More programming experience with the Orion will be required before E.M.A., GSP and the Orion Monitor Program can be made to handle restart procedures completely satisfactorily.

Improvements in other directions will also be necessary should the program prove of lasting use. Much of the user's E.M.A. section could be standardized; in particular a convenient method of testing whether variates transgress limits should be made available to replace the present somewhat *ad hoc* procedures. Some redundancies in the coded instructions for (*c*), (*d*) and (*e*) should be removed, and provision made for automatic allocation of storage for tables (as in the 401 program). Some loop or jump facility with modification would be useful for the tabulation and table manipulation instructions; this would greatly reduce the number of instructions required.

The increase in speed resulting from using compilation instead of interpretation for sections (*a*) and (*b*) is indicated by a comparison (the only one so far available) with SEP. This job involved six variates with relatively few derived variate operations, and only four tabulations per cycle. SEP performed the analysis at 70 cards/minute as against 130 cards/minute for GSP, using the E.M.A. card-reading routine written by J. A. Nelder of the National Vegetable Research Station, Wellesbourne, Warwick. (The maximum speed of the card reader is 600 cards/minute.) When the GSP tabulation section was used as a routine instead of as a separate chapter (thus avoiding drum transfers of program) the speed increased to 200 cards/minute. With an improved card-reading routine (for numerical material only but with tests for limits incorporated) the speed was further increased to 450 cards/minute. Another job with 460 variates and 20 tabulations per cycle, involving data previously transferred from cards to magnetic tape, was analysed in this way at 1500 cards/minute. This use of the tabulation section as a routine will therefore probably become standard practice.

6. Acknowledgements

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Book Review

Digital Communications with Space Applications, by S. W. Golomb, *et al.*, 1965; 210 pages. (London: *Prentice-Hall International*, 96s.)

This book is a product of the pioneering space programme of the *Jet Propulsion Laboratory*. It deals with the use of pseudo-random (shift register) sequences in space communication and ranging, and does not give a general treatment of digital communication. There are eight chapters, each almost self-contained, together with four appendices.

The editor's first chapter introduces pseudo-random sequences and indicates their uses. The remaining chapters are the work of four other authors. Up to Chapter 5 the basic ideas and processes involved in the use of pseudo-random sequences for communication are presented. The second chapter gives an interesting account of the methods of generating specified sequences, and includes some fundamental theorems. Chapter 3 deals with the calculation of the power spectra of random sequences from the auto-correlation function, by the standard method.

Various types of orthogonal codes are discussed in Chapter 4 and the use of Hadamard matrices is introduced. Chapter 5 extends the work of Chapter 3 to obtain the power spectra of pseudo-random sequences to specify bandwidth requirements, and concludes by discussing modulation and reception.

Chapters 6 and 8 deal with tracking and synchronization. In Chapter 6 the interest is in ranging rather than communication and the acquisition properties of sequences are investigated; the performance in noise is estimated. The subject of Chapter 8 is the synchronization of pseudo-random communication codes; the 'random source' method in which the value of one digit position is constant, and the 'comma free' method in which no part of two consecutive code words is also a code word, are both considered.

Signalling error probabilities in the presence of noise with optimum detection methods are calculated in Chapter 7 for orthogonal codes; a comparison is made with uncoded communication and the Shannon limit.

Appendix 2 gives a useful list of shift register sequences, while Appendix 3 contains a list of logics and terminating words for counting up to 2047 with these sequences.

The classified origins of much of the work on pseudo-random sequences and their uses has created pockets of knowledge in various organizations, and the dispersion of this knowledge by such books must be welcomed. Although the space application is of limited direct interest the valuable ideas presented have a wide field of interest.

The joint authorship of the book has caused some repetition even to the extent of repeating one figure; little detailed cross referencing occurs (only one author numbers expressions) and the symbolism is not consistent nor always clear. These defects make reading rather difficult; it is, however, rewarding.

D. WILLIAMS