Dear Dr. Glassman,

Enclosed is the final report on ONR Contract N00014-87-K-0389, entitled "Temporal Planning and Management Decision Under Risk and Uncertainty."

Sincerely yours,

A. Charnes

University Professor across The University of Texas System
John P. Harbin U.T. Regents' Chair
Director, Center for Cybernetic Studies

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FINAL REPORT

"TEMPORAL PLANNING AND MANAGEMENT DECISION UNDER RISK AND UNCERTAINTY"

Contract No. N00014-87-K-0389

Submitted to the Office of Naval Research

by

A. Charnes

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John P. Harbin Centennial Chair
Director, Center for Cybernetic Studies

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CENTER FOR CYBERNETIC STUDIES

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Introduction

The Principal Investigator was Dr. A. Charnes, who is a University Professor across The University of Texas System and the John P. Harbin Centennial Chair. As such, he is Professor in the Department of Mathematics, the Department of Computer Sciences, the Department of General Business, the Graduate School of Biomedical Sciences, and the Biomathematics Research Group of the M.D. Anderson Cancer Center in Houston, Texas.

The theoretical research accomplished heretofore will continue to arise from concrete analytical problems of direct relevance to operations research of a military nature. Many of these are identical or closely similar in form to situations in industry, engineering, and other sciences to the extent that progress in one area implies progress in the other. Mathematically, the fields covered involve linear and non-linear optimization, integer and chance-constrained programming, mathematical statistics, game theory, multicriteria or multi-extremal optimization, algorithmic and computational methods.

To be especially noted is that the project work has corresponded to directions indicated for accelerated research initiatives by the Mathematics Division of ONR.

Significant Accomplishments and Intended Directions of Effort

The major areas of significant research contributions were linear programming solution theory, convex duality and chance-constrained programming, stochastic and inverse problems, minimum discrimination information theory, data envelopment analysis,
and computational methods. As may be noted, it is intended to continue in these directions of endeavor following the lead of openings suggested by these accomplishments.

Re the call in the Accelerated Initiative that "methods for moving from points interior to the polytope to nearby basic solutions must be discovered," these were already invented by the Principal Investigator and K. Kortanek and W. Raike in 1963 on ONR supported research, have been currently used in published research papers with R. Armstrong and C. Haksever (Ph.D. student of Charnes) in "Implementation of Successive Linear Programming Algorithms for Non-convex Ratio Goals Problems," (CCS Research Report 515) with accepted publication in Computers and Operations Research Journal.

The finding that, contrary to statements of its progenitors, Karmarkar's algorithm movements tend to cling to polytope boundaries was shown in CCS 517, "Karmarkar's Projective Algorithm: A Null Space Variant for Multi-Commodity Generalized Networks," published in Acta Mathematicae Applicatae Sinica of China. In this paper the precise position of each point at each step of the algorithm is analytically given for almost the simplest possible polytope. This shows that having to keep in the interior can be influenced as greatly by local boundaries as are extreme point methods, i.e., instead of creeping along edges in the latter, one may be creeping along just under the surface boundary.

The character of the Karmarkar algorithm as a "barrier" method of the type developed by Fiacco (Ph.D. student of Charnes) and McCormick was first pointed out in CCS 501, "An Explicit Solution Sequence and Convergence of Karmarkar's Algorithm." The idea of using (differential) extrapolation to improve the convergence path of solution presented as new by Karmarkar in a recent TIMS/ORSA meeting was anticipated and published by Fiacco and McCormick 25 years ago in connection with their SUMT algorithm, the first rigorously convergent "barrier" algorithm.

Re ability to handle problems of larger and larger size, cited as a major reason for meaninglessness of the "computational complexity" criterion, the rigorous analysis and
development of requisite data structures for the class of network and general network problems (which are involved in approximately seventy percent of real applications) shows that Karmarkar's scheme cannot compete and becomes impossible for sizes which can be handled by the special extreme point algorithms as developed and employed over the past three decades.

Work is especially active in various directions of Data Envelopment Analysis. As shown in the Charnes, Cooper, Golany, Seiford, Stutz published paper, all the so-called "efficiency measure models" are simply the Charnes-Cooper test for vector (Pareto) or multi-objective optimality. These are employed to develop a generalization of the empirical distribution function process of mathematical statistics in the form of an empirical "production" function. I.e., as with other mathematical statistics estimations, they involve a class of inverse problems---here in multi-objective programming. The study of such stability (and sensitivity analysis of DEA) continues with Dr. L. Neralic, formerly Visiting Professor from the University of Zagreb (See CCS 531, 536, 542, 543, 544, and 545) and Dr. S. Zlobec of McGill University (CCS 560). In particular, the relations between it and multi-objective programming have been pushed forward in work generalizing the CCR ratio model to a semi-infinite programming structure with Visiting Professor Wei of the People's University of China and Ph.D. student Z. Huang (CCS 551). A further extension to normed linear spaces (CCS 575) has just been made by Charnes, Huang and Wei. Besides releasing one from confinement to polyhedral production possibility sets, the new structure may enable one to formulate and develop a stochastic base for DEA theory.

Extensions of this strategy to the so-called "additive" DEA model are underway as well as for the new "extended additive" model just developed (CCS 558). They require new informatics and software developments which are taking place conjointly.

The research in constrained stochastic network analysis (CCS 514) continues with the development of models for multiple aircraft systems which pose significant new problems for complexity reduction and effective computation.
Other work in stochastic and chance-constrained programming analysis and convex duality continues with Professors A. Ben-Tal and M. Teboulle. It is expected also that new efforts, involving variously P. Brockett, M. Wolfe, M. Keane, and L. Seiford, in the area of minimum discrimination information methods in computerized tomography, which can be vital for recovery of information concerning a hostile territory from perimeter measurements, will achieve successful culminations.
Special Awards and Honors


A China State Dinner in the Great Hall of the People, Beijing, China was given by the Ministry of Science and Technology of China in honor of Professor Charnes in connection with his invited lecture tour of China for The State Science and Technology Commission (Ministry); Guangzhou, Guilin, Xian, Tsinghua, Beijing Universities.

Chair, Optimization and Expert Systems session, annual Optimization Days meeting, Montreal, Quebec, May 12 - 15, 1987.

Professor Charnes is an International Advisory Committee Member for the Thirteenth International Symposium on Mathematical Programming, August 29 - September 2, 1988, Tokyo, Japan and has been made chairman and organizer of two sessions there: (1) Applied Game Theory, and (2) Data Envelopment Analysis.

Invited paper for the Gerhard Tintner Memorial Volume.

Two invited papers for the Karl Fox Seventieth Birthday Festschrift.

A 70th birthday Festschrift and meeting in honor of Charnes is slated for 14 - 16 of October 1987 in Austin. The only invited participants are students and lineal academic descendants of students of Charnes. Other 70th birthday events are scheduled for Guadalajara, Mexico at the annual meeting of Academia Nacional de Ingenieria de Mexico, September 22-24, 1987, also at Belgrade/Dubrovnik by Yugoslav Academy of Sciences and Yugoslav Operations Research Society October 6 - 9, 1987, also at International Conference on Combinatorial Optimization and Statistics, Srinagar, India August 17 - 19, 1987.
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