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Center for Army Analysis

ANALYZING COMPLEX THREATS FOR OPERATIONS AND READINESS

SEPTEMBER 2001

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13. ABSTRACT *(Maximum 200 Words)*

This study uses recently developed data mining tools and draws upon an extensive database that includes annually aggregated data covering political, economic, and socio-cultural domains for some 159 countries over the period 1975-1999 to forecast the likelihood that countries throughout the world will experience a certain level of intensity of instability over the period 2001-2015. The study uses a pattern classification algorithm—Fuzzy Analysis of Statistical Evidence (FASE)—developed by Chen (2000) on behalf of the US Army to identify and analyze the relationships between country macro-structural factors and historical occurrences of instability. The results demonstrate the potential capability of the model to accurately forecast not just the occurrence, but also the level, of intensity of country instability 6 years in advance with about 80 percent overall accuracy. The results of the analysis are used in support of the Enabling Strategic Responsiveness (ESR) and Deployment Optimization Research in Tools and Operations (DORITO) studies.

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ANALYZING COMPLEX THREATS FOR OPERATIONS AND READINESS (ACTOR)

SUMMARY

THE PROJECT PURPOSE was to deepen and extend the ACT (Analyzing Complex Threats) (CAA-SR-99-4) methodology to validate and apply a model to forecast the likelihood of country instabilities that could challenge US national security interests annually through fiscal year (FY) 2015. The results of the analysis were used in Enabling Strategic Responsiveness (ESR) and Deployment Optimization Research in Tools and Operations (DORITO) to assist in determining the optimal stationing of prepositioned equipment sets.

THE PROJECT SPONSOR was the Office of the Deputy Chief of Staff for Operations and Plans (ODCSOPS), War Plans Division (DAMO-SSW), Headquarters, Department of the Army.

THE SCOPE OF THE PROJECT was to use Fuzzy Analysis of Statistical Evidence (FASE), first developed and applied in the ACT Study, to forecast the likelihood that a low, moderate, or high intensity level of instability would occur in each of 159 countries with populations greater than 500,000 over each of the next 15 years (2001-2015).

THE BASIC APPROACH for this project was to:

- Identify the country macro-structural factors that might contribute to different levels of intensity of country instabilities.
- Evaluate the historical relationship between these macro-structural factors and historical instances of country instability.
- Validate a 15-year forecast of country instability using these macro-structural factors.
- Forecast the likelihood of different levels of intensity of instability occurring in every major country in the world over the period 2001-2015.

THE PRINCIPAL FINDINGS were that FASE demonstrated the capability to accurately forecast the likelihood that a country would experience a certain level of intensity of instability up to 6 years in advance with greater than 80 percent overall accuracy. The ACTOR model-generated forecasts were reconciled and adjusted for forecasts conducted by the Joint Analysis Center, US European command (USEUCOM) and the Marine Corps Intelligence Activity, as well as an environmental security assessment commissioned from academia. Despite the methodological diversity, there was substantial consistency in the forecasts generated by each of the four studies.

THE PROJECT EFFORT was conducted by Dr. Sean O'Brien, Resource Analysis Division, Center for Army Analysis (CAA).

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1 INTRODUCTION

1.1 Analyzing Complex Threats for Operations and Readiness (ACTOR)

This study, Analyzing Complex Threats for Operations and Readiness (ACTOR), was sponsored by the Office of the Deputy Chief of Staff for Operations and Plans (ODCSOPS), War Plans Division, Headquarters, Department of the Army.

1.2 Purpose

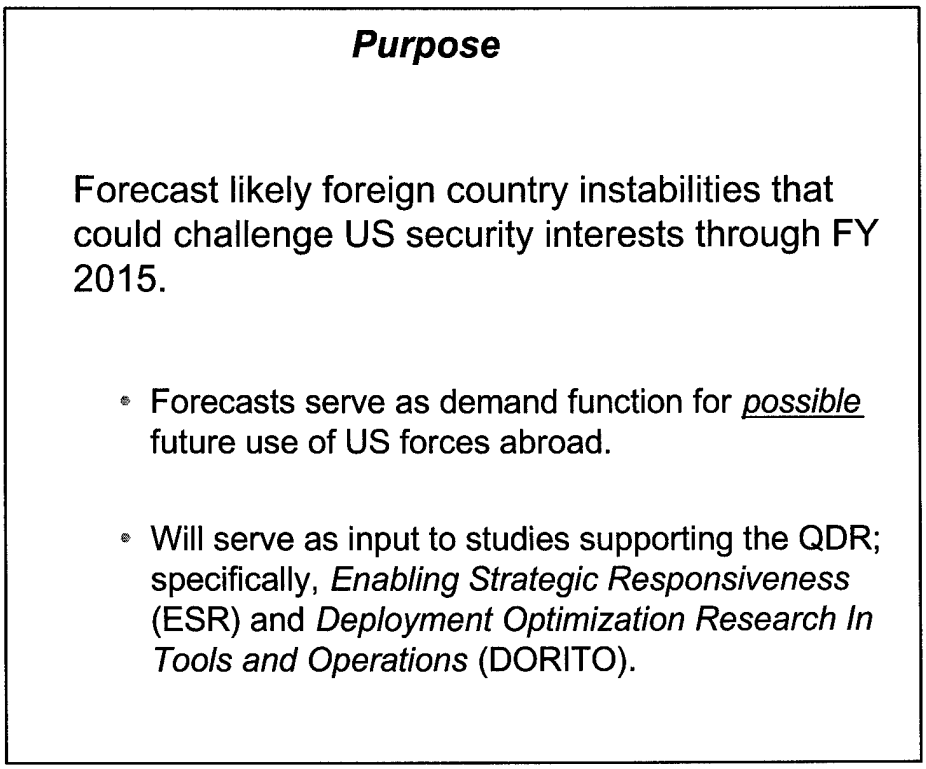

Figure 1. Purpose

The purpose of ACTOR is to forecast the likelihood of country instabilities that could challenge US national security interests annually through FY 2015. These forecasts can also serve two more specific purposes. First, at a very broad level, they could be used as a stand-alone demand function for the possible future use of US forces abroad. Second, they are being used as input into other studies the Center for Army Analysis (CAA) is conducting to determine where best to place Army prepositioned equipment sets to facilitate rapid, global deployment. These include the Enabling Strategic Responsiveness (ESR) and the Deployment Optimization Research in Tools and Operations (DORITO) studies.

1.3 ESR and DORITO

- ESR: Develop and apply an analytical methodology to determine how the Army should configure and place pre-positioned equipment sets to aid rapid, global deployment.
- DORITO: Develop and apply an optimization based model for deployment planning, new system and infrastructure tradeoff analysis (PREPO placement), identification of bottlenecks, and improve current sensitivity analysis capabilities in support of the QDR.

Figure 2. ESR and DORITO

The purposes of ESR and DORITO are described more fully in Figure 2. Taken together, these studies seek to develop and apply a methodology to, among other things, help determine where best to place Army prepositioned equipment sets throughout the world in order to enhance the strategic responsiveness of the Army consistent with the Chief of Staff's deployment goals. An important consideration in this process is the uncertainty about where US forces may be called upon to serve in the future. Addressing that uncertainty requires an assessment of where threats and crises are likely to occur in the world over the next several years.

1.4 Background

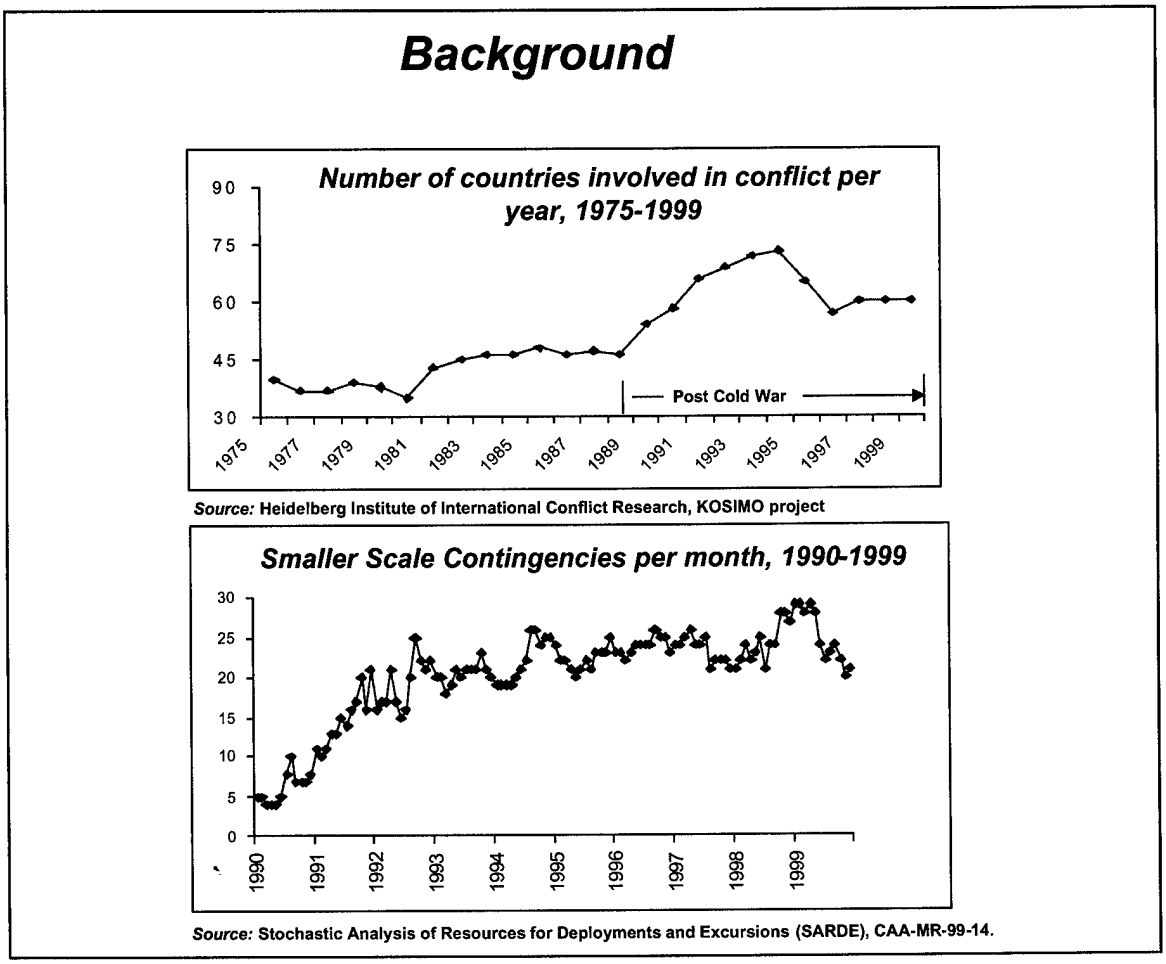

Figure 3. Background

The graphs in Figure 3 help place the ACTOR study in a broader context. Since the end of the Cold War, country instabilities of different types have erupted around the globe. The first chart in Figure 3 depicts the number of countries involved in some form of of conflict--ranging from foreign policy crises, to intra- and interstate wars--over each of the past 25 years. Increasingly, during the post-Cold War period, the US military, its allies, and others have responded to these threats and crises with a myriad of smaller-scale contingencies (SSCs). These SSCs have spanned the gamut of operations other than major warfare including peacekeeping operations in the Balkans, enforcing sanctions in the Persian Gulf and no-fly zones over Iraq, evacuating civilian noncombatants in Africa, and conducting maritime interdictions in the Caribbean.

These charts assist in conveying two somewhat interrelated points. First, though the frequency of SSCs appears to have leveled off, these operations continue to occur in an environment of ever-shrinking resources. There is little on the horizon to suggest that this trend will not continue into the future. Therefore, second, those in the military who must plan for the resource

requirements that permit US forces to respond to the full spectrum of these threats and crises need tools and models to provide them with insights into where these threats and crises are likely to occur in the future so they can anticipate where US forces may be called upon to serve and plan accordingly. The ACTOR approach contributes to this need.

1.5 ACTOR Methodology

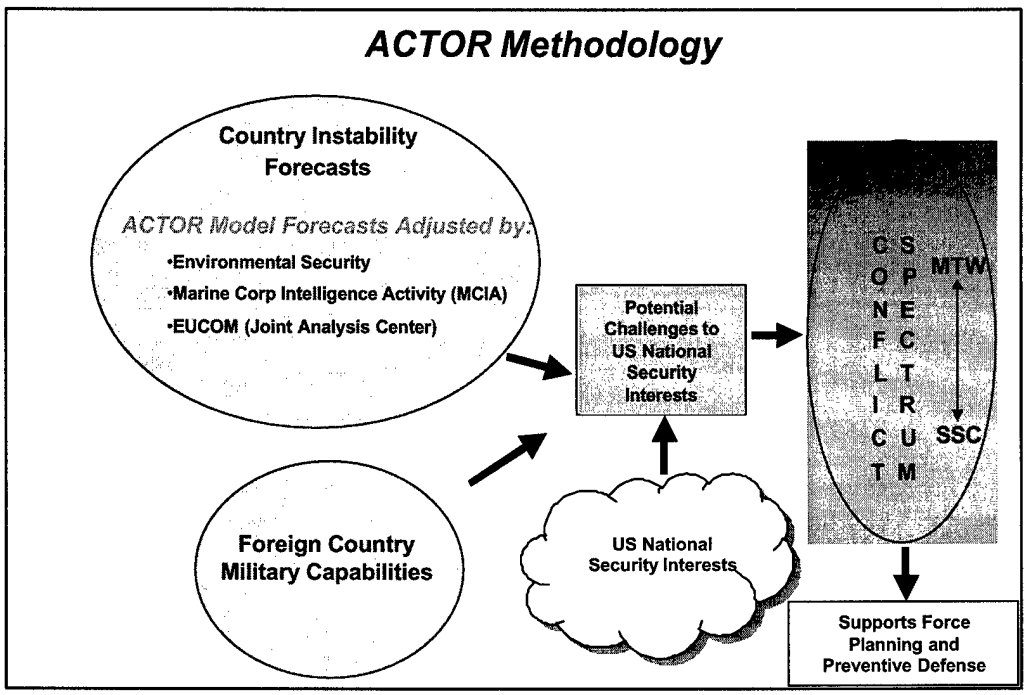

Figure 4. ACTOR Methodology

Figure 4 depicts the study's conceptual methodology. ACTOR seeks to identify, evaluate, and ultimately forecast those factors primarily internal to countries that, when combined with events or triggers (e.g., riots, natural disasters, or cancellations of popular elections), could contribute to an environment conductive to conflict and instability. The ACTOR model is used to generate the statistical likelihood that countries throughout the world will experience a certain level of instability. The ACTOR model-generated forecasts are then reconciled against forecasts conducted by other organizations, specifically the Marine Corps Intelligence Activity (MCIA) and the European Command's Joint Analysis Center (JAC). In addition, a qualitative assessment of each country's environmental problems and adversities (e.g., desertification, deforestation, water quality concerns) was considered for its potential impact on the likelihood that it might become unstable at some specific point in the future. Finally, an assessment of the strength of each country's military forces was conducted for those countries that are expected to experience instability in the future. It is these countries--those that are expected to become unstable in the future and that also possess significant military capabilities--that may not only have the opportunity to challenge US national security interests in the future, but also the capacity to do so.

2 APPROACH

2.1 Three Perspectives on the Causes of War and State Conflict

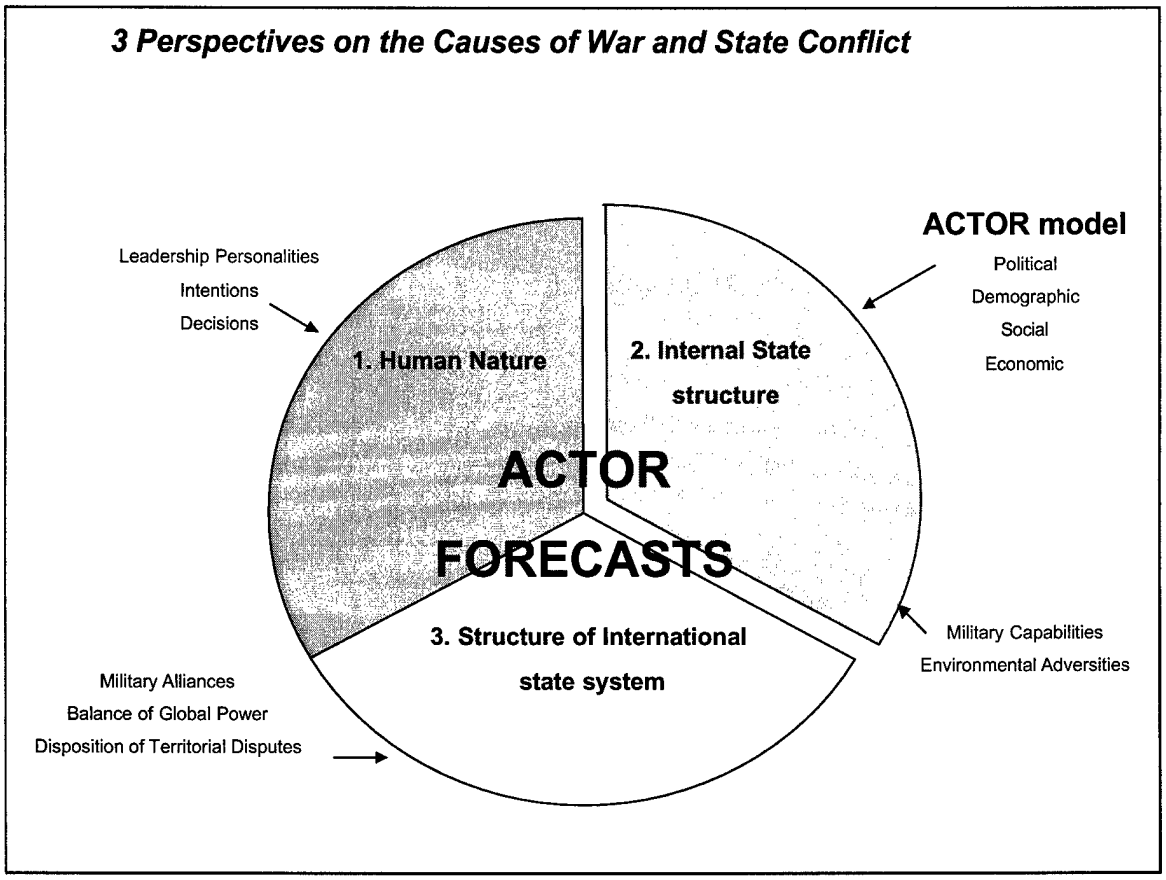

Figure 5. Three Perspectives on the Causes of War and State Conflict

Political scientists generally study war and state conflict from at least one of three different perspectives. "First image" analysts view conflict as an innate element of human nature. In order to develop a capability to anticipate when and under what circumstances a foreign leader may decide to initiate a war, first image analysts emphasize the importance of analyzing the decisions and personalities of those individual leaders in a historical context.

"Second image" analysts view war and state conflict as emanating from the factors and failings internal to states, be it poor economic performance, indifference to the social welfare of the nation's people, or tensions among religious and ethnic groups among other factors. In contrast to first image analyses where the human being is usually the unit of observation, the country or state is the unit of observation in second image analyses.

Finally, "third image" analysts--so-called "realists"--view war as the inevitable consequence of the dilemma all states face in an international system devoid of any formal authority. In such an anarchic environment, states must acquire military arms and seek external power in order to defend their interests from other states and, more fundamentally, ensure their survival. However, since power is relative, one state's attempt to arm and protect itself will inevitably threaten, even if only implicitly, the ability of other states to do likewise.

The resulting "security dilemma" often manifests itself in arms races among rivals specifically and competition among states for power and resources more generally. In this conception, the international environment is characterized by belligerency in nation-state relations, threat misperception, and miscalculations that can lead to war and other forms of interstate conflict.

The ACTOR model is a second image model and as such provides one perspective on the important problem of forecasting country instability. A complete picture requires all of these images, however, so the ACTOR model forecasts were reconciled with forecasts conducted by MCIA and the JAC, supplemented by a qualitative assessment of the environmental problems or progress that may affect some country's prospects for instability, and evaluated in the context of the military capabilities that each unstable country currently possess. As such, the ACTOR forecasts, as distinct from the ACTOR model forecasts, are the culmination of quantitative and qualitative analyses that take place across multiple levels of analyses and, as a result, should be stronger than what might otherwise be the case.

2.2 ACTOR Model Process

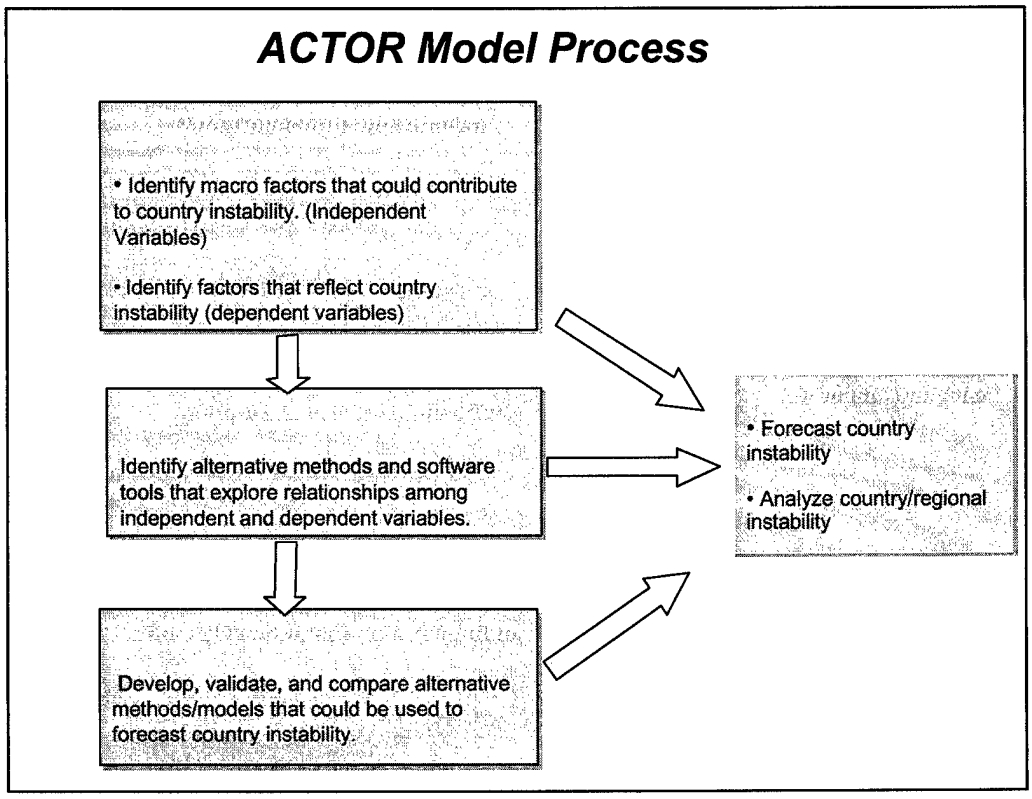

Figure 6. ACTOR Model Process

Figure 6 depicts the ACTOR model process. The development of the ACTOR model consisted of four primary activities:

Data Collection and Analysis. We identified the macro-structural factors at the nation-state level that might contribute to or provide an environment conducive to instability. These factors were identified by reference to prior studies conducted by the Center for Army Analysis, including Analyzing Complex Threats (ACT) (CAA-SR-99-4) and Political and Economic Risk in Countries and Lands Evaluation Study (PERICLES) (CAA-SR-96-9) and by a general examination of the academic literature. Based on an examination of this literature, and given the data that was available to us, we constructed a comprehensive database that includes annual observations across a range of these macro-structural factors for every major country in the world (with greater than 500,000 population) for each year that a country existed going as far back as 1945 in many cases and as recently as 1999 in almost all cases. This database also includes information on the historical propensity of these countries to experience conflict or to have become unstable in the past. The database underpins the historical, validation, and forecast analyses.

Methods and Tools Selection. We needed to identify, evaluate, and ultimately we even created our own analytical techniques and statistical algorithms to explore how different levels and configurations of country macro-structurals have been associated with different kinds of country instabilities. Much of this comparative methodological assessment was conducted in the ACT study.

Model Development and Validation. It was necessary to demonstrate or validate that the techniques being considered were capable of learning the patterns in these relationships well enough to conduct a long-term forecast. This was accomplished by adopting a split-sample research design. One portion of the historical data--the training set--was used to train or fit a model of country instability. Here we were interested to see how well the analytical techniques being considered could learn the patterns in the relationships between these macro-structurals and country instability. To examine how well the analytical techniques could learn the patterns in the relationships and how robust those patterns were through time, the macro-structural factors in the other portion of the data set--the test set--were used to classify countries by their expected levels of intensity of instability, given the patterns uncovered in the training set. These projections were compared with the historical record, and performance metrics were calculated to determine how well the algorithms could forecast beyond the training sample. These performance metrics provide us with an indication of how accurate the true forecasts (e.g., the forecasts into the future) are likely to be.

Forecast Analysis. Finally, the entire historical database was used as a training set, the historical data was used as a baseline, and the historical trend exhibited by each macro-structural attribute for each country was forecast into the future through FY 2015. Based on the patterns observed in the training set and the values of the forecasts on the macro-structural attributes, the likelihood that each country will experience a certain level of intensity of instability was computed.

2.3 Independent Variables

1. **Percent of history spent in state of conflict:** Percent of time (in years) spent in a state of conflict as defined by KOSIMO (to include crises, violent crises, and wars). Note: percent of time in conflict spans the years in training data ONLY. Source: *KOSIMO data project*; Pfetsch and Rohloff (2000).

2. **Infant Mortality Rate** (1975-1997: Number of deaths of children under 1 year of age per 1,00 live births. Source: *US Bureau of the Census, International Database* (www.census/gov/ipc/www).

3. **Trade Openness** (1975-1998): Value of a country's total imports and exports as a percent of GDP per capita. Source: *PENN World Tables* (1975-1992); *1999 World Bank Development Indicators* (1993-1998).

4. **Youth Bulge** (1975-1997): Ratio of population aged 15-29 to those aged 30-54. Source: *US Bureau of the Census, International Database (*www.census/gov/ipc/www).

5. **Civil Liberties Index** (1975-1998): Measure of the freedom of country's people "to develop views, institutions, and personal autonomy apart from the state." Seven-point ordinal scale with 1=free, 7=not free. Source: *Freedom House* (www.freedomhouse.org).

6. **Life Expectancy** (1975-1997): Average life expectancy (males and females combined). Source: *US Bureau of the Census, International Database* (www.census/gov/ipc/www).

7. **Political Rights Index** (1975-1998): Measure of rights to participate meaningfully in the political process (same scaling as for Civil Liberties Index). Source: *Freedom House* (www.freedomhouse.org).

8. **Democracy** (1975-1998): Measure of degree of democracy; ranges from –10 (least democratic) to 10 (most democratic). Sources: *Polity98* project (Gurr and Jaggers 1995; Gleditsch and Ward 1997; http://kleditsch.socsci.gla.ac.uk/Polity.html); (see also Marshall and Jaggers n.d. for a recent update).

9. **Religious Diversity** (1975-1999): Largst religious group in country as a percent of total population. Sources: CIA World Fact Book; Country Indicators of Foreign Policy Project (CIFP); Ellingsen (1996); *Handbook of the Nations; Britannica Book of the Year; Demographic Yearbook*.

10. **Caloric Intake** (1975-1997): Estimate of the average number of calories consumed per person, per day. Source: *Food and Agriculture Organization of the United Nations* (http://apps.fao.org).

11. **GDP per Capita** (1975-1998): Annual gross domestic product per person measured in constant 1998 US dollars. Source: World Bank (1999). *World Development Indicators*.

12. **Ethnic Diversity** (1975-1999): Largest ethnic group in country as a percent of total population. Sources: same sources used to measure religious diversity above.

Figure 7. Independent Variables

Figure 7 lists the macro-structural factors on which we collected data. Taken together, they reflect a country's commitment to economic performance, its ability to achieve economic performance, its commitment to political rights and civil liberties, and its commitment to the rules of global trade (as reflected in its *trade openness* score). The database also includes information about how old or young people are in each country as well as how ethnically and religiously diverse each society is. These are factors that at some level or in some configuration are likely to contribute to an environment conducive to instability.

Though it was not the purpose of this study to test and evaluate hypotheses *per se*, an implicit hypothesis is that if a country's macro-structurals are in poor condition--if the country is experiencing weak or regressive economic performance, is unable or unwilling to deliver minimally adequate health care to its people, has weak or underdeveloped global trade links, an abundance of idle or underemployed youth, little respect for political rights and civil liberties, tensions between ethnic and religious groups, and a history of resolving differences through conflict--then these factors may serve as the "oily rags" for a potentially combustible situation. The more oily the rags, the more likely a single spark (i.e., a riot, natural disaster, or assassination) could produce an explosive situation. Conversely, the better performing a country is with respect to these factors, or the less oily those rags, the more likely it can marshal the will

and capacity to withstand a series of sparks or shocks to its system without imploding under the weight of the event(s). The ability of the US government to respond to natural disasters that take place within its borders is one such example. It is worth emphasizing that the ACTOR model seeks to forecast the "oiliness" of these rags only, not the spark that may ignite them.

2.4 Dependent Variable

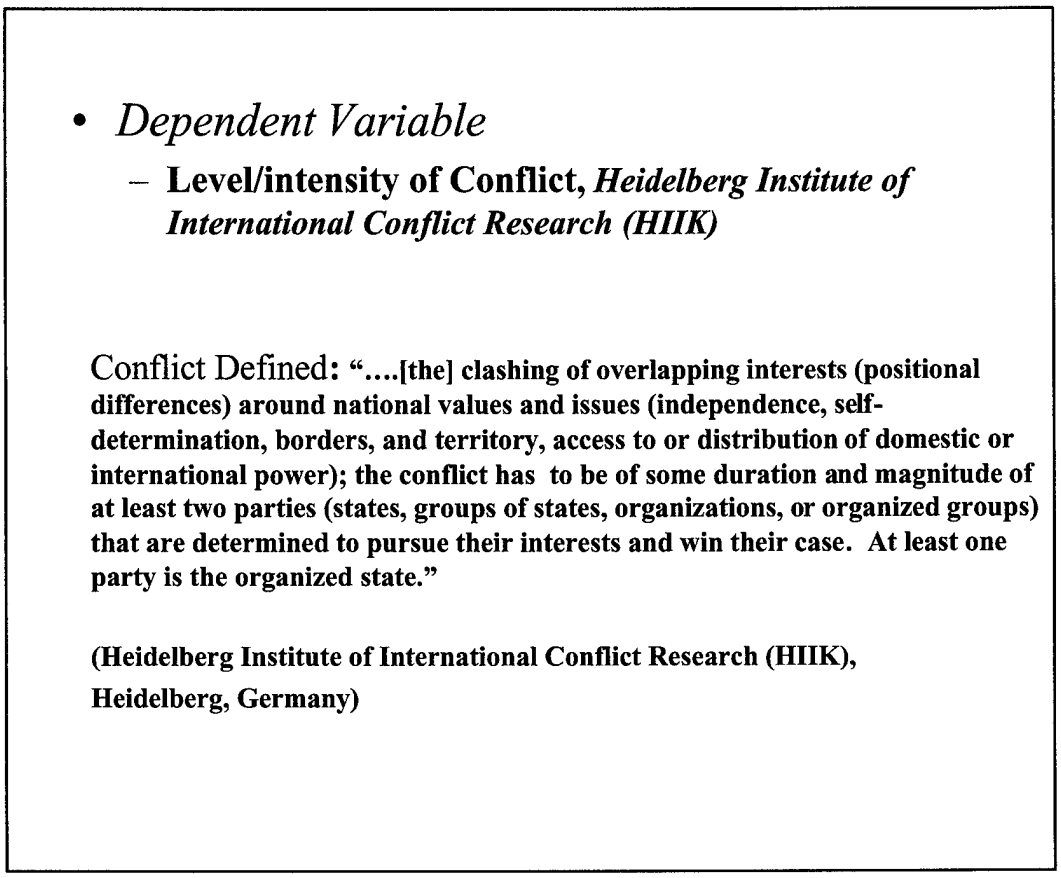

Figure 8. Dependent Variable

An indicator of instability is required in order to validate these macro-structural factors as relevant contributors to instability. Unfortunately, there is no universal consensus on what exactly instability is, not to mention good data sources that track and measure it on a global basis over a substantial period of time. Therefore, we use the maximum level or intensity of conflict experienced by a country in any given year as an approximate index of instability. These data were acquired through the KOSIMO project at the Heidelberg Institute of International Conflict Research in Germany (www.hiik.de). The definition of conflict used by the principal investigators of this data project is formally indicated in Figure 8.

The purpose of the KOSIMO data project was to develop a comprehensive database of all the conflicts that have occurred over the period 1945-1999 regardless of whether the conflict was a foreign policy crisis, interstate war, intrastate war, and so forth. Many of these conflicts were drawn from well-known academic data projects such as the Correlates of War (COW) project at the University of Michigan (recently moved to Penn State University) and the International Crisis Behavior (ICB) data project at the University of Maryland. KOSIMO researchers collected data indicators on every conflict that fit this definition, such as when the conflict began and ended, estimates of the number of casualties (if any), the issues and countries that were involved, and so forth.

Importantly, from the perspective of this study, the KOSIMO project also classified these conflicts by the general levels of violence that characterized them. Four principal groupings were identified: wars (both inter- and intrastate), violent crises, mostly nonviolent crises, and latent conflicts. With the exception of latent conflicts, which are excluded from the analysis because they were so benign as to be uninteresting, Figure 9 provides additional definitions and examples of each conflict type.

2.5 Levels of Instability Intensity

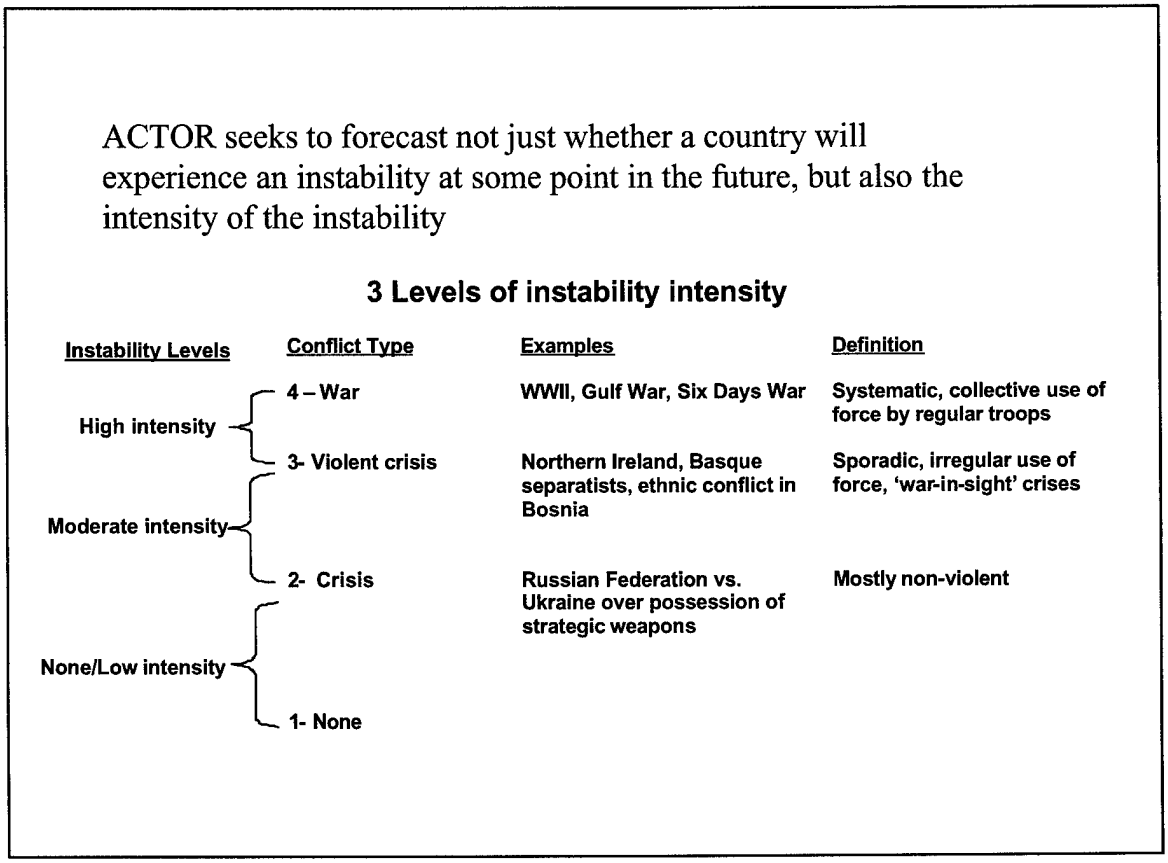

Figure 9. Levels of Instability Intensity

Using the information in the KOSIMO database, a score from 1 to 4 was assigned for each country-year in the ACTOR database based on the maximum level or intensity of conflict the country experienced that year. For instance, if the most intense conflict in which a country engaged was a war--either as an initiator or as a defender--then it receives a score of 4 for that year. It receives a score of 3 if it experienced, at most, a violent crisis, a 2 if it experienced no more than a nonviolent crisis, and a 1 if it experienced none of these three conflict event types. This four-category, ordinal-level scale is the proxy measure of instability used to validate the factors described above as relevant contributors to instability.

The algorithm used to forecast the level of intensity of instability will, in the validation and forecasting phase, estimate the probability that each country will experience each of the four conflict types in each year. To derive the expected level of intensity of instability, we aggregate these probabilities across the four conflict types using the following decision rules:

1. If the combined probabilities of conflict types 1 and 2 occurring in a given country are greater than 67 percent, then the expectation is that the country will experience *none* or a *low* intensity instability.

2. If the combined probabilities of conflict types 2 and 3 occurring in a given country are greater than 67 percent, then the expectation is that the country will experience a *moderate* intensity instability.

3. If the combined probabilities of conflict types 3 and 4 occurring in a country are greater than 67 percent, then the expectation is that the country will experience a *high* intensity instability.

4. If more than one of the first three decision rules applies to a particular country-year forecast, select as the forecast the one that reflects the highest intensity level of instability.

5. If none of these decision rules applies--that is, if the probability is roughly equally distributed across the possible conflict event types--then we are *uncertain* about that country's likelihood of instability. (An *uncertain* forecast is neither correct nor incorrect as far as the performance of the forecasting algorithm is concerned. In any given year, approximately 10-15 percent of all predictions made are of an *uncertain* nature. Historically, about 50 percent of these cases ultimately experience a conflict type 2, 3, or 4 in that year.)

6. A forecast is correct **if and only if** a country experiences, as its maximum intensity level of conflict, one of the two conflict type events covered by the forecasted level of instability intensity, as defined in Decision Rules 1-3.

In addition to the ease with which they facilitate the presentation and interpretation of results, these decision rules were developed because they also facilitate an arguably fair, and somewhat conservative, test of the forecasting method's performance. The sixth decision rule, for instance, articulates the conditions under which a forecast will be considered correct. If the algorithm correctly forecasts that a country will be unstable, but does not identify the correct *intensity level* of that instability, then the forecast is considered incorrect. For example, if the algorithm were to forecast that Country "B" in 1995 had a 76 percent probability of experiencing a moderate intensity instability (e.g., either conflict type 2 or 3) and the country actually experienced a war that year (conflict type 4), then that forecast would be considered a miss, and therefore incorrect.

3 MODEL DEVELOPMENT AND VALIDATION

3.1 Forecasting Method

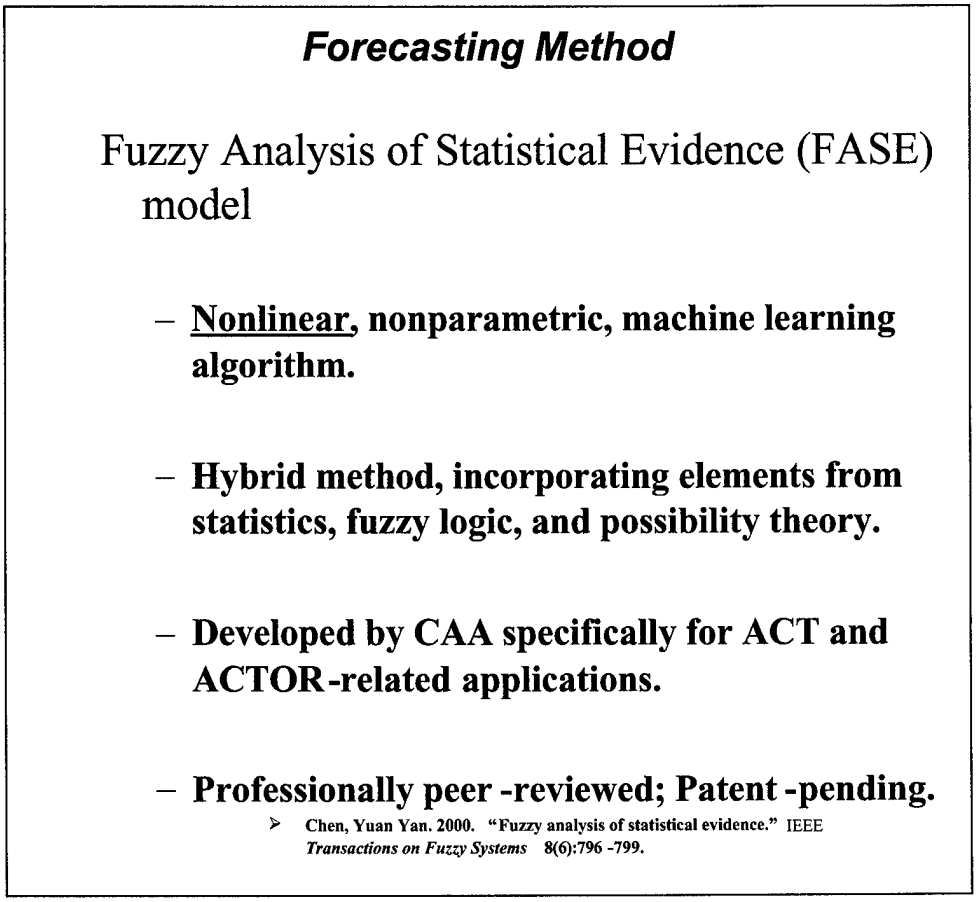

Figure 10. Forecasting Method

In the ACT Study (CAA-SR-99-4), analysts evaluated several different analytical techniques, including logistic regression, classification and regression trees (CART), temporal decision trees, and neural networks to determine how well each could identify or "learn" patterns in the relationships between country macro-structurals and the likelihood of country instability. The technique that consistently demonstrated an ability to accurately distinguish those countries that would and those that would not subsequently experience an instability, given the values of country macro-structurals, was one that was developed by the Center for Army Analysis specifically for these types of classification problems. Fuzzy Analysis of Statistical Evidence is a nonlinear, nonparametric classification algorithm. It is a hybrid technique that incorporates theoretical elements from statistics, fuzzy logic, and possibility theory. FASE was used in the

ACTOR study to perform the validation tests and forecast country instability through FY 2015, as presented below.

3.2 FASE: Historical Instability Likelihood Estimates

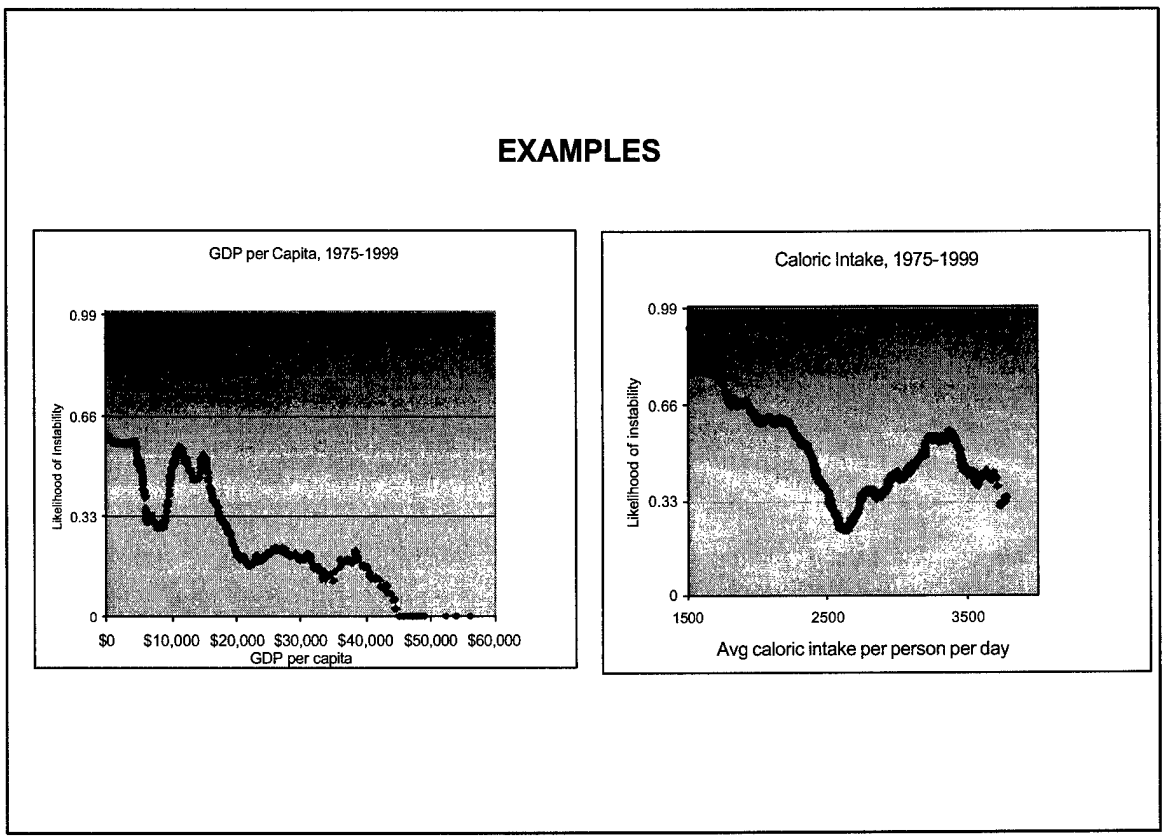

Figure 11. FASE: Historical Instability Likelihood Estimates

Figure 11 displays examples of the relationships estimated by FASE. The left-hand chart displays the relationship between a country's gross domestic product (GDP) per capita (in 1998 constant dollars) and the likelihood that a country would experience any one of the three conflict event types shown in Figure 9 (i.e., war, crisis, nonviolent crisis). As a country's GDP per capita increases, the likelihood that that country will become involved in a conflict decreases. The chart on the right-hand side of Figure 11 shows the relationship between the average caloric intake per person per day and the likelihood that the country will experience any one of the conflict types. The relationship assumes a pattern consistent with a sine curve; there is a negative relationship between caloric consumption and the likelihood of conflict up to around 2,600 calories consumed per person per day. However, the relationship between caloric consumption and likelihood of conflict is positive for daily caloric consumption values between 2,600 and around 3,500, before turning negative once again.

In the training phase, FASE will estimate likelihood relationships between each of the 12 macro-structurals in relation to each of the 4 categories on the index of instability. In the validation and

in the forecast phase, a country's observed macro-structural values (or forecasted macro-structurals in the forecast phase) are fitted to these likelihood curves. These likelihood measures are then aggregated across the 12 curves. The results inform us of the probability that a country with that particular configuration of macro-structural attributes will experience each of the conflict types 1, 2, 3, and 4. To determine the expected intensity level of instability, we then aggregate those probabilities across the categories using the six decision rules described above.

3.3 Model Development, Training, and Validation

- *Model Development/Training data: 1975-1984*
  - **Algorithm "learns" how structural independent variables have been associated with different levels of conflict historically.**
- *Model Validation/Test data: 1985-1999*
  - **Program algorithm to predict probability and intensity of conflict based on values of observed independent variables and patterns "learned" in training set.**
  - **Compare algorithm's predictions to historical record; compute performance metrics (accuracy, recall, precision).**

Figure 12. Model Development, Training, and Validation

In order to validate FASE's ability to forecast out 15 years, a split-sample validation design is used. FASE is "trained" on the historical data over the period 1975-1984. By *trained,* we mean FASE is given full visibility of every country's macro-structural values for each year covered by the training period and each country's position for that year on the proxy index of instability. Here we examine how well FASE can identify the patterns in the relationships between these macro-structurals and the likelihood of a specific intensity level of instability. To test how well FASE can learn these patterns, FASE is given the macro-structural indicators only for the period 1985-1999--the test set--and tasked to classify the countries in the test set by their expected level of instability given those values on their macro-structurals. We then compare FASE's classification with what we know actually occurred over the period 1985-1999 and compute some performance metrics.

Three performance metrics are computed and their formulas are displayed in Figure 13. ***Overall accuracy*** refers to the overall ability of FASE to correctly differentiate between those countries that did and those that did not experience some level of instability in the period covered by the test set. It is simply the percentage of correct classifications completed overall. ***Recall*** tests the ability of the algorithm to correctly forecast on the element of interest, in this case the correct

conflict level. A recall score of 90 percent would indicate that of all the conflicts that occurred over some specified period of time, the algorithm correctly identified and classified 90 percent of them, having missed 10 percent. ***Precision*** tests the ability of the algorithm to correctly forecast accurately without producing too many false positives. An 80 percent precision score would indicate that 80 percent of the conflict predictions were *not* false positives, or, stated differently, 20 percent of the conflict predictions that were forecast to occur did not.

3.4 5-15 Year Validation of FASE Model

Overall Accuracy	Recall	Precision
# of correct predictions / # of predictions made	# of correctly predicted conflicts / # of conflicts that occurred	# of correctly predicted conflicts / # of conflicts predicted to occur

Average Performance Scores For Different Training Sets / Forecast Periods

Length / Period of Training Set	Forecast Period: 1985-89	1990-94	1995-99
10 years (1975-84)	90% 88% 82%	77% 66% 72%	74% 64% 57%
15 Years (1975-89)	--	79% 74% 71%	77% 72% 61%
20 Years (1975-94)	--	--	81% 87% 65%

- **For any given forecast period, the longer the training data set, the more accurate the forecasts tend to be.**
- **The ability of FASE to generate accurate forecasts degrades with time.**

Figure 13. 5-15 Year Validation of FASE Model

The first row of cells in Figure 13 report the results of the 15-year validation. The results in each cell indicate the *average* performance metrics for each 5-year period in the test set. For the first 5-year period in the 15-year validation (1985-89), 88 percent of all the conflicts that occurred were correctly identified and classified by the level of intensity at which they occurred. Only 18 percent of conflict predictions turned out to be false positives. Turning to the second 5-year period in the 15-year validation (1990-94), both the recall and the precision scores remain above 2/3; however, a degradation in the performance is witnessed across the second and third 5-year periods. For the period 1995-99, both the recall and the precision dip below two-thirds.

Though the database contains data across country macro-structurals over the period 1945-1999, the temporal domain of the analysis was restricted to the period 1975-1999 for two reasons. First, the quality and consistency of the data inevitably suffer the farther one goes back in time. Second, it seemed prudent to ensure that an analysis of conflict in and around the post-Cold War era (and well beyond to 2015) was not unduly influenced by the nature and amount of conflict that occurred primarily between major powers around World War II. Still, working with only 25 years worth of data provides us with only 10 years of data on which to train a FASE model for the 15-year validation analysis. Eventually, though, we will use the entire 25-year database as a training set to forecast country instability over the period 2001-15. This begs the question--as we lengthen the training set (ultimately from 10 to 25 years)--are we likely to forecast better with the benefit of the additional data? To provide at least a partial answer to this question, we performed two additional validation analyses, in each instance lengthening the training set by 5 years from 10 to 15 years and from 15 to 20 years. The results of these additional validation analyses are displayed in the second and third rows of the table in Figure 13. Specifically, we are interested in determining whether and to what extent the additional data in the training set allows us to predict more accurately in any given 5-year period in the test set. The results in Figure 13 suggest that it does. With the addition of 5 years' worth of training data, the recall score for the test set period 1990-94 improves 8 percentage points from 66 percent to 74 percent. The effect is even more pronounced in the 1995-99 timeframe. With each additional 5-year increase in the training set, the recall scores improve from 64 percent to 72 percent to 87 percent, respectively.

3.5 Key Correlates of Instability, 1975 - 1999

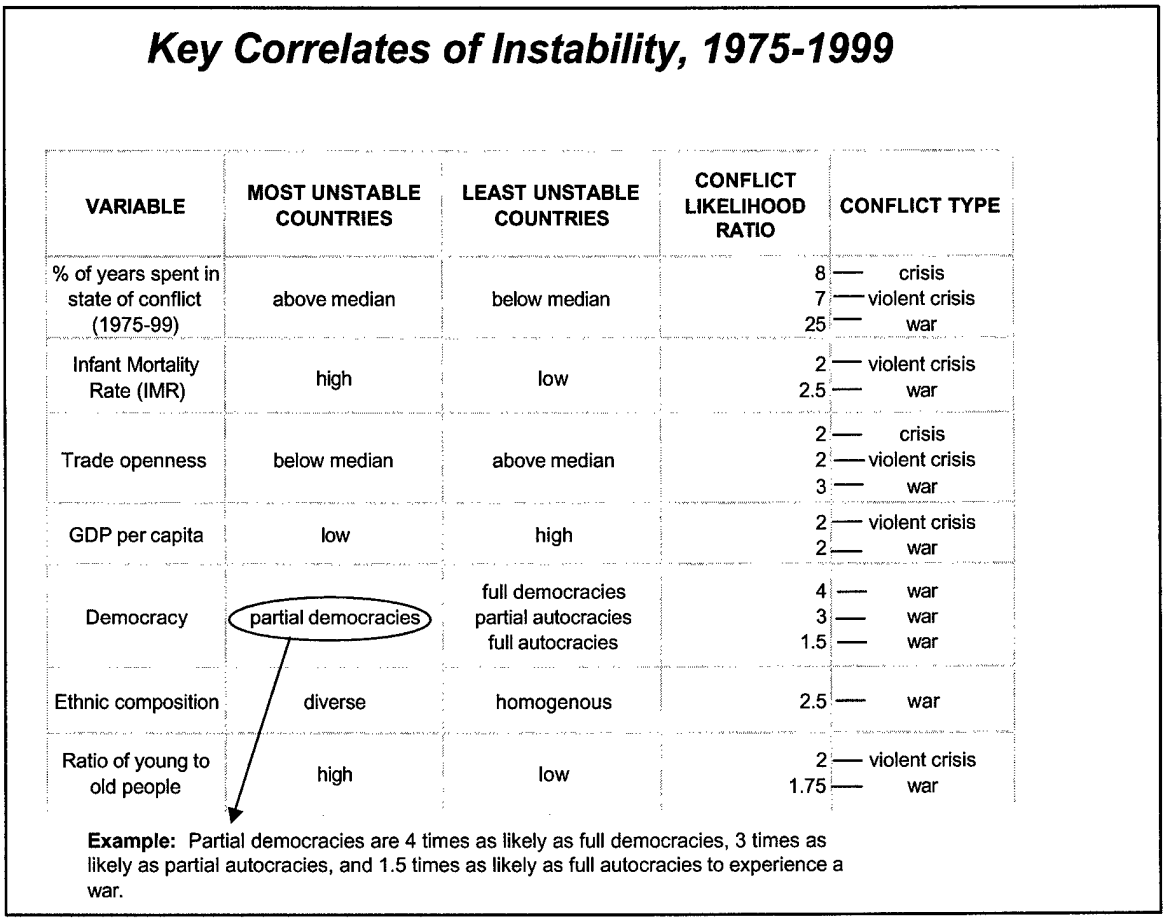

Figure 14. Key Correlates of Instability, 1975 - 1999

The table in Figure 14 displays the results of an analysis performed in an effort to isolate the key correlates of instability. In this case, it was of particular interest to determine the degree to which the relationships between country macro-structurals and country instability were stronger at the higher or lower intensity levels of instability. For this analysis, which covers all countries over the period 1975 through 1999, each macro-structural indicator was split on its median, and those countries below the median were compared with those above the median with respect to their likelihood of experiencing any one of the three conflict event types. The second column in the table in Figure 15 provides a profile of the typical unstable state, which would appear to be an ethnically diverse, partial democracy, with a high ratio of young people. Such a country has spent a fair amount of its history (more than 6 of the last 25 years) in some state of conflict. More likely than not, it experiences a high infant mortality rate, reports a low GDP per capita, and has weak or underdeveloped global trade links. The fourth column of the table in Figure 15 indicates how much more likely unstable countries are to experience any one of the three principal conflict types compared to more stable states. For instance, countries with high infant

mortality rates are twice as likely to experience violent crises and 2.5 times as likely to experience wars, as are those with low infant mortality rates. Further, partial democracies are 4 times as likely as full democracies, 3 times as likely as partial democracies, and 1.5 times as likely as full autocracies to experience a war.

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4 ANALYSIS

4.1 ACTOR Forecast Analysis

- Train model with data from 1975-1999 to examine how structural variables have been associated with various levels of instability during that period.
- Using historical observations as a baseline, forecast each structural factor over period FY 2000-2015.
- Given patterns uncovered during training phase, and based on forecasted structural factors, instruct algorithm to assign probability that a certain level of instability will occur in each year for each country during FY 2000-2015.
- Reconcile ACTOR instability forecasts with forecasts conducted by the intelligence community; make necessary adjustments.

Figure 15. ACTOR Forecast Analysis

In moving from the validation to the forecast phase, we simply take the analysis one step further. We use the entire historical database (1975-99) as a training set, and, using the historical data as a baseline, we project over the period 2000-15 the historical trend for each macro-structural for each country. Then, once again, given the patterns uncovered in the training set, and the values of these forecasted macro-structurals, we simply compute the likelihood that each country will experience a certain level of intensity of instability as described above.

4.2 Assumptions and Limitations of Base Case Forecast

- *Key Assumptions*
  - **Forecasts of structural values are generally correct.**
  - **State conflicts are associated with or preceded by conditions of instability.**
  - **Structural conditions conducive to both intra- and interstate conflict are generally the same.**
  - **Data used in the analysis are timely and accurate.**
  - **The independent variables contribute to or are indicators of country stability/instability.**
- *Key Limitations*
  - **Data were unavailable for some variables for some countries in some years.**
  - **Model does not provide insights into specific events that might trigger instabilities.**
  - **Environmental influences are not directly modeled.**

Figure 16. Assumptions and Limitations of Base Case Forecast

Several assumptions used in the ACTOR forecasts are revealed in Figure 16. First, we assume that the forecasts on the macro-structurals to 2015 will be generally correct. This is an important assumption because the forecasts on the macro-structurals form the backbone of the forecasts of country instability. If the macro-structural forecasts are generally correct, then the forecasts of country instability to 2015 should be about as accurate as those generated in the validation analyses reported in Figure 13. Second, it is assumed that state conflicts are preceded by conditions conducive to instability; that is, conflicts do not occur in a vacuum. Third, the structural conditions conducive to intrastate conflicts are similar to those for interstate conflicts. This assumption is necessary because the proxy index of instability includes both intra- and interstate disputes. Fourth, the data used in this study come from a variety of primary and secondary sources, government agencies, nongovernment agencies, and scholars. The assumption is that these data are timely and accurate. Finally, we assume that the independent variables are indeed indicators of or contributors to instability.

Several key limitations to the study are also identifiable. First, some data for some of the indicators were missing for some countries entirely or for some countries in certain years. For instance, GDP per capita data is not available for North Korea or for Afghanistan. We treat these data holes as vacuous in the analysis as they provide no assistance in determining whether a country will or will not be unstable. Second, the model does not provide insight into what might trigger these instabilities, be it government repression, the cancellation of popular elections, and so forth. Rather it forecasts the conditions conducive to instability, the conditions that form the context from which these dynamic "trigger" events often emerge. Finally, many relevant structural factors--such as environmental influences, for instance--were not included in the model because consistent, high quality data could not be identified for those factors.

4.3 2001 ACTOR Forecast

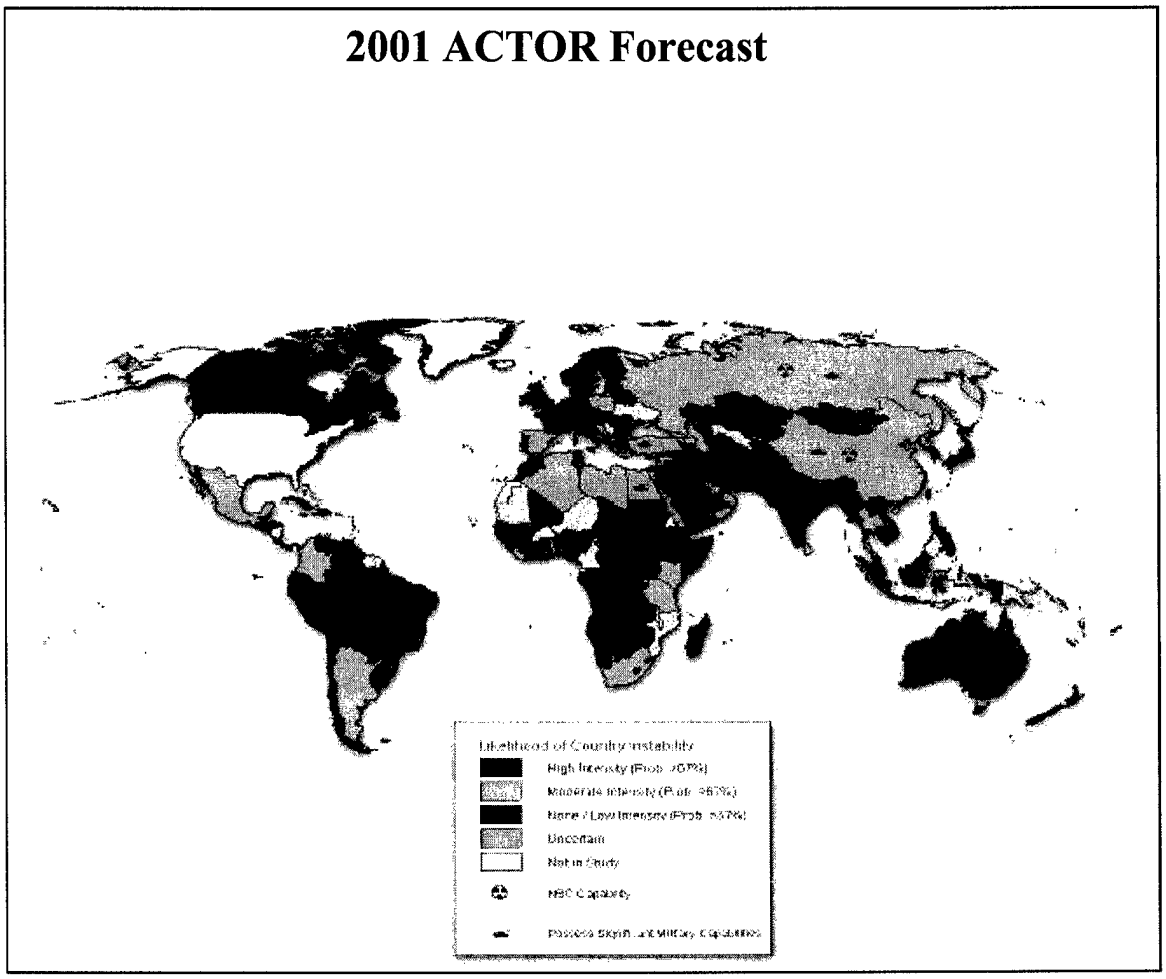

Figure 17. 2001 ACTOR Forecast

The map in Figure 17 shows the forecasts of country instability generated for 2001. Countries shown in green have a two-thirds or better probability of experiencing none-to-low intensity

levels of instability; those shown in amber have a two-thirds or greater probability of experiencing a moderate intensity instability; and red countries have a two-thirds or better probability of experiencing a high intensity level of instability. Countries depicted in gray are those about which we are uncertain; that is, the likelihood that the country will experience a none-to-low, moderate, or high intensity level of instability is equally distributed across the intensity levels. Countries shown in white are those that were excluded from the analysis. Countries flagged by the radiation symbol are those that possess either a nuclear, biological, or chemical capability. Finally, the tank symbol indicates those countries that possess a military force that is, in both a qualitative and quantitative sense, at least as good as Iraq's military forces on the eve of the Gulf War in 1991. This assessment was facilitated using the National Ground Intelligence Center's (NGIC) Prism model. Prism is a global model that aims to evaluate foreign force effectiveness. NGIC analysts rank the quality of each country's military forces on a scale of 1 (low quality) to 10 (high quality) across a range of dimensions including sustainability, command, control, communications, and computers (C4), maneuverability, fire support capabilities, air defenses, engineer capabilities, combat engineer support, joint and combined operations, infrastructure, economics, and soldier morale, among other factors. Those countries that scored an average of 5 across each category were deemed to have "significant military forces."

The ACTOR model-generated forecasts served as the base case from which a hybrid of several different forecast analyses was fashioned. The ACTOR model-generated forecasts were reconciled with forecasts conducted by two other Defense Department agencies: the European Command's Joint Analysis Center (JAC) and the Marine Corps Intelligence Activity (MCIA) at Quantico. JAC analysts focus on countries in the European Command's area of responsibility (AOR) and assess the social, political, and economic circumstances in each country with respect to determining in an impressionistic manner the degree to which the confluence of these events may lead to internal instability. The MCIA regularly surveys its analysts, asking individual country experts to rank each country on its prospects for instability across a broad range of factors. These ratings are aggregated across the factors and transformed into a single score. Those countries whose instability scores ranked among the top 20 percent globally were deemed to be "states of concern" or vulnerable to instability, through FY 2010. In addition, an environmental security assessment was performed in which the forecasts of instability were adjusted in light of the level of environmental adversity or degradation occurring in some countries around the world.

This process of reconciling the ACTOR model-generated forecasts with the three complementary examinations consisted of downgrading or upgrading ACTOR model forecasts depending on how consistent the forecast was across the examinations. A country that was forecast by ACTOR to be unstable but was not forecast to be unstable in the other studies was downgraded. Conversely, a country that was not forecast by ACTOR to be unstable, but was forecast to be unstable by at least two of the three complementary studies, was upgraded to reflect this. The forecast adjustments were applied to each affected country throughout the entire period 2001-15. This process led to the following adjustments to the initial ACTOR model-generated forecasts:

- France and the United Kingdom were downgraded from amber to green.
- Morocco was downgraded from amber to green and South Africa from red to amber.
- Haiti, Indonesia, and Nigeria were all upgraded from amber to red.

- Bosnia was upgraded from green to amber, and Congo-Brazzaville and Central African Republic were upgraded to red.

These adjustments are reflected in the instability forecasts for 2001, 2008, and 2015 as reflected in Figures 17 through 19. Not surprisingly, most of the high intensity instability is expected to occur in South Asia and East and Central Africa.

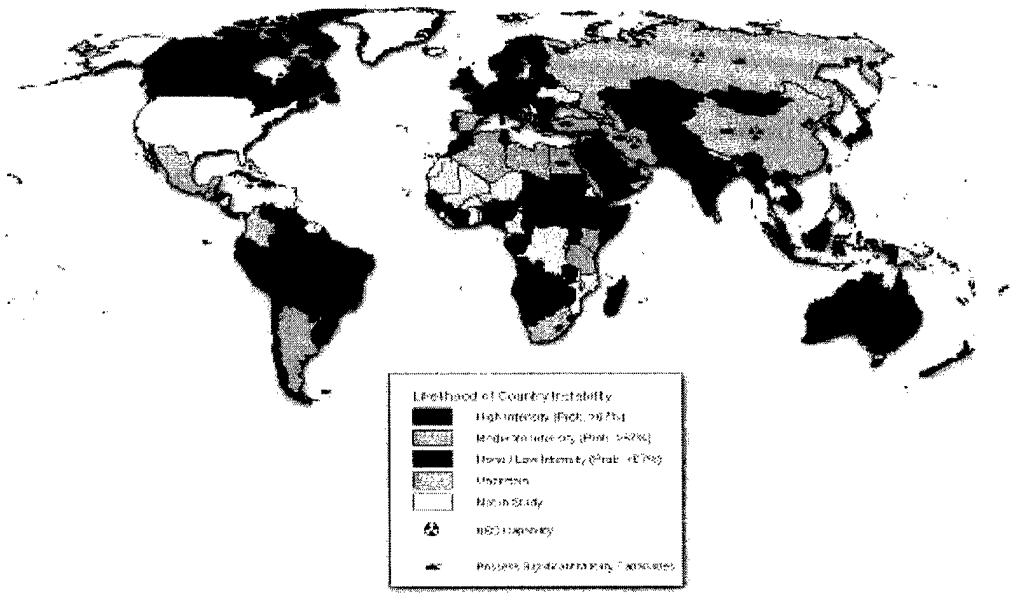

Figure 18. 2008 ACTOR Forecast

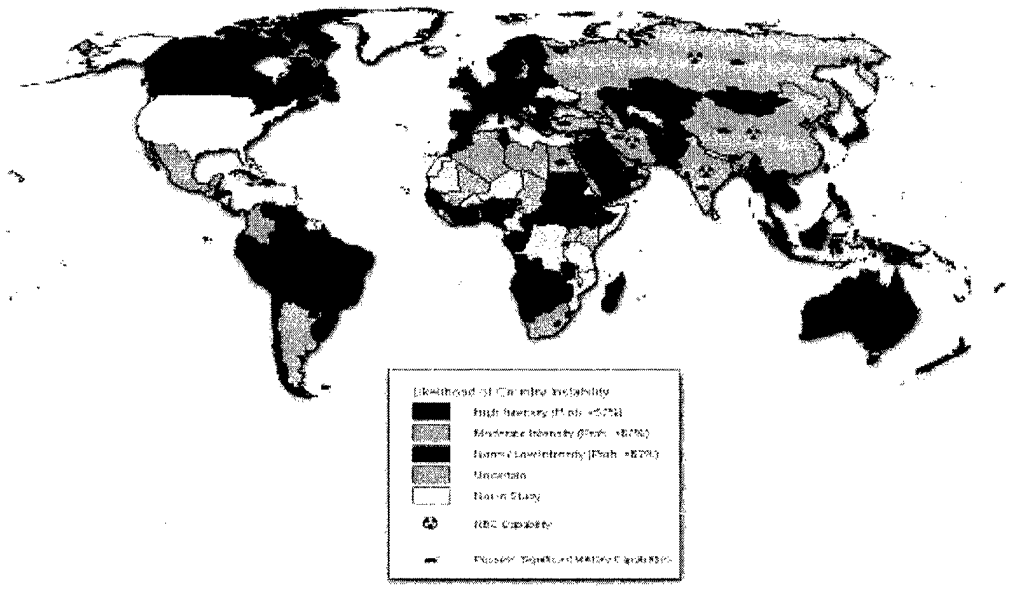

Figure 19. 2015 ACTOR Forecast

5 SUMMARY

5.1 Summary of ACTOR Forecasts

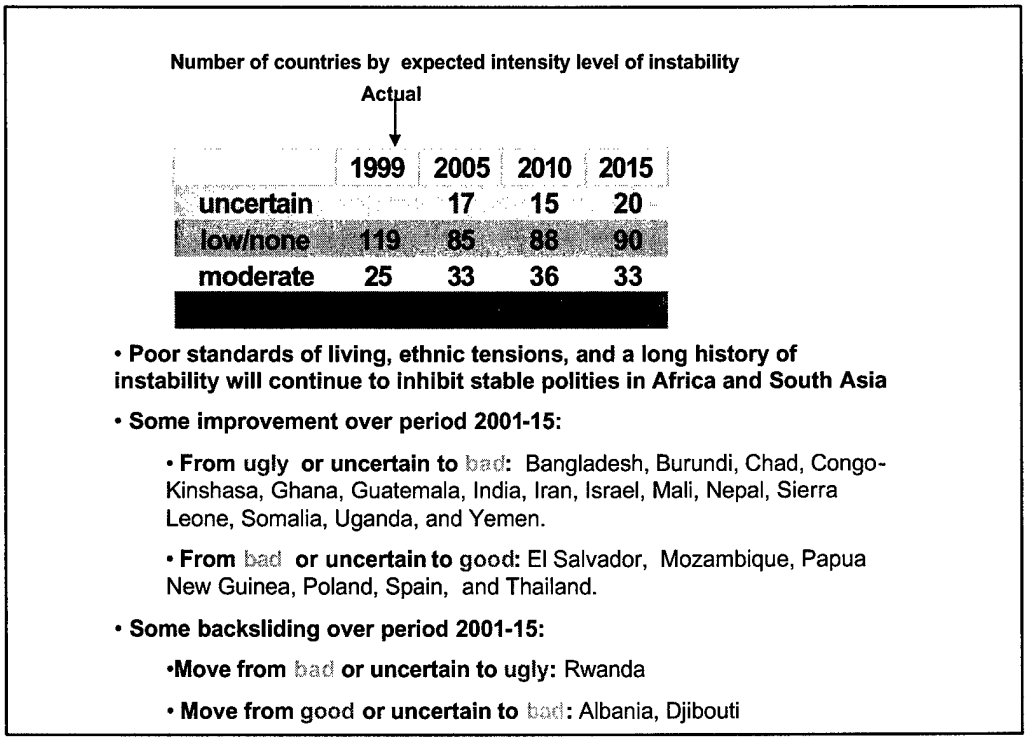

Figure 20. Summary of ACTOR Forecasts

Figure 20 displays a summary of the number of countries expected to experience each of the three different intensity levels of instability for select years compared to the 1999 baseline. Essentially, the ACTOR forecasts envision a world that will become increasingly unstable, at higher intensity levels, out to about the year 2008. Thereafter, the world is expected to make significant improvements, especially around some of the worst regions, principally South Asia and East Africa. The following paragraphs provide a description of the countries that are expected to make improvements. Along with the macro-structural rationales for each, they include the following:

? Bangladesh: *infant mortality* rate improves (from 67 to 37), *GDP per capita* improves, average *life expectancy* increases slightly (from 61 to 68), *youth bulge* declines, and *trade openness* increases by almost 50 percent.

? Chad: average *caloric intake* increases, *infant mortality* rate drops, restrictions improve on *civil liberties*, average *life expectancy* improves (from 48 to 54), and *trade openness* improves slightly.

? Ghana: average *caloric intake* increases slightly, restrictions on *civil liberties* and *political rights* relax somewhat, *life expectancy* increases (from 57 to 62), prospects for *democratization* improve, and *trade openness* improves.

? Indonesia: *caloric intake* increases, *infant mortality* rate drops (from 55 to 33), average *life expectancy* increases (from 63 to 69), *youth bulge* declines, and *trade openness* improves.

? Iran: *infant mortality* rate drops (from 28 to 14), *youth bulge* experiences a precipitous decline (from 1.29 to .78), and *trade openness* improves.

? Israel: *GDP per capita* improves, *youth bulge* declines slightly, *trade openness* improves.

? Mali: *infant mortality* rate declines, average *life expectancy* improves (from 48 to 55), and *trade openness* improves.

? Uganda: *infant mortality* rate declines (from 86 to 66), restrictions on *political rights* and *civil liberties* improve, and trade openness improves.

? Yemen: *infant mortality* rate improves (from 67 to 39), average *life expectancy* increases somewhat (from 61 to 67), and its *trade openness* improves markedly.

? El Salvador: *caloric intake* increases, *GDP per capita* improves, *youth bulge* declines, and *trade openness* improves.

? Mozambique: *caloric intake* increases, restrictions on *political rights* and *civil liberties* relax, average *life expectancy* increases (from 46 to 55), *youth bulge* declines, *GDP per capita* increases by 50 percent, and *trade openness* improves.

? Papua New Guinea: *infant mortality* rate declines, *youth bulge* declines, and *trade openness* improves.

? Spain: *GDP per capita* increases, *youth bulge* declines, and *trade openness* improves.

? Poland: *GDP per capita* increases 50 percent, *youth bulge* declines precipitously, and *trade openness* improves.

? Thailand: *infant mortality* declines, *GDP per capita* increases, *youth bulge* declines, and *trade openness* improves

In addition, it is expected that a few countries will move in the opposite direction toward higher intensity instability. This includes Rwanda, Albania, and Djibouti. Life expectancy slips in Rwanda, *GDP per capita* declines in Albania, and the *youth bulge* increases in Djibouti. Also, in all three cases, the *trade openness* measure is expected to decline. Indeed, *trade openness* seems to have a powerful effect on the prospects for countries to remain or become unstable. *Trade openness* is improving in every country that is expected to become more stable in the future and is receding in every country that is expected to become less stable. This is consistent with arguments and findings from the academic literature that suggest a positive association between the development of trade bonds and peaceful behavior.

5.2 Concluding Remarks

In summary, this study presents a macro-structural approach for forecasting the conditions conducive to conflict and instability throughout the world. The model validation results suggest that, given knowledge or reasonable expectations about the performance of several of a country's macro-structural attributes, the likelihood that the country will experience a certain level of intensity of instability can be anticipated up to 6 years in advance with about 80 percent accuracy. As a baseline starting point, the approach can generate forecasts that provide the strategic decision maker with a good sense of how countries of varying degrees of vulnerability will likely be distributed, both geographically and over time.

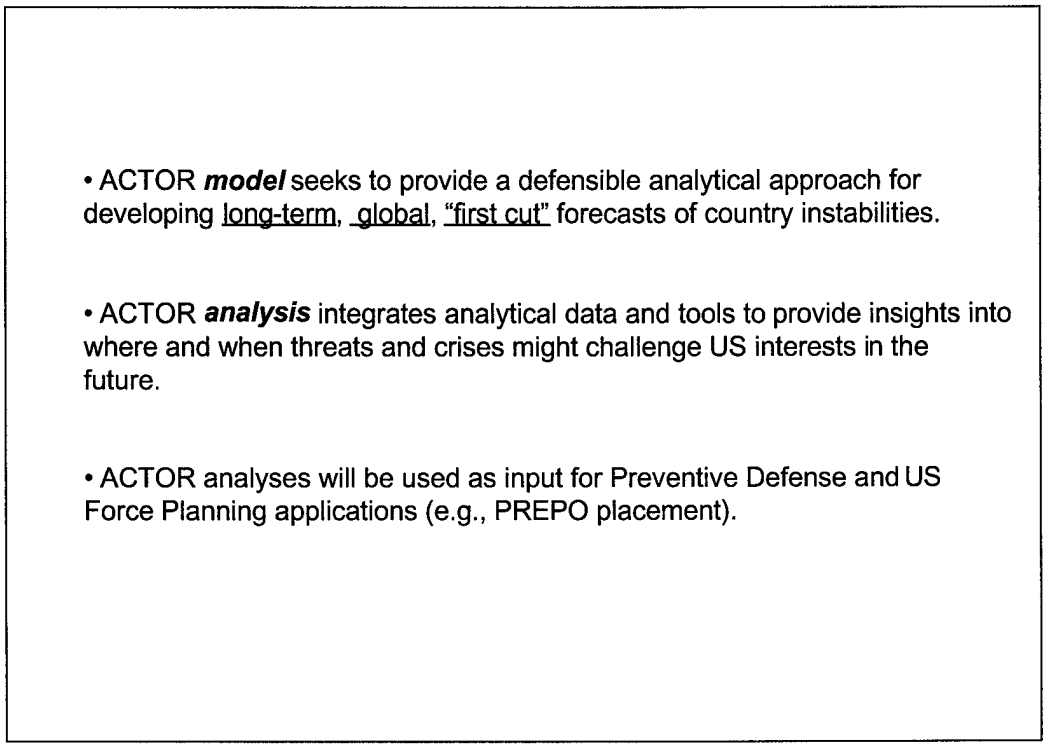

Figure 21. Summary

The approach is not without several limitations, however, and this report concludes by addressing two of the most important weaknesses. First, the model is missing several relevant factors. Part of the reason is that there is a paucity of reliable data that are consistently and regularly collected for a large number of countries. For instance, we know that environmental degradation--water scarcity in the Middle East, deforestation in Latin America, desertification in Sub-Saharan Africa--is at least indirectly a potential source of conflict, within and between countries. However, remarkably few organizations are seriously engaged in the collection of international environmental data. The data on ethnic and religious groups are somewhat more plentiful; however, it is not uncommon to find yawning discrepancies between different sources in estimates of the size and characteristics of ethnic and religious groups.

Second, the approach relies on macro-structural attributes to the neglect of more dynamic causal factors because only a country's macro-structural attributes can be statistically forecast into the future with a reasonable degree of expected accuracy. Consequently, the model can anticipate the oiliness of the rags, but not the spark that will set them ablaze. This limitation can be addressed to some extent by incorporating more dynamic factors, such as indicators of antigovernment protest and government repression, in the historical training set. This would allow one to conduct "what-if" drills, develop alternative scenarios, and examine how changes in protest and government repression (or any other modeled factor) might interact with macro-structural factors to alter a country's prospects for stability. This capability is currently being integrated into the approach.

APPENDIX A PROJECT CONTRIBUTORS

1. PROJECT TEAM

a. Project Director

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Mr. John Warren

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Prof. James R. Lee, American University

Mr. Scott Mingledorf, National Ground Intelligence Center

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APPENDIX B REQUEST FOR ANALYTICAL SUPPORT

P ***Performing Division:*** RA ***Account Number:*** **2000168**

A ***Tasking:*** Verbal ***Mode (Contract-Yes/No):*** No

R ***Acronym:*** **ACTOR**

T

Title: Analysis of Complex Threats for Operations and Readiness (ACTOR)

1 ***Start Date:*** 22-May-00 ***Estimated Completion Date:*** 31-Jul-00

Requestor/Sponsor (i.e., DCSOPS): DCSOPS ***Sponsor Division:*** SSW

Resource Estimates: ***a. Estimated PSM:*** 4 ***b. Estimated Funds:*** $0.00

c. Models to be

Description/Abstract: This study forecasts country instabilities through FY 2015. The forecasts will facilitate analyses of alternative sites for prepositioned equipment in support of the Deployment Optimization Research In Tools and Operations (DORITO) and Enabling Strategic Responsiveness (ESR) projects.

Study Director/POC Signature: ***Original Signed*** ***Phone#:*** 703-806-5361

Study Director/POC: **Dr. Sean O'Brien**

If this Request is for an External Project expected to consume 6 PSM or more, Part 2 Information is Not Required. See Chap 3 of the Project Directors' Guide for preparation of a Formal Project Directive.

Background:

P DCSOPS wants to know where instabilities may occur that could involve Army forces over the next 15 years (2001-15) and consequently where Army assets should be prepositioned.

A

R ***Scope:***

T Forecasts generated annually for each of 159 countries over 2001-15. Historical data set includes observations for 12 country macro-structural attributes, and associated conflict levels, over the period 1960-1999.

2 ***Issues:*** Which countries/regions are likely to be unstable over the next 15 years?

Milestones: 2000 November: initial country instability forecasts. 2001 January: Global forecasts reconciled with forecasts generated from within the intelligence community. 2001 April: final forecasts.

Signatures ***Division Chief Signature:*** ***Original Signed and Dated*** ***Date:***

Division Chief Concurrence:

Sponsor Signature:Original Signed and ***Date:***

Sponsor Concurrence (COL/DA Div Chief/GO/SES)

Entry Date: *17-May-00* ***Print Date:*** *05-Nov-01*

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GLOSSARY

ACT	Analyzing Complex Threats (study)
AOR	area of responsibility
C4	command, control, communication, and computers
CAA	Center for Army Analysis
CART	classification and regression tree
COW	Correlates of War
DORITO	Deployment Optimization Research in Tools and Operations
ESR	Enabling Strategic Responsiveness (study)
EUCOM	European Command
FASE	Fuzzy Analysis of Statistical Evidence
FY	fiscal year
GDP	gross domestic product
HIIK	Heidelberg Institute of International Conflict Research
ICB	International Crisis Behavior
JAC	Joint Analysis Center
MCIA	Marine Corps Intelligence Activity
MTW	major theater war
NGIC	National Ground Intelligence Center
ODCSOPS	Office of the Deputy Chief of Staff for Operations and Plans
PERICLES	Political and Economic Risk in Countries and Lands Evaluation Study
PREPO	prepositioned
QDR	Quadrennial Defense Review
SSC	smaller-scale contingency
US	United States
USEUCOM	US European Command

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