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## WHAT GOOD ARE WARFARE MODELS?

Thomas E. Anger

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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

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\* 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,

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\*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.

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\*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

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\* 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.\*

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\*Quoted in Horace Freeland Judson, 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 Polynomials," 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  
Morowitz, 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 Pork 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 Gorkhov Articles: The New Gorkhov 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  
Melich, 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," Dec 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, Stioff, Peter and Spruill, 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," 35 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 39th MORS Working Group on Manpower and Personnel Planning, Annapolis, Md., 28-30 June 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, 19(1), pp. 298-307, Jan 1978, with Erratum in same journal 21 (1980), p. 1965). AD A040 107
- PP 187  
Coile, Russell C., "Nomography for Operational 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  
Durch, 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 680
- 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  
Classen, 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 Lomtor, 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  
Classen, 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  
Durch, 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  
Durch, 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 429
- 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 Lancaster 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  
Mizrahi, 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  
Mizrahi, 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  
Ittloff, Kathleen, "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  
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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
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- PP 298  
Mizrahi, Maurice M., "A Markov Approach to Large Missile Attacks," 31 pp., Jan 1981, AD A096 159
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