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A Command Post Layout Optimization Model: An Interim Report

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A COMMAND POST LAYOUT OPTIMIZATION MODEL: AN INTERIM REPORT

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A COMMAND POST LAYOUT OPTIMIZATION MODEL: AN INTERIM REPORT

Introduction

The Chief of Staff, U.S. Army has determined that a standard Command Post (CP) layout for each specific type of unit would facilitate efficient performance of command and control. Consequently the Combined Arms Center at Fort Leavenworth, Kansas, has initiated a program aimed at standardizing command post design. Standardized CPs would also enable a commander or staff officer to enter any command post of a given type of unit and know immediately where each piece of command and control equipment was located.

Many of the current CP work space designs have deficiencies that hamper the function of a CP (Michel & Fallesen, 1990). The design and evaluation of CP layouts has, in the past, been a time consuming, manual process that did not ensure an optimal arrangement. A computerized tool to assist designers and evaluators in the layout of a CP would be of tremendous benefit to those tasked with the design of CPs, especially if this tool incorporated human engineering design specifications for work stations, walkways, exits, and various facilities and equipment, while also minimizing human travel distances, congestion, and crossover traffic (links).

Objective

This report documents an ongoing effort to develop a technology that can be used to optimize the layout of command posts.

Background

Link analysis is a method for systematically evaluating traffic patterns and communications between various work stations or individuals in a given facility (Chapanis, 1959, p. 51-62). In military settings, link analysis has been used to evaluate combat information centers (Fallesen & Quinkert, 1990).

Software packages exist for evaluating and performing link analyses of facility layouts, but none fully meets the Army's need. LOCATE (Hendy, 1989), a computer-aided workspace layout program, comes closest to meeting the Army's need. The LOCATE model attempts to optimize the quality of high priority communications (links). The quality formula for communication is applied to link analysis techniques for assessing the adequacy of workspace layout. However, the LOCATE model is experimental, only partially developed, and not available for general use.

Command Post Layout Optimization Model

The Command Post Layout Optimization Model (CPLOM) being developed at the Fort Hood Field Unit is FORTRAN based software for aiding the designer and evaluator of the CP physical layout. The CPLOM is designed for two-dimensional layout problems of various CP configurations. The current status of the CPLOM will be presented, followed by a discussion on limitations and enhancements to be integrated in future versions.

Current Status

Currently the CPLOM works interactively with a user. The CPLOM starts by prompting the user to enter the outside dimensions of a rectangular CP. Next the user is prompted to enter the location and length of interior walls. The CPLOM saves this skeletal configuration for future use or reference.

The user then enters candidate locations of work stations in the CP and the CPLOM saves this initial CP layout. A fast shortest-path algorithm is then applied. It calculates the shortest path between all pairs of work stations. This result, along with a drawing or print out of the CP layout, can be used for some elementary or initial analyses.

The CPLOM next requires the user to enter the frequency of human traffic or interaction between all pairs of work stations. The user can also enter the importance or priority of traffic between particular work stations. The CPLOM saves the frequency and priority data. Then the CPLOM generates and evaluates every possible arrangement of work stations given the previously entered work station locations. The objective of evaluating the CP arrangements is to minimize a linear function of distance, traffic frequency and priority between all work stations. To satisfy the objective, work stations with high priority or frequent interactions will be placed in close proximity. This analysis approximates and replaces manual link analysis used to evaluate traffic flows. The CPLOM will list the top or best arrangements for further manual analysis.

The user can generate totally new layouts or reuse parts from previous layouts (skeletal configuration, work station locations, or traffic frequencies and priorities). Reusing data from earlier runs will save immense amounts of time. Modifying or moving the locations of work stations with the same skeletal configuration and the same traffic data can lead to finding optimal CP layouts.

Limitations and Enhancements

Physical structure. Currently only a rectangular CP can be modeled and all interior walls must adjoin an outside wall. More flexibility will be built into later versions, allowing other shapes of CPs (L, T, etc.) and free standing partitions or walls to be included in the model.

Human Engineering. The most obvious limitation of the current CPLOM is that work stations do not occupy any real space. Work stations will occupy a real space (desk and chair, map boards, etc.) in later versions of CPLOM. Later versions will also incorporate design guidelines from Department of Army Human Engineering Standards.

Rearrangement of work stations. Currently all possible arrangements of 'n' work stations are being generated for evaluation. This is not a very efficient method of searching for an optimum. Simulations of workplace layouts are more efficient (Rabideau & Luk, 1975), but ensure only an approximation, rather than an optimal layout. An assignment algorithm will ensure an optimum when the location of a component or piece of equipment has a value or relationship to an operator. However, optimizing on the total of all pair relationships is not a typical math programming problem. An investigation into more efficient search methods for optimal work station layouts is ongoing and should result in a more efficient search method being incorporated in later versions.

Creating data. To design a CP model using the CPLOM, one must enter the work stations and the traffic relationships between all the work stations using the CPLOM. This is very time consuming. In the future a data base will be produced that contains generic skeletal configurations, initial work station locations, and traffic frequency and priority information. Accessing this data base should enhance designers' capabilities in using the CPLOM.

Computer hardware. Currently the CPLOM runs on TEXCOM's IBM 4381 at Fort Hood and is portable to other mainframes with a FORTRAN 77 compiler. Eventually the CPLOM should run on an IBM PC compatible.

Conclusion

Initial progress has been made in developing a computerized tool to aid in the design and evaluation of the physical layout of command posts. The CPLOM has potential to be a valuable tool for the designers of Army Command Posts. However, much work remains to be done.

References

- Chapanis, A. (1959). Research Techniques in Human Engineering. Baltimore, Maryland: The John Hopkins Press.
- Fallesen, J. and Quinkert, K. (1990). Workspace Design Handbook for Standardized Command Posts. U.S. Army Research Institute Working Paper LVN-90-01.
- Hendy, K. C. (1989). A Model for Human-Machine-Human Interaction in Workspace Layout Problems. Human Factors. Vol. 31, 5, pp. 593-610.
- Hendy, K.C., Berger, J. and Wong, C. C. (1989). Analysis of DDH280 Bridge Activity Using a Computer-Aided Workspace Layout Program (LOCATE). DCIEM No. 89-RR-18. Downsview, Ontario: Defence and Civil Institute of Environmental Medicine.
- Michel, R. and Fallesen, J. (1990). Workspace Assessment of a Battalion Task Force Command Post. U.S. Army Research Institute Working Paper LVN-90-02.
- Rabideau, G. F. and Luk, R. H. (1975). A Monte Carlo Algorithm for Workspace Optimization and Layout Planning - WOLAP. In Proceedings of the 19th Annual Meeting of the Human Factors Society (pp. 187-192). Santa Monica, CA: Human Factors Society.