (see reports B7, B15, C2, C27). It seems likely that a related effort will be carried out by the Public Service Satellite Consortium with support from HEW. It was also hoped initially that some portion of our research could be devoted to educational satellite utilization vis-a-vis less developed countries. However, this was not possible because of the primary focus of the sponsoring agency on U.S. applications. We have just begun to scratch the surface in identifying and analyzing both short and long-term impacts of educational satellite applications (see A20). More direct interaction with potential "users" could have been undertaken.

Nevertheless, all things considered, the program output as reflected in the bibliography would seem to justify the support and confidence placed in the program by the sponsoring agency over the past six years. The general program objectives have been reasonably well met. The Needs Analysis document (C26) represents a comprehensive planning tool for large-scale educational telecommunications utilization with application to many technologies and users. Early program work stressed the importance of considering all possible media (e.g. CA_1) and not just television in planning for educational satellite utilization. An educational satellite conference held in 1970 was helpful in defining and pushing forward with the ATS-6 satellite experiment. A study for the Appalachian Regional Commission (C15) helped ARC define their portion of that experiment. Project output ranged from a Delphi forecast for technology in education (B6) to hardware for a 12 GHz microwave

receiver (B9); from studies of educational production functions (C13) to cost analyses of various educational telecommunications networks (C5, C6, B15, B16); from studies of educational needs of various groups (B14, B17, C18, C19, C21) to computer models for satellite system analysis and optimization (B7, B13). Although various studies were undertaken to provide inputs to the needs analysis and systems synthesis efforts, the studies as written stand on their own. Breadth of coverage of topics is believed to be essential in considering socio-technological systems such as educational satellite networks.

Finally, I would like to personally acknowledge the efforts of those who contributed to the program effort: the faculty, students and staff of Washington University and particularly to Jai P. Singh, who served as co-principal investigator of the program from January, 1973 - November 1973, when he returned to India to work for the Indian Space Research Organization; and the several NASA officials who either monitored or otherwise interacted with this effort in various constructive ways. In general, we had much freedom to make our own mistakes and to learn from them. I hope that at a time when short-term contract research appears to be becoming the prevailing mode of doing business, future university-based research efforts will continue to enjoy the kind of freedom that we have had.

FINAL CUMULATIVE BIBLIOGRAPHY

APPLICATION OF COMMUNICATIONS SATELLITES TO EDUCATIONAL DEVELOPMENT*

A. Of General Interest

1. "Progress Report: Washington University Program on Application of Satellite Communication to Educational Development," Submitted to Office of University Affairs, NASA, January 20, 1970 (Out of Print).

2. "Progress Report: Washington University Program on Application of Communications Satellites to Educational Development," Submitted to Office of University Affairs, NASA, November, 1970 (Out of Print).

3. "Progress Report: Washington University Program on Application of Communications Satellites to Educational Development," Submitted to Office of University Affairs, NASA, November, 1971. (ERIC No. ED 062 777)** [NASA-CR-124724]**

4. "Semi-Annual Progress Report: Application of Communications Satellites to Educational Development," July - December, 1973.

5. "Semi-Annual Progress Report: Application of Communications Satellites to Educational Development," January - June, 1974.

6. "Semi-Annual Progress Report: Application of Communications Satellites to Educational Development," July - December, 1974.

7. "Semi-Annual Progress Report: Application of Communications Satellites to Educational Development," January - June, 1975.

8. Morgan, R. P., Singh, J. P., Ohlman, H. M., and J. R. DuMolin, "Application of Communications Satellites to Educational Development: An Overview of the Washington University Program," in Proceedings of Colloque International - Les Satellites d'Education, Centre National D'Etudes Spatiales, Nice (France), 1971, 32 pp. (ERIC No. ED 052 638) [NASA-CR-119680]

9. Morgan, R. P. and F. J. Rosenbaum, "Satellites, Media and Education: An Interdisciplinary Program Relating Technology to Societal Needs," Proceedings of the IEEE, Special Issue on Engineering Education, Vol. 59, No. 6, pp. 1001-1003, June, 1971.

9a. Morgan, R. P. and J. B. Margolin, "Systems for Emerging Nations: An Overview," in Communications Satellites for the 70's: Systems, Vol. 26, Progress in Astronautics & Aeronautics Series, pp. 89-99, MIT Press, 1971.

---

*Unless otherwise indicated, all documents were supported at least in part by NASA Grant NO. NGR-26-008-054. Related documents completed during the grant period and supported by other sources are also included and identified by appropriate footnotes.

**Reports for which ERIC ED numbers are given are available through the ERIC Document Reproduction Service, Computer Microfilm International, Corp., P. O. Box 190, Arlington, VA 22210; Phone: (703) 841-1212. Reports bearing the NASA-CR designation are available from National Technical Information Service, Springfield, VA 22151.

10. Morgan, R. P. and J. P. Singh, "A Guide to the Literature on Application of Communications Satellites to Educational Development," Series One Paper, The ERIC Clearinghouse on Educational Media and Technology, Stanford, CA, April, 1972. (ERIC No. ED 060 661) [NASA-CR-125933]

11. Morgan, R. P., Singh, J. P., Anderson, B. and E. Greenberg, "Satellites for U.S. Education: Needs, Opportunities and Systems," AIAA Paper No. 72-523, 4th AIAA Communications Satellites System Conference, Washington, DC, April 24-26, 1972. Revised version published in Communications Satellite Systems (P. L. Bargellini, Ed.), AIAA Progress in Astronautics and Aeronautics Series, Vol. 32, pp. 441-480, MIT Press, 1974.

12. Singh, J. P., Morgan, R. P., and F. J. Rosenbaum, "Satellite Networks for Education," Proceedings of International Telemetering Conference, Los Angeles, CA, October 10-12, 1972, pp. 419-439. (ERIC No. ED 070 273) [NASA-CR-129257]

13. Morgan, R. P. and J. P. Singh, "Satellite Utilization for Educational Communications in the United States," AAS Paper No. 73-150, 19th Annual Meeting, American Astronautical Society, Dallas, Texas, June 19-21, 1973. In The Second Fifteen Years in Space, Vol. 31, Science and Technology, 1973, AAS, Tarzana, CA.

14. Morgan, R. P. and J. P. Singh, and B. E. Robinson, "Technology in the Future of Education," A paper prepared for the Symposium on Improving Productivity of School Systems Through Educational Technology, Research for Better Schools, Inc., Philadelphia, PA, August 20-22, 1973, pp. 293-319.

15. Morgan, R. P. and J. P. Singh, "Communication Satellites in Education," in Handbook on Contemporary Education, A Xerox Corporation Publication, R. R. Bowker Company (forthcoming).

*16. Singh, J. P. and D. T. Jamison (Educational Testing Service), "The Satellite Instructional Television Experiment in India: A Case History," A Report prepared for the Academy for Educational Development, Inc., Washington, DC, July, 1973.

17. Morgan, R. P., "Communications Technology in the Future of Higher Education in the United States," Proceedings of International Symposium on Communications Media in the Future of Higher Education, Deutsche Verlags-Anstalt GmbH, Stuttgart, Germany, pp. 60-67, 1974. (In German) Also available in English from ERIC, as No. ED 089 664).

18. Robinson, B. E. and R. P. Morgan, "A Delphi Forecast of Technology in Education with Implications for Educational Satellite Development," Paper prepared for Seminar on Educational Uses of Communication Satellites at the 4th Annual National Educational Technology Conference, San Francisco, CA, March 14, 1974. To be published in The Educational-Training Uses of Broadcast Satellites: Status, Applications, Costs and Issues (A Book of Readings edited by K. A. Polcyn), Educational Technology Publications, (forthcoming).

---

*Supported by Academy for Educational Development.

19. Morgan, R. P. and J. P. Singh, "Communications Satellites in Education," Educational Media Yearbook 1975, R. R. Bowker Company (forthcoming).

20. Morgan, R. P., "A Preliminary Assessment of Potential Impacts of Educational Telecommunications Systems," Journal of Educational Technology Systems (forthcoming).

*21. Rothenberg, D. and R. P. Morgan, "Case Studies of Innovation in the Educational Service Sector," (168 pp.), July, 1974 (with contribution by Lane Gustafson).

B. Thesis Reports

1. Ohlman, H. M., "Communications Media and Educational Technology: An Overview and Assessment with Reference to Communications Satellites," M.S. Thesis, Department of Applied Mathematics and Computer Science, Washington University, Report No. (R)T-71/1, (232 pp.), May, 1971. (ERIC No. ED 053 540 - microfiche only) [NASA-CR-122037]

2. Sharma, G., "Still-Picture (SPTV) Transmission," M.S. Thesis, Department of Electrical Engineering, Washington University, Report No. (R)T-71/2, (83 pp.), May 1971. [NASA-CR-122042]

3. Sene, A. and F. J. Rosenbaum, "Wideband CW Microwave Amplification Using Gunn Effect Devices," Based upon M.S Thesis by A. Sene, Department of Electrical Engineering, Washington University, Report No. (R)T-71/3, (94 pp.), May, 1971. [NASA-CR-122947]

4. Dhawan, B. D., "Economics of Satellite Television for India," Ph.D. Dissertation, Department of Economics, Washington University, Report No. (R)T-72/1, (183 pp.), May, 1972.

5. Newman, B. A. and F. J. Rosenbaum, "A Wideband 12 GHz Down-Converter," Based upon M.S. Thesis by B. Newman, Department of Electrical Engineering, Washington University, Report No. (R)T-72/2, (136 pp.), September, 1972. [NASA-CR-128394]

6. Robinson, B., "A Delphi Forecast of Technology in Education," M.A. Thesis, Program in Technology and Human Affairs, Washington University, Report No. (R)T-73/1, (129 pp.), August, 1973. (ERIC No. ED 082 497) [NASA-CR-135477]

7. Stagl, T., Morgan, N. H., Morley, R. E., and J. P. Singh, "Computer-Aided Communication Satellite System Analysis and Optimization," Based upon M.S. Thesis by T. Stagl, Department of Electrical Engineering, Washington University, Report No. (R)T-73/2, (155 pp.), October, 1973. (ERIC No. ED 086 226) [NASA-CR-136201]

**8. Goldstein, N. W., "Alternative Television: Status, Trends and Issues," M.A. Thesis, Program in Technology and Human Affairs, Washington University, Report No. (R)T-74/1 (134 pp.), May, 1974. (ERIC No. ED 092 113)

---

*Supported by National Institute of Education.

**Supported by Center for Development Technology, Washington University.

9. Risch, C. O., Rosenbaum, F. J., and R. O. Gregory, "Design of a 12 Channel FM Microwave Receiver," Based upon M.S. Thesis by C. Risch, Department of Electrical Engineering, Washington University, Report No. R(T)-74/2, (155 pp.), July, 1974. (ERIC No. ED 094 761) [NASA-CR-140056]

10. Wong, M. D., "The Role of Technology in Non-Traditional Higher Education," M.S. Thesis, Program in Technology and Human Affairs, Washington University, Report No. R(T)-74/3, (307 pp.), August, 1974. (ERIC No. ED 094 760) [NASA-CR-140016/NTIS Accession No. PB 241320]

*11. Reich, J. J., "Telemedicine: The Assessment of an Evolving Health Care Technology," M.S. Thesis, Program in Technology and Human Affairs, Washington University, Report No. R(T)-74/4, (245 pp.), August, 1974. (ERIC No. ED 095 883)

*12. Johnson, R. C., "Telecommunications Technology and the Socialization of Black Americans: Issues, Concerns and Possibilities," M.A. Thesis, Program in Technology and Human Affairs, Report No. THA 74/7 by THA Program and Black Studies Program, Washington University, (350 pp.), September, 1974. (ERIC No. ED 096 988)

13. McCuller, J. B., "A Computer Program for Small-Terminal Fixed/Broadcast Satellite System Parameter Optimization," M.S. Thesis, Department of Electrical Engineering, Washington University, (314 pp.), May, 1974.

14. Perrine, J. R., "Telecommunications Technology and Rural Education in the United States," M.A. Thesis, Program in Technology and Human Affairs, Report No. R(T)-75/1, (283 pp.), March, 1975. (Available from ERIC in near future) [NASA-CR-142694]

15. Morley, R., and L. F. Eastwood, Jr., "Alternative Network Designs for an Operational PLATO IV CAI System," M.S. Thesis by R. Morley, Dept. of Electrical Engineering, Washington University, Report No. R(T)-75/3, (125 pp.), August, 1975.

16. Ballard, R., "Planning Communications Networks to Deliver Educational Services," M.S. Thesis, Department of Electrical Engineering, (316 pp.), May, 1975.

17. Molden, V., "Telecommunications and Black Americans: A Survey of Ownership, Participation and Control," M.A. Thesis, Program in Technology and Human Affairs, Report No. R(T)-75/2, (736 pp.), August, 1975.

**18. Li, V., "Fiber Optics Communication Technology: Components, System and Error Probability," M.S. Thesis, Department of Electrical Engineering, Washington University, May 1975.

---

*Supported by Program in Technology and Human Affairs, Washington University.

**Supported by National Science Foundation.

19. McClung, R., "Identification of an Educational Production Function for Diverse Technologies in Higher Education," Ph.D. Dissertation, Department of Economics, Washington University, (forthcoming).

C. Memoranda

1. Singh, J. P. and R. P. Morgan, "Computer-Based Instruction: A Background Paper on Its Status, Cost/Effectiveness and Telecommunications Requirements," Memorandum IM-71/1, (36 pp.), April 10, 1971. (ERIC No. ED 055 429) [NASA-CR-122945]

2. DuMolin, J. R. and R. P. Morgan, "An Instructional Satellite System for the United States: Preliminary Considerations," Memorandum IM-71/2, (36 pp.), July, 1971. (ERIC No. ED 055 428) [NASA-CR-122946]

3. Singh, J. P. and R. P. Morgan, "Educational Electronic Information Dissemination and Broadcast Services: History, Current Infrastructure and Public Broadcasting Requirements," Memorandum IM-71/3, (90 pp.), August, 1971. (ERIC No. ED 055 419) [NASA-CR-121910]

4. Denzau, A., "Public Educational Finances: 1949-1985," Memorandum 71/4, (45 pp.), November, 1971. (ERIC No. ED 057 573)

5. Barnett, H. J. and A. T. Denzau, "Future Development of Instructional Television," Memorandum 71/5, (43 pp.), November, 1971, (with assistance from J. R. DuMolin and J. P. Singh). (ERIC No. 057 574) [NASA-CR-124700]

6. Denzau, A. T. and H. J. Barnett, "Appendix to 'Future Development of Instructional Television'," Memorandum 71/5A, (75 pp.), November, 1971.

7. DuMolin, J., "Instructional Television Utilization in the United States," Memorandum 71/6, (48 pp.), October, 1971. (ERIC No. ED 055 427) [NASA-CR-124734]

8. Singh, J. P. and R. P. Morgan, "Educational Computer Utilization and Computer Communications," Memorandum 71/7, (94 pp.), November, 1971. (ERIC No. ED 057 575)

9. Newman, B. A., Singh, J. P. and F. J. Rosenbaum, "Design of a 12-GHz Multicarrier Earth-Terminal for Satellite-CATV Interconnection," Memorandum 71/8, (64 pp.), November, 1971. (ERIC No. ED 057 576) [NASA-CR-124699]

10. Singh, J. P., "Operating Frequencies for Educational Satellite Services," Memorandum 71/10, (65 pp.), November, 1971. (ERIC No. ED 057 577) [NASA-CR-124725]

11. Hurtado, M. and F. J. Rosenbaum, "A CW Gunn Diode Switching Element," Memorandum 71/12, (10 pp.), November, 1971. [NASA-CR-124733]

12. Niehaus, C. A., "Utilization of Telecommunications by Academic and School Libraries in the United States," Memorandum 72/1, (51 pp.), March, 1972. (ERIC No. ED 064 901)

13. Anderson, B. and E. Greenberg, "Educational Production Functions for Teacher-Technology Mixes: Problems and Possibilities," Memorandum 72/2, (96 pp.), March, 1972. (ERIC No. ED 064 900)

14. Stagl, T. W. and J. P. Singh, "A Computer Program for Mapping Satellite-Borne Narrow-Band Antenna Footprints on Earth," Memorandum 72/3, (26 pp.), March, 1972. [NASA-CR-129283]

*15. a. Morgan, R. P., Singh, J. P., and C. A. Niehaus, "Educational Telecommunications in Appalachia," Phase I Report to the Appalachian Regional Commission, May, 1972, (150 pp.), (with assistance from H. Jackoway and J. Itzikowitz).

b. Singh, J. P. and R. P. Morgan, "Identification of Fixed/Broadcast Satellite-Based Educational and Health Telecommunications Services for the Appalachian Region," Phase II Report to the Appalachian Regional Commission, June, 1972, (135 pp.).

c. Singh, J. P. and R. P. Morgan, "Identification of Tele-Education/Medicine Experiments for the ATS-F Satellite for the Appalachian Region," Phase III Report to the Appalachian Regional Commission, June, 1972, (34 pp.), (with assistance from T. Stagl).

16. Stagl, T. W. and J. P. Singh, "Computer Programs for Plotting Spot-Beam Coverage from An Earth-Synchronous Satellite and Earth-Station Antenna Elevation Angle Contours," Memorandum 72/4, (37 pp.), October, 1972. [NASA-CR-129282]

17. Bernstein, N. N., "Legal Restraints on Dissemination of Instructional Materials by Educational Communications Systems," Memorandum No. 72/5, (33 pp.), October, 1972. [NASA-CR-129271]

18. Rothenberg, D., "Vocational/Technical Education: Status, Trends and Issues Related to Electronic Delivery," Memorandum No. 73/1, (113 pp.), January, 1973. (ERIC No. ED 071 438) [NASA-CR-130532]

19. Rothenberg, D., "Early Childhood Education: Status, Trends and Issues Related to Electronic Delivery," Memorandum No. 73/2, (111 pp.), May, 1973. (ERIC No. ED 077 217) [NASA-CR-133028]

20. Walkmeyer, J., "Planning Alternative Organizational Frameworks for a Large Scale Educational Telecommunications System Served by Fixed/Broadcast Satellites," Memorandum No. 73/3, (112 pp.), June, 1973. (ERIC No. ED 078 663) [NASA-CR-133646]

21. Rothenberg, D., "Education of the Handicapped: Status, Trends and Issues Related to Electronic Delivery," Memorandum 73/4, (92 pp.), December, 1973. (ERIC No. ED 086 235) [NASA-CR-136628]

---

*Supported by and submitted to Appalachian Regional Commission as one volume entitled "Communications Technology and Health-Care Delivery in Appalachia."

22. Demerath, N. J., and L. A. Daniels, "How to Make 'The Fourth Revolution'--Human Factors in the Adoption of Electronic Instructional Aids," Memorandum No. 73/5, (84 pp.), December, 1973. (ERIC No. ED 086 262) [NASA-CR-136862]

23. Lipman, D., "Technology in the Public Schools?", Memorandum 73/6, (95 pp.), December, 1973. (ERIC No. ED 087 463) [NASA-CR-136829]

24. Ballard, R. and L. F. Eastwood, Jr., "Telecommunications Media for the Delivery of Educational Programming," Memorandum 74/1, (143 pp.), November, 1974. (ERIC No. ED 100 349) [NASA-CR-140880]

25. Eastwood, M. A. and L. F. Eastwood, Jr., "A Software Implementation of a Satellite Interface Message Processor," Memorandum 74/2, (59 pp.), December, 1974. (ERIC No. ED 100 347) [NASA-CR-141280]

26. Morgan, R. P., Singh, J. P., Rothenberg, D. and B. E. Robinson, "Large-Scale Educational Telecommunications Systems for the U.S.: An Analysis of Educational Needs and Technological Opportunities," Memorandum 75/1, (425 pp.), April, 1975. (Available from ERIC in near future) [NASA-CR-142619]

27. Walkmeyer, J. E., Jr., Morgan, R. P. and J. P. Singh, "Market Scenarios and Alternative Administrative Frameworks for U.S. Educational Satellite Systems," Memorandum 75/2, (168 pp.), April, 1975.

*28. Lieberman, D. L. and R. P. Morgan, "Privacy Impacts of Educational Telecommunications and Information Systems," Memorandum 75/3, (25 pp.), April, 1975.

**29. Li, V., "Fiber Optics Communication Technology for Educational Communications," Memorandum 75/4, (78 pp.), April, 1975.

**30. Rothenberg, D., "Continuing Professional Education: Status, Trends and Issues Related to Electronic Delivery," Memorandum 75/5, (74 pp.), August, 1975.

31. Ballard, R. and L. F. Eastwood, Jr., "Planning Communications Networks to Deliver Educational Services," Memorandum, (forthcoming).

D. Technical Articles

1. Rosenbaum, F. J. and M. Hurtado, "A CW-Gunn Diode Bistable Switching Element," IEEE Transactions on Election Devices, Vol. 19-ED, pp. 1130-1131, October, 1972.

2. Rosenbaum, F. J. and A. Sene, "Wide-Band Gunn-Effect CW Waveguide Amplifier," IEEE Transactions on Microwave Theory and Techniques, Vol. MTT-20, 1972.

---

*Supported by Program in Technology & Human Affairs, Washington University.

**Supported by National Science Foundation.

3. Olson, D. J. and F. J. Rosenbaum, "MICTPT--A Minicomputer General-Purpose Microwave Two-Part Analysis Program," IEEE Transactions on Microwave Theory and Techniques, pp. 340-342, March, 1974.

4. Risch, C. O., Singh, J. P., Rosenbaum, F. J. and R. O. Gregory, "A Low-Cost, Multiple Channel, 12 GHz Receiver for Satellite Television Broadcasting," IEEE Transactions on Microwave Theory and Techniques, Special Issue, Microwave Communications, April, 1975.

5. Eastwood, L. F., Jr., and R. Ballard "The PLATO IV CAI System: Where Is It Now? Where Can It Go?," Journal of Educational Technology Systems (forthcoming).

6. Eastwood, L. F., Jr., "Broadcast Delivery of Computer-Aided Instruction," Invited Paper to be presented at Conference on Ten-Year Forecast for Computers and Communications: Implications for Education, Airlie House, Warrenton, Virginia, September 17, 1975.

7. Eastwood, L. F., Jr., and R. Ballard, "Dedicated Bidirectional Cable Networks for the Delivery of Educational Services," Paper to be presented at 25th Annual Broadcast Symposium, IEEE Broadcasting Group, Washington, DC, September 26, 1975.

8. Eastwood, L. F., Jr., and R. E. Morley, "Two-Way Radio Delivery of Computer-Aided Instruction," Paper to be presented at IEEE National Telecommunications Conference, New Orleans, LA, December 1-3, 1975.