

AD-A100 421

CENTER FOR NAVAL ANALYSES ALEXANDRIA VA
WHAT GOOD ARE WARFARE MODELS?(U)
MAY 81 T E ANGER

F/6 15/7

UNCLASSIFIED

CNA-PP-306

NL

1 of 1
AD A
T 19821

END
DATE
FORMED
7-81
DTIC

PROFESSIONAL PAPER 306 / May 1981

②

LEVEL II

AD A100421

WHAT GOOD ARE WARFARE MODELS?

Thomas E. Anger

DTIC
ELECTE
S JUN 22 1981 D
E

DTIC FILE COPY



CENTER FOR NAVAL ANALYSES

81 6 19 025

12 12

WHAT GOOD ARE WARFARE MODELS?

Thomas E. Anger

14 CNA-71-3D

Accession For	
NIIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	<i>FORM 50 FOR</i>
By _____	
Distribution/ _____	
Availability Codes	
Dist	Avail and/or Special
A	



Office of the President

CENTER FOR NAVAL ANALYSES

2000 North Beauregard Street, Alexandria, Virginia 22311

07727-

2

If in the following pages I seem to express myself dogmatically, it is only because I find it very boring to qualify every phrase with an "I think" or "to my mind." Everything I say is merely an opinion of my own. The reader can take it or leave it. If he has the patience to read what follows he will see that there is only one thing about which I am certain, and that is that there is very little about which one can be certain.

W. Somerset Maugham
The Summing Up

If, as Whitehead said, "the certainty of mathematics depends on its complete abstract generality," the attraction of mathematical models of warfare is their apparent certainty.

Aside from a natural urge for certainty, faith in quantitative models of warfare springs from the experience of World War II, when they seemed to lead to more effective tactics and equipment. But the foundation of this success was not the quantitative methods themselves. Rather, it was the fact that the methods were applied in wartime. Morse and Kimball put it well:

Operations research done separately from an administrator in charge of operations becomes an empty exercise. To be valuable it must be toughened by the repeated impact of hard operational facts and pressing day-by-day demands, and its scale of values must be repeatedly tested in the acid of use. Otherwise it may be philosophy, but it is hardly science.*

Contrast this attitude with the attempts of analysts for the past twenty years to evaluate weapons, forces, and strategies with abstract models of combat. However elegant and internally consistent the models, they have remained as untested and untestable as the postulates of theology.

There is, of course, no valid test to apply to a warfare model. In peacetime, there is no enemy; in wartime, the enemy's actions cannot be controlled. Morse and Kimball, accordingly, urge "hemibel thinking":

Having obtained the constants of the operations under study... we compare the value of the constants obtained in actual operations with the optimum theoretical value, if this can

* Philip M. Morse and George E. Kimball, Methods of Operations Research (Washington, D.C.: Operations Evaluation Group, 1946), p. 10.

be computed. If the actual value is within a hemibel (...a factor of 3) of the theoretical value, then it is extremely unlikely that any improvement in the details of the operation will result in significant improvement. [When] there is a wide gap between the actual and theoretical results...a hint as to the possible means of improvement can usually be obtained by a crude sorting of the operational data to see whether changes in personnel, equipment, or tactics produce a significant change in the constants.*

In other words, combat is not a mathematical process, F.W. Lanchester notwithstanding. One may describe the outcome of combat mathematically, but it is difficult, even after the fact, to determine the variables that made a difference in the outcome.

Much as we would like to fold the many different parameters of a weapon, a force, or a strategy into a single number, we can not. An analyst's notion of which variables matter and how they interact is no substitute for data. Such data as exist, of course, represent observations of discrete events -- usually peacetime events. It remains for the analyst to calibrate the observations, but without a benchmark to go by. Calibration by past battles is a method of reconstruction -- of cutting one of several coats to fit a single form -- but not a method of validation.

Lacking pertinent data, an analyst is likely to resort to models of great complexity. Thus, if useful estimates of detection probabilities are unavailable, the detection process is modeled; if estimates of the outcomes of dogfights are unavailable, aerial combat is reduced to minutiae. Spurious accuracy replaces obvious inaccuracy; untestable hypotheses and unchecked calibrations multiply apace. Yet the analyst claims relative if not absolute accuracy, certifying that he has identified, measured,

*Morse and Kimball, op. cit., p. 38.

and properly linked, a priori, the parameters that differentiate weapons, forces, and strategies.

In the end, "reasonableness" is the only defense of warfare models of any stripe.

It is ironic that analysts must fall back upon the appeal to intuition that has been denied to military men -- whose intuition at least flows from a life-or-death incentive to make good guesses when choosing weapons, forces, or strategies.

It is not surprising, however, that analysts must finally appeal to intuition. A warfare model, like any system of formal logic, is ineluctably incomplete: It cannot prove itself or define the truths lying outside the reach of its axioms and rules of inference. One must go outside a warfare model for its proof, which, given the impossibility of validation, throws the analyst back on intuition. Nor does sensitivity analysis save the day; at best, it illuminates faintly the boundaries of a model, without establishing the truth or falsity of what lies on either side of the boundaries. A political observer, in another connection, put it more elegantly:

The power of analysis, of course, has its limits. Intense assessment of the shots on the board misses the shots that are not on the board -- the truly revolutionary departures that bend the course of history.*

In short, it is impossible to quantify warfare without having a war to quantify. Only then are there data embodying the true complexities of combat. No number of iterations of a warfare model can create such data. Zero a thousand times is still zero.

*Joseph Kraft, "Lippmann: Yesterday, Today, and Tomorrow," Washington Post September 11, 1980.

What good, then, are our models of warfare? If there is no salvation in complexity, must we retreat into solipsism? Has the work of two decades been for nothing?

If the power of quantitative analysis had not been overrated and oversold by Mr. McNamara, it might be unnecessary to answer -- or even ask -- such questions. The "McNamara revolution" was a victory not for quantitative analysis, but for the intuitions of civilian analysts over those of professional warriors. One result of this upheaval was a blurring of the line between quantitative analysis and policy-making. Policies appeared to spring full-blown from quantitative analysis, demonstrating once more that analysis done with a conclusion in mind is bound to seem conclusive -- at least at first glance. It is no wonder that some thought civilian analysts "could invoke the contemporary resources of mathematics...to perfect... managerial magic."*

It is improbable that such naivete infected the military leaders of the day. They, no doubt, understood that Mr. McNamara was using quantitative analysis as a means of establishing his dominance by finding their proposals wanting for reasons military, not budgetary.** Eventually, however, the military was forced to back its qualitative arguments with quantitative "evidence," which the civilians -- given the last word in nearly every dispute -- could pick apart at will.

The civilians, of course, chose to view their ability to pick apart the services' studies as evidence of the inferiority of the services' brand of analysis. What the civilians had, in fact, demonstrated was the wisdom

* Arthur M. Schlesinger, Jr., A Thousand Days (Boston: Houghton Mifflin Company, 1965), p. 127.

** See Arnold Kanter, Defense Politics (Chicago: The University of Chicago Press, 1979), pp. 87-91.

of "hemibel thinking" -- of relying on quantitative analysis for only a "crude sorting" of alternatives, not a judgment of which was "best."

Should we really attach little significance to differences of less than a hemibel? Consider a five-parameter model, involving the conditional probabilities of detecting, shooting at, hitting, and killing an opponent -- and surviving, in the first place, to do any of these things. Such a model might easily yield a cumulative error of a hemibel, given a twenty-five percent error in each parameter. My intuition is that one would be lucky if relative errors in the probabilities assigned to alternative weapons and forces were as low as twenty-five percent.

Some may protest that quantitative analyses of warfare alternatives are not helpful if we cannot claim for them greater accuracy than a hemibel. On the contrary, only by admitting the inaccuracy of such analysis can we help to turn decision-makers from the futile and fitful search of two decades for the "best" defense posture to the deliberate achievement of a "good" one -- and give the lie to decision-makers who would evade responsibility for their choices by hiding behind analytical half-truths.

If our clients are disappointed that we do not always have answers, we should remind them that there are no answers -- only difficult choices. We do not help them to make better choices by pretending to know what is beyond our ken.

Newton said it best:

I do not know what I may appear to the world, but to myself
I seem to have been only like a boy playing on the seashore,
and diverting myself in now and then finding a smoother
pebble or a prettier shell than ordinary, whilst the great
ocean of truth lay all undiscovered before me.*

*Quoted in Horace Freeland Julson, The Search for Solutions (New York: Holt, Rinehart and Winston, 1980), p. 5.

As Newton's self-doubt was not an attack on science, neither have I essayed an attack on quantitative analysis -- only on the abuses of it that are too often found in the company of warfare models. It is too easily forgotten, by analysts and decision-makers alike, that warfare modeling is an art, not a science. With this art we may portray vividly the few pebbles and shells of truth that we have grasped; we can but vaguely sketch the ocean of warfare whose horizons are beyond our reach.

CNA Professional Papers — 1976 to Present†

- PP 141
Mizrahi, Maurice M. "Generalized Hermite Poly nomials." 5 pp., Feb 1976 (Reprinted from the Journal of Computational and Applied Mathematics, Vol. 1, No. 4 (1975), 273-277).
*Research supported by the National Science Foundation
- PP 143
Horowitz, Stanley and Sherman, Allan (LCDr, USN). "Maintenance Personnel Effectiveness in the Navy." 33 pp., Jan 1976 (Presented at the RAND Conference on Defense Manpower, Feb 1976) AD A021 581
- PP 144
Durch, William J. "The Navy of the Republic of China - History, Problems, and Prospects." 66 pp., Aug 1976 (Published in "A Guide to Asiatic Fleets, ed. by Barry M. Blechman and Robert Berman, Naval Institute Press) AD A030 460
- PP 145
Kelly, Anne M. "Port Visits and the "Internationalist Mission" of the Soviet Navy." 36 pp., Apr 1976. AD A023 436
- PP 147
Kessler, J. Christian. "Legal Issues in Protecting Offshore Structures." 33 pp., Jun 1976 (Prepared under task order N00014-68-A-0091-0023 for ONR) AD A028 389
- PP 149
Squires, Michael L. "Counterforce Effectiveness: A Comparison of the Tsipis "K" Measure and a Computer Simulation." 24 pp., Mar 1976 (Presented at the International Study Association Meetings, 27 Feb 1976) AD A022 591
- PP 150
Kelly, Anne M. and Petersen, Charles. "Recent Changes in Soviet Naval Policy: Prospects for Arms Limitations in the Mediterranean and Indian Ocean." 28 pp., Apr 1976. AD A 023 723
- PP 151
Horowitz, Stanley A. "The Economic Consequences of Political Philosophy." 8 pp., Apr 1976 (Reprinted from Economic Inquiry, Vol. XIV, No. 1, Mar 1976)
- PP 152
Mizrahi, Maurice M. "On Path Integral Solutions of the Schrodinger Equation, Without Limiting Procedure." 10 pp., Apr 1976 (Reprinted from Journal of Mathematical Physics, Vol. 17, No. 4 (Apr 1976), 566-576)
*Research supported by the National Science Foundation
- PP 153
Mizrahi, Maurice M. "WKB Expansions by Path Integrals, With Applications to the Anharmonic Oscillator." 137 pp May 1976. AD A025 440
*Research supported by the National Science Foundation
- PP 154
Mizrahi, Maurice M. "On the Semi-Classical Expansion in Quantum Mechanics for Arbitrary Hamiltonians." 19 pp., May 1976 (Published in Journal of Mathematical Physics, Vol. 18, No. 4, pp. 789-790, Apr 1977). AD A025 441
- PP 155
Squires, Michael L. "Soviet Foreign Policy and Third World Nations." 26 pp., Jun 1976 (Prepared for presentation at the Midwest Political Science Association meetings, Apr 30, 1976) AD A028 388
- PP 156
Stallings, William. "Approaches to Chinese Character Recognition." 12 pp., Jun 1976 (Reprinted from Pattern Recognition (Pergamon Press), Vol. 8, pp. 87-98, 1976) AD A028 692
- PP 157
Morgan, William F. "Unemployment and the Pentagon Budget: Is There Anything in the Empty Park Barrel?" 20 pp., Aug 1976 AD A030 455
- PP 158
Haskell, LCDr Richard D. (USN). "Experimental Validation of Probability Predictions." 25 pp., Aug 1976 (Presented at the Military Operations Research Society Meeting, Fall 1976) AD A030 458
- PP 159
McConnell, James M. "The Gorshkov Articles: The New Gorshkov Book and Their Relation to Policy." 93 pp., Jul 1976 (Published in Soviet Naval Influence: Domestic and Foreign Dimensions, ed. by M. McGwire and J. McDonnell, New York: Praeger, 1977) AD A029 227
- PP 160
Wilson, Desmond P., Jr. "The U.S. Sixth Fleet and the Conventional Defense of Europe." 50 pp., Sep 1976. AD A030 457
- PP 161
Melch, Michael E. and Peet, Vice Adm Ray (USN Retired). "Fleet Commanders: Afloat or Ashore?" 9 pp., Aug 1976 (Reprinted from U.S. Naval Institute Proceedings, Jun 1976) AD A030 456
- PP 162
Friedheim, Robert L. "Parliamentary Diplomacy." 106 pp Sep 1976 AD A033 306
- PP 163
Lockman, Robert F. "A Model for Predicting Recruit Losses." 9 pp., Sep 1976 (Presented at the 84th annual convention of the American Psychological Association, Washington, D.C., 4 Sep 1976) (Published in Defense Manpower Policy (Richard V. L. Cooper, ed.) The Rand Corporation, 1979) AD A030 459
- PP 164
Mahoney, Robert B., Jr. "An Assessment of Public and Elite Perceptions in France, The United Kingdom, and the Federal Republic of Germany." 31 pp., Feb 1977 (Presented at Conference "Perception of the U.S. - Soviet Balance and the Political Uses of Military Power" sponsored by Director, Advanced Research Projects Agency, April 1976) AD A036 599
- PP 165
Jondrow, James M. "Effects of Trade Restrictions on Imports of Steel." 67 pp., November 1976. (Delivered at ILAB Conference in Dec 1976) AD A094 798
- PP 166 - Revised
Feldman, Paul. "Why It's Difficult to Change Regulation." Oct 1976 AD A037 682
- PP 167
Kleinman, Samuel. "ROTC Service Commitments a Comment." 4 pp., Nov 1976. (Published in Public Choice, Vol. XXIV, Fall 1976) AD A033 305
- PP 168
Lockman, Robert F. "Revalidation of CNA Support Personnel Selection Measures." 36 pp., Nov 1976
- PP 169
Jacobson, Louis S. "Earnings Losses of Workers Displaced from Manufacturing Industries." 38 pp., Nov 1976. (Delivered at ILAB Conference in Dec 1976). AD A039 809
- PP 170
Brechling, Frank P. "A Time Series Analysis of Labor Turnover." Nov 1976 (Delivered at ILAB Conference in Dec 1976). AD A096 630
- PP 171
Jordan, A. S.* and Halston, J. M. "A Diffusion Model for GaP Red LED Degradation." 10 pp., Nov 1976 (Published in Journal of Applied Physics Vol. 47, pp. 4518-4527, Oct 1976)
*Bell Laboratories
- PP 172
Classen, Kathleen P. "Unemployment Insurance and the Length of Unemployment, Jr 1976 (Presented at the University of Rochester Labor Workshop on 16 Nov 1976)
- PP 173
Kleinman, Samuel D. "A Note on Racial Differences in the Added Worker/Discouraged Worker Controversy." 2 pp., Dec 1976. (Published in the American Economist, Vol. XX, No. 1, Spring 1976)
- PP 174
Mahoney, Robert B., Jr. "A Comparison of the Brookings and International Incidents Projects." 12 pp. Feb 1977 AD A037 206
- PP 175
Levine, Daniel Stolloff, Peter and Sprull, Nancy. "Public Drug Treatment and Addict Crime." June 1976. (Published in Journal of Legal Studies, Vol. 5, No. 2)
- PP 176
Felix, Wendi. "Correlates of Retention and Promotion for USNA Graduates." 38 pp., Mar 1977 AD A039 040
- PP 177
Lockman, Robert F. and Warner, John T. "Predicting Attrition: A Test of Alternative Approaches." 33 pp Mar 1977 (Presented at the OSD/ONR Conference on Enlisted Attrition, Xerox International Training Center, Leesburg, Virginia, 4-7 April 1977). AD A039 047
- PP 178
Kleinman, Samuel D. "An Evaluation of Navy Unrestricted Line Officer Accession Programs." 23 pp April 1977. (Presented at the NATO Conference on Manpower Planning and Organization Design, Stresa, Italy, 20 June 1977). AD A039 048

†CNA Professional Papers with an AD number may be obtained from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22151. Other papers are available from the Management Information Office, Center for Naval Analysis, 2000 North Beauregard Street, Alexandria, Virginia 22311. An Index of Selected Publications is also available on request. The index includes a Listing of Professional Papers; with abstracts; issued from 1969 to June 1980.

- PP 179
Stoloff, Peter H. and Balut, Stephen J., "Vacate: A Model for Personnel Inventory Planning Under Changing Management Policy," 14 pp., April 1977. (Presented at the NATO Conference on Manpower Planning and Organization Design, Stresa, Italy, 20 June 1977). AD A039 049
- PP 180
Horowitz, Stanley A. and Sherman, Allan, "The Characteristics of Naval Personnel and Personnel Performance," 16 pp., April 1977. (Presented at the NATO Conference on Manpower Planning and Organization Design, Stresa, Italy, 20 June 1977). AD A039 050
- PP 181
Balut, Stephen J. and Stoloff, Peter, "An Inventory Planning Model for Navy Enlisted Personnel," 39 pp., May 1977. (Prepared for presentation at the Joint National Meeting of the Operations Research Society of America and The Institute for Management Science, 9 May 1977, San Francisco, California). AD A042 221
- PP 182
Murray, Russell, 2nd, "The Quest for the Perfect Study or My First 1138 Days at CNA," 57 pp., April 1977
- PP 183
Kassing, David, "Changes in Soviet Naval Forces," 33 pp., November, 1976. (Published as part of Chapter 3, "General Purpose Forces, Navy and Marine Corps," in Arms, Men, and Military Budgets, Francis P. Hoerber and William Schneider, Jr. (eds.), (Crane, Russak & Company, Inc., New York, 1977). AD A040 106
- PP 184
Lockman, Robert F., "An Overview of the OSD, ONR Conference on First Term Enlisted Retention," 22 pp., June 1977. (Presented to the 9th MORS Working Group on Manpower and Personnel Planning, Annapolis, Md., 28-30 Jun 1977). AD A043 618
- PP 185
Kassing, David, "New Technology and Naval Forces in the South Atlantic," 22 pp. (This paper was the basis for a presentation made at the Institute for Foreign Policy Analyses, Cambridge, Mass., 28 April 1977). AD A043 619
- PP 186
Mizrahi, Maurice M., "Phase Space Integrals Without Limiting Procedure," 31 pp., May 1977. (Invited paper presented at the 1977 NATO Institute on Path Integrals and Their Applications in Quantum Statistical and Solid State Physics, Antwerp, Belgium, July 17-30, 1977). (Published in Journal of Mathematical Physics, 1978, pp. 298-307, Jan 1978, with Erratum in same journal 21 (1980), p. 1965). AD A040 107
- PP 187
Coile, Russell C., "Nomography for Operations Research," 35 pp., April 1977. (Presented at the Joint National Meeting of the Operations Research Society of America and The Institute for Management Science, San Francisco, California, 9 May 1977). AD A043 620
- PP 188
Durrh, William J., "Information Processing and Outcome Forecasting for Multilateral Negotiations: Testing One Approach," 53 pp., May 1977. (Prepared for presentation to the 18th Annual Convention of the International Studies Association, Chase Park Plaza Hotel, St. Louis, Missouri, March 18-20, 1977). AD A042 227
- PP 189
Coile, Russell C., "Error Detection in Computerized Information Retrieval Data Bases," July, 1977, 13 pp. (Presented at the Sixth Cranfield International Conference on Mechanized Information Storage and Retrieval Systems, Cranfield Institute of Technology, Cranfield, Bedford, England, 26-29 July 1977). AD A043 580
- PP 190
Mahoney, Robert B., Jr., "European Perceptions and East-West Competition," 96 pp., July 1977. (Prepared for presentation at the annual meeting of the International Studies Association, St. Louis, Mo., March 1977). AD A043 661
- PP 191
Sawyer, Ronald, "The Independent Field Assignment: One Man's View," August 1977, 25 pp.
- PP 192
Holen, Arlene, "Effects of Unemployment Insurance Entitlement on Duration and Job Search Outcome," August 1977, 6 pp. (Reprinted from Industrial and Labor Relations Review, Vol. 30, No. 4, Jul 1977)
- PP 193
Horowitz, Stanley A., "A Model of Unemployment Insurance and the Work Test," August 1977, 7 pp. (Reprinted from Industrial and Labor Relations Review, Vol. 30, No. 40, Jul 1977)
- PP 194
Clayton, Kathleen P., "The Effects of Unemployment Insurance on the Duration of Unemployment and Subsequent Earnings," August 1977, 7 pp. (Reprinted from Industrial and Labor Relations Review, Vol. 30, No. 40, Jul 1977)
- PP 195
Brechtling, Frank, "Unemployment Insurance Taxes and Labor Turnover: Summary of Theoretical Findings," 12 pp. (Reprinted from Industrial and Labor Relations Review, Vol. 30, No. 40, Jul 1977)
- PP 196
Kathion, J. M. and Lorimer, O. G., "Degradation of Bulk Electroluminescent Efficiency in Zn, O-Doped GaP LEDs," July 1977, 3 pp. (Reprinted from IEEE Transactions on Electron Devices, Vol. ED 24, No. 7, July 1977)
- PP 197
Wells, Anthony R., "The Centre for Naval Analyses," 14 pp., Dec. 1977. AD A049 107
- PP 198
Clayton, Kathleen P., "The Distributional Effects of Unemployment Insurance," 25 pp., Sept. 1977. (Presented at a Hoover Institution Conference on Income Distribution, Oct. 7-8, 1977). AD A054 423
- PP 199
Durrh, William J., "Revolution From A F A R: The Cuban Armed Forces in Africa and the Middle East," Sep 1977, 15 pp. AD A046 268
- PP 200
Powers, Bruce F., "The United States Navy," 40 pp., Dec. 1977. (Published as a chapter in The U.S. War Machine by Salamander Books, England, 1978). AD A049 108
- PP 201
Durrh, William J., "The Cuban Military in Africa and The Middle East: From Algeria to Angola," Sep 1977, 87 pp. AD A045 675
- PP 202
Feldman, Paul, "Why Regulation Doesn't Work" (Reprinted from Technological Change and Welfare in the Regulated Industries, Brookings Reprint 219, 1971, and Review of Social Economy, Vol. XXIX, March, 1971, No. 1.) Sep 1977, 8 pp.
- PP 203
Feldman, Paul, "Efficiency, Distribution, and the Role of Government in a Market Economy," (Reprinted from The Journal of Political Economy, Vol. 79, No. 3, May/June 1971.) Sep 1977, 19 pp. AD A045 675
- PP 204
Wells, Anthony R., "The 1967 June War: Soviet Naval Diplomacy and The Sixth Fleet - A Reappraisal," Oct 1977, 36 pp. AD A047 236
- PP 205
Coile, Russell C., "A Bibliometric Examination of the Square Root Theory of Scientific Publication Productivity," (Presented at the annual meeting of the American Society for Information Science, Chicago, Illinois, 29 September 1977.) Oct 1977, 6 pp. AD A047 237
- PP 206
McConnell, James M., "Strategy and Missions of the Soviet Navy in the Year 2000," 48 pp., Nov 1977. (Presented at a Conference on Problems of Sea Power as we Approach the 21st Century sponsored by the American Enterprise Institute for Public Policy Research, 6 October 1977, and subsequently published in a collection of papers by the Institute). AD A047 244
- PP 207
Goldberg, Lawrence, "Cost Effectiveness of Potential Federal Policies Affecting Research & Development: Expenditures in the Auto, Steel and Food Industries," 36 pp., Oct 1977. (Presented at Southern Economic Association Meetings beginning 2 November 1977). AD A046 269
- PP 208
Roberts, Stephen S., "The Decline of the Overseas Station Fleets: The United States Asiatic Fleet and the Shanghai Crisis 1932," 18 pp., Nov 1977. (Reprinted from The American Neptune, Vol. XXXVII, No. 3, July 1977). AD A047 245
- PP 209
Classified
- PP 210
Kassing, David, "Protecting The Fleet," 40 pp., Dec 1977. (Prepared for the American Enterprise Institute Conference on Problems of Sea Power as We Approach the 21st Century, October 6-7, 1977). AD A049 109
- PP 211
Mizrahi, Maurice M., "On Approximating the Circular Coverage Function," 14 pp., Feb 1978, AD A054 479
- PP 212
Mangel, Marc, "On Singular Characteristic Initial Value Problems with Unique Solutions," 20 pp., Jun 1978, AD A058 535
- PP 213
Mangel, Marc, "Fluctuations in Systems with Multiple Steady States: Application to Lancheester Equations," 12 pp., Feb 78. (Presented at the First Annual Workshop on the Information Linkage Between Applied Mathematics and Industry, Naval PG School, Feb 23-25, 1978). AD A071 472

- PP 214
Weinland, Robert G., "A Somewhat Different View of The Optimal Naval Posture," 37 pp., Jun 1978 (Presented at the 1976 Convention of the American Political Science Association (APSA) Panel on "Changing Strategic Requirements and Military Posture"), Chicago, Ill., September 2, 1976), AD A056 228
- PP 215
Coile, Russell C., "Comments on Principles of Information Retrieval by Manfred Kochen," 10 pp., Mar 78, (Published as a Letter to the Editor, Journal of Documentation, Vol. 31, No. 4, pages 298-301, December 1975), AD A054 426
- PP 216
Coile, Russell C., "Lotka's Frequency Distribution of Scientific Productivity," 18 pp., Feb 1978, (Published in the Journal of the American Society for Information Science Vol. 28, No. 6, pp. 366-370, November 1977), AD A054 425
- PP 217
Coile, Russell C., "Bibliometric Studies of Scientific Productivity," 17 pp., Mar 78, (Presented at the Annual meeting of the American Society for Information Science held in San Francisco, California, October 1976), AD A054 442
- PP 218 - Classified
- PP 219
Huntzinger, R. LaVar, "Market Analysis with Rational Expectations. Theory and Estimation," 60 pp., Apr 78, AD A054 422
- PP 220
Maurer, Donald E., "Diagonalization by Group Matrices," 26 pp., Apr 78, AD A054 443
- PP 221
Weinland, Robert G., "Superpower Naval Diplomacy in the October 1973 Arab Israeli War," 76 pp., Jun 1978 (Published in *Seapower in the Mediterranean: Political Utility and Military Constraints*, The Washington Papers No. 61, Beverly Hills and London: Sage Publications, 1979), AD A055 564
- PP 222
Mizrah, Maurice M., "Correspondence Rules and Path Integrals," 30 pp., Jun 1978 (Invited paper presented at the CNRS meeting on "Mathematical Problems in Feynman's Path Integrals," Marseille, France, May 22-26, 1978) (Published in Springer Verlag Lecture Notes in Physics, 106, (1979) 234-253) AD A055 536
- PP 223
Mangel, Marc, "Stochastic Mechanics of Molecule Ion Molecule Reactions," 21 pp., Jun 1978, AD A056 227
- PP 224
Mangel, Marc, "Aggregation, Bifurcation, and Extinction in Exploited Animal Populations," 48 pp., Mar 1978, AD A058 536
*Portions of this work were started at the Institute of Applied Mathematics and Statistics, University of British Columbia, Vancouver, B.C., Canada
- PP 225
Mangel, Marc, "Oscillations, Fluctuations, and the Hopf Bifurcation," 43 pp., Jun 1978, AD A058 537
*Portions of this work were completed at the Institute of Applied Mathematics and Statistics, University of British Columbia, Vancouver, Canada
- PP 226
Ralston, J. M. and J. W. Mann, "Temperature and Current Dependence of Degradation in Red Emitting GaP LEDs," 34 pp., Jun 1978 (Published in *Journal of Applied Physics*, 50, 3630, May 1979), AD A058 538
*Bell Telephone Laboratories, Inc.
- PP 227
Mangel, Marc, "Uniform Treatment of Fluctuations at Critical Points," 50 pp., May 1978, AD A058 539
- PP 228
Mangel, Marc, "Relaxation at Critical Points: Deterministic and Stochastic Theory," 54 pp., Jun 1978, AD A058 540
- PP 229
Mangel, Marc, "Diffusion Theory of Reaction Rates. I. Formulation and Einstein-Smoluchowski Approximation," 50 pp., Jan 1978, AD A058 541
- PP 230
Mangel, Marc, "Diffusion Theory of Reaction Rates. II. Ornstein-Uhlenbeck Approximation," 34 pp., Feb 1978, AD A058 542
- PP 231
Wilson, Desmond P. Jr., "Naval Projection Forces: The Case for a Responsive MAF," Aug 1978, AD A058 543
- PP 232
Jacobson, Louis, "Can Policy Changes Be Made Acceptable to Labor?" Aug 1978 (Submitted for publication in *Industrial and Labor Relations Review*), AD A061 528
- PP 233
Jacobson, Louis, "An Alternative Explanation of the Cyclical Pattern of Quites," 23 pp., Sep 1978
- PP 234 Revised
Jandrow, James and Levy, Robert A., "Does Federal Expenditure Displace State and Local Expenditure: The Case of Construction Grants," 25 pp., Oct 1979, AD A061 529
- PP 235
Mizrah, Maurice M., "The Semiclassical Expansion of the Anharmonic Oscillator Propagator," 41 pp., Oct 1978 (Published in *Journal of Mathematical Physics* 20 (1979), pp. 844-855), AD A061 538
- PP 237
Maurer, Donald, "A Matrix Criterion for Normal Integral Bases," 10 pp., Jan 1979 (Published in the *Illinois Journal of Mathematics*, Vol. 22 (1978), pp. 672-681)
- PP 238
Ittgoff, Kathleen Clasen, "Unemployment Insurance and The Employment Rate," 20 pp., Oct 1978 (Presented at the Conference on Economic Indicators and Performance: The Current Dilemma Facing Government and Business Leaders, presented by Indiana University Graduate School of Business), AD A061 527
- PP 239
Trost, R. P. and Warner, J. T., "The Effects of Military Occupational Training on Civilian Earnings: An Income Selectivity Approach," 38 pp., Nov 1979, AD A077 831
- PP 240
Powers, Bruce, "Goals of the Center for Naval Analyses," 13 pp., Dec 1978, AD A061 759
- PP 241
Mangel, Marc, "Fluctuations at Chemical Instabilities," 24 pp., Dec 1978 (Published in *Journal of Chemical Physics*, Vol. 69, No. 8 Oct 15, 1978), AD A063 787
- PP 242
Simpson, William R., "The Analysis of Dynamically Interactive Systems (Air Combat by the Numbers)," 160 pp., Dec 1978, AD A063 760
- PP 243
Simpson, William R., "A Probabilistic Formulation of Murphy Dynamics as Applied to the Analysis of Operational Research Problems," 18 pp., Dec 1978, AD A063 761
- PP 244
Sherman, Allan and Horowitz, Stanley A., "Maintenance Costs of Complex Equipment," 20 pp., Dec 1978 (Published By The American Society of Naval Engineers, *Naval Engineers Journal*, Vol. 91 No. 6, Dec 1979) AD A071 473
- PP 245
Simpson, William R., "The Accelerometer Methods of Obtaining Aircraft Performance from Flight Test Data (Dynamic Performance Testing)," 403 pp., Jun 1979, AD A075 226
- PP 246
Brechtling, Frank, "Layoffs and Unemployment Insurance," 35 pp., Feb 1979 (Presented at the NBER Conference on "Low Income Labor Markets," Chicago, Jun 1978), AD A096 629
- PP 248
Thomas, James A., Jr., "The Transport Properties of Dilute Gases in Applied Fields," 183 pp., Mar 1979, AD A096 464
- PP 249
Glasser, Kenneth S., "A Secretary Problem with a Random Number of Choices," 23 pp., Mar 1979
- PP 250
Mangel, Marc, "Modeling Fluctuations in Macroscopic Systems," 26 pp., Jun 1979
- PP 251
Trost, Robert P., "The Estimation and Interpretation of Several Selectivity Models," 37 pp., Jun 1979, AD A075 941
- PP 252
Nunn, Walter R., "Position Finding with Prior Knowledge of Covariance Parameters," 5 pp., Jun 1979 (Published in *IEEE Transactions on Aerospace & Electronic Systems*, Vol. AES-15, No. 3, March 1979)
- PP 253
Glasser, Kenneth S., "The d-Choice Secretary Problem," 32 pp., Jun 1979, AD A075 225
- PP 254
Mangel, Marc and Quanbeck, David B., "Integration of a Bivariate Normal Over an Offset Circle," 14 pp., Jun 1979, AD A096 471
- PP 255 - Classified, AD B051 441L
- PP 256
Maurer, Donald E., "Using Personnel Distribution Models," 27 pp., Feb 1980, AD A082 218

- PP 257
Thaler, R. "Discounting and Fiscal Constraints Why Discounting is Always Right," 10 pp., Aug 1979, AD A075 224
- PP 258
Mangel, Marc S. and Thomas, James A., Jr. "Analytical Methods in Search Theory," 86 pp., Nov 1979, AD A077 832
- PP 259
Glass, David V., Hsu, Ih-Ching, Nurn, Walter R. and Perin, David A., "A Class of Commutative Markov Matrices," 17 pp., Nov 1979, AD A077 833
- PP 260
Mangel, Marc S. and Cope, Davis K., "Detection Rate and Sweep Width in Visual Search," 14 pp., Nov 1979, AD A077 834
- PP 261
Vila, Carlos L., Zvijac, David J. and Ross, John, "Franck Condon Theory of Chemical Dynamics. VI. Angular Distributions of Reaction Products," 14 pp., Nov 1979 (Reprinted from Journal Chem Phys. 70(12), 15 Jun 1979), AD A076 287
- PP 262
Peterson, Charles C. "Third World Military Elites in Soviet Perspective," 50 pp. Nov 1979, AD A077 835
- PP 263
Robinson, Kathy I., "Using Commercial Tankers and Containerships for Navy Underway Replenishment," 25 pp., Nov 1979, AD A077 836
- PP 264
Weinland, Robert G., "The U.S. Navy in the Pacific Past, Present, and Glimpses of the Future," 31 pp. Nov 1979 (Delivered at the International Symposium on the Sea sponsored by the International Institute for Strategic Studies, The Brookings Institution and the Yomuri Shimbun, Tokyo, 16-20 Oct 1978), AD A066 837
- PP 265
Weinland, Robert G., "War and Peace in the North: Some Political Implications of the Changing Military Situation in Northern Europe," 18 pp. Nov 1979 (Prepared for presentation to the "Conference of the Nordic Balance in Perspective: The Changing Military and Political Situation," Center for Strategic and International Studies, Georgetown University, Jun 15-16, 1978), AD A077 838
- PP 266
Utgoff, Kathy Classen and Brechling, Frank, "Taxes and Inflation," 25 pp. Nov 1979, AD A081 194
- PP 267
Trout, Robert P. and Vogel, Robert C., "The Response of State Government Receipts to Economic Fluctuations and the Allocation of Counter Cyclical Revenue Sharing Grants," 12 pp., Dec 1979 (Reprinted from the Review of Economics and Statistics Vol. LXI No. 3 August 1979)
- PP 268
Thomson, James S., "Seaport Dependence and Inter-State Cooperation: The Case of Sub-Saharan Africa," 141 pp., Jan 1980, AD A081 193
- PP 269
Weiss, Kenneth G., "The Soviet Involvement in the Ogaden War," 42 pp., Jan 1980 (Presented at the Southern Conference on Slavic Studies in October 1979), AD A082 219
- PP 270
Remnek, Richard, "Soviet Policy in the Horn of Africa: The Decision to Intervene," 52 pp., Jan 1980 (To be published in "The Soviet Union in the Third World: Success or Failure," ed by Robert H. Donaldson, Westview Press, Boulder, Co., Summer 1980), AD A081 195
- PP 271
McConnell, James, "Soviet and American Strategic Doctrines: One More Time," 43 pp., Jan 1980, AD A081 192
- PP 272
Weiss, Kenneth G., "The Azores in Diplomacy and Strategy, 1940-1945," 46 pp., Mar 1980, AD A085 094
- PP 273
Nakada, Michael K., "Labor Supply of Wives with Husbands Employed Either Full Time or Part Time," 39 pp., Mar 1980, AD A082 220
- PP 275
Goldberg, Lawrence, "Recruiters Advertising and Navy Enlistments," 34 pp., Mar 1980, AD A082 221
- PP 276
Goldberg, Lawrence, "Delaying an Overhaul and Ship's Equipment," 40 pp., May 1980, AD A085 095
- PP 277
Mangel, Marc, "Small Fluctuations in Systems with Multiple Limit Cycles," 19 pp., Mar 1980 (Published in SIAM J. Appl. Math., Vol. 38, No. 1, Feb 1980), AD A086 229
- PP 278
Mizrahi, Maurice, "A Targeting Problem: Exact vs. Expected Value Approaches," 23 pp., Apr 1980, AD A085 096
- PP 279
Walt, Stephen M., "Causal Inferences and the Use of Force: A Critique of Force Without War," 50 pp., May 1980, AD A085 097
- PP 280
Goldberg, Lawrence, "Estimation of the Effects of A Ship's Steaming on the Failure Rate of its Equipment: An Application of Econometric Analysis," 25 pp., April 1980, AD A085 098
- PP 281
Mizrahi, Maurice M., "Comment on 'Discretization Problems of Functional Integrals in Phase Space,'" 2 pp., May 1980, AD A094 994
- PP 283
Dismukes, Bradford, "Expected Demand for the U.S. Navy to Serve as An Instrument of U.S. Foreign Policy: Thinking About Political and Military Environmental Factors," 30 pp., April 1980, AD A085 099
- PP 284
J. Keilson,* W. Nunn, and U. Sumita,** "The Laguerre Transform," 119 pp., May 1980
*The Graduate School of Management, University of Rochester and the Center for Naval Analyses
**The Graduate School of Management, University of Rochester, AD A085 100
- PP 285
Remnek, Richard B., "Superpower Security Interests in the Indian Ocean Area," 26 pp., Jun 1980, AD A087 113
- PP 286
Mizrahi, Maurice M., "On the WKB Approximation to the Propagator for Arbitrary Hamiltonians," 25 pp., Aug 1980 (Published in Journal of Math. Phys., 22 (1) Jan 1981), AD A091 307
- PP 287
Cope, Davis, "Limit Cycle Solutions of Reaction-Diffusion Equations," 325 pp., Jun 1980, AD A087 114
- PP 288
Golman, Walter, "Don't Let Your Slides Flip You: A Painless Guide to Visuals That Really Aid," 28 pp., Oct 1980
- PP 289
Robinson, Jack, "Adequate Classification Guidance - A Solution and a Problem," 7 pp., Aug 1980, AD A091 212
- PP 290
Watson, Gregory H., "Evaluation of Computer Software in an Operational Environment," 17 pp., Aug 1980, AD A091 213
- PP 291
Maddala, G. S.* and Trost, R. P., "Some Extensions of the Nerlove-Press Model," 17 pp., Oct 1980, AD A091 946
*University of Florida
- PP 292
Thomas, Jr., James A., "The Transport Properties of Binary Gas Mixtures in Applied Magnetic Fields," 10 pp., Sept 1980 (Published in Journal of Chemical Physics 72 (10), 15 May 1980)
- PP 293
Thomas, Jr., James A., "Evaluation of Kinetic Theory Collision Integrals Using the Generalized Phase Shift Approach," 12 pp., Sept 1980 (Printed in Journal of Chemical Physics 72 (10), 15 May 1980)
- PP 294
Roberts, Stephen S., "French Naval Policy Outside of Europe," 30 pp., Sept 1980 (Presented at the Conference of the Section on Military Studies, International Studies Association, Kiawah Island, S.C.), AD A091 306
- PP 295
Roberts, Stephen S., "An Indicator of Informal Empire: Patterns of U.S. Navy Cruising on Overseas Stations, 1869-1897," 40 pp., Sept 1980 (Presented at Fourth Naval History Symposium, US Naval Academy, 26 October 1979, AD A091 316)
- PP 296
Dismukes, Bradford and Peterson, Charles C., "Maritime Factors Affecting Iberian Security," (Factores Maritimos Que Afectan La Seguridad Iberica) 14 pp., Oct 1980, AD A092 733
- PP 297 - Classified
- PP 298
Mizrahi, Maurice M., "A Markov Approach to Large Missile Attacks," 31 pp., Jan 1981, AD A096 159
- PP 299
Jondrow, James M. and Robert A. Levy, "Wage Leadership in Construction," 19 pp., Jan 1981, AD A084 797

PP 300

Jondrow, James and Peter Schmidt*, "On the Estimation of Technical Inefficiency in the Stochastic Frontier Production Function Model," 11 pp., Jan 1981, AD A096 159
*Michigan State University

PP 301

Jondrow, James M.; Levy, Robert A. and Hughes, Claire, "Technical Change and Employment in Steel, Autos, Aluminum, and Iron Ore, 17 pp., Mar 1981

PP 302

Jondrow, James M. and Levy, Robert A., "The Effect of Imports on Employment Under Rational Expectations," 19 pp., Apr 1981

PP 304

Duffy, Michael K.; Greenwood, Michael J.* and McDowell, John M.**, "A Cross-Sectional Model of Annual Interregional Migration and Employment Growth: Intertemporal Evidence of Structural Change, 1958-1975," 31 pp., Apr 1981
*University of Colorado
**Arizona State University

PP 305

Nunn, Laura H., "An Introduction to the Literature of Search Theory," 32 pp., Jun 1981

PP 306

Anger, Thomas E., "What Good Are Warfare Models?" 7 pp., May 1981

PP 309

Weinland, Robert G., "An (The?) Explanation of the Soviet Invasion of Afghanistan," 44 pp., May 1981

PP 310

Stanford, Janette M. and Tai Te Wu*, "A Predictive Method for Determining Possible Three-dimensional Foldings of Immunoglobulin Backbones Around Antibody Combining Sites," 19 pp., Jun 1981
(Published in J. theor. Biol. (1981) 88, 421-439
*Northwestern University, Evanston, IL

PP 311

Marianne Bowes, Frank P. R. Brechling and Kathleen P. Classen Utgoff, "An Evaluation of UI Funds," 13 pp., May 1981 (Published in National Commission on Unemployment Compensation's Unemployment Compensation: Studies and Research, Volume 2, July 1980)

PP 312

Jondrow, James; Bowes, Marianne and Levy, Robert, "The Optimum Speed Limit," 23 pp., Jun 1981