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This report summarizes the results of a user survey for the Building Loads Analysis and System Thermodynamics (BLAST) program and presents a recommended plan for implementing BLAST in Air Force projects.

General overall response to BLAST was favorable. However, users identified the need for improved user documentation, including a revised user's manual and input booklet, and a detailed description of algorithms used in

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BLAST. A revised user's manual and new input booklet (now in the final development stages) will enhance the system's usability.

It was recommended (1) that BLAST be implemented throughout the Air Force immediately, (2) that an engineers manual for BLAST be developed, and (3) that an interactive input data processing system be developed for BLAST.

PREFACE

This research was conducted by the Energy and Habitability Division (EH), U.S. Army Construction Engineering Research Laboratory (CERL) for the Department of the Air Force, Detachment 1, Civil and Environmental Engineering Development Office, Air Force Engineering and Services Center, Tyndall AFB, FL, under Project Order DTC-8-138, dated 10 May 1978.

Senior Master Sergeant Edward E. Stapleton was the Air Force Technical Monitor. Mr. Douglas C. Hittle was the CERL Principal Investigator. Administrative support was provided by Dr. D. J. Leverenz of CERL, and Mr. R. G. Donaghy, Chief of CERL-EH.

COL J. E. Hays is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

This report has been reviewed by the Information Office (IO) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

AFCEC-TR-CEEDO- -

BLAST PROGRAM USER SURVEY AND RECOMMENDED IMPLEMENTATION PLAN

Department of the Army
CONSTRUCTION ENGINEERING RESEARCH LABORATORY
Corps of Engineers
P. O. Box 4005
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April 1979

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SECTION I

INTRODUCTION

BACKGROUND

The Building Loads Analysis and Systems Thermodynamics Program (BLAST) is a comprehensive computer program for estimating (1) hourly space heating and cooling requirements, (2) hourly performance of fan systems, and (3) hourly performance of conventional heating and cooling plants, total energy plants, and/or solar energy systems. It is used principally in the design and evaluation of energy-conserving buildings and building systems.

The BLAST program has been used by the Air Force and Army since February 1977 and by GSA personnel and the general public since December 1977. BLAST has been made available to nongovernment computing services and is currently in use on the Boeing Computer Service in Seattle, WA, and the Control Data Corporation, Cybernet Computing Service in Minneapolis, MN. Both these services offer training and user support for BLAST to both Government and private-sector personnel. In addition, the BLAST program is being used on several Government-owned computer services, including the computer at Eglin Air Force Base, FL.

Since some services have now used BLAST for up to 2 years, the Air Force Civil and Environmental Engineering Development Office (CEEDO) proposed that these users be surveyed to determine future development requirements and the general applicability of BLAST. In addition, this survey was intended to provide background information for revising a recommended plan for implementing BLAST within the Air Force.

OBJECTIVE

The objectives of this work were: (1) to determine user problems and to obtain user recommendations for improving BLAST, its application, and its implementation, and (2) to develop a plan for implementing BLAST throughout the Air Force.

APPROACH

A user questionnaire, developed in coordination with CEEDO and the Air Force Civil Engineering Center (AFCEC),* was distributed to all known Government users of BLAST (Table 1). Responses were collated and summarized. Based on these responses and a review of current practices in the Air Force Energy Audit program, a recommended BLAST implementation plan was developed.

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* Now part of the Air Force Engineering and Services Center (AFESC).

TABLE 1. DISTRIBUTION LIST FOR BLAST QUESTIONNAIRE (CONTINUED)

Division Engineer
US Army Engineer Division, Southwestern
ATTN: SWDED
Main Tower Building
1200 Main Street
Dallas, TX 75202

Commander
Engineering and Technology Office
(2 Questionnaires)
USAF Civil Engineering Center
Tyndall AFB, FL 32401

Superintendent
US Air Force Academy
ATTN: DEVCT
US Air Force Academy, CO 80840

Officer in Charge
USN Civil Engineering Laboratory
ATTN: Code L03AE - (2 Questionnaires)
Pt Hueneme, CA 93030

Commander
Aberdeen Research and Development Center
ATTN: NDB/FSC/DE - (2 Questionnaires)
Bldg E4434 Edgewood Area
Aberdeen Proving Ground, MD 21010

District Engineer
US Army Engineer District, Fort Worth
P.O. Box 17300
Ft. Worth, TX 76102

Commander
USAF Civil Engineering Center
ATTN: AFCEC/DE/21
Tyndall AFB, FL 32403

Boeing Computer Services Co.
P.O. Box 24346
Seattle, WA 98124

Control Data Corporation
8100 34th Avenue, South
Minneapolis, MN 55440

Commander
Headquarters, Air Force Institute
of Technology - (2 Questionnaires)
ATTN: DET
Wright-Patterson AFB, OH 45433

Commander and Director
US Army Facilities Engineering
Support Agency
ATTN: FESA-HQ
Research and Development Division
Ft. Belvoir, VA 22060

HQDA (DAEN-MCE-U) - (2 Questionnaires)
WASH, DC 20314

Commander
3345 Air Base Group - (2 Questionnaires)
ATTN: DEEED
Bldg 56, Stop 27
Chanute AFB, IL 61868

Commander
HQ Air Training Command
ATTN: DEEEM
Randolph AFB, TX 78148

Commander
Civil and Environmental Engineering
Development Center
ATTN: DET 1 ADTC/PRF
Tyndall AFB, FL 32403

Director
Headquarters, Army Air Force Director
Exchange Service
ATTN: Engineering Division
Dallas, TX 75220

General Services Administration
Professional Services Division
3PCS
7th & D Streets, S.W.
Washington, DC 20407

TABLE 1. DISTRIBUTION LIST FOR BLAST QUESTIONNAIRE (CONCLUDED)

Martin-Marietta Corporation
Data Systems Division, MP-52
P.O. Box 5837
Orlando, FL 32805

McDonnell Douglas Automation
(2 Questionnaires)
P.O. Box 516, Bldg 73
St. Louis, MO 63166

Public Buildings Service
Professional Srvices Division
General Services Administration
(6 Questionnaires)
18th & F Streets, N.W.
Washington, DC 20405

Professional Services Division
Control Data Corporation
215 Mofett Park Drive
Sunnyvale, CA 94086

Ayres & Associates
1180 Beverly Drive
Los Angeles, CA 90035

Department of Mechanical Engineering
Texas A&M University
College Station, TX 77843

Center for Building Technology
National Bureau of Standards
Washington, DC 20234

Argonne Labs - (2 Questionnaires)
Building 221, A.M.D.
9700 S. Cass Avenue
Argonne, IL 60439

Department of Mechanical Engineering
University of Illinois - (2 Questionnaires)
Urbana, IL 61801

Lawrence Berkeley Laboratory
Energy and Environment Division
50B-5238
Berkeley, CA 94720

SECTION II

USER SURVEY

A user questionnaire (see Appendix) was developed, reviewed by AFCEC and CEEDO personnel, and distributed to personnel who either had previously attended BLAST training seminars or who were known users of BLAST. Responses were received from 16 of 41 persons who received the questionnaire. This chapter summarizes the results of the 16 questionnaires received.

Questions 1, 2, and 3 provide the user's name, organization, and telephone number.

Question 4. Of the 16 responses, eight people had received formal training in the use of the BLAST program and eight had not.

Question 5. A total of 26 projects had been analyzed using BLAST.

Question 6. Seven respondents are currently using the program. Eight had not used the program except during training, and one had not used the program for 2 months.

Question 7. The projects which have been analyzed with BLAST ranged in size from a family home to buildings of several hundred thousand square feet (project size was not always identified by the respondents). The program has been used to analyze new construction projects, analyze retrofit construction projects, and perform research studies.

Question 8. Four respondents indicated that training was desirable, and seven indicated that it was essential. None indicated that training was unnecessary. This question, however, needs to be examined further, since the four respondents who indicated that training was desirable had not received formal training; however, all seven of the respondents who indicated that training was essential had received training. Therefore, it appears that the essential nature of training is a perceived need rather than a real one, although training appears to be highly desirable.

Question 9. Responses to question 9 were largely suggestions for improving the BLAST Users Manual (Reference 1) and identification of weak areas. Several respondents indicated a need for a more comprehensive sample problem. Another frequent comment was that more descriptive error messages or a key to the less descriptive error messages should be provided either in the BLAST program or in the users manual. Several respondents suggested that a more complete description of the algorithms used in BLAST would be useful.

Question 10. Users were asked to provide suggestions for the development of a BLAST Input Booklet; specifically, examples of other input booklets were solicited as sample formats for a BLAST Input Booklet. Four of the users surveyed responded, and in each case, the TRACE (Reference 2) program booklet was cited as a possible sample.

Question 11. The seven respondents to this question indicated what other energy analysis programs they have used. Five had used the TRACE program, and three had used the E-CUBE program; others mentioned included NBSLD, NECAP, AXCESS, and DOE-1.

Question 12. Users were asked to identify the strong and weak features of BLAST and, if possible, to contrast them with the strong and weak points of other energy analysis programs they had used. Generally, BLAST was praised for being comprehensive and flexible, for having a user-oriented input language, and for having a program library. Accuracy, the low cost of running the BLAST program, and the nonproprietary nature of BLAST were also listed as advantages. Weaknesses listed included difficulty in describing building geometry to the BLAST program via the input language and the lack of an input booklet such as that for TRACE.

Question 13. Five respondents indicated simulation capabilities that they felt would be useful additions to BLAST. These features included passive solar analysis capability, additional scheduling of internal sensible and latent loads, and more flexible report options.

Questions 14 and 15. Questions 14 and 15 were intended to identify user satisfaction with the computer system on which they were currently using BLAST. Generally, the users were satisfied with the computer support received. However, at least one user had switched from the Lawrence Berkeley Laboratory Computer to commercial computer service to obtain better turnaround.

Question 16. BLAST users were asked whether they believed that energy analysis programs were necessary to accomplish their jobs. All of the 13 who responded replied affirmatively. They indicated that the need to quantify the expected energy consumption of various building design and energy conservation options was essential to the proper design of a building or retrofit project and indicated that this was the principal reason that use of energy analysis programs was becoming a daily task. The ability to quantify expected energy use was cited in 12 of the 13 responses.

Question 17. All but one of the 11 respondents to this question indicated that BLAST should be used for new construction and retrofit projects; however, the negative response indicated that BLAST should be used to develop standards for such projects. The optimum project size thought to be appropriate for BLAST analysis ranged from $100,000 to $500,000 in construction costs. However, several respondents suggested that project size was not an appropriate means of judging whether BLAST should be used. One user recommended that projects should be analyzed if the savings potential exceeded the cost of the BLAST analysis. Another suggested that the program should be used as long as new knowledge or information can be gained from a building analysis.

Question 18. Of the responses to whether a formal policy regarding the use of BLAST should be issued, four were negative and three were affirmative. The Department of Defense, Department of Energy, and Headquarters, U.S. Air Force were mentioned as the agency which should formulate such a policy.

SUMMARY

It appears that BLAST can be used successfully by both trained and untrained personnel; however, most BLAST users believe that training is desirable.

The existing BLAST users manual must be clarified and strengthened. A BLAST program input booklet is also needed; the TRACE Input Booklet was suggested as a guide for format and style.

BLAST was praised for its comprehensiveness and flexibility; however, the incorporation of additional passive solar simulation capability and more flexible scheduling of internal heat gains were suggested as improvements.

Most BLAST users believe that energy analysis programs are necessary to accomplish their work, but there was no consensus about the size of projects which should be analyzed or on the issuance of a formal policy for using BLAST.

REMAINING PROBLEMS

Many of the weaknesses and desirable additions identified by BLAST users will be resolved by BLAST Version 2.0, its revised users manual, and its new input booklet. Specifically, the new users manual will include more detailed input data descriptions, a complete index, and a list and description of BLAST error messages; in addition, it will be better organized. The new BLAST input booklet will provide input forms and step-by-step instructions for completing them, thus providing necessary user guidance. BLAST Version 2.0 also includes more flexible internal load scheduling.

Funding has not been provided either for writing a comprehensive description (in engineering terms) of the BLAST program algorithms, or for developing additional passive solar energy analysis capability. However, a proposal for the latter has been submitted to the Department of Energy. The results of questionnaires distributed after each BLAST training seminar indicated that an interactive program to prompt for and check user input data would be a useful tool for enhancing program usability. This program would complement the users manual and input booklet and be a valuable aid to infrequent users of BLAST; however, the development of such an interactive program is unfunded.

SECTION III

RECOMMENDED IMPLEMENTATION PLAN

STATUS OF THE PROGRAM

BLAST, the most comprehensive and flexible program of its kind, is complete, fully documented, fully operational, and effectively supported. Its users and reference manuals were published in December 1977. The program was field-tested at Chanute AFB, the Air Force Civil Engineering Center, the Air National Guard Bureau, and at the Corps of Engineers Fort Worth District. BLAST was publicly released in January 1978. Copies of the program have been made available to all vendors of Control Data Corporation computer services who are part of the Teleprocessing Services Program (TSP) run by the General Services Administration. Four CERL-sponsored training seminars have been conducted, one of which (in July 1978) offered training to the various computer service vendors interested in offering BLAST.

Following the vendor training program, two major computer service vendors implemented the BLAST program, developed user training and support programs, and began offering full support to BLAST. These vendors are the Boeing Computer Service in Seattle, WA, and Control Data Corporation, Cybernet, in Minneapolis, MN. Both vendors offer BLAST at no additional charge and are offering four-day training seminars at a cost of $525 and $125, respectively. The McDonnell-Douglas Automation Company and Martin-Marietta Company have also expressed an interest in using BLAST, although neither currently offers a full range of training and support services. Although costs vary considerably among computer service bureaus and depend on the user-specified priority, a four-zone, one-system, one-central-plant case performing a full 8760-hour (1-year) analysis can be completed for less than $30 of computer expense.

Under the sponsorship of the Air Force Civil Engineering Center, the BLAST users manual has been revised and an input booklet developed. These documents are to be field-tested and are scheduled for publication in June 1979. Both these documents are for BLAST Version 2.0, an enhanced program which includes features considered desirable by BLAST users. Its development was sponsored by the General Services Administration. Some of the program's new features include the ability to predict heat transfer between zones at different temperatures (AF funded), to simulate direct expansion air-conditioning systems (both package and built-up systems), and to handle single-zone draw-through air-conditioning systems. It also provides a more comprehensive economic analysis subprogram and enhanced reports. Development and extensive testing of BLAST Version 2.0 have been completed and copies of the new program have been made available to computer service vendors in the Teleprocessing Services Program.

IMPLEMENTING ACTIONS

The following steps should be taken to implement the BLAST program throughout the Air Force.

Instructions from AF/LEE

The Air Force Deputy Chief of Staff, Logistics and Engineering, Directorate of Engineering and Services (AF/LEE) should issue engineering instructions authorizing the use of BLAST for evaluating all new building projects and major retrofits, and for the second phase of the Air Force Energy Audit program.

Use of BLAST by Support Contractors

Since BLAST is nonproprietary, fully operational, and cost-effective, architect/engineers (AEs) performing design and study services for the Air Force which involve detailed energy analysis should be directed to use BLAST.

Transition of Air Force Special Teams

To maintain the recently acquired in-house building energy analysis capability, the special teams currently performing phase 1 of the Air Force Energy Audit Program should be trained in the use of BLAST. One or more members of each team should attend a training seminar offered by one of the vendors supporting BLAST; each other team member should be given a BLAST users manual and an input booklet. By following this procedure, the first line of user training and support for the highly skilled specialized teams will be the key team members who attend formal BLAST training seminars. User training can be made available to other individuals as necessary; user support can be provided by the key team members, the computer service vendor, and the vendor's consultants. The final recourse for difficult problems will remain CERL's responsibility.

If the in-house workload for building energy analysis remains high, high-speed batch computer terminals should be retained or acquired for each Major Command where an Energy Audit team is based to provide necessary access to BLAST (and other programs as needed). Since the data input required for BLAST differs little from that required for the other energy analysis programs, a smooth transition to BLAST is expected.

MAINTENANCE REQUIREMENTS

BLAST requires little or no routine maintenance. CERL will provide the technical backup for correcting user-found errors in BLAST or for enhancing the program's capabilities. AFESC should be responsible for identifying and providing funds for program maintenance activities performed by CERL. There should be no charge for minor routine maintenance performed by the vendors.

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

BLAST has been successfully applied to the analysis of several new buildings and retrofit projects.

Response to the BLAST program is generally favorable; however, users have identified the need for improved documentation, including a revised users manual, an input booklet, and a detailed description of the algorithms used in BLAST. The new BLAST users manual and input booklet currently in preparation should satisfy part of the requirements for improved documentation. Users feel that formal training in the use of BLAST is highly desirable. Two computer service vendors offer formal training designed to meet this need.

The development of an interactive input data preparation system is potentially a very important user aid.

The BLAST program is fully operational and extensively supported. The soon-to-be published revised documentation will further enhance program usability.

A three-step plan to implement BLAST throughout the Air Force has been devised: (1) authorizing use of BLAST for evaluating all new building projects and major retrofits, (2) requiring use of BLAST by AEs performing detailed energy analysis for Air Force projects, and (3) training of one or more members of each special team involved in energy analysis of in-house Air Force projects.

RECOMMENDATIONS

It is recommended that AFESC and OCE consider providing funds to (1) develop an engineering manual which would describe and illustrate the algorithms used in BLAST, and (2) provide an interactive input data preparation system.

The BLAST implementation plan outlined in Chapter 3 of this report should be carried out immediately.

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APPENDIX

BLAST QUESTIONNAIRE

1. Name, title, and one-line job description:

2. Organization:

3. Telephone:

4. Have you received formal training in the use of BLAST, and if so, when?

5. How many projects have you used BLAST on?

6. When did you use BLAST last?

7. Please list the name and a one-line description of the projects you have analyzed using BLAST.

8. Do you think formal training in the use of BLAST is essential, desirable, or unnecessary?

9. The BLAST users manual is being revised. One addition to the manual will be a complete index. Please list in order of importance other revisions or additions you feel are essential or desirable.

10. A BLAST input booklet is being developed. It will include overprinted input forms. If you have used input forms for other computer programs, please give the name and source for these input forms if you feel they might serve as a useful guide for developing BLAST input forms (please attach copies of the forms if possible).

11. What other building energy analysis programs have you used?

12. Please list the strong and weak features of the BLAST program and any other building energy analysis programs you have used.

13. BLAST is currently being enhanced to include the following capabilities:

a. Heat transfer across partitions.

b. Different schedules for each day of the week.

c. Simulation of dual-duct VAV systems, thermostatic baseboard heat (already implemented) single-zone, draw-through units, DX systems, and air-to-air heat recovery.

d. Additional life cycle costs analysis of building and system alternatives.

e. Revised reports.

Have you encountered the need for additional simulation capabilities not now in BLAST or in the above list? If so, please list capabilities you think should be added to BLAST.

14. What computer system are you using for BLAST runs?

15. Has computer support been adequate? If not, why not (i.e., poor turnaround, no consulting support, confusion on job card requirements, etc.)?

16. Do you think energy analysis programs are necessary to accomplish your job? Please explain briefly.

17. Should BLAST be used on new construction and retrofit projects and, if so, how large should the project be (in thousands of dollars) before a complete analysis is required?

18. Do you feel a formal policy statement on the use of BLAST is required? If so, who should issue a policy statement (Air Force, Army, Navy, DOD, GSA)? Please explain (to be answered by Government personnel only).

19. Please offer any additional comments you feel might help make BLAST a more useful tool.

REFERENCES

1. Hittle, D.C., The Building Loads Analysis and System Thermodynamics (BLAST) Program - Volume I: User Instructions, Technical Report E-191/ADA048734, U.S. Army Construction Engineering Research Laboratory, November 1977.

2. The Trane Air Conditioning Economics Program, Trane Co., 1978.