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**Center for  
Army  
Analysis**

**ANALYSIS OF COMPLEX THREATS - PACIFIC**

**NOVEMBER 2000**



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**ANALYSIS OF COMPLEX THREATS - PACIFIC (ACT-PAC)****SUMMARY**

**THE PROJECT PURPOSE** was to apply the ACT (CAA-SR-99-4) methodology to analyze country instability in the US Pacific Command (USPACOM) area of responsibility (AOR) through year 2010. The intent of this analysis was to provide USPACOM intelligence analysts with an analytically defensible approach for determining potential locations of intelligence assets.

**THE PROJECT SPONSOR** was the Research and Analysis Division, Headquarters, US Army Commander in Chief, Pacific Command (USCINCPAC).

**THE SCOPE OF THE PROJECT** was to use Fuzzy Analysis of Statistical Evidence (FASE) and Temporal models used in the ACT study to forecast the likelihood of instability for the 27 countries in the USPACOM AOR through end of calendar year 2010.

**THE MAIN ASSUMPTIONS** include: the data used in the analysis are timely and accurate. History can be useful in forecasting a country's likelihood of becoming unstable. The independent variables (GDP per capita, infant mortality rate, youth bulge, calorie consumption per person per day, and political rights index) are indicators of country stability/instability. The dependent variable (Uppsala conflict) reflects country instability.

**THE BASIC APPROACH** for this project was to use the FASE and Temporal data mining techniques that performed best in the ACT Study to explore and model the relationship between structural factors that may contribute to the stability (or instability) of a country and historical instances of country instability.

**THE PRINCIPAL FINDING** was that ACT-PAC provided insights to USPACOM regarding locations where challenges to US security could possibly occur. The results of ACT-PAC forecasts can be compared with USPACOM intelligence analysts' insights to provide another perspective on regional stabilities in the USPACOM AOR and also serve as a screening tool for more in-depth analysis. This combination of intelligence and analytical views provides a defensible foundation for strategic planning in general.

**THE PROJECT EFFORT** was conducted by Ms. Judy Bundy, Resource Analysis Division, Center for Army Analysis.

**COMMENTS AND QUESTIONS** may be sent to the Director, Center for Army Analysis, ATTN: CSCA-RA, 6001 Goethals Road, Suite 102, Fort Belvoir, VA 22060-5230.

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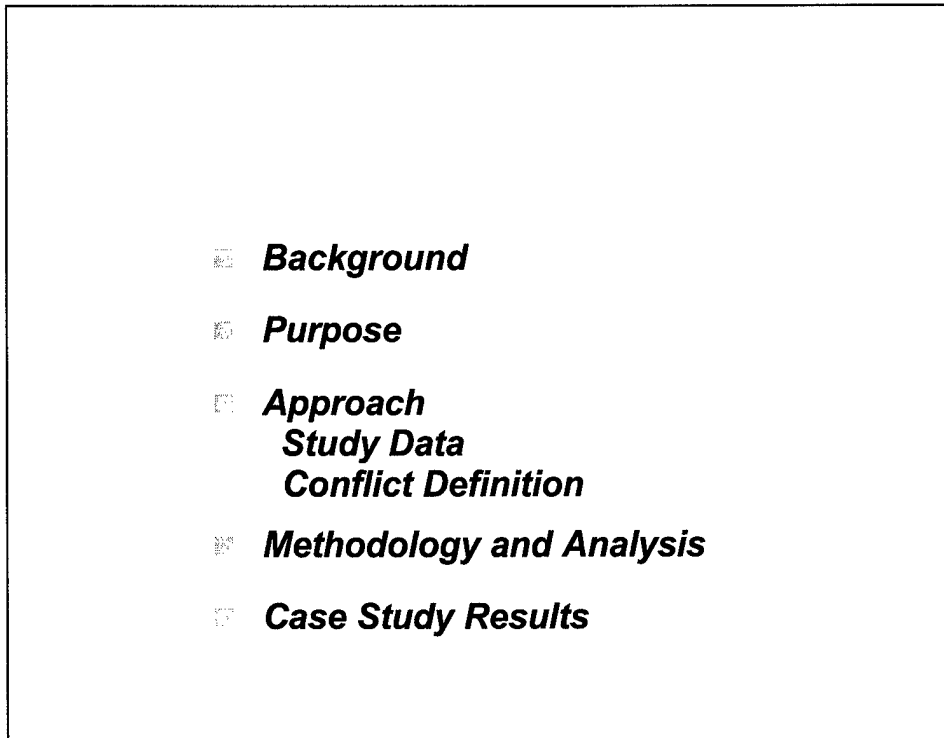
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# 1 INTRODUCTION

## 1.1 Outline



**Figure 1. Report Outline**

The Analysis of Complex Threats-Pacific (ACT-PAC) effort was sponsored by the Research and Analysis Division, Headquarters, US Commander in Chief, Pacific (HQ USCINCPAC). Figure 1 presents the outline for this report.

## 1.2 Background

- ***ODCSOPS War Plans Division asked CAA to develop and demonstrate a methodology to forecast likely foreign country and regional instabilities that could challenge US security interests and precipitate smaller-scale deployments by the Army (ACT Study).***
- ***USCINCPAC Director for Intelligence requested support from the Research & Analysis Division of J-8 to develop an analytical method for determining the location of future intelligence assets.***
- ***The USPACOM Research & Analysis Division investigated quantitative methodologies for forecasting intrastate instability in the Asia-Pacific region and explored key instability indicators for regional countries. The ACT methodology was one of several quantitative forecasting methodologies considered.***

**Figure 2. Background**

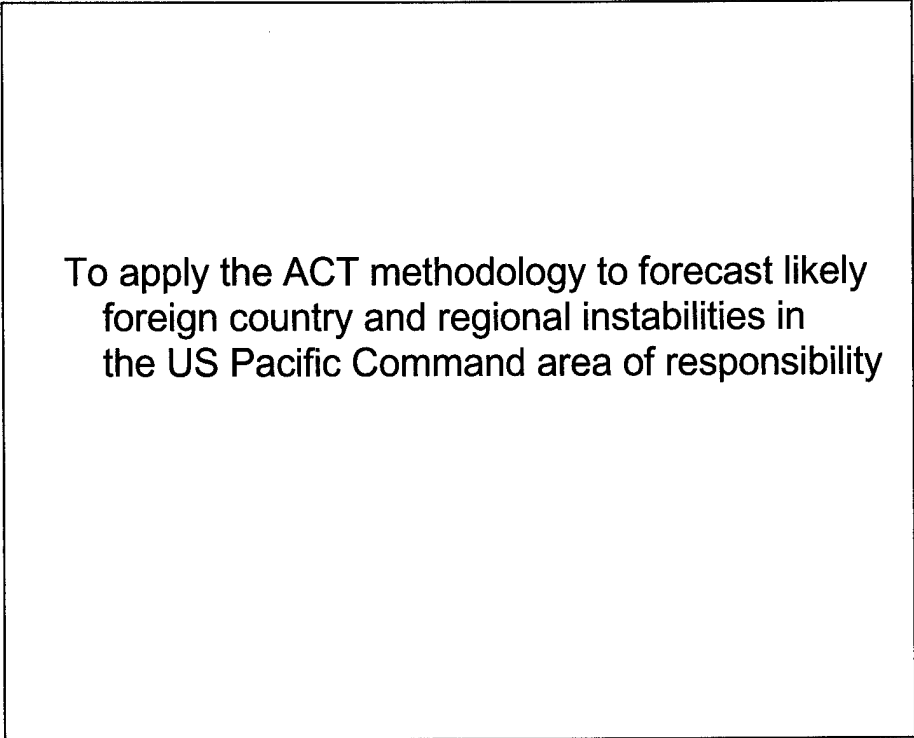
In November 1997, the Office of the Deputy Chief of Staff for Operations and Plans War Plans Division, asked the Center for Army Analysis (CAA) to develop and demonstrate a methodology to forecast likely foreign country and regional instabilities that could challenge US security interests and precipitate smaller-scale deployments by the Army. The War Plans Division wanted an analytically defensible approach for supporting the development and evaluation of long-range scenarios in which the Army may be deployed to defend and support US national security interests. The Analysis of Complex Threats (ACT) Study developed, demonstrated, and validated such a methodology. This methodology is documented in the ACT Study Report, CAA-SR-99-4.

The USCINCPAC Director for Intelligence (J-2) requested support from the Research and Analysis Division of J-8 to develop a method for determining where intelligence assets could be needed by forecasting where future crises are likely to occur. The PACOM Research and Analysis Division project objectives included investigating quantitative methodologies for forecasting intrastate instability in the Asia-Pacific region and exploring key instability indicators for regional countries. The ACT methodology was one of several quantitative forecasting methodologies considered. ACT used data mining techniques to explore and model the relationship between structural factors that may contribute to the stability (or instability) of a country and historical instances of country instability.

The ACT-PAC methodology and preliminary results were briefed to the sponsor and to methods and subject matter experts at the US Pacific Command Instability Analysis Methodology Workshop sponsored by the USPACOM Research and Analysis Division. The workshop was held on 25-27 May 1999 at the Center for Army Analysis.

ACT-PAC was also presented at the ninth Japan/US Operations Research Seminar (JUORS IX) in Tokyo 18-22 October 1999.

### **1.3 Purpose**



To apply the ACT methodology to forecast likely foreign country and regional instabilities in the US Pacific Command area of responsibility

**Figure 3. Purpose**

In March 1999, the US Pacific Command Research and Analysis Division asked the Center for Army Analysis to apply the ACT methodology to analyze country instability in the USPACOM area of responsibility (AOR) through 2010. The intent of this analysis was to provide USPACOM intelligence analysts with an analytically defensible approach to support determining the positioning of intelligence assets.

### 1.4 Approach

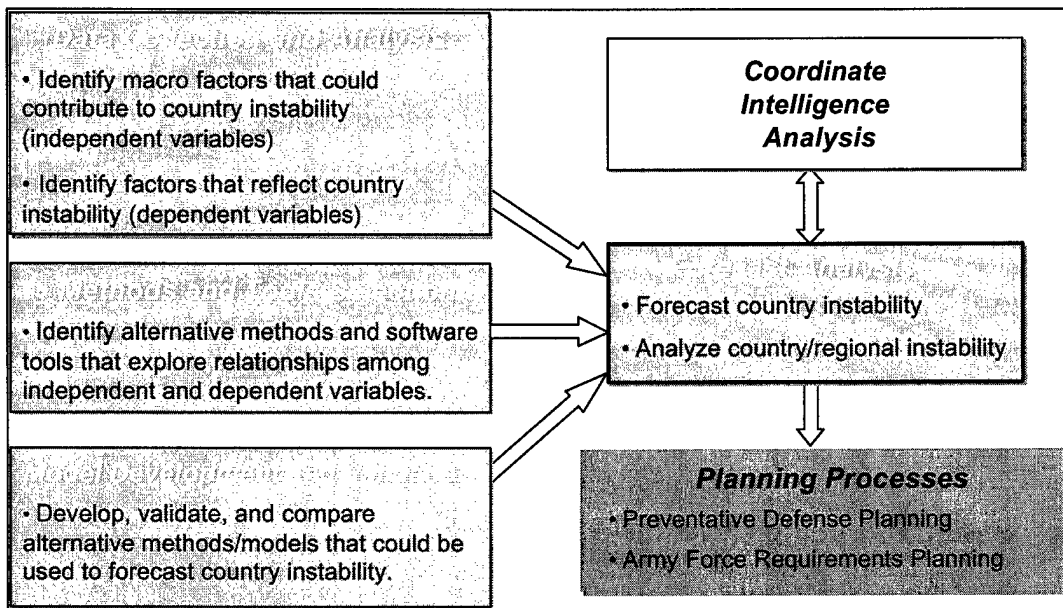
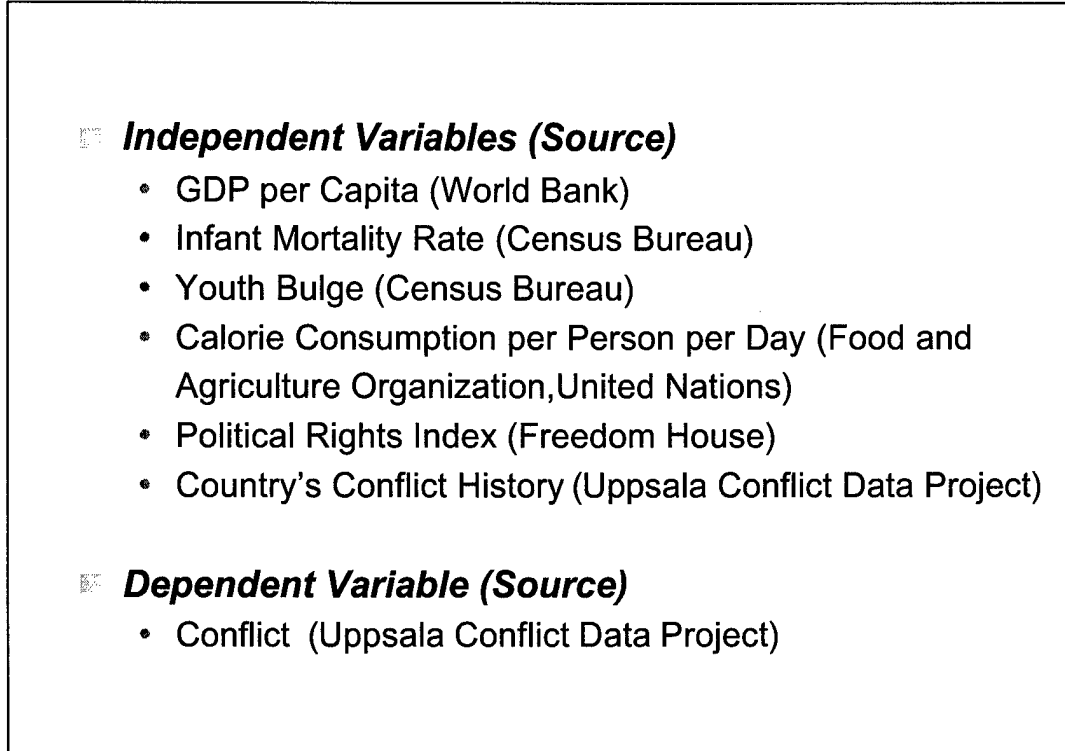


Figure 4. Approach

The ACT approach consists of five activities: data collection and analysis, methods and tools selection, model development and validation, forecast analysis, and coordinate intelligence analysis. These activities are being done to support preventative defense and US Army force requirements planning.

This project addressed the four activities appearing in the blue boxes. The purpose of the Coordinate Intelligence Analysis activity is to highlight the role of ACT as a support capability for strategic planning and intelligence requirement purposes. The results of ACT analytical models can be compared with intelligence analysts' insights to provide another perspective and serve as a screening tool for more in-depth analysis. The results of this combination of intelligence and analytical views provide a more balanced assessment for use in strategic planning processes.

### 1.4.1 Study Data



**Figure 5. Study Data**

ACT uses several of a country's internal structural factors--gross domestic product (GDP) per capita, infant mortality rate, political rights index, youth bulge, and daily calorie consumption per person that were identified in prior CAA studies. Criteria such as explainability and coverage were used to select these factors from the pool of potential indicators. Explainability refers to whether the data element is a meaningful indicator of country instability. Coverage is the extent that the data covers all the countries and years of interest. In addition to these factors, a *country's conflict history* (that is, the frequency of prior conflicts occurring in a country) and a *region's conflict history* (that is, the frequency of prior conflicts occurring in a region) were used as inputs in some of the models.

A dependent variable reflecting instability was needed to validate these factors as good indicators of country instability. Using criteria similar to those used for selection of the independent variables, conflict was selected as the factor to reflect instability.

#### **1.4.2 Conflict Definition**

“An armed conflict is a contested incompatibility which concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths.”

(Uppsala Conflict Data Project: States in Armed Conflict, Uppsala University, Sweden)

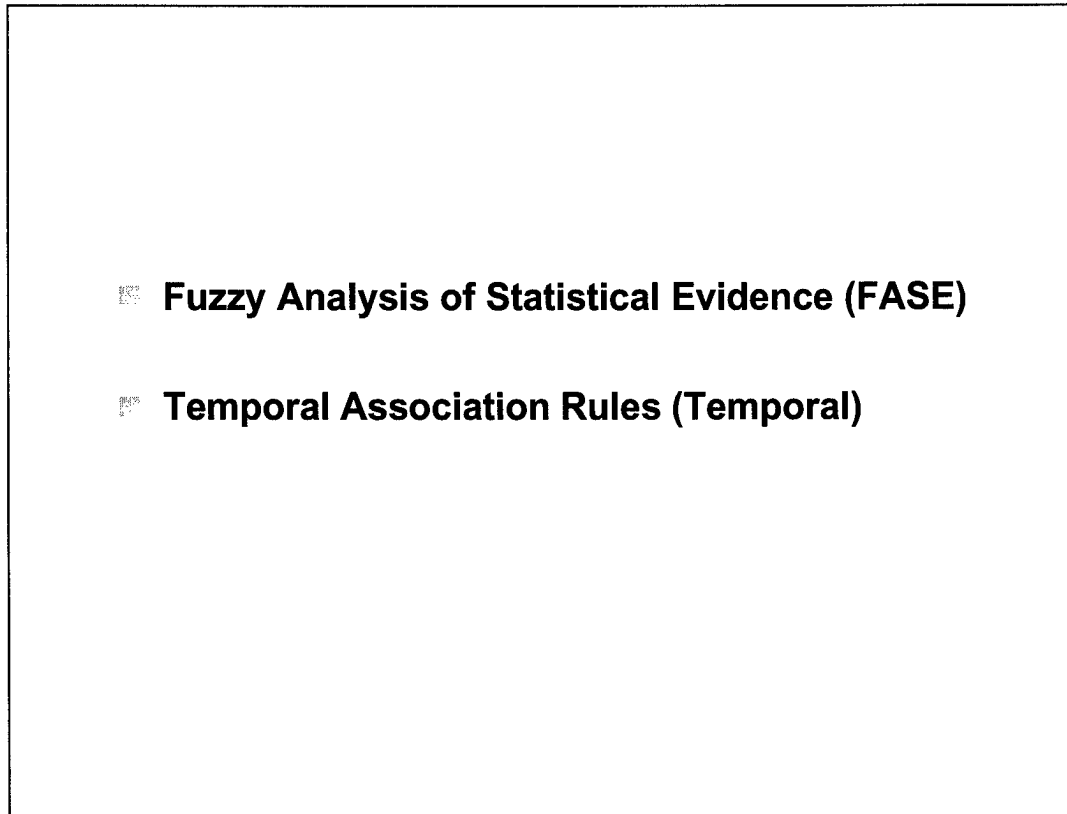
**Figure 6. Conflict Definition**

For purposes of the ACT and ACT-Pacific Studies, the definition of conflict was chosen from the Uppsala Conflict Data Project: States in Armed Conflict, Uppsala University, Sweden. It includes armed conflicts involving at least 25 battle-related deaths that occurred between 1989 and 1997.

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## 2 METHODOLOGY AND ANALYSIS

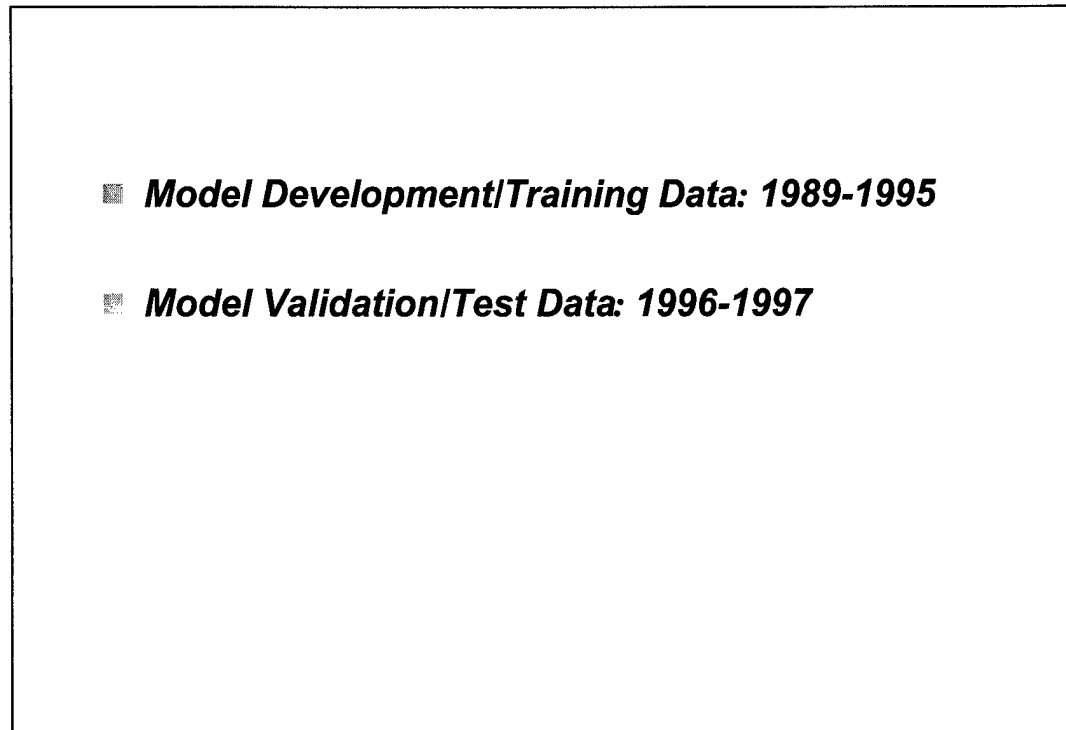
### 2.1 Methods



**Figure 7. Methods**

The ACT Study considered traditional machine learning/data mining and statistical methods to develop instability forecasting models. In addition, two new methods were developed as part of the ACT Study and explored for their ability in assessing country instability. One of the new methods, Temporal Association Rules (Temporal) extends traditional rule induction algorithms to take advantage of temporal data. The other new method, Fuzzy Analysis of Statistical Evidence (FASE), combines elements of statistics, possibility theory, and fuzzy logic. Both FASE and Temporal models performed well in the validation tests in the ACT Study. Therefore, they were used in the ACT-PAC project to explore the relationship between a country's internal structural factors (that is, the independent variables) and historical instances of armed conflict (the dependent variable).

## 2.2 Model Development and Validation



**Figure 8. Model Development and Validation**

To determine whether the methods were useful for forecasting and analyzing country instability, CAA developed and validated global, European Command, and Pacific Command models for making a 2-year forecast through fiscal year (FY) 2000. A split sample validation technique was used to evaluate the performance of each model. To do this, the data were divided into a model development or training segment (for the years 1989-95) and a validation or test segment (for the years 1996-97). Once each model was trained on the model development set, it provided predictions on the test set. Since the correct responses to the test set were known, each model's performance could then be evaluated.

**2.3 Model Performance Metrics**

<b>Overall Accuracy</b> = $\frac{\text{Correct predictions of both conflict and nonconflicts}}{\text{Total cases}}$
<b>Recall</b> = $\frac{\text{Number of correctly predicted conflicts}}{\text{Number of actual conflicts}}$
<b>Precision</b> = $\frac{\text{Number of correctly predicted conflicts}}{\text{Total predicted conflicts}}$

**Figure 9. Model Performance Metrics**

Three performance metrics were the principal criteria used to measure the performance of each model: accuracy, recall, and precision. Accuracy is the number of correct predictions/number of test samples, recall is the number of correctly predicted test sample occurrences of conflict/number of test sample occurrences of conflict, and precision is the number of correctly predicted test sample occurrences of conflict/number of predicted test sample occurrences of conflict. Recall and precision measure the effectiveness of the model to retrieve conflict occurrences.

## 2.4 Validation Test Results for Best USPACOM Models

<b>Validation Test Results for Best USPACOM Models (27 Countries)</b>						
<b>Two-year Validation Results</b>						
Method	# Variables	Overall Accuracy	Recall	Precision		
Temporal Association Rules	23	0.96	0.91	0.91		
Fuzzy Analysis of Statistical Evidence	6	0.93	0.85	0.85		
<b>FASE Model - 2- to 5-year Validation Results</b>						
Training Set Size	Training Set Years	Test Set Size	Test Set Years	Overall Accuracy	Recall	Precision
7 Years	89-95	2 Years	96-97	0.93	0.85	0.85
6 Years	89-94	3 Years	95-97	0.94	0.82	0.95
5 Years	89-93	4 Years	94-97	0.86	0.65	0.80
4 Years	89-92	5 Years	93-97	0.86	0.63	0.81

**Figure 10. Validation Test Results for Best USPACOM Models**

Temporal Association Rules and Fuzzy Analysis of Statistical Evidence models performed well in the validation tests for the European Command. Therefore, they were used in the Pacific Command forecast analysis.

Figure 10 shows the results of the 2- to 5-year validation tests for these models. Each of these methods obtained an overall accuracy in the 90 percent range and recall and precision in the 80 to 90 percent range. As expected, the accuracy has decreased from 0.93 to 0.86 as we made a longer term forecast from 2 years to 5 years.

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### 3 CASE STUDY RESULTS

#### 3.1 Forecast Analysis - USPACOM Case Study

##### ***Forecast Analysis - USPACOM Case Study***

###### **■ Purpose**

To demonstrate the ACT methodology by analyzing country instability for the USPACOM AOR

###### **■ Scope**

- Used the FASE and Temporal Association Rules methods
- 27 countries in the USPACOM AOR
- 1989-97 global data used to develop/train the model
- Forecasted to 2010 (end of calendar year)

**Figure 11. Forecast Analysis - USPACOM Case Study**

The purpose of the forecast analysis was to demonstrate the ACT methodology for 27 countries (see Table 1) in the US Pacific Command area of responsibility through the year 2010. We started with 31 countries, but removed North Korea, Bhutan, and Burma because of missing GDP per capita data and removed Singapore from the study set for missing calorie consumption data.

As stated earlier, only the FASE and the Temporal Association Rules models were used in the Pacific Command forecast as a result of their good performance during validation tests. Because the USPACOM study set was relatively small, global data for the years 1989 through 1997 were used to develop/train the USPACOM models.

**Table 1. Countries in USPACOM Considered in the ACT-PAC Analysis**

Australia	Japan	Pakistan
Bangladesh	South Korea	Papua New Guinea
Brunei	Laos	Philippines
Cambodia	Madagascar	Russia
China	Malaysia	Seychelles
Comoros	Mauritius	Sri Lanka
Fiji	Mongolia	Taiwan
India	Nepal	Thailand
Indonesia	New Zealand	Vietnam

### 3.2 Assumptions/Limitations

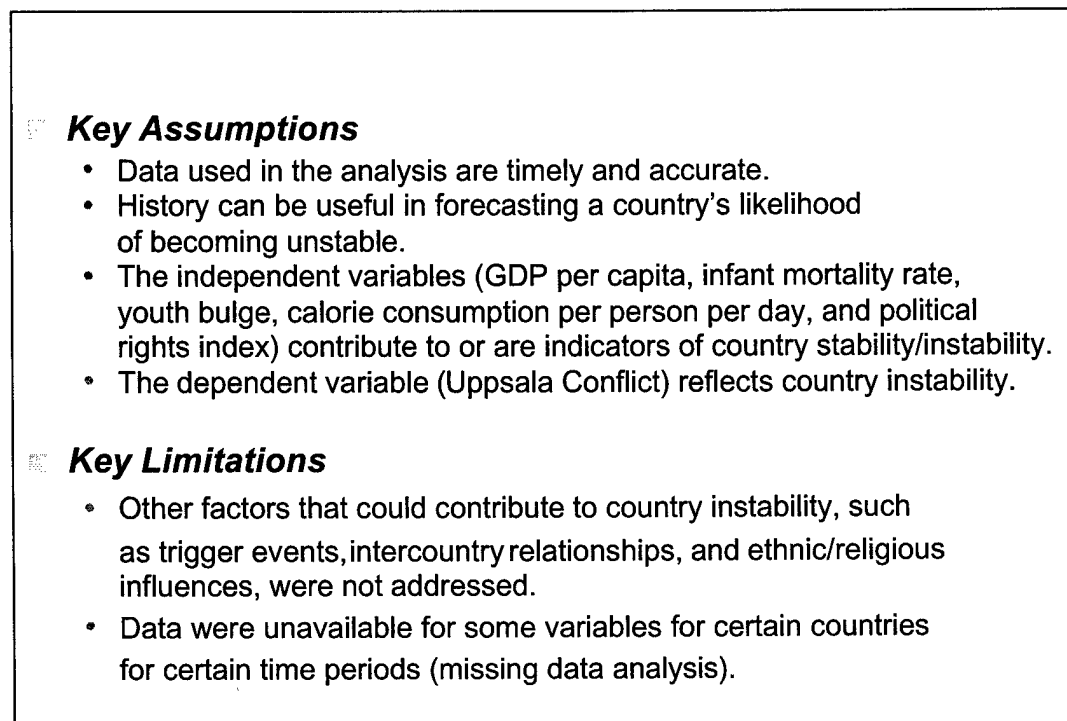
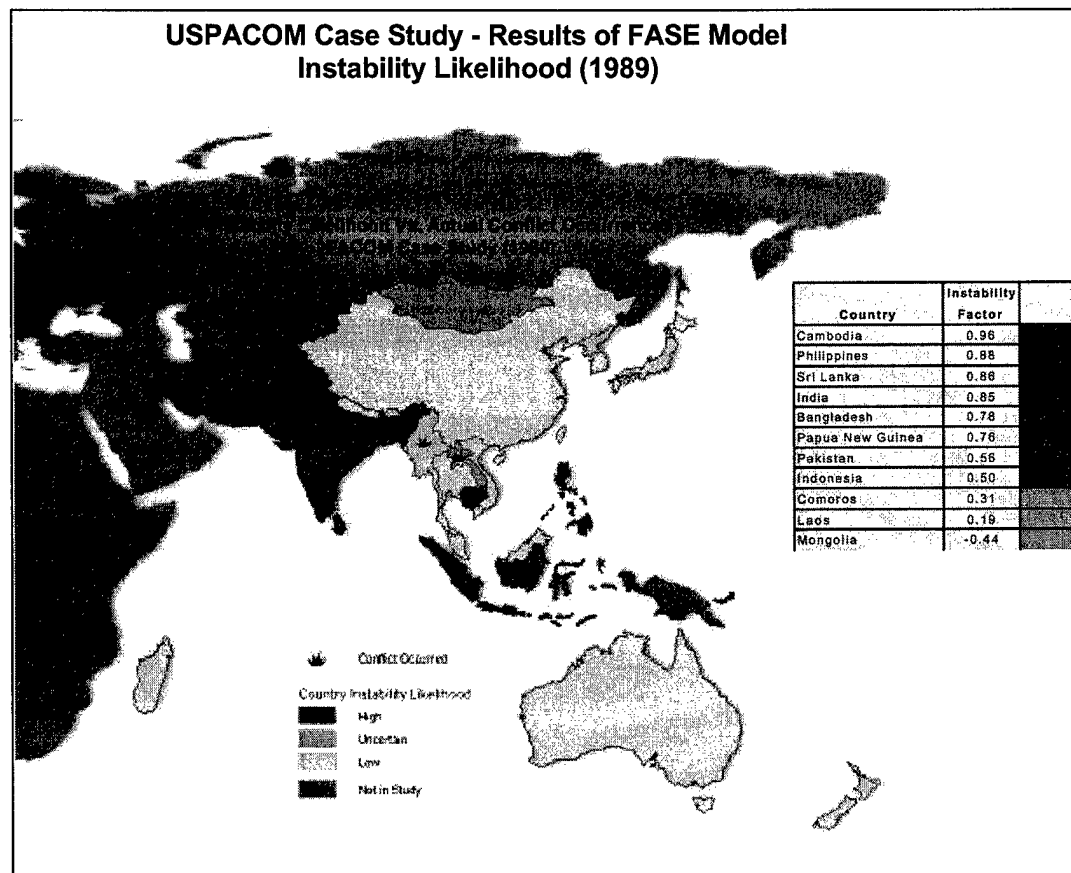
**Figure 12. Assumptions/Limitations**

Figure 12 outlines the key assumptions and limitations of the Pacific Command case study. It was recognized that ethnic and cultural influences are likely key instability indicators for the US Pacific Command and elsewhere; however, it was not possible to incorporate them in this analysis.

### 3.3 USPACOM Case Study FASE Model Instability Likelihood Results - 1989



**Figure 13. USPACOM Case Study FASE Model Instability Likelihood Results - 1989 (validation example)**

FASE forecasts for the years 2000, 2005, and 2010 are shown in Figures 14 through 16. Figure 13 shows the validation results for 1989.

The map areas colored red, orange, and gold represent each country's likelihood of conflict based on certainty factors developed using the FASE model. Red areas indicate countries that are at high risk for instability, with a certainty factor between .5 and 1. Countries in orange have a certainty factor between -.5 and .5. This indicates insufficient evidence or high uncertainty about the country's likelihood for instability. Countries in gold have a high likelihood for stability, with a certainty factor between -.5 and -1.

Validation results for year 1989 are shown in Figure 13, in which the explosion icon highlights a country where an actual conflict (as defined and recorded for the Uppsala Conflict Data Project) occurred. This demonstrates how well the model fits the data and how well it is likely to be able to forecast. In general, the red areas (countries predicted to be at high risk for instability)

coincide with actual occurrences of conflict. Countries where an actual conflict occurred that the model did not detect may reflect conflicts in countries that have good internal structural factors (that is, the country has a high GDP per capita) but may have problems due to ethnic/religious tensions. These instances highlight the need for ACT models to include other kinds of data, such as ethnic/religious data. The countries appearing in gray are the four countries removed from the study because of insufficient data. In Figures 14 through 16, the plus and minus signs in the legend indicate the increase or decrease in country instability from the previous year.

### 3.4 USPACOM Case Study FASE Model Instability Likelihood Results - 2000

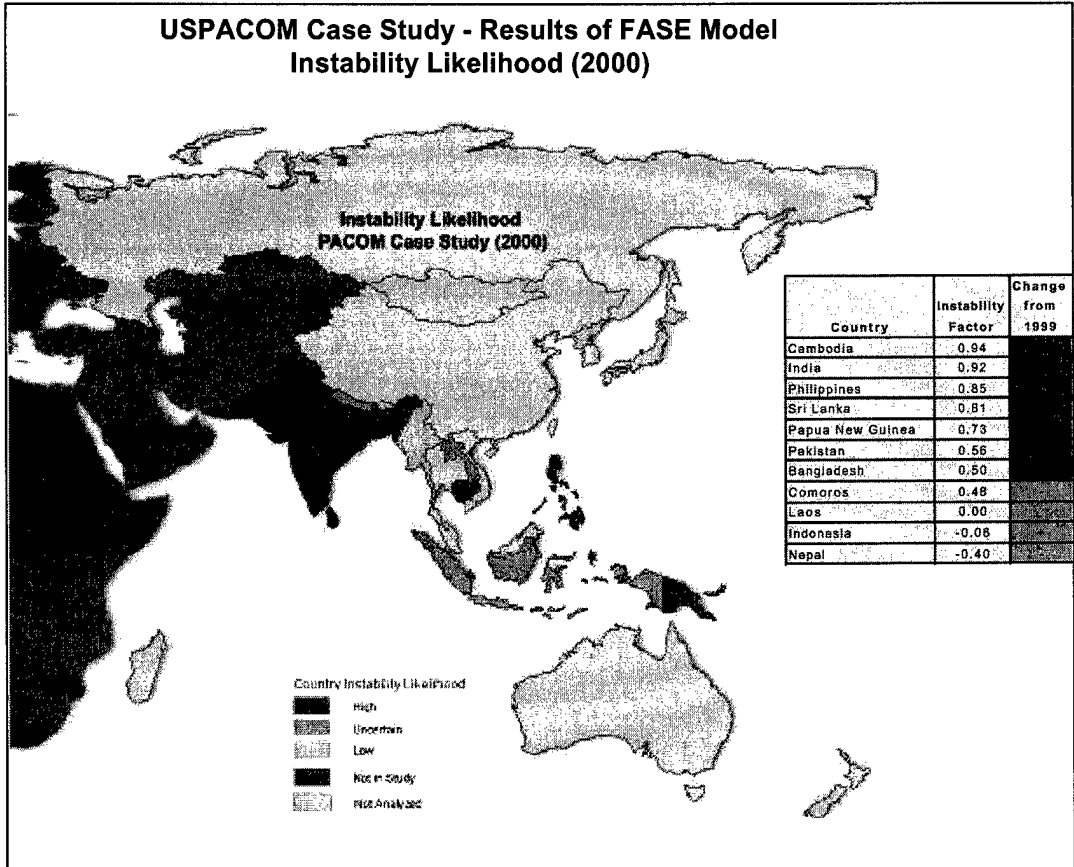


Figure 14. USPACOM Case Study FASE Model Instability Likelihood Results - 2000

### 3.5 USPACOM Case Study FASE Model Instability Likelihood Results - 2005

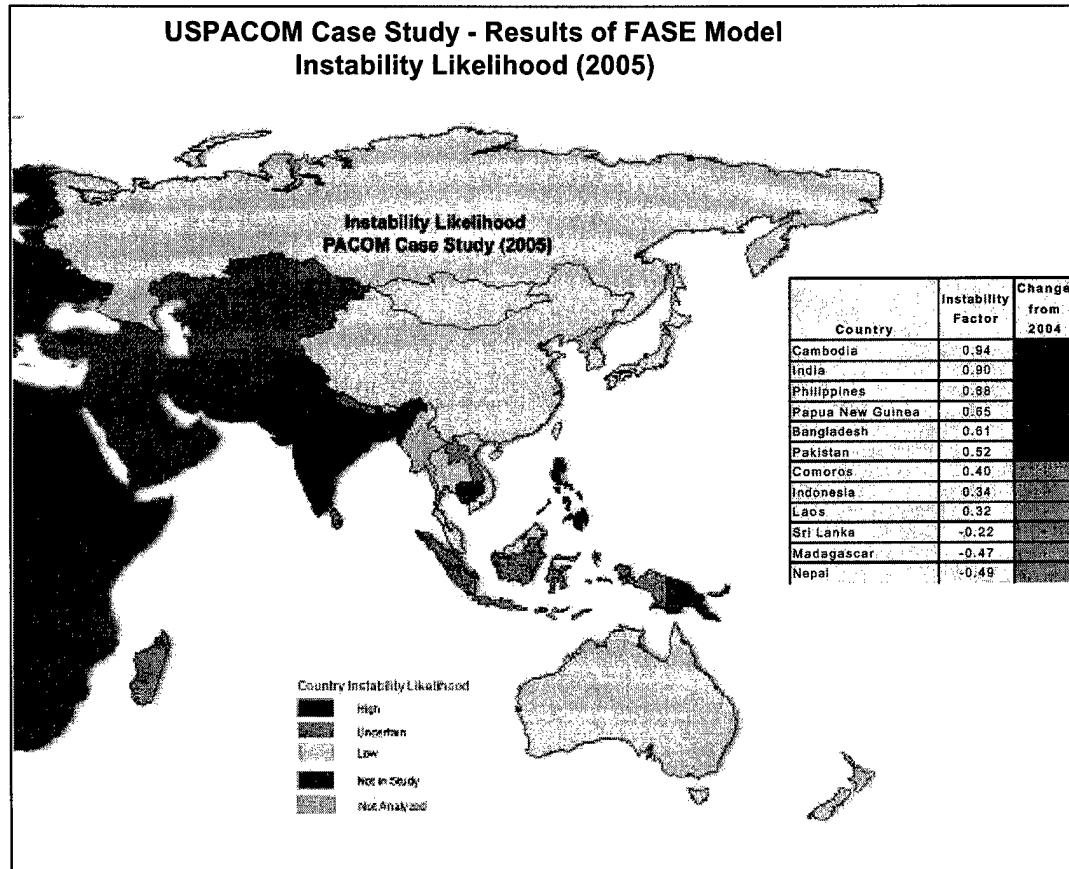
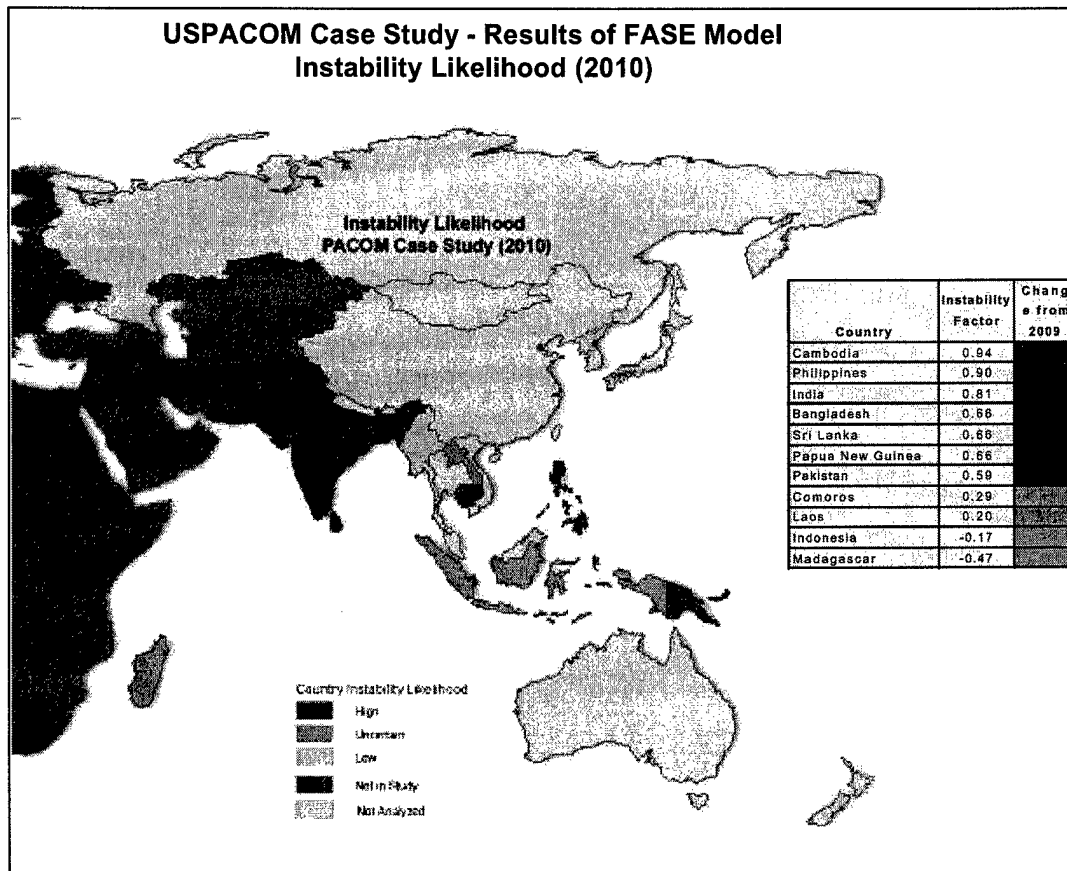


Figure 15. USPACOM Case Study FASE Model Instability Likelihood Results - 2005

**3.6 USPACOM Case Study FASE Model Instability Likelihood Results - 2010**



**Figure 16. USPACOM Case Study FASE Model Instability Likelihood Results - 2010**

### 3.7 USPACOM Case Study - Results of Temporal Model Instability Likelihood - 2000

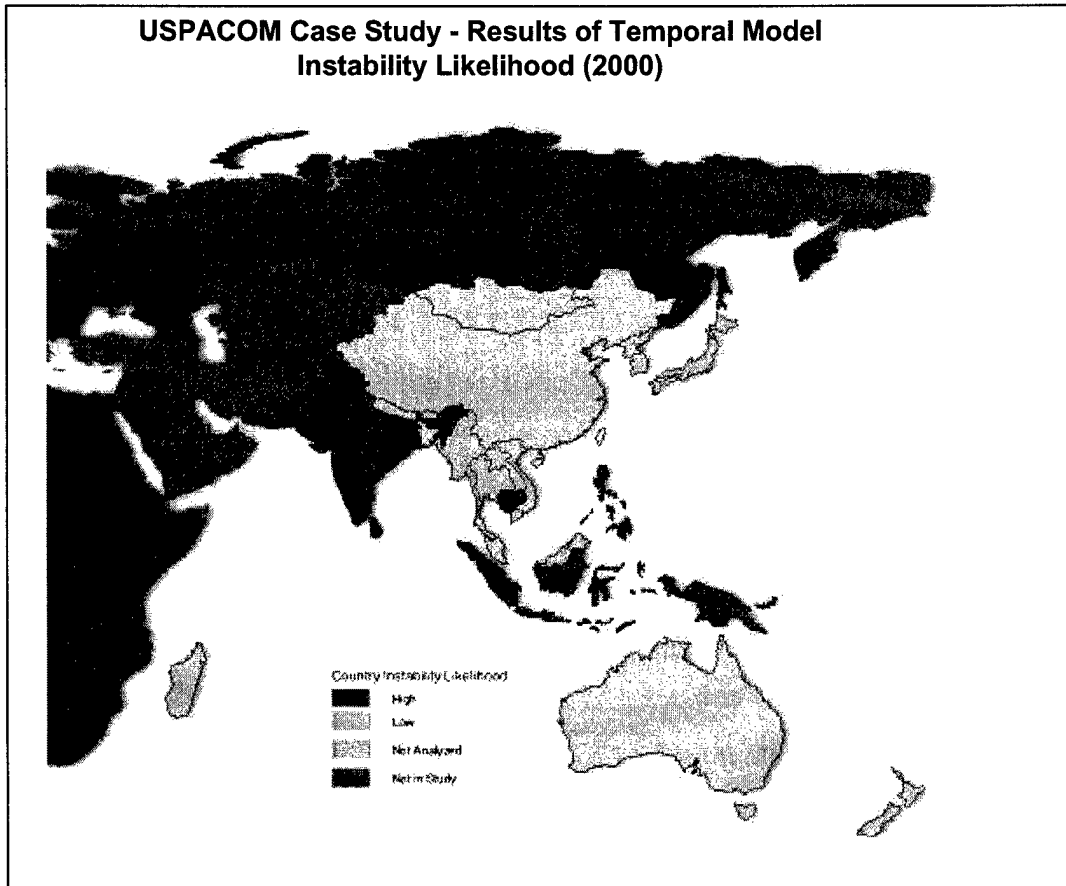
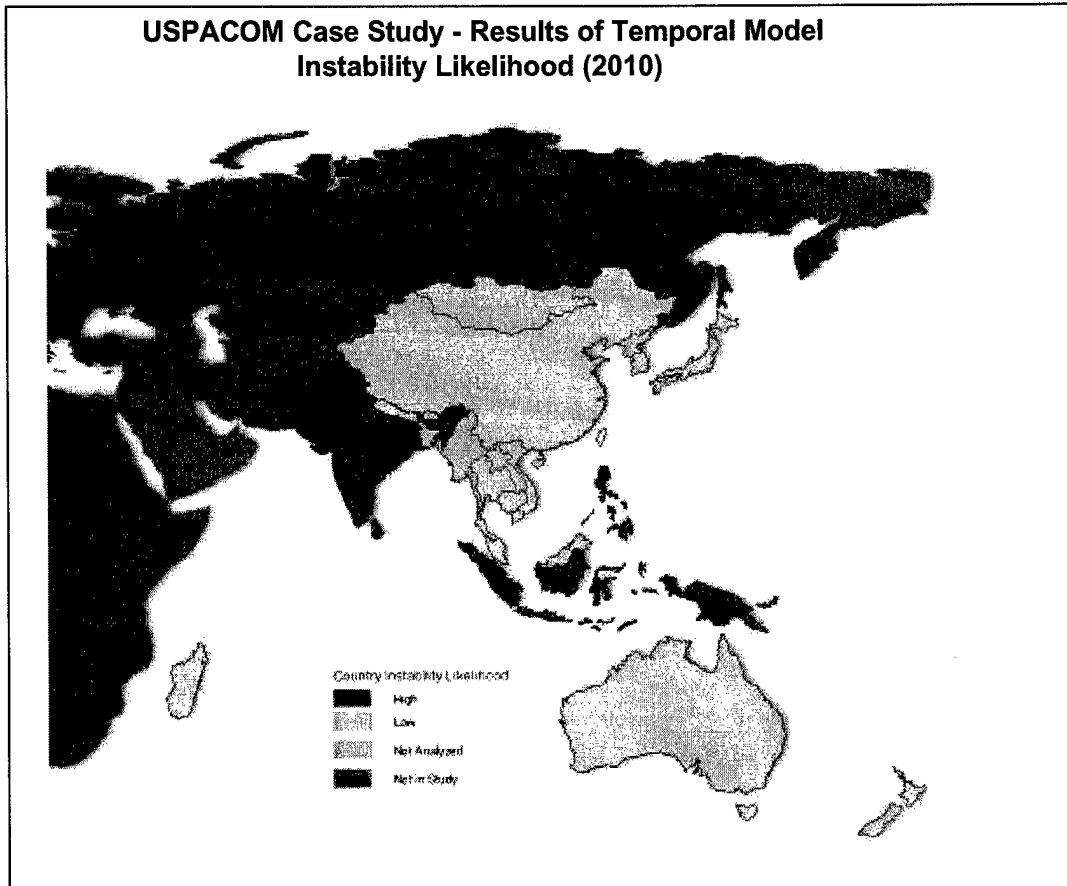


Figure 17. USPACOM Case Study - Results of Temporal Model Instability Likelihood - 2000

The results of the Temporal Association Rules model for years 2000 and 2010 are displayed on Figures 17 and 18. The Temporal Association Rules method classifies each country as belonging to one of two classes--the high likelihood of instability class shown in red or the low likelihood of instability class shown in gold.

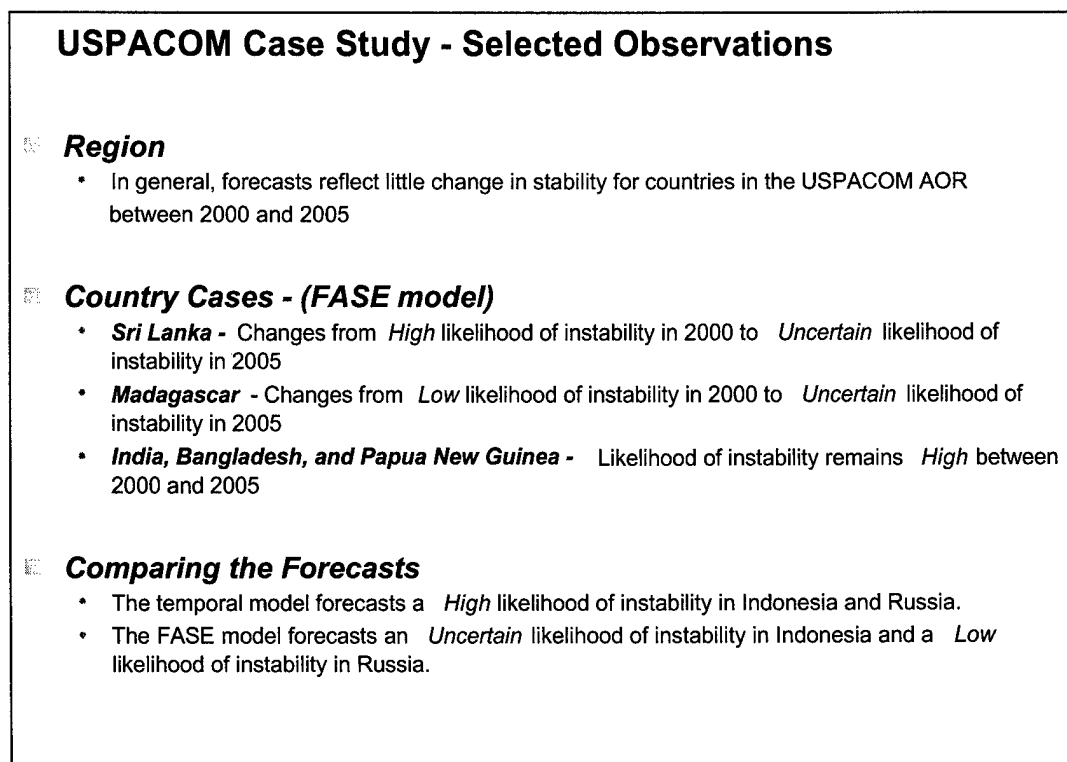
### 3.8 USPACOM Case Study - Results of Temporal Model Instability Likelihood - 2010



**Figure 18. USPACOM Case Study - Results of Temporal Model Instability Likelihood - 2010**

### 3.9 USPACOM Case Study - Selected Observations

We generated forecasts of instability for countries in the USPACOM AOR over the period 2000-2010. However, due to a lack of historical data, we could only validate a 5-year forecast (see Figure 10). Therefore, we only have measurable confidence in the forecasts we generated for USPACOM countries to 2005.



**Figure 19. USPACOM Case Study - Selected Observations**

The forecast results can be used for different kinds of analysis depending upon the content of the questions and issues to be examined. For example, what are the changes in the levels of stability for individual countries in a combatant command's area of responsibility over a time period of interest? Are the changes in stability gradual or sharp? Are there particular regions in the command's area of responsibility that require further and more detailed analysis?

Figure 20 illustrates selected observations derived from the USPACOM analysis. For example, in the case of *Sri Lanka*, there is a change from *High* likelihood of instability in 2000 to *Uncertain* likelihood of instability in 2005 due to a decrease in the infant mortality rate and youth bulge. In the case of *India*, the likelihood of instability remains *High* from 2000 through 2005 due to a high infant mortality rate and India's conflict history.

In general, the temporal and FASE forecasts are very close. However, there are some differences. For example, the temporal model forecasts a *High* likelihood of instability in Indonesia and Russia in 2000 and 2005, and the FASE model forecasts an *Uncertain* likelihood of instability in

Indonesia and a *Low* likelihood of instability in Russia in 2000 and 2005. One of the reasons for this difference in the results is that the Temporal model relies more heavily on a country's conflict history in making the forecast.

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## **APPENDIX A PROJECT CONTRIBUTORS**

### **1. PROJECT TEAM**

#### **a. Project Director**

Ms. Judy Bundy, Resource Analysis Division

#### **b. Team Members**

Dr. Yuan-Yuan Chen

Ms. Kumud Mathur

Mr. Mark Ricks

### **2. PRODUCT REVIEW**

Mr. Ronald J. Iekel, TQM Specialist

### **3. EXTERNAL CONTRIBUTOR**

Dr. George Karypis, Army High Performance Computing Research Center (AHPCRC),  
University of Minnesota

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## APPENDIX B REQUEST FOR ANALYTICAL SUPPORT

<b>P</b>	<b>Performing Division:</b> RA	<b>Account Number:</b> 99059
<b>A</b>	<b>Tasking:</b> Verbal	<b>Mode (Contract-Yes/No):</b> No
<b>R</b>	<b>Acronym:</b> ACT-PAC	
<b>T</b>	<b>Title:</b> Analysis of Complex Threats - Pacific	
<b>1</b>	<b>Start Date:</b> 29-Mar-99	<b>Estimated Completion Date:</b> 21-May-99
	<b>Requestor/Sponsor (i.e., DCSOPS):</b> PACOM	<b>Sponsor Division:</b>
	<b>Resource Estimates:</b>	<b>a. Estimated PSM:</b> 6 <b>b. Estimated Funds:</b> \$0.00
	<b>c. Models to be</b> FASE, CART, and others TBD.	
	<b>Description/Abstract:</b> Identify and analyze potential challenges to U.S. security interests in the PACOM area of responsibility (AOR).	
	<b>Study Director/POC Signature:</b> Original Signed	<b>Phone#:</b>
	<b>Study Director/POC:</b>	
	<b>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.</b>	
	<b>Background:</b>	
<b>P</b>	With the US military deploying more frequently in response to small-scale contingencies (SSC), there is a need to understand the conditions that precipitate conflict/state failure and the deployment of US Army forces. The application of analytical techniques coupled with assessments by intel analysts may provide information to the CINCPAC that is useful	
<b>A</b>	in developing theater engagement plans and preventive defense measures for shaping and influencing stability in the PACOM AOR.	
<b>R</b>	<b>Scope:</b>	
<b>T</b>	(1) Provide a forecast for countries in the PACOM AOR through 2010. (2) Provide additional macro analysis of countries as required by USCINCPAC.	
<b>2</b>	<b>Issues:</b>	
	1. Where is conflict/instability likely to occur in the PACOM AOR in 1999-2010?	
	2. Which macro conditions contribute to these forecasts for the selected countries?	
	3. PACOM will provide data/projections for the 2010 forecast. Additional discussion regarding data for the 2010 forecast and how the forecast will be performed is required.	
	<b>Milestones:</b>	
	4/30/99 2010 macro forecast for the PACOM AOR and make presentation to USPACOM staff.	
	5/21/99 Macro analysis of selected countries with National Ground Intelligence Center (NGIC) and make presentation to USPACOM staff.	
	6/18/99 Draft report. 7/16/99 Report publication.	
	<b>Signatures</b> <b>Division Chief Signature:</b> Original Signed and Dated	<b>Date:</b>
	<b>Division Chief Concurrence:</b> Mr. Steven Siegel	
	<b>Sponsor Signature:</b> Original Signed and Dated	<b>Date:</b>
	<b>Sponsor Concurrence (COL/DA Div Chief/GO/SES)</b> Dr. Lynda Jaques	

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