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# MOEs for Drug Interdiction: Simple Tests Expose Critical Flaws

Michael R. Anderberg



CNA
CENTER FOR NAVAL ANALYSES
4401 Ford Avenue • Post Office Box 16268 • Alexandria, Virginia 22302-0268

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Michael R. Anderberg

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This research memorandum seeks criteria for evaluating interdiction operations against illegal drugs flowing into the U.S. Six candidate measures of effective (MOEs) are subjected to a structured assessment process that tests them for key attributes. All six evaluate real-world operations. Some of the MOEs are shown to have potential for evaluating hypothetical operations explored through war games, exercises, and simulations. The assessment process itself offers a ready-made standard for testing additional candidate MOEs.

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*4401 Ford Avenue • Post Office Box 16268 • Alexandria, Virginia 22302-0268 • (703) 824-2000*

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1. Enclosure (1) is forwarded as a matter of possible interest. It reports on work done while the author was providing analytic support (via OP-642) to a Joint Staff working group on counternarcotics.

2. This research memorandum seeks criteria for evaluating interdiction operations against illegal drugs flowing into the U.S. Six candidate measures of effectiveness (MOEs) are subjected to a structured assessment process that tests them for key attributes. All six evaluate real-world operations. Some of the MOEs are shown to have potential for evaluating hypothetical operations explored through war games, exercises, and simulations. The assessment process, itself, offers a ready-made standard for testing additional candidate MOEs.

Jamil Nakhleh
Director
Operations and Support Division

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Michael R. Anderberg

*Operations and Support Division*

CNA

CENTER FOR NAVAL ANALYSES

*4401 Ford Avenue • Post Office Box 16268 • Alexandria, Virginia 22302-0268*

**ABSTRACT**

This research memorandum seeks criteria for evaluating interdiction operations against illegal drugs flowing into the U.S. Six candidate measures of effectiveness (MOEs) are subjected to a structured assessment process that tests them for key attributes. All six evaluate real-world operations. Some of the MOEs are shown to have potential for evaluating hypothetical operations explored through war games, exercises, and simulations. The assessment process itself offers a ready-made standard for testing additional candidate MOEs.

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## SECTION 1

## INTRODUCTION AND SUMMARY

This study seeks criteria for evaluating interdiction operations opposing the flow of illegal drugs into the United States. Its underlying purpose is to find analytically sound ways to assess the effectiveness of military roles in antidrug operations. Most such roles are in direct support of the border interdiction campaign where law enforcement agencies (LEAs) combat smugglers through searches, seizures, and arrests. Because military forces are prohibited from conducting these activities, their support is directed at enhancing the primary interdiction mission. As a result, the bulk of this study concentrates on finding measures of effectiveness (MOEs) for drug interdiction taken as a whole.

The results of this study are addressed to three groups:

- Persons and organizations who urge LEAs and the Department of Defense (DOD) to report performance of the antidrug mission in terms of MOEs
- Officials in these front-line agencies who are struggling to find valid MOEs
- Analysts trying to solve the problem for the other two groups.

Members of all these groups should find the study a source of concepts, methods, and results that will affect their views on this problem.

### SUMMARY

#### Criteria for MOEs

The key element of the study's evaluation process is a set of 11 attributes that are ideal properties for individual MOEs, plus 2 more attributes that apply to several MOEs used in combination. Each such attribute is accompanied by a criterion for gauging whether the MOE is up to standard. In brief, the attributes and associated criteria are:

- Mission oriented: If forces act to optimize their MOE scores, will they maximize mission accomplishment as well?
- Measurable: Can the required data be collected reliably and at a tolerable cost?
- Quantitative: Are the data numeric and collected according to a structured procedure that gives consistent results?

- Discriminating: Is the MOE's statistical uncertainty small enough to recognize real performance changes over practical time intervals?

- Realistic: Does the MOE reflect the facts of the operational situation, not some remote abstraction?

- Objective: Given common methodology and data, would two different people compute the same score on the MOE and come to a common interpretation of the result?

- Appropriate: Does the measured performance respond primarily to activities within the scope and authority of the forces being evaluated?

- Sensitive: Do MOE movements track well with effects the forces actually can induce? Can external factors mask the real results?

- Promptly responsive: If there is a real change in effectiveness, how long is the delay until the change is detected via the MOE?

- Simple to understand: Can people at all levels read the documentation and correctly explain how operations relate to the MOE?

- Validated: Have field tests shown that the MOE is practical to implement and responds as intended to events?

A practical system likely will require multiple MOEs; two additional attributes are defined for assessing suites of MOEs:

- Balanced: Does the suite of MOEs encompass all major mission objectives? Does any aspect receive undue prominence?

- Compact: Is the suite of MOEs as small as possible without seriously compromising the other attributes in this list?

Together, these 13 attributes and associated criteria serve as a standard for evaluating candidate MOEs.

**MOEs Evaluated**

The study evaluated six different MOEs under this standard.

- Raw seizures: tonnage seized

- Boarding success rate: fraction of boarding that result in a seizure
- Interdiction rate: fraction of drug-smuggling missions that end in seizure
- Smuggler success rate: fraction of all drug shipments reaching the U.S.
- Import-export price difference: the smuggler's markup
- Market share: fraction of national imports (for a given drug) passing through a given area of responsibility (AOR).

## RESULTS

### Evaluation of Interdiction Forces as a Whole

The six MOEs that seem attractive on the surface all turn out to harbor one or more of these deficiencies when evaluating real operations:

- Require data that cannot be collected in real operations
- Offer incentives to conduct operations in ways that actually undermine the mission
- Respond strongly to events that have nothing to do with the effectiveness of the forces being evaluated
- Are beset by such low event rates or high statistical variability that real changes in performance may be recognized only when the MOE moves in implausibly large steps, all smaller moves being indistinguishable from mere noise.

These same MOEs, however, still may be of value for analysis, planning, and training conducted within postulated scenarios where the behavior of both sides can be examined in virtually any degree of detail. This shift of venue brings a corresponding shift of emphasis from the problems of sample statistics to those of realistically modeling interdiction forces, smugglers, and their interactions.

### Military Roles in Interdiction

Determining measures of effectiveness to assess the contribution of military forces to the drug interdiction effort presents additional problems. First, attempts to link military contributions to measures based on seizures are suspect because military forces lack the authority and training to search conveyances, seize property, or arrest

suspects; only law enforcement agencies (Customs, Coast Guard, Drug Enforcement Administration, state and local police, and others) may do so. Second, it is all but impossible to separate the military contribution from the functions of civilian agencies that also operate surveillance assets, communication networks, command centers, interceptor aircraft, and seagoing vessels. Virtually everything a military unit can do either parallels or is entangled with someone else's performance.

## ORGANIZATION OF PAPER

The next section develops the family of attributes that characterize an ideal MOE for the drug interdiction mission; section 3 explores what interdiction means in the antidrug context; sections 4 through 10 evaluate some leading candidates for drug interdiction MOEs and a suite of three MOEs in combination; section 11 summarizes the performance of the candidate MOEs; section 12 addresses the military roles, particularly the legal restrictions and the peculiar problems of assessing their contribution; and section 13 contains the conclusions of this study. Appendix A explores the nature of MOEs--what they are, why one might want some MOEs, and the overall assessment system for which the MOEs are but the most visible element. It also introduces a set of contrasts to clarify discussions of MOEs. Appendix B contains an analysis of boarding success rate as an MOE, and appendix C explores the uses of postulated scenarios (as employed in exercises, war games, and simulations).

## SECTION 2

## CRITERIA FOR ANTIDRUG MEASURES OF EFFECTIVENESS

As a prelude to evaluating specific MOEs for antidrug operations, this section addresses the question of what attributes one should seek in these MOEs. Eleven such attributes are proposed for evaluating individual MOEs, each introduced with a narrative statement followed by a specific criterion for judging whether an MOE has the attribute. Two additional attributes are proposed for evaluating suites of MOEs, a reasonable prospect since practical systems for performance assessment are likely to include multiple MOEs. This list extends previous efforts from the operations research literature [1, 2, and 3] to define desirable qualities of MOEs; as far as could be determined in an extensive survey [4], only [3] addresses the topic for antidrug operations.

### CRITERIA FOR INDIVIDUAL MOEs

#### Mission Oriented

MOEs should measure how well operations meet mission objectives. Stating objectives in a manner suitable for measurement can be the most difficult step in the assessment process. One must take care to capture the substance of the issue in the MOE, not some marginal aspect that happens to be easy to measure. The chain of command must approach development of an MOE with the expectation that it will become a shorthand statement of the mission. CRITERION: If forces act to attain a top score on the MOE, will they maximize mission accomplishment as well?

#### Measurable

An MOE should represent a measurable concept, the required data being capable of routine collection with reasonable effort. If the data prove measurable in theory but not in practice, it may be possible to find some closely correlated surrogates, albeit at the price of additional uncertainty when interpreting the results. CRITERION: Can the required data be collected reliably and at a tolerable cost?

#### Quantitative

Numerical data and MOEs offer important advantages over qualitative alternatives. Numbers facilitate powerful mathematical tools and tend to reduce the chances of human judgement becoming embedded in the system. Still, the data-collection system needs safeguards to assure that even numerical reports are the product of a defined measurement process, not merely someone's intuition; it would be a poor system if the output changed significantly as a result of turnover in

leadership or a key staff position. CRITERION: Are the data numeric and collected according to a structured procedure that gives consistent results?

**Discriminating**

MOEs should exploit sharp distinctions to expose differences among alternatives and detect real changes in performance over time. Even carefully drawn theoretical contrasts can become fuzzy when faced with the errors, omissions, and ambiguities of data collected from operations. As a result, the reported value of an MOE must be recognized as only an estimate of actual performance, deserving to be accompanied by a statistical statement of uncertainty.[1] One way to narrow the uncertainty is to accumulate more data, usually through lengthening the time interval of the assessment; for example, year-to-year changes in performance are detectable with greater confidence than month-to-month changes. The statement of uncertainty for an estimate should be considered as important as the estimate itself. CRITERION: Is the MOE's statistical uncertainty small enough to recognize real performance changes over practical time intervals?

**Realistic**

One goal of the MOE design process should be to capture the essence of the operation while making due allowance for real-world limitations. It is easy to fall into the trap of reshaping the assessment problem into one with a convenient solution, while, in the process, letting the substance of the question slip away. CRITERION: Does the MOE reflect the facts of the operational situation, not some remote abstraction?

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1. Suppose some operation achieves an MOE score that is larger than the norm. How can an official decide whether this apparent improvement is a real gain over the past? The answer depends on both the uncertainty in the historic value and the size of the sample used in computing the new score. With an appropriate assumption for the form of the probability distribution describing such scores, a statistician can compute the probability that a new score this large is consistent with the historic distribution. This probability is a direct estimate of the risk that the official will be wrong if he decides that the new score is different from the historic level. If the risk is unacceptable, he concludes that the scores are really the same, any apparent difference merely reflecting statistical uncertainty in the estimates.

**Objective**

The results of the assessment system should have as little to do with institutional biases and expectations as possible.[1] More generally, objectivity is enhanced if scientific analysis has established the nature and strength of the relationship between the MOE and the activity it purports to measure. CRITERION: Given common methodology and data, would two different people compute the same score on the MOE and come to a common interpretation of the result?

**Appropriate**

MOEs should be keyed to the level of command and scope of operations under appraisal. It does little good to evaluate a commander on events beyond his influence. Though the nominal mission may be the same at several different echelons, each level might have its own distinctive suite of MOEs, some for external reporting and others for internal management. CRITERION: Does the measured performance respond primarily to activities within the scope and authority of the forces under evaluation?

**Sensitive**

A sound MOE should respond to changes in the quantity, quality, and character of operational events; if the answer stays about the same regardless of how tactical results change, the MOE is not very illuminating. By the same token, the MOE should be slow to react to extraneous factors; an MOE that suffers wide swings in response to the actions of other parties will tend to obscure rather than illuminate the mission performance of the forces under scrutiny. CRITERION: Do MOE movements track well with effects the forces actually can induce? Can external factors mask the real results?

**Promptly Responsive**

The process of collecting, correcting, and analyzing data necessarily takes time, but delays grow as the scheme adds reporting sources, especially ones outside the chain of command. At the same time, it is self-defeating to rush the process for an answer and then retract it later in the face of more definitive results. An MOE that produces month-to-month comparisons is far more responsive than another that can support only year-to-year contrasts; the time scale might be dictated by either the pace of interdiction events or the availability of essential data. CRITERION: If there is a real change in

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1. Apart from the MOEs and their supporting data stream, the commander and his staff always retain full authority to comment on operations and bring out issues beyond the scope of any formal assessment system.

effectiveness, how long is the delay until the change is detected via the MOE? How does the time scale compare with the typical action-reaction cycle of the effects the MOE is designed to measure?

**Simple To Understand**

If an MOE is to perform well, it must be readily understandable to all persons directly involved with collecting data, compiling reports, and interpreting results. Authoritative, readable, and concise documentation is central to acquiring this understanding. Comparison and aggregation of results across a range of activities depends on all levels of command sharing a common perspective on the meaning of the MOEs and their supporting data. CRITERION: Can people at all levels read the documentation and correctly explain how operations relate to the MOE? (Note that the criterion puts the burden on concept formulation and documentation, not on the readers.)

**Validated**

Any serious plan for assessing performance in the antidrug mission needs a thorough development and test phase; otherwise, fundamental shortcomings might appear during operations and undermine the credibility of the system. Whatever concepts finally emerge from this process, they will need to undergo testing to demonstrate that their theoretical properties actually work well enough in practice to justify the price of adoption. CRITERION: Have field tests shown that the MOE is practical to implement and responds as intended to events? In particular, has the validation process demonstrated that the essential data exhibit the required characteristics when collected via methods planned for routine use? If field tests require large start-up costs, Monte Carlo simulation methods might be an economical way to search for fatal flaws; a final endorsement still should rest on a full-fledged encounter with the real world.

## COLLECTIVE CRITERIA FOR MOE SUITES

Capturing all important aspects of drug interdiction operations almost surely is beyond the scope of any single measure; success probably will require a suite of mutually supporting MOEs to encompass the various missions and operations. Though most of the criteria just described can be used to evaluate a single MOE, the evaluation process probably is best performed in the context of a full system of MOEs to reveal how they complement, duplicate, and conflict with each other.

**Balanced**

The suite of MOEs should cover all important aspects of the mission. Some elements will prove easier to tap than others, but without a determined effort to achieve balance, the suite of MOEs will carry an implicit weighting of mission objectives that will skew operations.

CRITERION: Does the suite of MOEs encompass all major mission objectives? Does any aspect receive undue prominence?

**Compact**

Ideally, each member of a suite of MOEs should tap its own particular aspect of the problem while the other MOEs remain largely unresponsive to this same aspect. More technically, the system designer should seek MOEs that tend to be mutually independent, a property that supports spanning the decision space with a minimum number of MOEs. A small suite of MOEs reflecting relatively pure effects is preferred to long and complicated lists of every conceivable MOE. Some duplication and overlap are inevitable, and some redundancy may even be introduced deliberately if confirmation is needed on critical issues. CRITERION: Is the suite of MOEs as small as possible without seriously compromising the other attributes in this list?

**CONCLUSION**

This list of selection criteria is offered as a guide to MOE development and evaluation. In all likelihood, no suite of MOEs, or even individual measures, could come out perfect on every criterion. On the other hand, a candidate MOE that fails totally on any one of these criteria deserves a hard look as to whether it has any utility. The important point is to consider these qualities in the design stage of the assessment system and identify how the shortfalls will constrain interpretations of results from real operations or postulated scenarios. Sections 4 through 9 explore six candidate MOEs with particular attention to their most prominent features, including a systematic assessment of performance on these criteria. Section 10 applies these same criteria to a suite of three mutually supporting MOEs.

## SECTION 3

## THE INTERDICTION MISSION

The immediate effects of interdiction fall on smugglers as seizures and arrests, penalties that only LEAs may impose. Military forces serve in the national war on drugs primarily by providing surveillance, communications, logistics, and other support to enhance effectiveness of the LEAs. Arranging the roles this way means that the value of such military support is indeterminate unless there is a clear understanding of the value of interdiction. Accordingly, this section explores what interdiction means in the antidrug context.

### THE PLACE OF INTERDICTION IN THE WAR ON DRUGS

Interdiction focuses on smuggling methods that bypass points of entry (POEs) and evade the formal customs clearance process. Smuggling conveyances include: fishing vessels, pleasure craft, small merchant ships, private aircraft, motor vehicles operated off-road, even pack animals and human bearers. The principal participants in interdiction operations include the Customs Service, Coast Guard, Border Patrol, and military services.

In contrast, legitimate travelers and cargo entering the United States present their papers and clear customs at POEs. Only a small percentage of the traffic passing through these points can receive close examination, posing a huge potential for illegal drug imports. The flow includes large merchant vessels, cruise ships, cargo containers, trains, and commercial airliners. Smugglers exploit cargo, luggage, and the bodies of travelers in a wide variety of ways to conceal illegal drugs. The Immigration and Naturalization Service and the Customs Service are the principal agencies stopping drugs at POEs; however, National Guard troops and military working dog teams have growing roles in cargo searches (conducted out of the public eye).

Interdiction at and beyond the borders directly complements inspections at POEs; drug smugglers (as a group if not individually) can shift the weight of their effort from one to the other based on perceptions of costs and peril. Accordingly, the overall antidrug campaign is best served if these two segments are coordinated to deny smugglers any low-risk options.

LEAs typically have different points of emphasis about interdiction than do military forces; they focus on investigative activity where arrests bring the accused into custody and seizures provide the evidence necessary to clinch the case. As a result, interdiction must be executed with full regard for due process, protection for the rights of the accused, and preservation of an unbroken chain of custody for the evidence. Error in any of these respects can damage or negate the prosecution's case, leaving only the drugs and some seized property as

reward for the effort; smuggling organizations have proven willing to take such losses in stride, writing them off as a cost of doing business.

## OFFICIAL GOALS OF INTERDICTION

The *National Drug Control Strategy* [5] states the goals of interdiction in the following terms:

> The ultimate goal of interdiction is to deter drug smuggling by intercepting and seizing illicit drug shipments entering the United States. This disruption of drug trafficking operations raises the traffickers' cost of doing business by forcing them to take expensive countermeasures: using longer and more circuitous routes; training new personnel to replace those apprehended; purchasing sophisticated electronic equipment to detect law enforcement surveillance; developing new concealment techniques; replacing expensive seized assets; and stockpiling drugs closer to the production area, thus making them more vulnerable to foreign law enforcement efforts. (p. 93)

> The principal goal of air interdiction operations is to deter smugglers using aircraft by denying them safe, direct, and economical routes to major distribution areas in this country. A related goal is to seize the drugs, the aircraft, and the smugglers. (p. 95)

> Our maritime interdiction efforts focus principally on deterring drug smuggling by monitoring seaborne smuggling routes, detecting and seizing drug-smuggling vessels, and arresting their crews. (p. 97)

Thus, the official goal of interdiction is to deter drug smuggling; the mechanisms of enforcement include denial of preferred routes, seizures of drugs and related assets, and arrests of smugglers. Taken to extreme, fully effective interdiction might become so certain and the consequences so costly that only daredevils would run the risk.

Intensified interdiction is supposed to result in reduced smuggling, all other things being equal, but, in the decade of the eighties, each year has seen increases in both the resources devoted to interdiction and the quantities of drugs sold on the retail market. Smugglers have compiled a most respectable record of adaptation and evasion; when one avenue becomes difficult, they open another.

Incremental increases in law enforcement effort continue to provide the stimulus to find new opportunities, but not yet the motivation for a mass exit from the trade.

A fundamental problem in this mission statement is that it fails to recognize that deterrence is the product of much more than interdiction alone. Deterrence implies giving players in the drug trade convincing reasons to halt, restrain, or redirect their activity. Personal risks are increased by raising the probabilities of arrest, prosecution, and jail for all drug-related activities. Rewards are diminished by interrupting the flow of profits and other returns; specific effects include increased costs, an eroded stream of revenues, undermined predictability of revenues, and blocked paths for repatriation of profits. Clearly, interdiction taken alone has a limited capacity to deter drug trafficking; it affects just part of the transportation complex, but nothing of production, distribution, or money laundering.

Deterrence has not been translated into a set of goals with operational meaning for interdiction forces. Maybe it cannot be translated. What then are interdiction forces doing? If they justify their activities in terms of deterrence, is the rationale valid? More often, the agencies do not bother to speak of deterrence at all and so must be presumed to be working against some other goal. In either case, the disconnect in the chain of leadership leaves no explicit link between actions and goals.

## RELATING INTERDICTION TO NATIONAL LEVEL MOEs

The General Accounting Office cites macro-scale criteria to dramatize the size and intractable nature of the illegal drug problem [6]:

- Street prices continue in a long-run decline.
- Retail purity is increasing.
- Estimates of quantities imported and sold to users continue to climb.
- Emergency room case loads for illegal drug use keep growing.
- Numbers of drug users are larger than a few years ago, though recent survey results show small declines.

Such price-purity-availability criteria have a place in assessing whether the national campaign against illegal drugs is making headway; most of them are included in the quantitative goals set in [5]. There is a serious problem, however, with using these same criteria to evaluate the performance of any single agency or program (as in [7]). For interdiction in particular, such macro-measures are several steps removed from what the interdiction forces actually can achieve:

intercept some fraction of shipments on smuggling vehicles. Quantitative valuations of these macro-measures are strongly affected by events beyond the reach of interdiction forces:

- Domestic production: Reputedly, the world's best marijuana grows in the U.S., satisfying a large fraction of the national market; should crystal methamphetamine ("ice") grow from footholds in the western U.S. to achieve national popularity, domestic production in illicit chemistry labs could outstrip imports.

- Buffer stocks in the U.S.: Cocaine in stateside storage is often said to approximate six months of current demand.

- Smuggling via concealment in commercial shipments, notably the maritime container trade.

- Smuggling by courier, a key method for importing heroin and other opiates.

These same macro-measures also respond to market factors having little or nothing to do with interdiction. Dealers at all levels compete for market share, at times engaging in wars, price and otherwise; others who enjoy a locally dominant position in the market can gouge their customers, at least for a while; and the entire market responds to changing consumer fashion--this year's drug of choice may be overtaken by a new fad. Patterns of preference can vary widely by location as well as time; just two of many pertinent examples are the popularity of phencyclidine (PCP) in Washington, DC, and the slow acceptance of crack cocaine in Chicago.

Furthermore, interdiction is only one facet of a much larger effort, virtually all of whose elements can affect these same macro-scale measures:

- Domestic law enforcement programs (investigation, prosecution, imprisonment, rehabilitation)

- Education programs to discourage initial or continued use

- Treatment programs for addicts

- Antidrug programs of other countries and international organizations.

The credit (or blame) for changes in such price-purity-availability measures would be extraordinarily difficult to allocate among all these factors. On a purely technical level, it might be possible to design an input-output matrix, but with little hope of collecting the data necessary for credibly estimating its coefficients. As a result, the

subsequent sections of this paper explore measures much more closely related to the direct effects of interdiction.

## SOME LARGE-SCALE EFFECTS OF INTERDICTION

Interdiction also has large-scale effects on relationships within the smuggling community, some of which are not obvious to the casual observer but should not be overlooked while trying to evaluate interdiction operations. Otherwise, the outcomes may be unanticipated, and perhaps unintended.[1]

Drug smuggling involves large numbers of individuals and organizations whose resources, skills, sophistication, experience, and other attributes vary over a wide range. Unless interdiction is directed specifically at those positioned near the high end of the spectrum, the burden of seizures and arrests naturally falls most heavily on those at the low end. To the extent that the interdiction campaign is blind to these distinctions (no special priority goes to one smuggler over another--they are all bad), the more organized and ruthless players actually stand to improve their relative positions as a result of interdiction;[2] it is safe to say that strengthening the most notorious drug smugglers should not be an objective of U.S. government policy.

This anomalous situation follows directly from the fact that novices are far more likely to fall prey to interdiction than established smugglers. The interdiction program raises barriers to new entrants; as interdiction thins the ranks at the low end of the experience spectrum, the remaining smugglers enjoy growing market share. Cost increases induced by interdiction are passed through to the customer as higher import prices than would pertain otherwise, but the established smuggler realizes the higher prices without bearing the full burden of cost increases, perhaps even enjoying enlarged profit margins.

Another effect of higher prices is marginal growth in the propensity for fraud, theft, and violence among smugglers because they are dealing in an increasingly valuable product. That result may not seem so bad if the smugglers are the ones who suffer, but smugglers vary in their tendency toward violence and ruthlessness; those who are most inclined are most rewarded. This effect spills over into society as further assaults against morality, respect for law and order, and peace in the streets.

The pressure from successful interdiction encourages smugglers to search for adaptations and alternatives, some of which might turn out to be clear improvements over their old methods. For example, it remains

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1. See [8] for a readable microeconomic analysis covering these points and other aspects of drug law enforcement.
2. Prohibition produced exactly the same result; organized crime drove small operators out of business within a few years [9].

to be seen whether the development of large-scale drug routes through Mexico in the face of interdiction in the Caribbean amounts to a net gain for the government or the smugglers.

## SUMMARY

The national strategy declares the principal purpose of interdiction is deterrence against smuggling; denial of routes, seizures of drugs, and arrests of smugglers are not the ultimate goals, merely means to the end. Upon closer inspection, however, deterrence appears as an abstraction that cannot be linked to interdiction operations in any practical terms. Nor can interdiction bear the full burden for achieving deterrence; most other aspects of the war on drugs contribute as well. As a result, there seems no obvious way to evaluate interdiction directly in terms of deterrence, and no other statement of the mission has official blessing. Absent an operationally meaningful mission to guide evaluation, the MOEs considered in subsequent sections concentrate on the immediate effects that are primary results of interdiction.

## SECTION 4

## RAW SEIZURES

Many statistics about drug smuggling are beset with crippling anomalies and uncertainties; numbers reported to four significant digits can later prove to be in error by an order of magnitude.[1] Outstanding exceptions to this principle are statistics on drug seizures and smuggler arrests; LEAs have succeeded in counting arrests and measuring seizures with high accuracy.[2]

### INTERPRETATION OF RAW SEIZURE STATISTICS

Seizures and arrests traditionally have been cited as evidence of success in the interdiction mission. It is hard to find a summary of antidrug activity that fails to give prominence to seizures whenever some claim of credit might be justifiable. On the surface, a pattern of rising numbers seems plausible as an indicator of growing impact on smugglers (assumes seizures are growing faster than quantities smuggled). Paradoxically, if the pattern reverses to falling numbers of seizures and arrests, boosters for interdiction still claim success, this time insisting that the decline shows deterrence is working (assumes quantities smuggled are falling too, ideally at least as fast as seizures). Skeptics interpret the numbers in a directly opposite manner: a rising number of seizures is cited as evidence of increased smuggling (assumes interdiction forces continue seizing about the historic fraction of smuggled drugs); a falling series is said to show that

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1. Few examples are as dramatic as the recent shift in estimates of Mexican marijuana production, but the apparent disregard for statistical uncertainty is typical of official statistics on illegal drugs. For 1988, the State Department [10] reported production of Mexican marijuana at 5,655 metric tons and projected 4,750 metric tons for 1989. The next comparable report [11] estimated 1989 production at 47,590 metric tons, ten times as much. The difference is attributed not to a major increase in cultivation but to a change in estimation methodology; figures for previous years remained unaltered, though they were conceded to be probable underestimates. Despite having shown that alternative methods can produce answers differing by an order of magnitude, the State Department continues to report its figures as though they are precise, not even hinting that some range of uncertainty goes with the estimate.
2. The El Paso Intelligence Center (EPIC) keeps statistics for all the federal LEAs and publishes summary results in an annual report [12]. Before EPIC became the designated scorekeeper, however, national figures were derived by summing statistics compiled from each agency; the numbers were substantially inflated because of extensive double counts as drug busts frequently involved more than one agency, each including all relevant events in its figures. Coast Guard seizures (and most Navy involvement) are detailed twice per year in [13].

the smugglers have become clever enough to evade interdiction (assumes the amounts smuggled have remained steady, or at least not fallen as fast as seizures).

The embedded assumptions by both sides reflect not only hidden agendas but also the difficulty of making any sense from raw seizure statistics without referring to associated levels of smuggling and interdiction activity; standing alone, seizures are simply numbers without a context. As a result, raw seizures as an MOE is a measure of neither effectiveness nor efficiency. Although the results are evidence of some tactical success, every observer has to figure out for himself what the numbers might mean.

## RAW SEIZURES EVALUATED ON MOE CRITERIA

### Mission Oriented

Probably not. Seizures contribute to performance of the antidrug mission--drugs and smugglers are taken out of circulation; other smugglers are reminded that there are real risks; and the costs of doing business are nudged up--but a determined effort to maximize seizures holds serious potential for unintended effects. First, interdiction forces might validly maximize seizures by concentrating on the least experienced smugglers and largely ignoring the more sophisticated, better-equipped veterans. Such a strategy might look good on the surface as the numbers are reported, but it avoids the toughest part of the problem. Second, smugglers appreciate that they face risks and expect some fraction of their shipments will be seized; the rational step for them is to make those seizures serve their purposes as much as possible. Smugglers have been known to use deliberate sacrifices to give interdiction forces a score, but simultaneously exploited the distraction to push through a major shipment; the effect is something like a burglar who brings along a meaty bone to occupy the watchdog while the master's goods go out the door. Third, if police officials are susceptible to corruption (a common factor overseas and an occasional problem even in the U.S.), sham seizures might be staged as a cooperative event to make the police look good while the main trade goes on unimpeded.

### Measurable

Yes. Measurability is the strongest feature of seizures as an MOE; numbers of interdiction events and the quantities of contraband seized are reported in detail. Years ago, significant errors arose from multiple reporting as every agency involved in a seizure staked its claim, but, now, the El Paso Intelligence Center keeps one consistent set of books on seizures by all agencies and is reputed to have largely solved problems of over-counting.

**Quantitative**

Yes. Weight, volume, number of packages, vehicle characteristics, number of crew members, and a host of other parameters routinely are listed in contraband seizure reports.

**Discriminating**

Technically yes, for postulated scenarios,[1] where simply running the simulation or exercise a little longer will produce sufficient sample size, but often not for real operations. The lower the echelon, the smaller is the AOR and the number of seizures.[2] Statistics based on a small number of events have large standard errors; a very large change in the seizure statistics is required to have any confidence that an apparent gain is a real effect, not just the product of noise within a wide band of estimation uncertainty. The best chance to discern significant changes with justifiable confidence comes at the highest levels of aggregation (national, across all agencies) where the contribution of lower echelons is lost from sight.

**Realistic**

Only in part. Seizures provide a major source of evidence, and the associated arrests put the accused parties in custody, but the real prize for law enforcement agencies is prosecution and conviction. Merely capturing drugs is a rather hollow victory because the smugglers can easily replace their losses.

**Objective**

No. Optimists say rising seizures show success because interdiction forces are taking more drugs out of circulation; they argue that falling seizures show success because the smugglers are being deterred. Skeptics see rising seizures as signifying failure because smugglers are moving more drugs; they see falling seizures as further evidence of failure because the smugglers are evading law enforcement efforts. The answer depends on the biases one brings to the questions.

**Appropriate**

To a degree. Seizures made in an AOR are real events and represent an achievement for the forces involved; no one can build a consistent

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1. The discussion distinguishes between postulated scenarios and real operations where appropriate. The absence of distinction implies no important difference between the two contexts.
2. In 1988, maritime operations in the entire Atlantic Command AOR produced only 9 to 12 seizures, depending on specifics of the counting rules. Appendix B includes a detailed summary of these operational results.

record for long on luck alone, but the opportunity for seizures depends heavily on decisions by the smugglers. If smugglers make a major shift in their regional allocation of shipments, the amount of drugs moving through an AOR can change dramatically, with corresponding changes in seizure statistics. In such an instance, interdiction forces might deserve neither credit nor blame, despite large changes in the numbers.

**Sensitive**

In part. As with the preceding attribute, the number and size of seizures can be driven by smuggler action that has little to do with effectiveness of the interdiction forces involved.

**Promptly Responsive**

No. Despite the fact seizures are reported with minimal delay, they occur so infrequently that results need to accumulate over long periods before enough data exist for meaningful comparisons between periods.

**Simple To Understand**

Seemingly so on the surface, but not upon reflection. Data on seizure events and weight of contraband are straightforward and easy to grasp, but the meaning of these numbers in the overall scheme of the national antidrug strategy is much less clear. In particular, seizure statistics lie in a kind of limbo absent comparable figures on the drug flow from which the seizures are drawn. Seizures per se are statistics without a context; neither the forces on the front line nor their leaders in Washington have a sound basis for interpretation.

**Validated**

No. The litany of problems described here, especially those regarding objectivity and ease of understanding, give lie to any assertion that seizures have been validated as an MOE.

**SUMMARY**

Raw seizures have three critical failings, any one of which is enough to discredit its candidacy as an MOE for interdiction. First, even though the numbers are among the most reliable data collected on the effects of interdiction, they have little meaning taken alone; changes might be traced to many different causes, few of which have anything to do with effectiveness of interdiction forces. Second, evaluating operations on the basis of seizures gives a powerful incentive to focus on the least talented segment of the smuggling threat in order to squeeze the highest score from limited resources; in turn, sophisticated smugglers who present more difficult targets stand to benefit from systematically receiving less than their share of attention. Finally, experience in the Caribbean shows that seizures occur so

infrequently in the maritime arena that very long periods must elapse before enough data accumulate to make statistical comparisons capable of discriminating between noise and real effects; this latter point is explored extensively in the next section and in appendix B.

## SECTION 5

## BOARDING SUCCESS RATE

A substantial portion of interdiction effort is directed against smuggling aboard boats and ships of all descriptions. Coast Guard and Navy vessels carry law enforcement detachments (LEDETs) composed entirely of USCG personnel who conduct boardings, seize contraband, and arrest smugglers. The background level of legitimate traffic far outstrips the ability of these forces to visit and search; they must be judicious in their selection of targets, exploiting intelligence cues and profiles of smuggler attributes to concentrate effort on likely suspects. A naturally appealing MOE in this setting is

$$\text{Boarding success rate} = \frac{\text{Number of seizures}}{\text{Number of boardings}} .$$

It relates seizures to the level of surface maritime interdiction activity in an AOR. It is a measure of efficiency because results are compared with interdiction effort. An improvement in scores from one period to the next might be taken as an indication that intelligence cues and boarding criteria are becoming better targeted.

### CRITICAL FLAWS

In a naive, idealized sense, the MOE would signal perfection when every boarding produces a seizure. An obvious way to attain a high boarding success rate is to concentrate on targets that are a "sure thing." One plausible consequence is excessive attention to the relatively easy targets presented by smugglers who are careless, inexperienced, or untalented; sophisticated smugglers with their more elusive styles could end up operating with near immunity. The news releases might look good, but the outcome is likely to be counterproductive in the long run.

This bias toward the easy targets also invites a circular feedback process tending to enshrine a narrow range of intelligence methods. The quest for a high boarding success rate encourages concentration on smugglers tagged through top-quality intelligence cues; each new seizure stands to reinforce reliance on methods that produced the rewarding cues. The result is a powerful disincentive against any activity that might dilute the boarding success rate: pursuing low-probability cues, experimenting with new methods, or including random boardings in the CONOPS. In the process, opportunities for chance discoveries are narrowed, if not eliminated, providing even greater security to smuggling organizations whose methods successfully evade the principal intelligence indicators. Such an outcome provides an excellent example of how a plausible-sounding idea can produce unintended results.

A potential remedy to this problem is to break down the boardings according to the quality of the cue: high, low, experimental, random selection, and so on. Then interdiction forces would not risk a poor showing simply as a result of varying the mix of reasons for their boarding choices. This approach has two drawbacks. First is the temptation to game the process by tagging unproductive boardings (after the fact) as having originated with low-probability cues. Second, breaking the data stream into smaller pieces has the statistical effect of enlarging the uncertainty bands and lengthening the time necessary to discriminate real changes from routine variation. The example in the following section shows that this statistical problem is difficult even without subdividing the data.

## SAMPLE APPLICATION USING HISTORIC DATA

One good thing to be said about the boarding success rate is that its inputs are known with high accuracy. Despite data gaps and inconsistencies, the counts of both boardings and seizures potentially can be tabulated with near perfection. Most other candidates for interdiction MOEs depend on data that can be estimated only with substantial uncertainty. Even with this powerful advantage, implausibly large changes in this MOE would be required before it could signal a real change in effectiveness. These issues are illustrated with the following highlights from a detailed analysis presented in appendix B.

In calendar year 1988, surface drug interdiction operations under Commander Caribbean Squadron (COMCARIBRON)[1] executed 313 boardings and made 9 to 12 seizures (depending on the counting rules)--a boarding success rate in the range of 3 to 4 percent. A probability model can show how much this success rate must increase before one achieves statistical confidence that there has been a real effect. The required margin of difference shrinks with increased boardings because larger amounts of data narrow the band of uncertainty. As compared to a 4-percent historic success rate, table 5-1 shows the minimum improvement in the boarding success rate needed for the difference to be statistically significant (one-sided test, 5-percent significance), not just a chance product of variability in smuggling and interdiction activity.

For example, 30 boardings (one month of operations at the 1988 level of activity) would have to produce a boarding success rate over 13 percent, more than three times the baseline rate. Even a year's worth of new data is sufficient only if the change in the MOE exceeds 58 percent. Both the threat and interdiction operations are dynamic; the longer the time frame, the greater are the chances that an observed change is due to some uncontrolled (and perhaps unrecognized) effect, not the product of deliberate operational decisions. These large,

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1. In 1988, all Atlantic Fleet surface operations dedicated to the antidrug mission were under the tactical control of COMCARIBRON, a Coast Guard officer.

required improvement factors are the direct result of the low seizure frequency. A seizure is a sufficiently uncommon event that even fairly large numbers of boardings produce few successes; as a result, the statistical properties of the boarding success rate naturally result in large uncertainties.

**Table 5-1.** Thresholds for detecting a change in boarding success rate from a 4-percent baseline

| Number of boardings | Implied time frame | Required new success rate (percent) | Minimum improvement factor |
|---|---|---|---|
| 30 | 1 month | 13.33 | 3.33X |
| 100 | 3 months | 8.00 | 2.00X |
| 300 | 1 year | 6.33 | 1.58X |
| 1,000 | 3 years | 5.10 | 1.28X |

## BOARDING SUCCESS RATE EVALUATED ON MOE CRITERIA

### Mission Oriented

Yes, in part. Clearly, interdiction forces should target their boardings, but, if operations are organized to maximize the boarding success rate, there is incentive to concentrate on the highest probability targets as presented by the least capable smugglers. Effort expended on low-probability targets is expected just to lower the score. Indeed, if graded on just this MOE, it is in the commander's interest to underutilize the boarding capability of his forces unless faced with enough good targets to absorb all the capacity. A similar problem applies when using the measure to evaluate the quality of intelligence cues; it draws attention to indicators most likely to produce a seizure, normally those associated with the easiest targets. Sophisticated smugglers who present ambiguous cues stand to be systematically ignored if intelligence support is graded on this measure alone. Tagging each boarding with the quality of its cue offers a possible solution, but only at the price of lessened statistical sensitivity due to reduced sample size.

### Measurable

Yes. Both the numerator and denominator are capable of precise measurement by the forces conducting interdiction operations. The key fault to avoid is multiple counting as a result of several agencies reporting a single boarding or seizure.

**Quantitative**

Yes. Both numerator and denominator are numerical and represent sums of discrete events.

**Discriminating**

Yes, in postulated scenarios, but no in real operations. Even though numbers of boardings and seizures can be compiled with little or no reporting error, seizures come at such a slow pace (at least those with military involvement) that sampling error produces a large statistical uncertainty band, but this effect need not be a problem in postulated scenarios where the event rate can be controlled as an independent variable.

**Realistic**

No. As with several other criteria, the inherent bias toward easy targets draws interdiction forces into actions that look good but in fact are counterproductive. Even more damaging is the incentive for forces to reject opportunities that do not offer sufficient prospect of a seizure *a priori*.

**Objective**

Technically yes, but, practically, no. The data are capable of error-free collection and the MOE computation is straightforward; however, unless offset in some manner, the bias toward easy targets is a challenge to assertions of objectivity.

**Appropriate**

Yes. The measure is fully appropriate to commands having control over both the choice of targets for boarding and the performance of search parties. If these functions are split between commands, the measure still might be appropriate to their common parent command, if one exists.

**Sensitive**

No. At first glance, this measure would seem to deserve a yes as it directly captures the results of boarding activity, but if interdiction forces concentrate on easy targets and forgo low-probability targets, the resulting improvement in the MOE score is entirely misleading. In addition, the measure puts a premium on two elements that may be outside the control of the authorities in charge of the interdiction operations: intelligence cues and the boarding party's capability to find the drugs if they are present on a vessel.

**Promptly Responsive**

No. Seizures in maritime operations are sufficiently rare that long periods are required to accumulate enough events to discriminate realistic changes in performance. Using 1988 operations in the Caribbean as a reference point, the boarding success rate for 1989 would have had to improve by at least 58 percent for the change to be statistically significant.

**Simple To Understand**

Maybe. On its face, the measure would seem to warrant a yes answer, but the subtlety of its bias toward easy targets and the incentive to forgo low-probability opportunities confuses interpretation.

**Validated**

No. The measure's performance has not been subjected to field testing.

**SUMMARY**

The boarding success rate provides perverse incentives to look good at the expense of real effectiveness against drug smugglers. Like raw seizures, the measure has a built-in bias toward easy targets, but it adds another dimension through discouraging boardings that lack high *a priori* expectation of a seizure. Commanders have an incentive to exploit the full boarding capabilities of their forces only if intelligence produces enough high-probability targets. In turn, intelligence activities have an incentive to concentrate on the methods that produce the highest-probability cues, giving real security to smugglers who can evade the principal indicators. Any element of experimentation or randomness inherently is discouraged, resulting in stylized and predictable operations.

In addition, maritime seizures occur with such low frequency that long periods are needed to accumulate enough data for statistically meaningful comparisons. This measure illustrates that high-quality data are not enough to produce a statistically sensitive measure; small sample size stemming from a low event rate is just as debilitating as poor data.

## SECTION 6

## INTERDICTION RATE

Discussions about MOEs for interdiction operations often conclude that there is no way to measure the amount of drugs moving through an AOR in a given period. Such sentiments usually imply the speaker has in mind the interdiction rate, defined as

$$\text{Interdiction rate} = \frac{\text{Seizures}}{\text{Shipments}} .$$

In concept, the measure can be applied over a broad range, from a single patrol of an individual ship to multi-unit, wide-area operations over extended time periods. The formulation lends itself to aggregation over several units operating in parallel as in a barrier operation; handling sequential effects as with multiple barriers also is straightforward. The interdiction rate is a measure of effectiveness because the result is in terms of the smuggler's level of effort. Counts of "seizures" and "shipments" typically are in units of smuggling vehicles or sorties; however, some simulations and analyses in postulated scenarios use weights of drug shipments and seizures. The Coast Guard has extensively investigated the interdiction rate and its application [3, 14, and 15].

### CHARACTERISTICS OF THE INTERDICTION RATE AS AN MOE

In typical usage, the counts of seizures and shipments are tailored to the time and space targeted by the interdiction units of interest; for example, in the case of a temporary barrier at sea,

$$\text{Interdiction rate} = \frac{\text{Smuggling vessels seized}}{\text{Smuggling vessels entering barrier}}$$

during the period the barrier exists. The measure is figured only for the time and space where interdiction forces put smugglers at risk. As a result, smuggler action to wait out or go around the barrier is not reflected in the MOE, though such behavior is important in the real world. Neither is there any perspective on how meaningful these results might be from the smugglers' frame of reference; a high interdiction rate in one area may not be significant if the vast majority of the contraband is moving through another AOR. The next section examines the smuggler's rate of success and directly addresses these issues.

The interdiction rate may be useful as a criterion in postulated scenarios for operational planning, training exercises, and computer simulations. In all such cases, the level of smuggling activity is a stated input; therefore, computed interdiction rates are known perfectly (provided the scenarios and methods used to compute the numbers of

seizures are valid). These relationships are fully reversed when figuring the interdiction rate for real operations; seizures are known with high accuracy, but the relevant smuggling activity is characterized by estimates with large, unknown uncertainties. The validity of an interdiction rate computed from real operations rests almost entirely on the assumptions and methods used to estimate the base level of contraband shipments.

Ideally, the estimate of relevant smuggling activity in the denominator should be derived independently from the seizures in the numerator, but making a direct estimate of smuggling activity actually occurring in a given space and time is difficult. Seizures are the highest-quality evidence, but only a fraction of the total; this fraction is the interdiction rate. Additional segments of smuggling activity are indicated via intelligence, some valid and some not, the division unknown. Further, these data sources are limited to the smuggling activity already discovered; the part that is unknown could be substantial, but it is inherently not measurable on any current basis.

In one sense, the interdiction rate is a conservative measure. It credits interdiction forces only for seizures. Interdiction activities have other effects on the smuggler, however:

- Increased costs
- Delays as smuggling missions wait for more attractive opportunities
- Missions aborted to avoid interdiction forces
- Drugs jettisoned so smugglers avoid being caught with the evidence
- Heightened risks as efforts to avoid interdiction increase exposure to effects of night, weather, incompetence, and predatory action of other smugglers.

These effects are addressed in some of the measures introduced in later sections.

## INTERDICTION RATE EVALUATED ON MOE CRITERIA

### Mission Oriented

Yes, in part, but with important qualifications. If the duration or coverage of the interdiction activity is too narrow in scope, the smuggler may have the option to wait out or go around the interdiction forces; then, even an impressive interdiction rate is liable to be distinctly misleading, because the apparent local success pales in the larger scheme of events. On the other hand, if the concept of operations and supporting resource commitment produce a dense and continuing

presence over a wide area, the MOE probably comes close to being a capsule statement of the local mission. In addition, interdiction rate shares some flaws already described for raw seizures. Both measures offer an implicit incentive to concentrate on the easy targets and score maximum successes for a given level of effort, while, in the process, giving the sophisticated smuggler a degree of immunity. Further, both measures are susceptible to manipulation by smugglers who deliberately sacrifice some shipments as decoys.

**Measurable**

Yes, in postulated scenarios, but no in real operations. The count of seizures in the numerator is knowable with high precision, but the shipments in the denominator can be estimated only with substantial uncertainty in the real world. This latter problem has bedeviled proponents of the interdiction rate for years as some unknown amount of smuggling activity simply escapes the notice of surveillance assets. On the other hand, the MOE is eminently employable in plan development, simulations, and exercises where the level of smuggling activity is an independent variable under control of the investigator.

**Quantitative**

Definitely yes in postulated scenarios, but in real operations, it is hard to put any confidence in measurements of the smuggling activity from which the seizures are drawn. The tendency for opinion or intuition to shade the answers is hard to control in the presence of large uncertainties.

**Discriminating**

Yes in postulated scenarios where everything is known, but probably not for real operations. The uncertainty of estimated smuggling activity in real operations is not known at present, though it would be surprising if the margin of error is as small as a factor of two for a full year of Caribbean operations. In such a case, the interdiction rate for a year would have to double before one could be confident that the change is a real effect. (The uncertainty factor grows even larger as one attempts to evaluate either a smaller AOR or shorter period of interest.)

**Realistic**

Yes, with qualifications. With the background level of smuggling as a base of reference, the interdiction rate is more realistic than raw seizures as an MOE, but vulnerable to giving a distorted answer if intermittent operations leave smugglers with exploitable gaps. It does little good to score impressive interdiction rates whenever the operation is active if the more sophisticated smugglers are able to move the bulk of their goods during periods when the operation is suspended or concentrated elsewhere.

**Objective**

Yes, in theory, but the details of implementation can undermine objectivity in at least two ways. As already pointed out, a judicious choice of the domain of time and space over which the interdiction rate is computed can make operations look undeservedly good. Perhaps even more difficult are the uncertainties in estimating the underlying level of smuggling activity. Even honest disagreements over assumptions, data, and methods can result in estimation differences between extremes of dismal and outstanding.

**Appropriate**

Yes. The interdiction rate can be applied at any scale, from small (a single unit on patrol for a week) to grand (the national aggregate of all forces interdicting drugs in a year), provided a sufficiently reliable estimate of smuggling activity is available.

**Sensitive**

Yes, when the interdiction forces are taken collectively; however, it is poorly suited to assessing single-agency performance in a multi-agency operation where the contribution from each step in the process depends on preparatory and follow-up activities of the other participants. In the extreme, perfect performance by one actor can be offset fully by the poor performance of another.

**Promptly Responsive**

No, in real operations, as long as the underlying level of smuggling activity remains a critical uncertainty. Though it is difficult to be precise in the absence of more definitive work, this problem of uncertainty almost surely requires comparisons over relatively long periods to detect real changes in performance.

**Simple To Understand**

Yes, for the MOE itself. Interdiction rate is an easy concept, having pretty much the same meaning to operating forces, analysts, and the public; however, a common understanding among all these parties will be much harder to achieve regarding statistical uncertainty; yet this technical issue is critical in determining whether an apparent change in performance has any validity.

**Validated**

No. The intellectual and practical challenges of producing valid estimates for the level of smuggling activity in a specified period and AOR have yet to be overcome.

## SUMMARY

The biggest problem for evaluating real operations is uncertainty in measuring the underlying magnitude of smuggling through the area and period of interest. This difficulty might seem solved in postulated scenarios where both the level and character of smuggling activity are stipulated as inputs, but even here, statistical uncertainty is replaced by another uncertainty as to the realism of modeling interdiction forces, smugglers, and their interactions. Three other problems are more subtle. First, even though interdiction rate is defined in terms of the smugglers' level of effort, the domain of its implementation usually is defined over an area and period of interest tied to the interdiction forces. As a result, the measure inherently overlooks any segment of the smuggler community having the option to wait out or circumvent the interdiction operation of interest. Second, the measure retains the implicit incentive present in raw seizures to concentrate on the easiest targets. Third, the measure gives little insight into other positive effects of interdiction such as pushing smugglers into risky behaviors.

## SECTION 7

## SMUGGLER SUCCESS RATE

The measures explored in the three previous sections concentrate on finding some significance in seizures of smuggled drugs, as defined from the point of view of the interdiction forces. This section examines performance from the opposite frame of reference, that of the drug smuggler. The result is a true measure of effectiveness as it is conceived in terms of interdiction's impact on smugglers.

### INTERDICTION FROM THE SMUGGLER'S POINT OF VIEW

The immediate objective of a drug smuggler is to move a drug shipment from the source country into the U.S., all the while avoiding intercept, seizure, and arrest. The intervening interdiction forces are important to him primarily because they could deny this objective, but the threat is not uniform either in time or space. The gaps and weaknesses are the interesting parts for him; zones of strong defense are best left alone unless some compelling reason forces him to push the drugs through anyway. His assessments note what options have been denied, but prime attention goes to the opportunities remaining open.

Adopting the smuggler's point of view is potentially a powerful device for evaluating interdiction operations; the aggregate of all interdiction effort is seen through one lens. Differences among regions, agencies, commands, and programs are of little interest to the smuggler unless they affect his risks and costs of delivering the drugs. Irrelevant detail is suppressed and attention is riveted on whether interdiction operations are having an effect. Planning oversights, resource shortages, coordination failures, and other shortcomings are scored for the real openings they offer to a smuggler.

### PROPERTIES OF THE SMUGGLER SUCCESS RATE

The rational smuggler should avoid unnecessary risk. He can take a variety of actions to manage his exposure; the most elementary is simply to avoid contact with interdiction forces. A prime tactic is to blend with the background and exploit the fact that interdiction forces have the capacity to inspect only a small fraction of all the traffic encountered. Keeping a low profile depends on controlling any cues that might attract unwanted attention, a prescription for practicing good operational and communications security (OPSEC and COMSEC). A more active approach entails close study of interdiction operations to discover and exploit their weaknesses. Further tactical measures include tracking the location and status of interdiction forces for

real-time evasion.[1] More aggressive smugglers employ OPDEC measures to distract (and even engage with a decoy) interdiction forces while the drug shipment goes through. Though these precautions reduce the chances of intercept and search, a risk-averse smuggler still prepares for the worst. A highly successful tactic is to separate the smuggler and the contraband--hand off to accomplices, stash in a safe place, or jettison overboard as a last resort--before an encounter with interdiction forces. As a final hedge, smugglers have improved their concealment methods to the point that they can afford to cooperate with boarding parties [17], believing they can endure a search with little risk, short of destructive inspections conducted in port.

From the smuggler's point of view, realized risk is neatly summarized as his rate (or probability) of success. This measure incorporates the real effects of all factors affecting smuggling operations. In addition to seizures and arrests, it also reflects interdiction's indirect effects, such as inducing the smuggler to adopt practices that expose him more forcefully to losses from weather, his own ineptness, and predation by other drug smugglers.[2] The smuggler's rate of success is meaningful within any geographic slice of the drug traffic, and results are suitable for aggregation across boundaries to produce measures spanning several AORs. From the interdiction forces' point of view, a change in the smuggler's rate of success is a direct measure of the shifting balance of resource commitment and tactical skill between the two sides.

**Functional Forms of the Smuggler's Rate of Success**

All variants of the MOE are of this basic form:

$$\text{Smuggler success rate} = \frac{\text{Measure of drugs landed at destination}}{\text{Measure of attempted drug shipments}} .$$

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1. For example, in Operation Market Time, U.S. and Vietnamese surface interdiction forces sought to search the largest possible number of junks in the surveillance zone along the coast. To make maximum use of available resources, they adopted a rule that upon completion of a search, the nearest uninvestigated vessel would be the next one boarded. North Vietnamese arms smugglers were able to evade simply by keeping at least one vessel between themselves and the patrol boat [16, p. 21].
2. The interdiction rate, examined in the previous section, is a close cousin. It differs from the smuggler's rate of success in three respects: the perspective is that of the interdiction forces, not the smugglers; it is defined only over the time and space where smugglers are at risk to interdiction; and it credits only seizures, ignoring other effects.

The denominator reflects the magnitude of smuggling activity at the origin, and the numerator captures how much of it is successful. Though the ultimate destination of interest is the U.S. and its territories, some evaluations might usefully be structured around intermediate destinations such as the Bahamas or Mexico.

The term "measure" simply refers to the counting rules and units of expression that make the MOE functional. Basic to all the concepts offered here is the idea that a smuggling mission begins with the initial departure of a load of drugs and ends with one of several conclusive outcomes: successful delivery, seizure by law enforcement agents, theft by pirates, destruction in an accident, or abandonment. Aborted flights and sailings are merely temporary delays along the way to mission completion.[1]

A number of alternatives for measures are possible; perhaps several might be used in combination to illustrate different aspects of the problem:

*Missions*

$$\frac{\text{Number of smuggling missions completed}}{\text{Number of smuggling missions attempted}}$$

Though the aggregate over all missions (flights, voyages, shipments) might be computed, more meaningful results will emerge from a breakdown of missions by drug and mode of transportation (e.g., cocaine via general aviation aircraft or marijuana via noncommercial vessels).

*Amount of drugs*

$$\frac{\text{Amount of drugs landed at destination}}{\text{Amount of drugs in attempted shipments}}$$

This measure necessarily will be broken down by drug. An aggregate over drugs of different types would be meaningless because a ton of marijuana and a ton of cocaine are vastly different in physical volume, dollar value, social impact, or any other relevant respect. The raw results of forming ratios based on weight are likely to be somewhat different from those obtained using missions as the unit of account simply because shipments come in a range of sizes, thereby weighting some successful missions more heavily than others.

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1. If each departure following an abort were counted as a new mission, each abort would be valued the same as a seizure, theft, accident, or abandonment; the result clearly would underestimate the smuggler's ability to deliver drugs.

*Dollar Value*

$$\frac{\text{Value of successful drug shipments}}{\text{Value of attempted drug shipments}}$$

Ratios based on tonnage or value should be much the same for a given drug, unless prices exhibit significant regional or temporal discrepancies. Because money is a universal denominator, however, this measure might support a variety of interesting aggregates across drugs, smuggling modes, agencies, commands, and geographic areas. The hard part may be managing controversy over the choice of prices, particularly the problem of assuring that different drugs are valued in a comparable manner. The usefulness of such an MOE could be compromised if burdened with explanations and qualifications that smother the message.

**SMUGGLER SUCCESS RATE EVALUATED ON MOE CRITERIA**

**Mission Oriented**

Yes. In the abstract, this measure is the most mission oriented of the six reviewed in this paper. It addresses precisely the prime operational activity of the interdiction force, attrition of the smuggler. It goes further than the interdiction rate by taking account of all kinds of losses the smuggler may suffer, not just seizures by law enforcement agents. The measure is so inclusive, however, that it is suitable only for evaluating the collective performance of all agencies acting in the AOR and period of interest; for a single agency, the measure is sensible only when that agency has an exclusive franchise over the AOR. Earlier measures have been seen to encourage concentration on the easy targets; applications of the smuggler success rate can address this problem quite naturally by dividing the smuggler population into strata or layers. For example, different rates might be computed for novices and professionals, explicitly recognizing the sophisticated smuggler as a more difficult target. Finally, interdiction successes against decoy shipments are more likely to be recognized as marginal events when seen from the smuggler's point of view rather than from that of the interdiction force.

**Measurable**

Yes, in postulated scenarios, but no in real operations. There is no reasonable hope of collecting sufficient data to make precise estimates of actual smuggler shipments and deliveries in a chosen AOR. The MOE does fit this criterion, however, when used in postulated scenarios such as: CONOPS development, simulations, exercises, or evaluation of operations against assumed smuggler profiles. In all of these instances, smuggler shipments are an input variable and smuggler deliveries are the product of analysis or measurement. Such applications require extraordinary care and skepticism in developing the methodology to avoid bogus results.

**Quantitative**

Yes, but with qualifications. In real operations, the data are quantitative only in theory, because they are not collectable to any useful extent. When applied in postulated scenarios, the necessary data are quantitative, though with the qualification that they are no better than the quality of the models that produce the numbers.

**Discriminating**

Potentially yes. For postulated scenarios, any final judgement must rest on a critical evaluation of model implementation, data quality, and the specific manner in which the models are employed to investigate performance and potential weaknesses in operations. In real operations, the uncertainty of estimated smuggling activity is not known at present, though it would be surprising if the margin of error is as small as a factor of two for a full year of Caribbean operations; then the interdiction rate for a year would have to double before one could be confident that the change is a real effect, not mere noise. (The uncertainty factor grows even larger as one attempts to evaluate either a smaller AOR or shorter period of interest.)

**Realistic**

Yes, in postulated scenarios, if models are adequately representative. In real operations, the MOE is realistic in principle, but that benefit is of no practical value because the required data are not available under any foreseeable conditions.

**Objective**

Yes, for postulated scenarios, but in a mechanical way, because results can only be the product of a model. Not likely for real operations given the broad uncertainty in the baseline quantity of smuggler shipments.

**Appropriate**

Yes, if applied at a level that includes all interdiction activity in the period and AOR of interest, a condition that probably means the activities of several agencies are inseparably intertwined.

**Sensitive**

Potentially yes in postulated scenarios. The actual degree of sensitivity will depend on characteristics of the models and their implementation; any validation process should make a special point of assessing this property. As for real operations, uncertainty in the estimate of smuggler shipments virtually rules out any chance of the MOE being validly sensitive to changes in CONOPS.

**Promptly Responsive**

No. Whether the passage of time is real or simulated, interdiction events occur too slowly for rapid feedback.

**Simple To Understand**

Yes. The MOE itself is simple and easy to grasp. The hard part comes in establishing confidence in estimates of real smuggling activity or in demonstrating that models are adequate.

**Validated**

Not yet for postulated scenarios; the posited, linked models must be constructed and thoroughly tested before putting faith in the idea that their output will be useful. Validation of the MOE for real operations appears out of the question.

**SUMMARY**

Taking the smuggler's point of view is potentially a powerful device; it rolls together all interdiction activity in the area and period of interest and draws attention to the aspects smugglers can exploit. Measuring performance in these terms would strongly reinforce understanding of the mission. Offsetting these virtues is the fact that the MOE has no value for real operations because the data are not collectable in any practical sense. Nevertheless, the concept is suitable for postulated scenarios such as games, simulations, and exercises.

## SECTION 8

## IMPORT-EXPORT PRICE DIFFERENCE

The rewards of drug smuggling are profits. Remove the financial gain, and the incentive to deal in drugs dissipates, even if risks fade at the same time. Whether smugglers are considered individually or as a group, their actual costs and profits are not susceptible to direct measurement. However, Peter Reuter and colleagues at the Rand Corporation [18] proposed the difference between import and export prices as a closely related measure and used it in their high-level policy analysis of whether interdiction could be effective. This section explores whether such a measure might have some utility for evaluating operational performance.

### THEORETICAL FOUNDATION

The import price is realized during the first transaction after the drugs are landed in the U.S.; the export price is the smuggler's purchase cost in the source country. The difference between the two reflects transportation costs, risk premiums, and smuggler profits. (The Rand study assesses the effects of interdiction on export prices as sufficiently small to be neglected safely.)

All costs are passed through to the customer, but only in the long run and on average. A smuggling ring that suffers a seizure cannot raise prices to recover added costs if its customers can turn to alternative sources that are not experiencing the same cost burden. Likewise, the class of smugglers at risk to interdiction cannot raise prices to recover fully their added costs, because any price increase will induce greater supply from other transport modes not exposed to the same risk (e.g., mail, commercial cargo, body carry). At equilibrium, the smugglers suffering the effects of interdiction will see both a price that covers only some fraction of their increased costs and a smaller market share; therefore, the difference between import and export prices will grow, but by something less than the full increase in costs to the affected smugglers. Also, as their market share declines, a falling fraction of the costs imposed by interdiction will show up in the price difference, in the extreme reaching zero if drug smugglers shift their entire flow to transport methods not subject to interdiction. These perturbations take time to work their way through the market, the effects appearing with some lag.

### SUITABILITY FOR EVALUATING OPERATIONAL PERFORMANCE

Given these characteristics, is there any utility in using the import-export price difference as a measure of operational performance? On the positive side, price is a powerful mechanism for summarizing all factors with an economic effect: smuggler costs, alternative smuggling methods, risk of arrest, consumer response, and so on. The Rand study

concludes, however, that smuggling costs and profits compose only about 10 percent of the import price for cocaine. If interdiction is intensified to the point that it doubles the costs of smuggling, the import price could increase by 10 percent, at most, and probably somewhat less since other transport methods have significant market share. Is it possible to detect with confidence a price change of a few percent in a useful time frame?

The Drug Enforcement Administration collects data from undercover negotiations and completed buys, compiling the results quarterly. The Rand study examined these data and found them of sufficiently doubtful quality that they warranted treatment with only the most robust of methods. That study presents data [18, appendix B] showing that the interquartile range (the band containing 50 percent of the data, centered around the median) is about 20 to 25 percent of the median, on average; that is, if cocaine's median import price during a quarter was $25,000 per kilogram, half of the data should fall in a range of about $22,000 to $28,000. To continue the example, assume the median export price is $4,000, with an interquartile range of $3,500 to $4,500. The difference between import and export prices then has a median of $21,000 and an interquartile range of $18,500 to $23,500; these numbers are shown as the baseline case in table 8-1.

**Table 8-1. Effects of interdiction on cocaine prices**

| | | Baseline case | | Smuggling costs are doubled | |
|---|---|---|---|---|---|
| | Export price | Import price | Import-export difference | Import price | Import-export difference |
| Upper quartile | 4,500 | 28,000 | 23,500 | 30,800 | 26,300 |
| Median | 4,000 | 25,000 | 21,000 | 27,500 | 23,500 |
| Lower quartile | 3,500 | 22,000 | 18,500 | 24,200 | 20,700 |

Now consider the significance if some change in the CONOPS doubles the cost of smuggling and the next quarter shows a full 10-percent increase in the import price (median of $27,500 and interquartile range of $24,200 to $30,800) while the export price figures remain steady. Standard nonparametric statistical tests are designed to operate on the

raw data,[1] not on summaries as in table 8-1; however, some insight can be gained from thinking of the interquartile ranges as 50-percent confidence intervals, illustrated in figure 8-1.

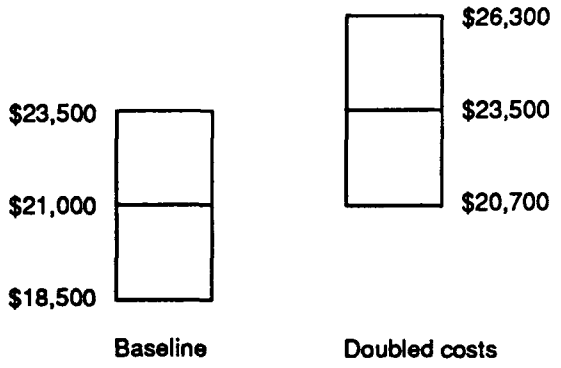


**Figure 8-1.** Hypothetical comparison of import-export difference when interdiction doubles smuggling costs

The import price increase moved the median for the second quarter just to the edge of the first quarter's interquartile range. As a result, there is about a 50-50 chance that the second quarter's import-export price difference is not a significant divergence from the first, the apparent change being merely a result of sampling variation between the two periods. Furthermore, statistical decisions commonly rely on confidence intervals of 90 or 95 percent, not 50 percent; the change in the price difference would have to be two or three times larger than in the example to satisfy this more typical standard. In sum, it seems unlikely that a change in the effectiveness of interdiction so dramatic as to double the costs of smuggling would result in a significant change in the import-export price difference from one quarter to the next.

Taking a longer view, data from several quarters preceding and following a change in CONOPS might supply acceptable evidence of a break in the price trend, even though changes between successive periods are modest. Even if a correlation can be established, there still remains the question of whether the apparent relationship is one of cause and effect, or merely coincidence. As already noted, import modes not subject to interdiction hold a sizable fraction of the market; actions by either smugglers or LEAs in these other segments have the power to

1. The Wilcoxin rank sum test is commonly used for deciding whether the medians of two random samples are significantly different. Its theoretical foundation and practical application are described in standard texts on nonparametric statistics [e.g., 19].

obscure the price effect stemming from interdiction. As a result, a practical system would need to be broadly conceived, assessing the price impact of all market sectors, including an important domestic component for products such as marijuana.

## IMPORT-EXPORT PRICE DIFFERENCE EVALUATED ON MOE CRITERIA

### Mission Oriented

Probably not. Interdiction forces likely would have difficulty seeing how their operations affect the import-export price difference. Even estimating their impact on the smugglers' costs is likely to entail large uncertainties. As a result, the MOE would not supply much guidance for commanders trying to choose among alternative strategies or deployments.

### Measurable

Yes, for postulated scenarios, but the issue is whether the modeling is good enough to make the results of any value. Potentially yes for real operations. If LEAs considered it worth the effort, data quality might be improved substantially. Not only would it be necessary to reduce the incidence of recording and handling errors, but also a substantial effort would be needed to correctly identify the stage of drug distribution represented in each reported transaction.

### Quantitative

Potentially, yes. The MOE gives a measured numerical result, but the issue is whether the numbers are to be believed. The Rand researchers found existing data did not deserve much better than qualitative treatment. Though the problem is different, building worthwhile models for use in postulated scenarios is likely to be as great a challenge as collecting adequate data from the real world.

### Discriminating

No, at least with the data quality presently available. The example presented above showed that a doubling of smuggler costs would have an effect on the MOE that is much too small to discern within the quality of available data.

### Realistic

No. The relationship between interdiction operations and the MOE almost surely will be obscure to the deployed forces.

**Objective**

Probably not. The stage of the drug distribution process represented in each transaction is often difficult to determine. Alternative criteria for selecting the appropriate data points will produce different results.

**Appropriate**

No. The import-export price difference is the joint result of the balance among all antidrug activities and all sources of illegal drugs, much of which is beyond the influence of interdiction.

**Sensitive**

No. Interdiction acts principally to raise smuggling costs, an element the Rand researchers estimate as amounting to only 10 percent of the import-export price difference. Even an interdiction campaign so severe as to double smuggling costs could increase the MOE by only 10 percent.

**Promptly Responsive**

No. The Rand researchers found that quarterly data were of barely useful quality; even with good data, the small role of smuggling costs makes it likely that the MOE could detect only implausibly large changes in a few quarters.

**Simple To Understand**

Not likely. Personnel not schooled in economics probably would have difficulty grasping the connection between interdiction operations and the import-export price difference. In addition, outside the realm of interdiction, numerous activities of both smugglers and LEAs can affect the difference.

**Validated**

No. The MOE is no more than a hypothetical concept.

**SUMMARY**

In summary, three key difficulties undermine the import-export price difference as a prospective MOE for operational evaluation. First, smuggling costs are such a small element of import prices that even large increases have little apparent effect. Second, current data on relevant prices seem too low in quality to discriminate plausible effects when comparing successive quarters. Third, the import-export price difference for a given drug is the joint result of all sources acting together, only some of them subject to interdiction. An assessment system based on this measure would have to be comprehensive so it

could allocate all effects to sources; its sponsorship and administration clearly would be beyond the reach of the interdiction community acting alone.

## SECTION 9

## MARKET SHARE

In the extreme, a drug smuggler might be deterred when hazards become intolerable or profits evaporate, but long before reaching this point, a rational smuggler experiencing increased pressure should move into alternatives offering a better mix of risks and rewards. Historic adaptations to interdiction success are instructive in this regard. Smuggling from Latin America has shifted away from Caribbean routes and into Mexico. Transport methods have changed from direct delivery to multistage movements. More drugs are moving through ports of entry concealed in commercial cargo. Farther afield, smugglers have encouraged new markets in Europe and the Far East. They have even opened other lines of business that complement the drug trade or capitalize on its skills and resources. The very fact of such adaptations is sometimes cited as evidence that interdiction forces are effective [e.g., 20].

This line of thought suggests that changes in the allocation of smuggling activity among alternatives might give some insight into whether interdiction is doing any good. For example, today's marijuana smuggling in the Caribbean is only a shadow of its former self; though substantial activity remains, the traffic has shrunken markedly and its particulars have changed over the past decade. Movements over the Mexican border combined with domestic production have become the dominant factors in a notably enlarged supply [21].[1]

One possibility for quantifying such changes is to track the market share held by smuggling methods subject to interdiction. This measure would seem to capture the direct effects of removing drugs from the pipeline, price impacts from moving to alternative smuggling methods, and deliberate actions by smugglers to shift the mode or location of their activities.

### IMPLEMENTATION ISSUES

Tracking market shares entails estimating the quantities moved via the methods and regions subject to interdiction, complemented by compatible estimates of all other flows of that same drug into the country. However plausible this notion may sound, experience with national drug

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1. When seen in this larger context, the value of interdiction's apparent success is deflated; smuggling is down where interdiction has been at work, but the overall problem is worse than ever. Taken alone, the deterrent effect of interdiction may be no more than local, simply displacing traffic to safer avenues. Antidrug efforts will encounter this frustration as long as a market exists and smugglers can find (or create) gaps in the shield of interdiction and law enforcement.

estimates from the National Narcotics Intelligence Consumers Committee (NNICC) [21] suggests that the kind of statistics presently available will not provide useful results. Four factors support this conclusion.

First, the regional distribution of market share is not compiled currently in any systematic way. NNICC estimates of illegal drug supplies are the results of two macro-scale approaches. One method begins with global surveys of raw materials (acres of coca, marijuana, or opium poppies) and computes outputs at each stage of the production process to estimate aggregates of finished drug supplies available in the U.S. The other method starts with surveys of the user population and then develops estimates for consumption and the magnitude of the associated market.

Second, any bureaucratically realistic approach would either have to be integrated with the current NNICC process or replace it outright--the agencies involved could not afford the resources for an independent alternative. References [22] and [23] detail shortcomings in the NNICC methods, many of them related to inadequate treatment of uncertainty. Figures usually are reported as point estimates; occasionally a range is cited but without explanation as to what it means. Absent a quantitative understanding of uncertainty in the estimates, there is little basis for judging whether a change in an estimate from one year to the next is a signal or just routine noise. Reference [22] gives a clear idea of the difficulties in making the estimates and the even greater challenge of characterizing uncertainty. These problems for national aggregates will be multiplied not only in number, but also in severity, if the process is refined to produce component estimates broken down by smuggling method and region. The prospects for producing useful market-share data are dismal without some dramatic improvement in data and methods.

Third, even if annual estimates are released on schedule (one or two quarters into the following year), they still are not timely feedback to the chain of command as to the success or failure of operations. Shortening the time slice to quarterly or monthly, however, would shrink sample size and exacerbate the uncertainty problem.

Fourth, interpreting changes in market share is likely to present formidable problems (assuming estimates can be made with enough accuracy to justify the effort). Movements in market-share statistics are relative; a rise or fall in the target sector's market share depends as much on what is happening in other sectors as it does on interdiction's effectiveness.

All in all, market share is liable to be a blunt tool, rarely giving confident signals; if it does signal a major shift, the event is likely to be apparent without going to all the trouble of computing

regional market shares. This combination of insensitivity and enormous estimation problems leaves the measure as having little more than theoretical interest for evaluating operations.

## MARKET SHARE EVALUATED ON MOE CRITERIA

### Mission Oriented

Yes, for postulated scenarios, but only if corrected for all external effects. No, for real operations. Reducing the market share for an AOR is a step forward, provided the gain is not compensated by increased smuggling activity in other areas, a phenomenon known among LEAs as displacement. Progress entails reducing the size of the entire market, not just moving the pieces around.

### Measurable

Possibly, for postulated scenarios, if the process can be modeled credibly. Not likely for real operations. Current methods of estimating the annual size of the national market are fraught with uncertainty; results of doing the same for regional shares on shorter time scales would have the quality of a fairy tale without a substantial improvement in data and methods.

### Quantitative

Yes, for postulated scenarios, but trivially so unless models conform well to reality. Probably not for real operations. Though market share is numeric in concept, believable figures suitable for evaluating real operations seem beyond the reach of estimation methods currently employed.

### Discriminating

Yes, for postulated scenarios, but in an artificial way; models can produce sample sizes unobtainable in the real world. No, for real operations. A key problem with even the best statistics about market size is uncertainty; though error bands rarely are reported, qualitative indications suggest they should be large.

### Realistic

No. Market share has little connection to the operational situation as seen from the perspective of interdiction forces.

### Objective

Yes, for postulated scenarios, provided the models are sufficiently realistic. Indeterminate for real operations, in the absence of any realistic prospect of computing market shares.

**Appropriate**

No. Market share in one sector depends not only on the outcome of the contest there, but also on results in other sectors as well.

**Sensitive**

No. A deliberate smuggler decision to shift weight of effort to methods not subject to interdiction (e.g., the commercial container trade) would have a large impact on market shares and yet have nothing to do with the effectiveness of interdiction.

**Promptly Responsive**

No. The only official estimate of the overall size of the drug market appears as annual data, and that report is released one or two quarters after the fact. It would take a large additional effort to do even this well with regional market share estimates.

**Simple To Understand**

No. The link between interdiction operations and a subsequent estimate of market share is likely to be obscure and complicated because the result is subject to many external influences as well as a broad range of uncertainty.

**Validated**

No. Market share as a measure of operational performance is no more than a hypothetical concept.

**SUMMARY**

Reliable data showing the allocation of market share over smuggling regions probably would be useful for gaining a strategic perspective, but market share seems to have little potential as an MOE for evaluating interdiction operations on a regional basis. The chief problem is that market shares can change due to a host of factors, interdiction effectiveness in some target region being only one of many. A more practical problem is the poor prospect for estimating market shares with sufficient precision to tell when a real change occurs. Current estimates offer breakdowns no lower than the national market and no more often than annual; yet, even this degree of aggregation is difficult to compile and leaves large uncertainties.

## SECTION 10

## EXAMPLE OF A SUITE OF MOEs

Of the six MOEs reviewed in preceding sections, none proved to be winners on all counts; however, combinations might be attractive if one MOE can neutralize liabilities of another. Combinations might also be appealing if two or more MOEs complement each other by assessing different aspects of the same operation. Both possibilities are present in a three-member suite consisting of:

- Smuggler success rate
- Interdiction rate
- Boarding success rate.

The smuggler success rate assesses force effectiveness in terms of impact on the smuggler's overall operation. The MOE is figured on the AOR taken as a whole, including the times and places not covered by interdiction forces; this latter aspect is important because it accounts for the opportunities remaining open to smugglers despite the interdiction effort. Taking the smuggler's point of view also facilitates dividing the criminal population according to level of sophistication, setting the stage for scoring interdiction effectiveness against each segment. Results in this disaggregated form should quickly reveal whether interdiction forces have concentrated their effort against the easiest targets, a key problem when interdiction rate and boarding success rate are used alone as MOEs.

The interdiction rate assesses force effectiveness in terms of the fraction of smuggling effort interdicted. In contrast to the smuggler success rate, this MOE is figured only for the portion of the tactical area (in time and space) where the forces put smugglers at risk of interdiction, characterizing how well the forces perform against the threat within their reach.

The boarding success rate assesses force efficiency in terms of how often a boarding results in a seizure. It is a direct measure of how well boarding activity is targeted. One key difficulty with this MOE is that it tempts forces to concentrate on the easy targets and rely on only the strongest cues; a way to combat this bias is to break down the assessment according to different types of boardings, for example:

- Proven intelligence cuing methods
- Experimental or unproven cuing methods

- Random selections and other methods designed to detect smugglers who have figured out how to avoid cuing techniques currently in use.

It might also be necessary to introduce a measure of how fully boarding capacity is used to counteract the implicit rewards to withholding resources from low probability endeavors.

Taken together, these three MOEs provide the means to evaluate a single set of operations from both the smuggler and law enforcement perspectives, simultaneously. Further, both efficiency and effectiveness of the interdiction forces are assessed jointly.

Three factors limit this suite of MOEs to a narrow range of application. First, this combination is meaningful only for the surface maritime smuggling threat, the only realm in which boarding success rate is defined.[1] Second, the MOE suite can be used only in postulated scenarios, because data needed to compute interdiction rate and smuggler success rate are not available from real operations. Third, even if real-world data were of sufficient quality, interdiction events happen at too low a rate to stratify the data according to smuggler sophistication and boarding type; dissecting operations to this extent is possible only in postulated scenarios where event rates and the passage of time are not constraints on using models or simulations to accumulate a sufficient mass of data.

## SUITE EVALUATED ON MOE CRITERIA

The MOE attributes and evaluation criteria presented in section 2 are as meaningful for a combination of measures as they are for individual MOEs; indeed, two of the criteria are pertinent principally for suites. Keep in mind throughout the following evaluation that the context is constrained to just postulated scenarios of surface maritime interdiction.

### Mission Oriented

Yes. The suite provides a three-tiered evaluation: effectiveness against the smuggler's overall program, effectiveness against vessels at risk to interdiction forces, and efficiency of the boarding program. Doing well on each measure manifestly contributes to mission success. There is no explicit priority among the three measures, however; different resource allocations will result in changes in the profile of MOE scores, in effect assigning implicit weights.

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1. Much of the discussion in this section still applies to a more restricted combination of just smuggler success rate and interdiction rate; the pair could be used in a broader array of scenarios than just surface maritime interdiction.

**Measurable**

Yes. Analyses, simulations, and field exercises have the advantage that scenario durations and event rates can be controlled to provide high-quality data in desired amounts. One must remember these data are not real, but merely the product of some model or simulation that could harbor subtle (but critical) omissions and errors.

**Quantitative**

Yes. All three measures are numerical.

**Discriminating**

Yes, but possibly in a misleading way. In a postulated scenario, one can generate enough data to assure that the results are not handicapped by small sample size, but these data may reflect conceptual errors imbedded in the models of smugglers, interdiction forces, and their interaction. Distinctions that seem compelling in a postulated scenario may prove totally unreliable in reality because of errors and oversights in the models.

**Realistic**

Potentially yes. Presumably, a competent analyst would not deliberately model interdiction in an unrealistic manner, but ambiguities and information gaps may produce the same effect. The problem is likely to be more critical for analyses and simulations because live exercises involving interdiction forces engage at least part of the real world.

**Objective**

Possibly, depending on the formulation and modeling of the postulated scenario. Without the discipline of real-world data, biases might become embedded in the design and execution of the models.

**Appropriate**

Yes, provided the models are tailored to be representative of the forces under study.

**Sensitive**

Yes, with proper model design. The chief risk comes from concentrating on internal details of the scenario and models while overlooking external factors that end up driving the answer.

**Promptly Responsive**

No. In real-world operations, the key sources of feedback delay are data reporting and slow event rates. Though the passage of time can be accelerated in a simulation, the elapsed time inside the scenario to accumulate a critical mass of data is unchanged.

**Simple To Understand**

Yes. Intuitive understanding of all three measures is consistent with their more formal meanings.

**Validated**

No. However obvious and appealing these measures might be, they still have not been validated in any real-world sense. Neither is it clear how validation could be carried out, given the improbability of collecting real-world data of the kind needed to compute either the smuggler success rate or interdiction rate.

**Balanced**

Yes. Though these three measures may not cover everything interdiction forces do, they provide a nested assessment of three central issues: effectiveness against the smuggler's overall program, effectiveness against smuggling vessels at risk to interdiction, and efficiency of using a critical resource, boarding capacity.

**Compact**

Yes. At first glance, it might seem that this suite of three MOEs is redundant in that they all employ at least some of the same information, but, in fact, each measure takes a different field of view and illuminates an aspect of the problem beyond reach of the other two measures. This complementarity suggests that one could not achieve the same effect with a smaller set, or at least not one retaining any of these three measures.

**SUMMARY**

This suite of three illustrates how several MOEs might be combined into a system of mutually supporting measures. Properties of one can offset deficiencies of another; multiple MOEs can evaluate a given set of operations from different but complementary frames of reference, while, in the process, producing a more balanced and comprehensive result. On the other hand, this combination is restricted to a narrow range of application: postulated scenarios of surface maritime interdiction. The insights obtained through this trio of MOEs should be moderated by concern for how faithfully the modeling captures the real world, particularly smuggler capabilities and behavior.

## SECTION 11

## PERFORMANCE SUMMARY FOR INTERDICTION MOEs

### INTERDICTION MOEs APPLIED TO REAL OPERATIONS

The tables on the following pages briefly summarize the standing of the six MOEs on each of the 11 criteria. Table 11-1 concerns their application in real operations. All six MOEs have such serious drawbacks in this context that none of them is likely to be very useful for evaluating tactical performance of actual interdiction forces. The dominant shortcomings include the following:

- Interdiction rate, smuggler success rate, and market share are not measurable because they rely on unknowable information about the real flow of illicit drugs.
- Raw seizures, boarding success rate, and interdiction rate all harbor an implicit incentive for the forces to concentrate on the least sophisticated slice of the smuggler spectrum.
- Import-export price difference and market share both respond to a host of factors beyond the realm of interdiction, making it difficult to tell just what factors might be responsible for an observed change.
- All six MOEs require long periods to give officials feedback about the effects of a change in operations. The import-export price difference and market share rely on a lengthy collection and analysis process that provides data only a year or more after the fact. The other four MOEs depend on events that accumulate so slowly that even year-to-year comparisons require extraordinary changes in the MOE to recognize that a real change has occurred.

### INTERDICTION MOEs APPLIED TO POSTULATED SCENARIOS

Table 11-2 summarizes application of these MOEs in postulated scenarios such as war games, simulations, and exercises; the table also includes the three-member suite of MOEs for surface maritime interdiction operations, as explored in section 10. Postulated scenarios have some advantages that ease selected problems encountered in real operations.

Table 11-1. Summary of MOE evaluations for real interdiction operations

| Attribute | MOE raw seizures | Boarding success rate | Interdiction rate | Smuggler success rate | Import-export difference | Market share |
|---|---|---|---|---|---|---|
| Mission oriented | Probably not | Yes, in part | Yes, with qualification | Yes | Probably not | No |
| Measurable | Yes | Yes | No | No | Yes, potentially | Not likely |
| Quantitative | Yes | Yes | Yes, in theory | Yes, in theory | Yes, potertially | Probably not |
| Discriminating | Often not | No | Probably not | Yes, potentailly | No | No |
| Realistic | Only in part | No | Yes, with qualification | Yes, in principle | No | No |
| Objective | No | Technically, yes | Yes, in theory | Not likely | Probably not | Indeterminate |
| Appropriate | To a degree | Yes | Yes | Yes, if full aggregate | No | No |
| Sensitive | In part | No | Yes | Unlikely | No | No |
| Promply responsive | No | No | No | No | No | No |
| Simple to understand | No | Maybe | Yes | Yes | Not likely | No |
| Validated | No | No | No | No | No | No |

Table 11-2. Summary of MOE evaluations for postulated scenarios

| Attribute | MOE raw seizures | Boarding success rate | Interdiction rate | Smuggler success rate | Import-export difference | Market share | Example suite |
|---|---|---|---|---|---|---|---|
| Mission oriented | Probably not | Yes, in part | Yes, with qualification | Yes | Probably not | Yes, if corrected | Yes |
| Measurable | Yes | Yes | Yes | Yes | Yes | Possibly | Yes |
| Quantitative | Yes | Yes | Yes | Yes, with good models | Yes, potentially | Yes, with good models | Yes |
| Discriminating | Technically, yes | Yes | Yes | Yes, with good models | No | Technically, yes | Yes, but artificial |
| Realistic | Only in part | No | Yes, with qualification | Yes, with good models | No | No | Yes, potentially |
| Objective | No | Technically, yes | Yes, in theory | Yes, but mechanically | Probably not | Yes, with good models | Possibly |
| Appropriate | To a degree | Yes | Yes | Yes, if full aggregate | No | No | Yes, with good models |
| Sensitive | In part | No | Yes | Yes, potentially | No | No | Yes, with good models |
| Promply responsive | No | No | No | No | No | No | No |
| Simple to understand | No | Maybe | Yes | Yes | Not likely | No | Yes |
| Validated | No | No | No | No | No | No | No |

- Both sides of the contest can be instrumented as desired; the evaluator has access to ground truth about all simulated events, notably the timing, routing, and quantities of smuggled contraband. Virtually anything in a postulated scenario is subject to measurement, though the result may be specious unless great care is taken to assure realistic results.

- External factors that obscure the impact of interdiction forces can be tracked and the results adjusted for their effects.

- Problems of low event rates, long data-accumulation times, and small sample sizes can be addressed by exercising the model at greater length to build a sufficient base of statistics.

Although these improvements ease difficulties and resolve some ambiguities, they do not solve all the problems.

- Results of the game, model, or simulation will be no better than the quality of the modeling that goes into them. If the representation of smuggler operations is seriously flawed or incomplete, expect the analytic results to suffer the same deficiencies.

- Biases embedded in some MOEs (e.g., incentive to concentrate on the least sophisticated smugglers) are still present; however, with their comprehensive oversight of the simulated events, controllers might be able to investigate the practical extent and significance of the biases.

- The number of raw seizures still is poorly conceived as an MOE, primarily because it lacks any reference to the level of effort on either side. Whatever the context, the meaning of rising or falling scores cannot be determined objectively.

**SUMMARY**

It is a formidable challenge to devise measures that send the right message to the forces, rely on data that can be collected in real operations, and give a result with sufficient sensitivity and responsiveness to be worth the trouble of making the effort. Simultaneously considering all these issues requires a systematic and disciplined approach of the sort used in this study.

None of the MOEs considered here are likely to be of much value for evaluating performance in real operations; measures that use good data suffer from serious conceptual problems, notably a lack of mission orientation; those that are soundly related to the mission require data that cannot be collected under any foreseeable circumstances.

The suite of three MOEs (smuggler success rate, interdiction rate, and boarding success rate) for surface maritime interdiction is attractive for postulated scenarios as in games, simulations, and exercises. Indeed, they complement each other, measuring both effectiveness and efficiency. Together, they capture views from both sides of the contest in a common frame of reference.

## SECTION 12

## RELEVANCE TO MILITARY ROLES IN INTERDICTION

Because military forces play only supporting roles, their contribution is to enhance the primary interdiction campaign as executed by the LEAs. An issue confronting DOD is how to measure the military contribution to the collective success of interdiction. Efforts to find an answer are confounded by both the policy restrictions on military activity and the difficulties of assessing in isolation just one part of a large undertaking with many interdependent pieces. This section explores this issue, particularly as it relates to the MOEs considered in earlier sections.

### MILITARY ROLES IN DRUG INTERDICTION

The Posse Comitatus Act of 1878 (with subsequent amendments) prohibits the Army and Air Force from enforcing a civil law; this injunction also extends to the Navy and Marine Corps as a matter of DOD policy. Military forces are prohibited specifically from rendering the following forms of direct assistance to LEAs:

- Interdiction of a vehicle, vessel, aircraft, or other similar activity
- A search or seizure
- An arrest, apprehension, stop and frisk, or similar activity
- Use of military personnel for surveillance or pursuit of individuals, or as undercover agents, informants, investigators, or interrogators.

With some limitations, however, military personnel may train law enforcement officers, provide expert advice, or maintain and operate equipment [24 and 25].

Until September 1988, the military role in drug interdiction was limited to providing equipment and services to LEAs; DOD forces did not initiate or conduct operations on their own. The FY 1989 National Defense Authorization Act [26] opened a new chapter by assigning DOD three missions:[1]

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1. These statements are the most current versions of the missions; they reflect the slight language adjustments contained in [27].

- "...serve as the single lead agency of the Federal Government for the detection and monitoring of aerial and maritime transit of illegal drugs into the United States."

- "...integrate into an effective communications network the command, control, communications, and technical intelligence assets of the United States that are dedicated (in whole or in part) to the interdiction of illegal drugs into the United States."

- Drawing on a special appropriation, fund the plans of state governors for using the National Guard (in non-Federal status) to conduct interdiction and counter-drug activities (paraphrased for clarity).

The Secretary of Defense assigned the detection and monitoring mission to the Chairman, Joint Chiefs of Staff (CJCS) for execution. In turn, tasking to develop regional concepts of operations went to five commanders in chief (CINCs): USCINCLANT, USCINCPAC, CINCFOR, USCINCSOUTH, and CINCNORAD. The first three established joint task forces (JTFs, numbered FOUR, FIVE, and SIX, respectively) to plan and execute antidrug operations in their areas of responsibility; the latter two CINCs chose to use their existing operations centers rather than create a new field organization.

The result is a wide range of antidrug activities assigned to military forces:

- Conduct surveillance with radar and other sensors from satellites, aircraft, aerostats, ships, and land sites. The Coast Guard, Customs Service, and the Federal Aviation Administration perform similar functions.

- Coordinate detection and monitoring activities of all participating agencies. Relevant defense intelligence is woven into tactical operations through the JTFs and CINC operations centers. Once an aerial target is identified, intercept control normally is handed off to operations centers belonging to LEAs.

- Intercept suspected smuggling aircraft for the purpose of identification and covert trail. Military aircraft are used outside U.S. borders when Coast Guard and Customs interceptors are not available for the mission.

- Provide platforms for interdiction operations. Navy ships carry Coast Guard law enforcement detachments whose members conduct all boardings of suspect vessels; throughout a visit and search, the Navy vessel remains under Coast Guard tactical control ([17] lays out full details). In other contexts, military aircraft and motor vehicles

carry law enforcement agents into action. These same functions also are performed with Coast Guard cutters, Customs Service launches (in coastal areas), and LEA aircraft.

- Pre-empt smuggler employment of an operating area. Congress has directed the Secretary of Defense to conduct military training exercises in drug interdiction areas to the maximum extent possible [27]. Smugglers seem reluctant to press their trade through an area where forces are exercising, whether on land or at sea; they choose to either stand down or head in another direction. Law enforcement agents can take the opportunity to redeploy for the duration of the exercise and concentrate their efforts elsewhere.

- Train law enforcement personnel. Examples of training subjects include: foreign languages, planning techniques, surveillance, field tactics, communications security, and maintenance of military equipment.

- Provide operational support. The services loan equipment, sometimes also sending military personnel along to operate and maintain the gear. Some items with obvious application are night vision goggles, secure communications, aircraft, and vehicles. Military facilities also play support roles based on their special capabilities or favorable locations (e.g., Howard AFB, Panama; NAS Roosevelt Roads, Puerto Rico; and NAS Guantanamo, Cuba).

One striking point about this list is that hardly any part of it is the exclusive province of military forces. The LEAs have developed their own forces, base structures, intelligence sources, operations centers, communications nets, tactics, and almost every other facet of antidrug activities. In addition, virtually everything a military unit might contribute to the antidrug campaign depends in some way on coordinated action by an LEA to realize a payoff. Accordingly, benefits from military participation are shared with other parties; a determined effort to isolate and evaluate the military contribution on its own runs a serious risk of losing sight of the big picture.

## SPECIAL PROBLEMS OF EVALUATING THE MILITARY CONTRIBUTION

This brief sketch of legal limitations and overlapping roles sets the stage for examining the special problems of evaluating the military contribution to interdiction.

### Seizures Are Disconnected From Military Roles

The three MOEs considered in sections 4, 5, and 6 (raw seizures, boarding success rate, and interdiction rate) are seizures in various

guises. Attempts to link military contributions to any such measures are suspect because military forces lack the authority and training to seize property or arrest suspects; only law enforcement agencies (Customs, Coast Guard, Drug Enforcement Administration, state and local police, and many others) may do so. If, nevertheless, one chooses to assess the DOD contribution via a seizure-related MOE, military performance depends on the follow-up performance of associated LEAs; at the logical extreme, perfect military execution would be meaningless if the LEAs are not effective in capitalizing on the resulting opportunities. Conversely, an improvement in LEA operations might be solely responsible for increases in the MOEs. Such MOEs totally fail the criterion for an MOE to be "appropriate."

Neither can military forces reliably demonstrate a connection between changes in their operations and subsequent seizure statistics, a failure of the criterion for an MOE to be "sensitive." Focusing on seizures underscores that military participants serve as mere accessories facilitating actions of others; military actions taken alone are devoid of any intrinsic value in this context.

Finally, a fundamental practical problem with MOEs built on seizures is how slowly these events accumulate over time, especially those with military involvement. The small sample sizes mean that huge changes in the rates are necessary to reach any statistical confidence that there is a real change in performance, the essence of the criterion "discriminating."

**Allocating Credit Is Subjective and Often Arbitrary**

At a press conference following the defeat of Cuban exiles at the Bay of Pigs, President John F. Kennedy said, "There is an old saying that victory has a hundred fathers and defeat is an orphan...." [28]. The truth of the adage is apparent when everything works right and a large load of drugs is seized. Half a dozen agencies may see themselves as instrumental in the seizure, but claims of credit may depend as much on fortune and administrative practice as on operational effectiveness. Authorities directing multi-agency operations often have a choice of which agency or unit receives the nod to intercept particular targets. It is distinctly unsatisfying to award credit without distinguishing between those who were instrumental and those who merely happened to be present; yet, in the midst of all the many participants, it is often difficult to tell the difference. As a result, an agency or a service might see rewards in leaving its fingerprints on as many interdiction events as possible, even if its real contribution is insignificant.

The smuggler success rate is no better basis for separately measuring a military contribution. First, a seizure is the most prominent way a smuggling mission can fail, already described as an inappropriate criterion for DOD forces. Second, though this MOE is a natural gauge of interdiction's effect on smugglers, the link to performance of

individual agencies is indirect and hard to trace. The measure recognizes effects other than seizures and takes into account opportunities for smugglers to go around interdiction forces, but these virtues are realized only in the aggregate. Unless one agency has the exclusive franchise in a sizeable area, its contribution will be described as contingent on the related performance of other agencies.

Looking at the other side of the struggle, the smugglers themselves can and do redirect the drug flow among various modes and routes, while, in the process, changing the opportunities for units, agencies, and geographic regions. As a result, the smuggler success rate and the three seizure-based MOEs could appear to make strong moves (in either direction) without any real change in performance by the interdiction forces. The more finely one tries to break down operations, the greater the possibility of this effect; all credibility evaporates by the time one attempts to allocate credit among agencies in a relatively small AOR.

Such problems for seizure-related MOEs are elementary when compared to allocating credit under the other two MOEs: import-export price difference and market share. Both measures embody a wide range of effects, only some of which are due primarily to the action of interdiction forces in the AOR under study. These MOEs are broadly inclusive, reflecting the balance of opportunity over all smuggling alternatives and the effects of law enforcement activity well beyond the scope of interdiction. An improvement in one of these MOEs might signal a local success, but, in fact, the change might just as well stem from altered risks and rewards in regions far beyond the AOR of interest.

## SECTION 13

## SUMMARY AND CONCLUSIONS

Peter Reuter and colleagues [18] devised methods of assessing the policy question of whether interdiction could make illicit drugs any less available in the United States and generally concluded the prospects were poor. This study takes a narrower focus, accepting as given that some resources will be devoted to interdiction and then seeking methods of measuring operational performance; the results show that the task has no easy solutions.

The main quest was to find ways of measuring how well interdiction forces are performing, preliminary to assessing how military forces are contributing to the success of interdiction. When used to assess real operations, all six of the candidate MOEs proved to have one or more of these critical deficiencies:

- Require data that cannot be collected in real operations
- Offer incentives to conduct operations in ways that actually undermine the mission
- Respond strongly to events that have nothing to do with the effectiveness of the forces under evaluation
- Are beset by such low event rates or high statistical variability that real changes in performance may be recognized only when the MOE moves in implausibly large steps.

Furthermore, none of these impediments has high prospects of being overcome in the foreseeable future.

The military role in interdiction is limited by statute and policy to supporting activities. Lacking the powers of search, seizure, and arrest, realizing benefit from military support to interdiction almost always depends on final action by a law enforcement agent. In addition, though DOD forces serve in a wide variety of roles, many of them parallel similar functions performed by LEAs. These restrictions and the lack of uniqueness combine to make it all but impossible to cleanly separate military roles and judge their value on their own terms.

Nevertheless, the question of characterizing the effectiveness of the military contribution to antidrug operations still remains. One possibility is to focus narrowly on the performance of actual military activities. For example, the mission of detection and monitoring might be characterized in terms of coverage, probability of detection, timeliness of notification to LEAs, fraction of targets tracked to intercept, and similar technical criteria. Such an approach has two attractive advantages: (1) the necessary data are internal to military

operations, not requiring collection from the smugglers and LEAs, and (2) the measures are of a kind familiar to military forces in other operational settings. There is a down side, however: doing well on such technical criteria gives no assurance that the effort has any useful impact. Smugglers still may find enough opportunities to evade, deceive, or circumvent so they can maintain the flow of drugs. As an extreme, envision an intensive and expensive effort to attain high technical performance, only to learn later that drug purveyors had outflanked the campaign through a shift of methods.

On the other hand, some of the MOEs examined in this study--particularly the trio discussed in section 10--appear to be attractive for assessments in postulated scenarios such as games, simulations, or exercises. The roles of all participants can be modeled and event data collected to any desired extent. In such applications, the emphasis shifts from collecting evidence on operations to modeling those operations in a sufficiently realistic manner. If the models err too far, the results will be not only wrong in detail, but also misleading about their implications for real operations. Validation is sure to remain a continuing problem in most such applications. Nevertheless, these postulated contexts may offer the best chance of gaining substantial insight into how military forces may be used to best effect while supporting drug interdiction.

## SECTION 14

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# APPENDIX A

# MOEs: A GENERAL DISCUSSION

## APPENDIX A

## MOEs: A GENERAL DISCUSSION

### WHAT IS A MEASURE OF EFFECTIVENESS?

Most people would assert that they understand the meaning of the term "measure of effectiveness" (MOE). Miles per gallon, rate of return on investment, casualty rate, and probability of detection are just a few examples of MOEs from a variety of settings. The literature of operations research includes many definitions of MOEs, usually reflecting some specific application the author has in mind. In this work, the motivation for developing MOEs is to support officials in the military and LEA chains of command as they assign roles and missions, allocate resources, and assess mission performance. The orientation is clearly toward decision-making in an operational context. With that proviso, the following definition is offered as a fundamental concept:

> An MOE is a quantitative criterion for making judgments or decisions. In general, MOEs summarize performance of a system (whether physical or organizational) in comparison with:
>
> - A standard, a goal, or an ideal--the perfect system
> - Some alternative system, real or conceptual
> - The same system in another time or context.

MOEs may be put to a number of different uses:

- Score operational performance of systems
- Determine how much of a specific resource is necessary to satisfy a goal
- Compare mission effectiveness achieved with alternative resource packages
- Measure changes in performance resulting from altered input factors (forces, equipment, tactics, or rules of engagement)
- Detect an unexpected change in operational effectiveness, perhaps as a cue for finding the cause.

### WHY MIGHT MEASURES OF EFFECTIVENESS BE NEEDED?

A skillfully constructed suite of MOEs can serve a host of useful purposes. At the policy level, the MOEs themselves concisely summarize

what it means to succeed in the mission. At the operational level, numerical valuations of the MOEs might capture performance of selected forces in a particular time frame and area of operations.

Lacking MOEs, performance reports tend to become an amalgam of figures on resource expenditures, anecdotes of specific operations, and carefully tailored contrasts of current versus previous operations. Comparisons of performance from one period to the next are liable to lack credibility in the absence of a consistent program constructed around a stable set of criteria.

MOEs assist in recognizing activities that previously were successful but have since lost their relevance; officials in the field can curtail operations that have not met expectations so that the resources may go where greater benefits are anticipated. MOEs that measure mission accomplishment also aid in evaluating new concepts of operation (CONOPS), and routine use of MOEs helps to focus attention on discovering why some kinds of operations are successful and others are not.

If MOEs can be tied to costs, they become a tool to help allocate resources. If the budget is reduced, where will the cuts have the smallest impact on performance? If additional funds become available, where should they be applied for best effect? Is the current program in balance? Would results stand to improve through shifting some resources?

Whatever the level of leadership, a suite of well-conceived MOEs clarifies the purpose of operations, serving as a shorthand statement of operational goals. Subordinate officials know the specific criteria on which they expect to be evaluated; in turn, they naturally organize their operations to score as well as they can on the MOEs.

Finally, MOEs and the supporting scheme of analysis are central to designing the data-collection system. Although many of the data items appropriate to evaluating mission performance are fairly obvious to a perceptive observer, a largely intuitive approach can never answer any of the following questions adequately:

- Are *all* required data being collected?
- Are some of the reported data superfluous?
- Are the required data being collected with the accuracy needed to support the intended analysis?
- Are resources being wasted through collecting data with more precision than needed in the analysis?
- Are all participants reporting uniformly? Do their similar-appearing data streams mask important differences that dominate the apparent outcomes?

## CONCEPT OF A PERFORMANCE ASSESSMENT SYSTEM

Putting the discussion in terms of MOEs should be seen as merely a concise way of talking about the overall performance assessment system. MOEs should be driven by program goals, supported by a solid analytic infrastructure, and fed by a well-designed stream of operational data. Assessing effectiveness of antidrug operations entails much more than merely promulgating MOEs as technical standards and then pushing operational data through formulas to produce an answer.

Clearly stated goals are the bedrock on which the whole system is built. If objectives are well crafted, formulating MOEs is more or less routine, but if the policy-makers are not agreed on what it means to succeed and how to recognize success when it happens, operations analysts lack the context for developing an appropriate suite of MOEs. At best they can offer options based on statements of possible goals in an effort to elicit intentions from top officials.

Analysis methods must be developed to fit the problem, then tested and validated with real operations. MOEs are just the most visible part of the overall analysis structure.

A key analytic task is to demonstrate the nature and strength of the link between goal satisfaction and the response behavior of proposed MOEs. If an MOE moves up or down, what does that result say about fulfillment of the goal? Are there some conditions where the answer is less definitive or valid than others?

Another analytic task is to investigate the statistical properties of candidate MOEs. Rare indeed is the measure that can be computed with certainty; a number reported for a given period is, in fact, merely an estimate compiled with some error. The associated range of uncertainty for that estimate is an essential ingredient for judging whether a change from one period to another is significant, or merely random variation. Just this sort of problem is a prominent difficulty with several MOE candidates considered in the text of this memorandum.

Reliable data are essential to realizing any value from a suite of MOEs. Quality control can reduce the incidence of oversights and administrative errors, but real success in this regard relies on motivated people who understand and support what they are doing.

## CONTRASTS TO CLARIFY DISCUSSIONS OF MOEs

Misunderstandings frequently arise in discussions of MOEs because the participants hold unstated assumptions. Three particular sets of contrasts are encountered frequently enough to warrant discussion:

- Effectiveness, efficiency, and activity

- Strategic versus tactical perspective
- Postulated scenarios versus real operations.

**Effectiveness, Efficiency, and Activity**

Even though evaluation criteria routinely are called measures of effectiveness, many proposals really deserve some other label. Three distinct varieties arise often in discussions of antidrug operations:

*Effectiveness* measures relate the results of antidrug operations to the smuggler's level of effort. If the results are about the same as last year, but the smugglers moved twice the volume of drugs, antidrug forces might be judged only half as effective as before. Clearly, emphasis is on assessing the degree to which operations affect the smuggler's success.

*Efficiency* measures relate operational results to the level of effort exerted by the antidrug forces. If operations achieve about the same outcome this year as last but use twice as many resources, they might be judged only half as efficient as before. The terminology becomes "cost effectiveness" when the antidrug forces' level of effort is expressed in terms of dollars or other resources. Two different force structures might achieve the same results and so be judged equally effective, but if one does the job at lower cost than the other, it is the more efficient or cost effective.

*Activity* measures describe the magnitude or intensity of operations. Tabulations of critical events (e.g., radar contacts, intercepts attempted, arrests, quantities of drugs seized) do no more than indicate the scale of activity. When accompanied by a relevant baseline standard of comparison, an activity measure might be transformed into a measure of either effectiveness or efficiency.

**Strategic Versus Tactical Perspectives**

When discussing antidrug MOEs in any sizeable group, the participants' frames of reference range over a full spectrum from the strategic impact on the national campaign to fine-grain assessment of tactical execution; rarely does a single MOE perform well across the full spectrum.

At the *strategic* end, the questions are large in scope. Can interdiction have a beneficial effect on national level goals? How large a part in the overall campaign should interdiction play? References [A-1]

and [A-2] are good examples of large-scale inquiries; incidentally, they conclude that interdiction has little prospect of affecting price, purity, or availability of illicit drugs at the retail level.

At the *tactical* end, there is a presumption that interdiction supports national goals, even though the relationship might not be quantified. As a result, the questions are somewhat narrower. Which of several candidate CONOPS stand to produce the best results? If additional resources become available, how should they be applied? How effectively (or efficiently) are the forces executing current operations?

This study concentrates on evaluating how well forces are performing and so tends toward the tactical tend of the spectrum; however, the perspective is that of a high level of authority: cabinet secretaries and their subordinates who head operating agencies.

**Postulated Scenarios Versus Real Operations**

Though the primary quest is for MOEs suited to evaluate performance of actual forces in real operations, the most common use might come in postulated scenarios such as planning efforts, war games, simulations, and exercises.

*Postulated scenarios* characteristically are under the full control of the analyst, planner, or exercise director; they might be created and fine-tuned to match the current understanding of smuggler activities or varied to explore effects of uncertainties and future possibilities. In either case, the magnitude, character, and location of the threat is an input to the evaluation. In addition, the effect of interdiction forces on this specific smuggling threat is determined through models of the process or, in the case of field exercises, measures under controlled conditions. Appendix C goes into more detail on using MOEs in this way.

*Real operations*, in contrast, are characterized by a threat that goes out of its way to remain unnoticed and difficult to quantify. Estimates of threat activity are partial at best and entail important uncertainties. Data concerning the origin, amount, and timing of drug smuggling are hard to acquire, leaving some attractive MOEs impossible to apply.

Candidate MOEs are evaluated in the main text explicitly for their usefulness in both postulated scenarios and real operations.

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# APPENDIX B

## BOARDING SUCCESS RATE AS A MEASURE OF EFFECTIVENESS

## APPENDIX B

## BOARDING SUCCESS RATE AS A MEASURE OF EFFECTIVENESS

The Atlantic Fleet routinely participates in Caribbean antidrug operations. In addition to making a large contribution to surface and airborne surveillance, ships of the Fleet carry Coast Guard law enforcement detachments (LEDETs) whose members board suspect vessels, conduct searches, seize contraband, and arrest suspects [B-1]. These seizures often become the focus of discussions concerning whether military forces are being effective in drug interdiction operations. This appendix uses the principles of probability and statistics to assess the usefulness of seizure data expressed as the boarding success rate. It begins with a review of some actual results and then proceeds to examine several relevant issues about this MOE. The presentation is structured deliberately as a tutorial to make the application of statistical methods as clear as possible.

### HISTORIC DATA

Records of past operations suffer from a number of important problems, including reporting gaps and inadequate definitions. These difficulties aside, summary results from 1988 illustrate the nature and magnitude of the numbers involved.

Because USN and USCG ships were not allocated in sufficient numbers to maintain a continuous Caribbean patrol, operations occurred in pulses of varying size and duration. During 1988, COMCARIBRON[1] conducted 12 pulses, the results of which are tabulated in table B-1. Highlights from these operations include:

- 5 of 12 pulses produced no seizures
- 313 vessels were boarded, largely for one of two reasons:
  - Specific prior intelligence on the vessel
  - Appearance or behavior fitting a "profile" of drug smugglers
- 54 of the boarded vessels were positive for drug history in the El Paso Intelligence Center (EPIC) data base

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1. The Commander, Caribbean Squadron, is a Coast Guard officer subordinate to Coast Guard District Seven headquartered in Miami. He exercised tactical control of USCG cutters and USN ships dedicated to antidrug operations in the Caribbean during 1988.

- 9 vessels were found to have significant amounts of marijuana on board, totalling 36,850 pounds
- 2 more vessels showed traces of marijuana residue
- 1 more vessel was boarded on the basis of prior intelligence; 22 hours of search failed to reveal any drugs; vessel was towed to port for continued search ashore where master finally confessed to 165 pounds of cocaine hidden in the keel.
- Prior intelligence identified all 12 seized vessels as probably on drug missions (and so all were positive in the EPIC data base).

**Table B-1.** USN/USCG dedicated surface operations in Caribbean--1988

| Pulse dates | Ship days | Vessels boarded | EPIC[a] positive | MJ[b] | C[c] |
|---|---|---|---|---|---|
| 1/23 - 2/2 | 84 | 10 | 0 | 0 | 0 |
| 3/4 - 3/19 | 82 | 49 | 5 | 0 | 0 |
| 4/14 - 4/18 | 4 | 4 | 0 | 0 | 0 |
| 5/9 - 5/26 | 82 | 35 | 4 | 1 | 0 |
| 6/3 - 6/20 | 19 | 18 | 8 | 1 | 0 |
| 6/22 - 7/12 | 20 | 27 | 3 | 0 | 0 |
| 7/6 - 7/27 | 38 | 14 | 8 | 1 | 0 |
| 8/12 - 8/31 | 75 | 35 | 8 | 3 | 0 |
| 9/6 - 9/20 | 26 | 13 | 4 | 1 | 0 |
| 9/16 - 9/26 | 25 | 9 | 1 | 0 | 0 |
| 10/8 - 11/14 | 182 | 60 | 4 | 2 | 1 |
| 11/15 - 12/20 | 173 | 39 | 9 | 2 | 0 |
| | 810 | 313 | 54 | 11 | 1 |

NOTE: Commander Robert L. Meyer, USNR, compiled the data in this table from operational reports while on an active duty training period at CINCLANTFLT during January 1989.
a. El Paso Intelligence Center.
b. Marijuana.
c. Cocaine.

Boarding success rates for individual pulses range from 0 to 8.6 percent. If all 12 seizures are taken as successes, the overall boarding success rate in 1988 is 12/313 = 0.038, or 3.8 percent of all boardings.

Some would exclude the two cases involving only marijuana residue because the drug smugglers had already completed their mission. Likewise, principal credit for finding cocaine in the keel went to the agency searching ashore. This more conservative view would recognize only 9 seizures for an overall rate of 9/313 = 0.029, or 2.9 percent of all boardings.

## UNCONTROLLED FACTORS

The small number of seizures in a full year suggests it will be necessary to accumulate data over long periods to achieve desirable statistical properties, notably tight error bounds. Yet, combining statistics from many successive operations raises important questions as to whether the latest data are comparable to the earliest. Several uncontrolled factors can affect apparent boarding success rates:

- *Fraction of population eligible for boarding that is actually carrying drugs.* Opportunities for success are bounded by the numbers of actual drug runners. No one knows how many smugglers are at sea during a pulse; however, there is good evidence that the more sophisticated organizations monitor movements of interdiction forces and restrict activities where risks are temporarily increased.

- *Effectiveness of intelligence cues in identifying subsets of the shipping population as probable drug carriers.* Timely notification is critical so tactical forces can operate on the information before it becomes history. Profiles of smuggling vessels help to sort likely targets from a vast background population; too much reliance on them, however, can distract attention from sophisticated smugglers who discern the profile and adjust their operations to avoid it.

- *Sophistication of smuggler countermeasures.* Smugglers are much less blatant than in the past. No longer do they stack marijuana bales on deck in plain view, but now their countermeasures go further to include decoys, deception, and encrypted communications. This arena is dynamic with no clear limits given the vast amounts of money available to buy talent and equipment.

- *Effectiveness of smuggler methods for hiding drugs aboard ship.* Hidden compartments and towed capsules are just two of the measures making searches long and difficult.

- *Search effectiveness of boarding parties.* Training, skill, morale, determination, and alertness are some of

the determinants of boarding-party effectiveness. As smugglers become better at hiding the goods, searches become longer, more intrusive, and more exhausting.

Any real-world attempt to assess the impact of changes in operational procedures and tactics must be sensitive to the possibility that an observed change could be due to variations in one or more of these factors.

**ANALYSIS**

Two questions arise repeatedly:

- Why do so many pulses fail to produce any seizures? This question is a serious issue; as in any endeavor, morale of the forces involved responds directly to perceptions of success and failure.

- If operational changes are introduced, how can authorities judge whether an apparent change in results is real or just a fluke?

Each question is restated in a formal manner and then examined in the setting of the 1988 statistics from Caribbean operations.

**Question 1**

Of vessels meeting criteria for boarding, a proportion $p$ carry significant amounts of drugs. What is the probability that $n$ boardings will reveal $0$ vessels carrying drugs?

*ANSWER*: The question parallels the classic probability problem of drawing black and white balls from an urn without replacement (would not revisit a vessel just boarded). The hypergeometric probability distribution precisely describes this process, but, for large numbers of boardings, the much handier binomial distribution gives practically the same results.

The binomial distribution has the following form:

$n$ = number of boardings

$x$ = number of seizures

$p = x/n$ = boarding success rate

$$p(x;\ n,\ p) = \binom{n}{x} p^x (1 - p)^{n-x} = \text{probability of } x \text{ successes}$$

$$= \frac{n!}{x!(n - x)!} p^x (1 - p)^{n-x}$$

$np$ = mean of $x$

$\sqrt{np(1 - p)}$ = standard deviation of $x$

$P(0;n,p) = (1 - p)^n$ = probability of *no* successes in $n$ boardings.

Table B-2 presents selected values of the binomial distribution; underlined entries are used in the sample applications following the table.

**Table B-2.** Selected values of binomial distribution

| $p$ | $1 - p$ | $n$ | $P(0)$ | $1 - P(0)$ | Mean $np$ | Standard deviation $\sqrt{np(1 - p)}$ |
|---|---|---|---|---|---|---|
| 0.01 | 0.99 | 10 | 0.90 | 0.10 | 0.10 | 0.31 |
| | | 30 | <u>0.74</u> | <u>0.26</u> | 0.30 | 0.55 |
| | | 100 | 0.37 | 0.63 | 1.00 | 0.99 |
| | | 300 | 0.05 | 0.95 | 3.00 | 2.97 |
| | | 1,000 | 0.000043 | 0.999957 | 10.00 | 3.15 |
| 0.03 | 0.97 | 10 | 0.74 | <u>0.26</u> | 0.30 | 0.54 |
| | | 30 | 0.40 | <u>0.60</u> | 0.90 | 0.93 |
| | | 100 | 0.05 | 0.95 | 3.00 | 1.71 |
| | | 300 | 0.0001 | 0.9999 | 9.00 | 8.73 |
| 0.05 | 0.95 | 10 | 0.60 | <u>0.40</u> | 0.50 | 0.69 |
| | | 30 | 0.21 | <u>0.79</u> | 1.50 | 1.19 |
| | | 100 | 0.006 | 0.994 | 5.00 | 2.18 |
| | | 300 | 0.0000002 | 0.9999998 | 15.00 | 3.77 |
| 0.10 | 0.90 | 10 | 0.35 | 0.65 | 1.00 | 0.95 |
| | | 30 | 0.04 | <u>0.96</u> | <u>3.00</u> | 1.64 |
| | | 100 | 0.00003 | 0.99997 | 10.00 | 3.00 |

*Sample Applications of the Binomial Probability Table*

If 3 percent of vessels meeting boarding criteria are carrying drugs, there is only a 26-percent chance of one or more seizures in 10 boardings. In 1988, six pulses each resulted in about 10 boardings (the range is 4 to 18); three of these pulses resulted in a seizure, almost double the expected 26 percent. Continuing at a 3-percent rate, 30 boardings have a 60-percent chance of at least one success. The 12 pulses in 1988 averaged 26 boardings; 7 of them resulted in seizures,

virtually the same as 60 percent (7/12 = 58 percent). Clearly, the number of pulses coming up empty-handed is consistent with the overall seizure rate.

If changes in tactics or operational procedures tighten boarding criteria so as to raise the density of drug smugglers to 5-percent of all boardings, a pulse of 10 boardings has a 40-percent chance of at least one success. Pulses of 30 boardings have a 79-percent chance of finding one or more drug smugglers.

If these changes are so selective that the proportion carrying drugs rises to 1 in 10 ($p = 0.1$), then 30 boardings have a 96-percent chance of revealing at least one smuggler. On the average, 30 boardings under such conditions should turn up 3 seizures.

Finally, high levels of success might prompt drug smugglers to transfer their trade to alternate routes and so drive the proportion of smugglers down, for example to 1 in 100 ($p = 0.01$) boardings. Then, a pulse of 30 boardings would have a 74-percent chance of coming up empty-handed (or just a 26-percent chance of one or more seizures).

**Question 2**

Suppose intelligence methods and operational tactics are revised to concentrate boardings on vessels having a high probability of being drug runners. How much must the boarding success rate improve before being confident that the difference is statistically significant, not merely a chance result?

*ANSWER*: This question calls for comparing boarding success rates seen before and after introducing the revised methods and tactics. A large but necessary assumption is that all uncontrolled factors are substantially the same in the new set of boardings as in the comparable historic period. If not, the action of these other factors might either mask a true difference or falsely suggest that the new methods have made a difference.

Let the following variables describe the new sample:

$n$ = number of boardings in new sample

$m$ = number of successes in new sample

$p$ = sample proportion of successes, $m/n$.

The sample proportion $p$ is an estimate of the fraction of drug smugglers in the class of vessels that meets boarding criteria. The sample actually selected for boarding may have a greater or lesser proportion of smugglers than the complete population satisfying the boarding criteria.

The method for answering this question calls on using a statistical device known as the sampling distribution. Imagine that a large number of independent samples (of size $n$) could be collected from the historic period. If all the sample proportions were arrayed in sequence from smallest to largest, the result would be a sampling distribution[1] something like the one shown in figure B-1. If there were enough such samples, the average proportion would converge to the true historic value $P$. The proportion computed from a new sample (such as one taken after some change in operations) could be compared to the sampling distribution for an assessment of whether there is a difference.

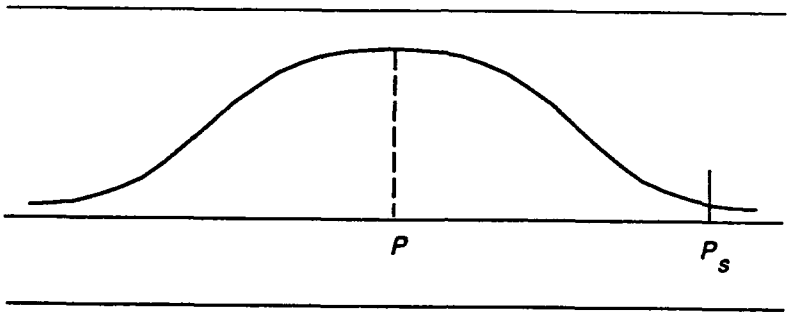


**Figure B-1.** Hypothetical distribution of sample proportion

Because the distribution includes all possible outcomes, the total area under the curve sums to probability one, or 100 percent. For any sample proportion $P_s$, this area splits into two pieces; the "tail" to the right is just the probability that a random sample drawn from historic experience would result in a proportion larger than $P_s$. This probability is the risk of being wrong if one chooses to reject the null hypothesis that the new sample is not different from the historic experience, concluding that the apparent difference between $P$ and $P_s$ stems from variability in sampling. Common practice is to require the probability in the tail (called the significance level) to be no more than 5 percent. With these preliminaries, question 2 can be restated as:

> For a sample of size $n$ and historic proportion $P$, what sample proportion $P_s$ is required to just reach the 5 percent significance level?

1. In practice, a sampling distribution is constructed by identifying the appropriate form of the distribution (e.g., normal or binomial) and then estimating its parameters.

The answer is computed by summing terms of the binomial distribution from zero up to the number of successes $m$ where the 5-percent significance level is reached. In equation form, this expression is:

$$probability\ in\ tail = 1 - \sum_{x=0}^{x=m} \frac{n!}{x!(n - x)!} P^x (1 - P)^{n-x} \leq 0.05 .$$

Reference [B-2] provides extensive tables of these sums; many statistics textbooks offer restricted tables for small values of $n$, but software packages for statistics probably are the best way to obtain exact results.[1] Table B-3 presents successive steps in the summing process for four different levels of $n$ (the number of boardings), demonstrating how the probability left in the tail declines with successive increases in the number of successes $m$. The asterisked entries designate the points where the probability in the tail just falls below 0.05.

For example, 30 boardings (one month of operations at the 1988 level of activity) would have to produce a boarding success rate ($P_s$) over 13 percent, more than three times the baseline rate. Taking a longer period to accumulate 100 boardings lowers the critical rate to 8 percent, still twice the baseline value. Even with a year's worth of data (300 boardings) in the new sample, the boarding success rate must grow from 4 percent to 6.3 percent, an increase of almost 58 percent. Extending to 1,000 boardings, 51 successes are required to conclude there is a difference; the ratio to the historic rate is 1.275. Thus, showing that a 27-percent improvement is significant requires over three years of operations at the current tempo. Is it reasonable to expect that drug smugglers would not change their methods over such a long time? Would U.S. authorities be willing to wait three years to learn whether an operational initiative makes a difference?

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1. As sample size becomes large (greater than 30), the normal distribution is a good approximation to the binomial; the critical proportion defining a 5 percent tail may be computed as

$$P_s = P + 1.645 \sqrt{\frac{P(1 - P)}{n}}.$$

Put another way, 5 percent of the area under the normal probability curve is contained in the tail beyond 1.645 standard deviations from the mean.

Table B-3. Sample proportions and tail probabilities

| $n$ | $m$ | $p_s = m/n$ | Probability in tail |
|---|---|---|---|
| 30 | 2 | 0.0667 | 0.3388 |
| | 3 | 0.1000 | 0.1169 |
| | 4 | 0.1333 | 0.0316* |
| | 5 | 0.1667 | 0.0063 |
| 100 | 6 | 0.0600 | 0.2116 |
| | 7 | 0.0700 | 0.1064 |
| | 8 | 0.0800 | 0.0475* |
| | 9 | 0.0900 | 0.0190 |
| 300 | 17 | 0.0567 | 0.0969 |
| | 18 | 0.0600 | 0.0591 |
| | 19 | 0.0633 | 0.0343* |
| | 20 | 0.0667 | 0.0190 |
| 1,000 | 49 | 0.0490 | 0.0881 |
| | 50 | 0.0500 | 0.0663 |
| | 51 | 0.0510 | 0.0491* |
| | 52 | 0.0520 | 0.0357 |

## CONCLUSIONS AND COMMENTS

Probability and statistics may be used to draw some implications for the boarding success rate as an MOE for drug interdiction operations. A probability model allows exploration of the effects from varying sample size (number of boardings) and the boarding success rate. An extension of that model supports an investigation of the sample size necessary to conclude that an observed seizure rate is significantly different from history. Key points emerging from the analysis are:

- Low success rates naturally mean a sizeable fraction of pulses come up empty-handed, as observed in 1988. If maritime forces increase seizures markedly, drug smugglers are likely to redirect their operations to other avenues and so drive seizure rates in the Caribbean even lower. It will be a major challenge of leadership to sustain an effective drug interdiction operation in the face of infrequent successes. Both crew morale and the question of "what are we getting for our money" will be difficult issues.

- Small changes in success rates are not sufficient to conclude there has been a significant change. Huge margins of improvement (doubling and tripling) are necessary to be confident of a real difference when samples represent just a few months of operations. Smaller margins might be believable when based on a few years of operations, but stability of uncontrolled factors is a serious issue over any long time span.

Statistical analysis of this sort can give commanders and other authorities a perspective on the significance of performance data. Ideally, such an analysis should be a prelude to any selection of specific MOEs as the litmus test of operational success.

## REFERENCES


[B-1] Surface Warfare Development Group Tactical Memo TM XZ0050-1-90, *Coast Guard Law Enforcement Operations From U.S. Navy Ships*, 15 Mar 1990 (249609)[1]

[B-2] Harvard University, *Tables of the Cumulative Binomial Probability Distribution*, Cambridge: Harvard University Press, 1955


1. The number in parentheses is an internal CNA control number.

# APPENDIX C

# USING POSTULATED SCENARIOS

## APPENDIX C

## USING POSTULATED SCENARIOS

Several of the MOEs explored in this study do not work for real operations because data on smuggler activities are so hard to obtain. In theory, perfect intelligence would provide the means to tote up departures and arrivals of drug shipments with few errors or oversights, but information collected in current operations falls far short of this ideal, at best providing a sample biased toward the unsophisticated end of the smuggler spectrum. Realistically, even the smugglers themselves probably would have difficulty collecting comprehensive and reliable statistics, assuming they had a reason to do so. Perhaps dozens of smuggling operations coexist in loose association; their relationships vary from opportunistic cooperation to murderous competition. Under these circumstances, drug smugglers probably consider hard data on their activities as private information to be shared sparingly and only when there is a good reason. Given the poor prospects of ever collecting such data on a wide scale, even well after the fact, modeling and simulation methods hold some appeal.

### USING MODELS TO EXPLORE IDEAS

In the absence of ground truth, a possible approach is to construct linked models of the opposing interdiction and smuggling campaigns and then investigate their joint performance. Similar concepts are employed routinely for military analyses of all kinds. Assessments of tank battles, air strikes, submarine engagements, and entire theater campaigns become the basis for decisions on budgets, systems acquisition, and operational plans. Antidrug interdiction operations seem as amenable to such treatment as these other subjects.

Analytic models express relationships in the form of mathematical equations whose parameters are estimated from operational data; for example, models for evaluating radar coverage and probability of detection against specified targets are well developed. Processes not modeled in closed form can be investigated via computer simulations. Once constructed, good models can serve many purposes: support operational planning, assess effectiveness of operations, and explore the consequences of changes in resources, tactics, or any other "what if" question about either side.

In principle, interdiction forces can be modeled to a high degree of precision because all the resources are under friendly control, but the level of fidelity likely will be restrained by cost, tolerance for lag time in producing results, and the operators' patience with the data-collection burden.

On the other hand, models of the smuggling side depend heavily on how well intelligence agencies have accumulated an understanding of the goals, values, methods, and other factors shaping smuggler operations. One of the principal challenges is to model all elements of the smuggling enterprise as a whole when available data are richest in information from the least successful players (the ones that were caught). Even here, however, such modeling holds an important advantage over methods relying solely on direct estimation from collected data: uncertainties can be explored through alternative descriptions of the enemy, and then the models run against each other to assess whether the apparent differences are significant to the performance of interdiction forces. Such a process offers a mechanism to call attention to the key issues, focus intelligence activities on critical indicators, and educate the forces on their own weaknesses that smugglers can exploit.

For planning purposes, analyses of interdiction forces might use programmatic or design values for the model parameters. After-the-fact evaluation of actual operations would involve running the models with collected data. For example, planning runs would take as inputs the programmed availability of sensors and interdiction assets; evaluation runs would use the actual hours, locations, and intensity of operations. Likewise, the smuggler model would use an intelligence forecast for planning and then incorporate collected data for evaluation.

## LIVE EXERCISES AND TESTING BY SURROGATE FORCES

Whenever one becomes heavily dependent on models for descriptions of fact, it is wise to subject the results to organized field testing, the more realistic and demanding, the better. In the case of drug interdiction, an obvious device is to assemble a team of skilled people to act as surrogates for the smugglers. They might study the organization and operations of interdiction forces to identify exploitable weaknesses and then test their insights with live infiltration, perhaps using vessels and aircraft seized from smugglers. Just such an operation was employed in Vietnam to evaluate the effectiveness of Market Time, the campaign to interdict North Vietnamese maritime smuggling of arms and supplies to forces operating in the south. A U.S. Navy team studied operations for cues available to an informed smuggler and then, using a patrol boat, demonstrated their understanding with actual penetrations. Accepted wisdom at the time held the probability of detection for a penetrating trawler to be 85 percent, a belief demolished when the interdiction forces detected only one of the surrogate's nine sorties.[1] The exercise further revealed that air patrols could not identify infiltrators at night, a critical fact that meant a sizeable fraction of expended effort was wasted. As a result, operations were revised radically, the new concepts themselves tested in further penetration

1. See CNA Research Contribution 280, *Market Time* (U), by J.C. Erdheim, Secret, Sep 1975, p. 42.

exercises. Such testing stands to produce solid data on the actual capabilities of forces because investigators can instrument both sides of the event.

## SUMMARY

This concept of a broadly applicable MOE, linked models, and live exercises has some appeal for exploring the potential performance of changes in forces, tactics, and operations; however, the scheme is far from perfect. Scores on an MOE are compiled as the result of exercises or modeling, not direct measurements from actual smuggling operations. Consequently, the outputs derive their credibility from the candor, objectivity, and thoroughness of the analytic process, rather than the fact of their occurrence as actual events. There should always remain a concern that some critical aspect of the smuggling threat is not adequately represented in the models and exercises; at the very least, smuggler innovations can be incorporated only after they become well known, a fact that assures important time lags and inevitable revisions to results reported earlier.