National Center for Border Security and Immigration

Work Plan – Year 2
March 9, 2009
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Introduction

Vision

As a consortium of premier universities that live and work on the border, The National Center for Border Security and Immigration (BSI) is committed to ensuring that government agencies and stakeholders have the necessary tools and information to better understand and proactively respond to border issues. Our singular focus will be to provide our sponsors with well-founded and scientifically-informed knowledge to expedite the development of innovative, practical, and cost-effective solutions to help satisfy the ever-changing demands of their operational environment.

Strategy

To respond to DHS identified interest areas, BSI will focus on seven major research areas:

- Detection: Humans, Vehicles and Decision Support
- Networks: Interoperability, Reliability and C³
- Fusion: Tools and Approaches
- Risk: Mitigation, Assessment and Alignment
- Population: Methods, Metrics and Estimates
- Immigration: Economics, Policies and Alternatives

In all these research areas, BSI will:

- Engage in both visionary and user-inspired research.
- Serve as a systems integrator between border security technologies, border management, and immigration policies to deliver innovative, practical solutions.
- Use lessons learned from social science, public policy analysis, institutional design, and management to help define publicly-acceptable approaches and speed their acceptance and implementation with consideration for privacy and civil liberties.
- Create a collaborative infrastructure and network-centric model to facilitate communication among partners, advisory boards, stakeholders, end users, and other interested parties.
- Create a "wiki-like" Internet portal that serves as single source for distribution and real-time web-based collaborative dialogues. This will offer multiple users access to topical information and techniques on border security, including data collection to facilitate future research.
Participants

Management Structure

The Director and PI is Dr. Jay F. Nunamaker, Jr., Regents and Soldwedel Professor of Management Information Systems (MIS), Computer Science, and Communication and director of the Center for the Management of Information (CMI). The Executive Director is Dr. Elyse Golob.

Partners

- Arizona State University
- Migration Policy Institute
- New Mexico State University
- Pennsylvania State University
- RAND Corporation
- RTI International
- San Diego State University
- University of Arizona – [RESEARCH LEAD]
- University of California – Irvine
- University of Minnesota
- University of New Mexico
- University of Texas – Pan American
- University of Washington
- West Virginia University
Research Overview

Introduction to Research Areas

The first four Research Areas address technologies for border security. Research Area 1: Detection looks at the identification, assessments and verification of humans and vehicles at border ports of entry. The set of projects focuses on detection deception – assessing whether an individual is being truthful or deceptive during the screening process. Various methods are used to access this including kinesics, vocalics and behavioral cues. Other projects examine various biometric technologies to confirm identity. Research Area 2: Networks looks at surveillance challenges between border ports of entry. The projects focus on the sensor platforms and communication networks that are used to detect activity in border region and distribute this information among agents. Major topics include sensor functioning in harsh border environments, alternate energy sources for sensors and C3. Research Area 3: Fusion addresses how to process all the data received from screening processes and sensor networks in a meaningful way to allow agents to make informed decisions. Challenges include resource allocation, contradictory data, etc. Research Area 4: Risk looks at methods of accessing potential breaches or dangers in the border environment, as well as the inherent risks involved in aligning new technologies with current or evolving policies.

Research Areas 5-7 address the economic and social dynamics of immigration policy. Research Area 5: Population explores the dynamics of illegal immigrants entering the United States, including origin countries, as well as subgroups of this population such as visa overstays. Research Area 6: Immigration examines the economic aspects of immigration policy, such as labor force supply and demand, the economic impacts of illegal immigration, and the costs of benefits of proposed immigration legislation. Project 7: Governance looks at the enforcement aspects of immigration, including 287(g) agreements and criminal networks. It also addresses policies to balance border security and the free flow of trade, as well as bi- and tri-lateral border cooperation and accords.

Technical Projects

Research Area 1: Detection: Humans, Vehicles, and Decision Support

- Lead: Jay Nunamaker, University of Arizona (jnunamaker@cmi.arizona.edu)

Project 1.1: Interviewing and Deception Detection Techniques for Rapid Screening and Credibility Assessment

- Jay Nunamaker, University of Arizona (jnunamaker@cmi.arizona.edu)
- Judee Burgoon, University of Arizona (jburgoon@cmi.arizona.edu)

Project 1.2: Field Study of Real-time Screening Decisions and Dissemination of Warnings and Alerts

- Jay Nunamaker, University of Arizona (jnunamaker@cmi.arizona.edu)
- Judee Burgoon, University of Arizona (jburgoon@cmi.arizona.edu)

Project 1.3: Avatar Kiosk for Rapid Screening and Credibility Assessment
- Jay Nunamaker, University of Arizona (jnunamaker@cmi.arizona.edu)
- Judee Burgoon, University of Arizona (jburgoon@cmi.arizona.edu)
- Mark Patton, University of Arizona (mpatton@email.arizona.edu)

Project 1.4: Biometric Measures for Human Identification
- Larry Hornak, West Virginia University (Lawrence.Hornak@mail.wvu.edu)
- Don Adjeroh, West Virginia University (daadjeroh@mail.wvu.edu)
- Bojan Cukic, West Virginia University (bojan.cukic@mail.wvu.edu)
- Arun Ross, West Virginia University (aaross@mail.wvu.edu)

Project 1.5: Human Identification from a Distance
- Larry Hornak, West Virginia University (Lawrence.Hornak@mail.wvu.edu)
- Don Adjeroh, West Virginia University (daadjeroh@mail.wvu.edu)
- Bojan Cukic, West Virginia University (bojan.cukic@mail.wvu.edu)
- Mridul Gautum, West Virginia University (mridul.gautam@mail.wvu.edu)
- Arun Ross, West Virginia University (aaross@mail.wvu.edu)

Project 1.6: High-Risk Vehicles Identification and Supply Chain Security
- Larry Head, University of Arizona (larry@sie.arizona.edu)

Project 1.7: Spatial-Temporal Patterns of Smuggling and Migration
- Douglas Stow, San Diego State University (stow@mail.sdsu.edu)

Research Area 2: Networks: Interoperability, Reliability, and C³
- Lead: Demoz Gebre-Egziabher, University of Minnesota (gebre@aem.umn.edu)

Project 2.2: Renewable Energy Sources for Sensor Nets
- Eric Johnson, New Mexico State University (ejohnson@nmsu.edu)
- Hong Huang, New Mexico State University (hhuang@nmsu.edu)

Project 2.3: Smart Border System for Localization and Tracking
- Demoz Gebre-Egziabher, University of Minnesota (gebre@aem.umn.edu)

Project 2.4: Fault Tolerant Sensor Networks for Border Activity Detection
- Bojan Cukic, West Virginia University (bojan.cukic@mail.wvu.edu)
- Arun Ross, West Virginia University (aarun.ross@mail.wvu.edu)
Project 2.5  Advanced Imaging Approaches for Detecting Obscured Objects
  ▪ Sumit Roy, University of Washington (roy@ee.washington.edu)
  ▪ Yasuo Kuga, University of Washington (kuga@ee.washington.edu)

Project 2.6:  Multi-Functional Autonomous Sensor Networks
  ▪ Nasser Peyghambarian, University of Arizona (nnp@u.arizona.edu)
  ▪ Axel Schülzgen, University of Arizona (axel@optics.arizona.edu)
  ▪ Robert Norwood, University of Arizona (rnorwood@optics.arizona.edu)
  ▪ Stanley Pau, University of Arizona (spau@optics.arizona.edu)

Research Area 3: Fusion: Tools and Approaches
  ▪ Lead: Daniel Zeng, University of Arizona (zeng@eller.arizona.edu)
  ▪ Project 3.2:  Fusion of Spatial-Temporal Sensor Data
    ▪ Daniel Zeng, University of Arizona (zeng@eller.arizona.edu)
    ▪ Hsinchun Chen, University of Arizona (hchen@eller.arizona.edu)
  ▪ Project 3.3:  Data Fusion for Decision Support
    ▪ David Hall, Pennsylvania State University (dlh28@psu.edu)
    ▪ Isaac Brewer, Pennsylvania State University (isaacbrewer@psu.edu)
  ▪ Project 3.4:  Dynamic Resource Allocation Using Market-based Methods
    ▪ Tracey Mullen, Pennsylvania State University (tam27@psu.edu)
    ▪ Isaac Brewer, Pennsylvania State University (isaacbrewer@psu.edu)
  ▪ Project 3.5:  Reduction of False Alarm Rates from Fused Data
    ▪ Huan Liu, Arizona State University (Huan.Liu@asu.edu)
    ▪ George Runger, Arizona State University (george.runger@asu.edu)
    ▪ Jeremy Rowe, Arizona State University (Jeremy.Rowe@asu.edu)

Research Area 4: Risk Assessment, Mitigation and Alignment
  ▪ Lead: Larry Head, University of Arizona (larry@sie.arizona.edu)
  ▪ Project 4.1:  Border Security Risk Assessment and Mitigation Decision Framework
    ▪ Larry Head, University of Arizona (larry@sie.arizona.edu)
    ▪ Ferenc Szidarovszky, University of Arizona (ferenc@email.arizona.edu)
    ▪ Jian Liu, University of Arizona (jliu@email.arizona.edu)
    ▪ Rick Van Schoik, Arizona State University (Douglas.Vanschoik@asu.edu)
Project 4.3: Border Security Readiness Assessment and Maturity Model
- Murray Jennex, San Diego State University (mjennex@mail.sdsu.edu)
- Eric Frost, San Diego State University (eric.frost@sdsu.edu)
- Robert Judge, San Diego State University (rjudge@mail.sdsu.edu)

Project 4.4: Prototype Border Security Risk Monitor
- Larry Head, University of Arizona (larry@sie.arizona.edu)
- Murray Jennex, San Diego State University (mjennex@mail.sdsu.edu)

Project 4.5: Adaptive, Risk-Informed Resource Allocation
- Henry Willis, RAND Corporation (hwillis@rand.org)
- Joel Predd, RAND Corporation (jpredd@rand.org)

Immigration Projects

Research Area 5: Population: Methods, Metrics and Estimates
- Lead: Frank D. Bean, University of California-Irvine (fbean@uci.edu)

Project 5.1: Improved Techniques for Estimating the Size of the Unauthorized Population
DELETED

Project 5.2: Estimates of Visa Overstay Population
- Frank D. Bean, University of California-Irvine (fbean@uci.edu)
- Jennifer Van Hook, Pennsylvania State University (jxv21@psu.edu)

Project 5.3: Determinants of Migrant Population Flows
- Christopher Timmons, Duke University (timmons@econ.duke.edu)
- Brooks Depro, RTI International (bmd@rti.org)

Research Area 6: Immigration: Economics, Policies, and Alternatives
- Lead: Judith Gans, University of Arizona (judygans@email.arizona.edu)

Project 6.1: Econometric Analysis of Immigrant Assimilation
- Christopher Timmons, Duke University (timmons@econ.duke.edu)
- Brooks Depro, RTI International (bmd@rti.org)

Project 6.2: Economic Impacts of Immigration Policy
- Judith Gans, University of Arizona (judygans@email.arizona.edu)

Project 6.3: Assessing Migrant Impacts on the U.S. Criminal Justice System
- Kevin J. Strom, RTI International (kstrom@rti.org)
- Pamela Lattimore, RTI International (lattimore@rti.org)
- John Hollywood, RTI International (jhollywood@rti.org)

Project 6.4: Immigration Enforcement Policies at the State Level
- Michael Fix, Migration Policy Institute (mfix@migrationpolicy.org)
- Doris Meissner, Migration Policy Institute (dmeissner@migrationpolicy.org)

Research Area 7: Governance: Law Enforcement and International Cooperation
- Lead: Jason Ackleson, New Mexico State University (jackleso@nmsu.edu)

Project 7.1: Optimizing Inter-agency Coordination
- Kevin J. Strom, RTI International (kstrom@rti.org)
- John Hollywood, RTI International (jhollywood@rti.org)

Project 7.2: Central American Gangs as a Proxy for Criminal Activity and Terrorism
- Charles M. Katz, Arizona State University (charles.katz@asu.edu)
- David Schaefer, Arizona State University (David.Schaefer@asu.edu)

Project 7.3: Local Law Enforcement Collaborations to Identify, Investigate, and Prosecute Criminal Aliens
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- Nancy Rodriguez, Arizona State University (nancy.rodriguez@asu.edu)

Project 7.4: Balancing International Trade and Border Security
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- Anna Ochoa O'Leary (olearya@email.arizona.edu)
- Elyse Golob, University of Arizona (egolob@email.arizona.edu)
- Rick Van Schoik, Arizona State University (Douglas.Vanschoik@asu.edu)
- Kevin O’Shea, National Law Center for Inter-American Free Trade (kjoshea@natlaw.com)
Research Project Details

Technical Project Details

Research Area 1: Detection: Humans, Vehicles, and Decision Support

In this research area, all the projects are tightly related and coupled to identify security risks as people and vehicles attempt to cross the northern and southern borders either through ports or wilderness crossings. Project 1.1 extends laboratory knowledge into field research for credibility assessment of rapid screening. Project 1.2 investigates how border agents make decisions in the field. Project 1.3 applies the cumulated knowledge to build an avatar kiosk for rapid screening. Project 1.4 improves the accuracy of fingerprinting, palm recognition, and iris recognition of persons passing through border entry ports. Project 1.5 identifies specific humans based on biometrics gathered from a distance. Project 1.6 identifies high-risk vehicles and solutions to secure national supply chain traffic. Project 1.7 elucidates spatial and temporal patterns of smuggling and illegal traffic across southern and northern borders.

End users:

- U.S. Immigration, Customs, Enforcement (e.g., field operations, intelligence specialists)
- U.S. Customs & Border Protection (e.g., field operations, intelligence specialists)
- DHS Counter Narcotics Enforcement
- Drug Enforcement Agency
- Federal Bureau of Investigation
- Central Intelligence Agency
- State Department
- State and Federal correctional administrators
- Local law enforcement agencies (e.g., command staff, gang units, human trafficking task forces, drug task forces)
Project 1.1: Interviewing and Deception Detection Techniques for Rapid Screening and Credibility Assessment

Investigators

- Jay Nunamaker, University of Arizona (jnunamaker@cmi.arizona.edu)
- Judee Burgoon, University of Arizona (jburgoon@cmi.arizona.edu)

Introduction

Our purpose is to investigate the effectiveness of interviewing tools and techniques in the field at border entry points to identify imposters, smugglers, terrorists, and other criminals and their associated behaviors. The goal is to identify video, audio and linguistic-based features that are reliable in detecting deception, impostership, and hostile intentions; identify physiological measures, e.g. heart rate, blood pressure, respiration, blink rate, thermal temperature changes, that indicate deception; and test the efficacy of laser Doppler vibrometer, thermal cameras, blink cameras, pupilometry and eye tracker for use in deception detection and credibility assessments.

The impact of this research is increased understanding of which cues/features/behaviors, in the kinesic, linguistic, physiological, and vocalic modalities, are reliable indicators of deception in a rapid screening environment and which are not; which screening interviewing techniques are effective or not; and to demonstrate the application of this knowledge to primary and secondary screening interviews, including in a field environment.

Benefits

- Experimental testing of deception detection technologies and techniques tailored to border screening environment
- Experimental findings tested in the field (Project 1.2) and used to inform and refine future research

Project Description

Previous work has identified several potentially discriminatory indicators of deception from laboratory experiments. In addition, several technological advances now provide researchers with access to additional indicators not previously investigated. This project validates those discriminators in a rapid screening environment, such as in border security settings.

We will conduct lab experiments and field studies exploring unobtrusive methods of behavior monitoring. These unobtrusive methods will include video-, audio-, and linguistic-based methods for credibility assessment. We will also test new deception detection technologies, not previously tested or that need field testing, such as thermal imaging, laser Doppler vibrometry, and layered voice analysis for use during rapid screening. All experiments and studies will involve highly motivated subjects (monetarily incentivized or facing legal proceedings). We will conduct lab experiments and field studies on the southern and northern U.S. borders to examine questioning techniques for information elicitation (e.g., behavior analysis interview, bait and alibi buster questions) A major contribution of this project is to replicate the knowledge discovered in laboratory experiments in a field environment and identify differences.
This research provides a foundation for future research by, testing new technologies that provide additional indicators not previously gatherable, identifying new key indicators of deception, and field testing current knowledge/technologies. Future research will be able to compare other deception indicators to this research, compare other deception detection devices to this research, and to resolve any new phenomenon discovered during this projects’ field investigation.

Methodology

- Experimentation
- Statistical Analysis
- Linguistic analysis
- Data Fusion
- Prototype Development
- Theory Development

Leverage

DACA funded a mock crime experiment and cultural benchmark experiment at the University of Arizona which provided investigation of thermal imaging, pupilometry, laser Doppler vibrometry in 20-30 minute interviews that may replace or augment polygraph testing. Our project will leverage the capital investments in experimental equipment and the lessons learned from conducting those experiments. In 2006, DHS funded an experiment at SUNY’s (DHS-FAST project) for use of thermal imaging in short interview/screening situations (3-5 minute interactions) using laboratory subjects. That experiment used 13 interview questions based on the Reid interrogation technique. Our project builds from these experiments by conducting field experiments with real subjects at the border; by expanding the cues set investigated testing (e.g. linguistics, LDV, blink, etc.); and by using different equipment to collect data. In general, verification of similar experiments, particularly verification in the field, is a good way to provide scientific validation. In addition to scientific peer-review, DJS-FAST will be provided information for periodic review.
Deliverables and Schedule (Project 1.1)

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<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
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<tr>
<td>A</td>
<td>Report analyzing lab experiments conducted with innovative credibility tools</td>
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<td>B</td>
<td>Report analyzing interviewing techniques for information elicitation in specific-issue and screening scenarios</td>
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<tr>
<td>C</td>
<td>Final report describing effective physiological and behavioral cue detection for rapid screening</td>
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<tr>
<td>D</td>
<td>Development of specific interviewing guidelines for screening with novel methods of deception detection</td>
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<tr>
<td>E</td>
<td>Context-specific (e.g., border crossings) guidelines for interviewing and unobtrusive detection methods</td>
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Completed Deliverables – Year 1 (June 2009)

- Analysis of Psycho-Physiological Datasets
  - Identify and process physiological datasets from deception experiments
- Lexical Analysis
  - Prepare transcriptions from deception experiment for analysis
- Collaborative Credibility Assessment Tools
  - Determine feasibility and requirements for collaboration tools for credibility assessment

Specific Deliverables – Year 2

- Analysis of Psycho-Physiological Datasets
  - Perform analysis on collected physiological datasets and determine which reliable cues for deception emerge
- Lexical Analysis
  - Transcribe deceptive interactions from experiment, refine linguistic deceptive cues, parse text from transcriptions and develop classification models for prediction deception
• Collaborative Credibility Assessment Tools
  o Create prototype(s)
Project 1.2: Field Studies of Real-time Screening Decisions and Dissemination of Warnings and Alerts

**Investigators**

- Jay Nunamaker, University of Arizona
- Judee Burgoon, University of Arizona

**Introduction**

The technologies developed as part of other COE projects must be examined and incorporated within the screening decision process and border constraints. We will understand border processes and enhance them with automated support. This project will investigate how border agents and other border-related law enforcement personnel make decisions during screening and test alternative mechanisms for delivering real-time alerts of suspicious activity involving vehicles and passengers. One goal is to assess the best practices in screening steps and identify the search patterns and decision processes that the most successful screeners utilize. The impact of this research is to disseminate best practices for screening and present them with effective real-time decision tools.

**Benefits to DHS**

- Ensures that research is in line with border constraints and processes
- Prototype tools will be developed to meet actual border security needs
- Improved border agent screening decisions and information sharing

**Project Description**

Prior work has focused on laboratory experimentation to identify cues and interviewing techniques. This work extends our understanding through field research on questioning techniques for rapid screening. We will conduct field studies investigating the screening steps border security personnel (both northern and southern borders) utilize in assessing individuals and vehicles. We will conduct an assessment of best practices in screening steps and identify the search patterns and decision processes that the most successful screeners utilize. These best practices will be leveraged in the development of a prototype to support novel screening capabilities introduced by the COE. This prototype will be specifically designed so that information alerts, and warnings can be effectively conveyed to screening personnel in real-time. We will conduct lab experiments examining the changes in information processing by security personnel and improvement in screening performance through use of the proposed prototype. Of primary concern will be the interplay between peripheral and central information processing during the screening process. We will conduct cognitive and human-system interface studies to ensure that our work augments rather than detracts from an agent’s attentiveness and decision-making ability. Care will be taken to avoid increases in workload and information processing steps.
Methodology

- Field studies at four border locations (two southern, two northern)
- Design science based on field studies (build and evaluate prototypes)

Leverage

- CMI Collaboration Research
- Defense Academy for Credibility Assessment funded laboratory experiments on interviewing techniques and assessing credibility
- Counter-Intelligence Field Activity funded laboratory experiments on interviewing techniques and assessing credibility
- National Science Foundation – CITeR funded laboratory experiments on interviewing techniques and assessing credibility
## Deliverables and Schedule (Project 1.2)

<table>
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<tr>
<td>A</td>
<td>Report on field study results examining current screening practices</td>
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<tr>
<td>B</td>
<td>Report describing best practices in screening</td>
<td></td>
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<tr>
<td>C</td>
<td>Report describing screening performance improvements through tool use</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Final report describing recommended cues for screening practices</td>
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### Completed Deliverables – Year 1 (June 2009)
- On-line literature review repository
- Structured interview protocol
- Decision process questionnaire
- Installed equipment at port-of-entry in Nogales, AZ
- Conducted northern border workshop in Seattle (February 2009)
- Conducted focus group with CBP, ICE, and FBI personnel using collaborative technology

### Specific Deliverables – Year 2
- Data collection gathered from field study locations
- Report of findings from field study in Nogales, AZ
- Report of findings from northern border field study
- Initial border constraint documentation
- Initial prototype designs
Project 1.3: Avatar Kiosk for Rapid Screening and Credibility Assessment

Introduction

We intend to implement a kiosk that can execute rapid screening for deception and intent in a field environment. This will be done by leveraging existing research streams in multiple disciplines as input for the research, design, evaluation, and iteratively refinement of the kiosk. To generate as much emotion in the screening subjects, we are using embodied avatars for question delivery, which research has shown individuals react too emotionally during interactions. The goal of this research is a kiosk that provides a useful level of discrimination in a field environment. Secondary goals include a platform for rapidly assessing the automated deployment of varying deception detection and biometric identification technologies, a modular framework for intelligent agent control of the kiosk, a database and fusion engines that can integrate real-time sensor data with multiple types of baseline information, and research into the effects of gender, ethnicity, and demeanor on the part of the interviewer on deception detection.

Investigators

- Mark Patton, University of Arizona
- Jay Nunamaker, University of Arizona
- Judee Burgoon, University of Arizona

Benefits to DHS

- Affordable high-volume rapid screening
- Reduction in human fatigue and overload
- Option for portable security checkpoints
- Consistent quality, controlling for interviewer confounds (demeanor, gender, race, language)
- Ability to deploy multi-lingual kiosks
- Potential to integrate complementary technologies (biometric identification, other sensors)

Project Description

We will develop a flexible kiosk platform which can be used to present avatars to subjects in rapid assessment scenarios and record the subject’s reactions and physiological characteristics using a variety of instruments. The kiosk will allow subjects to be assessed in a standing position, with or without a variable height counter top to stimulate and control arm placement and movement.

The kiosk will be equipped with robust and flexible computer and graphics technologies capable of supporting life like presentations, real-time intelligent agent processing and control, and real-time data capture and analysis. The kiosk will flexibly support the installation of audio, video, and other detection technologies to record the subject for either real-time or post-hoc analysis.
Multiple rounds of lab experiments will be conducted to evaluate avatar parameters, detection technologies, rapid assessment scenarios, subject personality characteristics, real-time agent based avatar control, and motivational factors. After each round of experimentation and data analysis, an evaluation of the technologies and designs will be made to identify open research questions. Refinements to the kiosk, avatar, and other technologies will be made to address open questions and identified improvements.

Assessment will focus on rapid assessment scenarios, but may include the use of biometric identification to evaluate rapid assessment of subjects with repeated baseline historical data versus rapid assessment of unknown individuals with no baseline data.

**Initial questions include:**

- Can we use a rapid assessment kiosk to quickly screen individuals for deceptive intent?
- What are the relevant parameters for the kiosk, avatar, and controlling agents?
- What combination of video, audio, detectable kinesic, detectable physiological and linguistic-based features are reliable in detecting deception, impostership, and hostile intentions in a standing kiosk environment?
- Are there any missing technologies necessary for an operational field setting?
- How effective is the kiosk under varying circumstances.

We will use iterative rounds of research-based design and experimentation, leveraging existing technologies and developing ones to create a flexible kiosk framework that works reliably in controlled settings and in the field.

**Leverage**

- All research based on existing academic research streams in human interact deception detection
- Kiosk utilizing DACA-developed embodied avatar
- CITeR grants utilized to fund the initial kiosk development and research
- Integration of existing research streams in remote biometric sensing and evaluation
## Deliverables and Schedule (Project 1.3)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1st Generation Kiosk</td>
<td></td>
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<tr>
<td>B</td>
<td>Preliminary study using DACA avatar to evaluate avatar perceptions, voice recognition, required Avatar capabilities</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Preliminary study evaluating subject standing positions, distances, kiosk counter position, sensor positions</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Preliminary study evaluating ability to implement deception technologies</td>
<td></td>
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<tr>
<td>E</td>
<td>2nd -generation kiosk</td>
<td></td>
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<tr>
<td>F</td>
<td>Phase I lab studies evaluating avatar parameters (realism, demeanor, gender, ethnicity, etc.)</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>Phase I lab studies evaluating deception technologies</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>Development of controlling intelligent agent</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Phase II lab studies evaluating intelligent agent control and real-time strategic interaction with subject</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>Phase II lab studies evaluating avatar parameters (realism, demeanor, gender, ethnicity, strategically selecting parameters based on subject)</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>Phase II lab studies evaluating deception technologies</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>3rd-generation kiosk - field quality kiosk, avatar, and intelligent agent</td>
<td></td>
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<tr>
<td>M</td>
<td>Field studies to determine field effectiveness and usage of deception detection technologies</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>Field studies to verify / calibrate kiosk, avatar, and controlling agent design and implementation</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>Final report and deliverables: Avatar design and implementation for effective rapid assessment; effective technologies for detecting physiological, behavioral, and verbal indicators of deception in the lab and in the field; appropriate kiosk design for rapid assessment; calibration of avatar, kiosk, and agent</td>
<td></td>
</tr>
</tbody>
</table>
Completed Deliverables – Year 1 (June 2009)

- First round of studies using first-generation kiosk optimized from pilot work
- Preliminary analysis of DACA avatar capabilities,
- Initial study of standing rapid assessment format
  - Standing positions
  - Distances
  - Kiosk counter position
- Initial study evaluating deception indicators in a standing rapid assessment environment
  - Kinesics
  - Vocalics
  - Proxemics

Specific Deliverables – Year 2

- Second round of studies using second-generation kiosk optimized from first generation and pilot work
- Research into the effects of baseline (individual versus group versus population) of detecting deception
- Ethnicity and gender studies
- Parameters for database that can support multiple types of baseline data
- Parameters for fusion engine that can integrate multiple types of real-time sensor and baseline data comparisons to deliver consistent evaluations
**Project 1.4: Biometric Measures for Human Identification**

**Investigators**

- Donald Adjeroh, West Virginia University
- Bojan Cukic, West Virginia University
- Larry Hornak, West Virginia University
- Arun Ross, West Virginia University

**Introduction**

This investigation aims at improving the accuracy of human identification by biometric measures of fingerprinting, multiple-finger fingerprinting, palm measurements, and iris recognition. The impact to border security will be the addition of validated biometrics to identify individuals on criminal or terrorist watch lists.

**Benefits to DHS**

- Increased knowledge of feasible biometric modalities.
- Enhanced biometric matching performance.

**Methodology**

- Lab and field experiments to study the *maturity, reliability, cost, performance, and feasibility* of new biometric modalities in the context of border security.

**Project Description**

Fingerprinting has been a proven biometric for decades. However, in a rapid screening environment acquiring a usable fingerprint is challenging, false positives are prevalent, and false negatives can have serious consequences. Adding additional biometrics to augment or replace older fingerprinting technology is needed. We will conduct lab experiments (and field tests, if possible) to examine the reliability and feasibility of new biometric measures (in addition to biometrics that are part of the US-VISIT program, which traditionally only requires printing the two index fingers). These new biometric features include iris, palm prints, face and voice recognition.

**Leverage**

The work will leverage our current work supported by DHS Human Factors and emphasize the noninvasive use of active sensor networks to acquire a multimodal set of features that together identify individuals with minimal inconvenience and disruption of border crossing flow.
### Deliverables and Schedule (Project 1.4)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Guidelines and procedures manual for field and lab data collection for innovative biometric methods</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>Report summarizing field and lab studies to examine innovative biometric methods</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>Report providing results and recommendations from innovative biometric methods study</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>White paper on biometrics storage and use</td>
<td>4</td>
</tr>
<tr>
<td>E</td>
<td>Final report on biometrics methods</td>
<td>1, 2, 3, 4, 5, 6</td>
</tr>
</tbody>
</table>

#### Completed Deliverables – Year 1 (June 2009)
- Analysis of existing performance studies
- Specified border application scenarios and their requirements
- Defined Year 2 lab experiments
- Defined Year 2 field experiments

#### Specific Deliverables – Year 2
- Guidelines and procedures manual for field and lab data collection for innovative biometric methods
- Report summarizing field and lab studies to examine innovative biometric methods
Project 1.5: Human Identification from a Distance

Investigators

- Donald Adjeroh, West Virginia University
- Bojan Cukic, West Virginia University
- Mridul Gautum, West Virginia University
- Larry Hornak, West Virginia University
- Arun Ross, West Virginia University

Introduction

Investigate the isolation of events in multimodal surveillance datasets (cameras, sensor networks, etc.) acquired at border zones in order to formulate a profile of human activity and identity. The goal is to identify individuals by constructing an evolving virtual identity profile based on the subject’s biometric features (e.g., face or gait), soft-biometric features (e.g., height, hair color, body dimensions) and transient features (e.g., color of clothing) obtained through different sensing modalities and platforms. From this research it is anticipated that DHS will be able to identify specific individuals from a distance rather than requiring close visual inspection.

Benefits to DHS

- Methods for human identification from surveillance videos

Methodology

- Develop a hierarchical approach to human recognition from a distance.
- Define event clustering in joint biometric – surveillance space.
- Search methods: from events to biometric profiles and vice versa.

Project Description

Previous work has worked to identify human faces under ideal conditions of a video exposure to a face straight, unmoving, close-up, and with many prior exposures. This research focuses on identifying humans at a distance where exposures may only contain a glancing profile or the gate of an individual. Event clustering in one biometric-surveillance space will be investigated to assist in the correlation of events detected across time and geographical locations. Our framework facilitates the following functionalities desirable in a smart surveillance system: (a) given the biometric profile of an individual or multiple individuals, the system will search through a database to retrieve events corresponding to profile(s); (b) given a sequence of frames depicting an event, the system will search through a database to retrieve biometric identities corresponding to this event. We will investigate how this identity-surveillance space enhances the capabilities of border detection grid systems by probabilistic characterization of events and identities and evidence fusion methodologies.

Leverage
The NSF has previously funded projects from these investigators for research into video technologies, facial detection in ideal laboratory conditions, video/image compression, and large image database searches, which are foundational requirements of implementing a system for identifying individuals from the scores of people that cross at entry ports or illegally through the wilderness.
Deliverables and Schedule (Project 1.5)

<table>
<thead>
<tr>
<th>Subtask</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>Report providing architecture of a joint identity-surveillance space</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Demo of efficient algorithms for object segmentation and labeling</td>
<td>X</td>
</tr>
<tr>
<td>C</td>
<td>Demo of fusion algorithms for human identification from a surveillance video</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Final Report on identity-surveillance space</td>
<td></td>
</tr>
</tbody>
</table>

Completed Deliverables – Year 1 (June 2009)

- Develop a hierarchical approach to human recognition from a distance
- Define event clustering in joint biometric – surveillance space
- Search methods: from events to biometric profiles and vice versa

Specific Deliverables – Year 2

- Report providing architecture of a joint identity-surveillance space
Project 1.6: High-Risk Vehicles Identification and Supply Chain Security

Investigators

- Larry Head, University of Arizona
- Jay Nunamaker, University of Arizona

Introduction

Develop models for identifying high-risk vehicles (land, water, air) and investigate methods to embed security features into the supply chain.

Project Description

We will conduct lab experiments, create simulations, and gather field data to develop predictive models for high-risk and low-risk vehicles. We will closely coordinate our research efforts with CBP to develop the most realistic screening conditions within which we will develop predictive models for testing in an actual screening environment. We will utilize Mutual Information Theory to better identify suspicious items and apportion screening resources. During these simulations, experiments and field studies we will examine the placement of screening resources at various stages in the supply chain – with an eye toward balancing the need for greater security against disruptions to commerce and trade.

Leverage

To be supplied.
## Deliverables and Schedule (Project 1.6)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>Report on simulations of vehicle screening</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>Report on cargo screening model</td>
<td>3</td>
</tr>
<tr>
<td>C</td>
<td>Report on lab testing of vehicle screening model</td>
<td>4</td>
</tr>
<tr>
<td>D</td>
<td>Report on field testing of vehicle screening model</td>
<td>5</td>
</tr>
<tr>
<td>E</td>
<td>Report analyzing placement of vehicle screening in border crossing flow</td>
<td>6</td>
</tr>
<tr>
<td>F</td>
<td>Final report</td>
<td></td>
</tr>
</tbody>
</table>

### Completed Deliverables – Year 1 (June 2009)

- None (begins Year 3, pending funding)

### Specific Deliverables – Year 2

- None (begins Year 3, pending funding)
**Project 1.7: Spatial-temporal Patterns of Smuggling and Migration**

**Investigators**

- Douglas Stow, San Diego State University

**Introduction**

The purpose of this project is to thoroughly understand the spatial-temporal patterns and drivers of smuggling and migration northward across the US-Mexico and US-Canadian borders and to thoroughly understand the transborder economic, social, and policy context of smuggling and migration. The goals are to assess the vulnerability to future smuggling and immigration across the US-Mexico and US-Canadian borders; determine the user and technical requirements for real-time change detection and monitoring of smuggling activities and infrastructure in the border zone based on high spatial resolution active and passive imaging sensors on piloted and autonomous aircraft; develop and transfer a real-time image-based change detection system that supports the remote monitoring objective stated immediately above; and present document and transfer tools and techniques to border law enforcement agencies through web-based media and communications. The research will impact decisions regarding allocations of border security resources, e.g. where, what and when.

**Benefits to DHS**

- Tools and technology assessments that will enable DHS and its line agencies to implement an operational remote monitoring program.
- US Border Patrol sectors enforcing land borders will receive geographic-specific information on physical terrain characteristics and smuggler interdiction history to better allocate and locate monitoring and enforcement resources.
- Remote sensing based change detection systems will enable spatially detailed yet comprehensive monitoring of smuggling infrastructure such as roads, trails, tunnels, and landing strips.

**Methodology**

- Develop/test remote image change detection and monitoring system,
- Analyze physical geographic landscapes of border zones in the context of smuggling potential and airborne monitoring, and
- Leverage BSI funding to conduct research and demonstration projects with industry and university partners.

**Project Description**

The proposed technical approach and research methodology will be closely linked to the research objectives. We will apply spatial data mining and analysis techniques to explore a large and growing database (Enforce) of several million records of immigrant/smuggler origins derived from cross-border interdictions on both the southern and northern borders. Building on this, we will develop robust, GIS-based models of cross-border vulnerability to smuggling and immigration and apply the model to the entire US-Mexico and US-Canadian border. A user
needs and technical requirements assessment will be conducted to aid in the development of a real-time system for monitoring of smuggling activities and infrastructure in the border zone based on high spatial resolution active and passive imaging sensors on piloted and autonomous aircraft. Related to this, we will develop and test semiautomated, object-based, real-time image change detection routines for mapping and monitoring of smugglers and smuggling infrastructure and vehicles. In order to facilitate three-way transfer of geo-spatial data sets between law enforcement officers in the border zone, piloted and autonomous aircraft, and border intelligence centers (BIC), we will integrate, test and implement wireless communication, global positioning system, data fusion, and personal computing technologies. For this component of the research, we will integrate our efforts and expertise with research on UAVs and real-time telemetry systems conducted by researchers at our partner universities (e.g., NMSU). To our knowledge, DHS is not currently funding a project similar to this one. This project builds a foundation for future research that can monitor changes in spatial-temporal patterns and how decision makers use this information to improve responses to security threats.

**Leverage**

The interdisciplinary project team at SDSU has been participating with the San Diego Sector of the US Border Patrol (USBP) on a NASA funded project titled “Spatial Decision Support System for Border Security” and this COE task will build on that effort.
### Deliverables and Schedule (Project 1.7)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Spatio-temporally varying predictive models of origin-destination associated with immigration and smuggling activities</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>B</td>
<td>Semi-automated, object-based, real-time image change detection system (primarily software)</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Semi-automated methods for spatial analysis of border interdiction data</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Web-based mapping services capable of integrating wireless communications, global positioning system, data fusion, and personal computing technologies for surveillance analyses</td>
<td></td>
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</tbody>
</table>

**Completed Deliverables – Year 1 (June 2009)**
- Collect data and report assessment of NGA US-wide border
- Generate image & compatible digital terrain data sets
- Report on tools for airborne image change detection

**Specific Deliverables – Year 2**
- Generate tool and report on object-based change detection
- Generate tool and report on window-based change detection
- Spatio-temporally varying predictive models of origin-destination associated with immigration and smuggling activities
Research Area 2: Networks: Interoperability, Reliability and C³

The projects contained in Research Area 2 cover a range of issues and challenges related to deploying sensors along the southern and northern borders. These projects address: renewable energy sources for sensor nets, improved ability for tracking people leaving and entering the U.S., improved network robustness and self-sustainability and advanced approaches for detecting obscured objects.

End Users:

- U.S. Immigration, Customs, Enforcement (e.g., field operations, intelligence specialists)
- U.S. Customs & Border Protection (e.g., field operations, intelligence specialists)
- DHS Counter Narcotics Enforcement
- Drug Enforcement Agency
- Federal Bureau of Investigation
- Central Intelligence Agency
- State Department
- State and Federal correctional administrators
- Local law enforcement agencies
Project 2.2: Renewable Energy Sources for Sensor Nets

Investigators
- Hong Huang, New Mexico State University
- Eric Johnson, New Mexico State University

Introduction
The lifetime of a sensor net is not a well understood concept. The effectiveness of a sensor net for target tracking depends not only on the number of sensors alive but also on the spatial and temporal distribution of sensor lifetime.

The goals of this project are to:
- Investigate methods to effectively utilize renewable energy sources suitable in the Southwest environments (solar energy in particular) in combination with battery sources
- Understand the relationship between the detection and tracking effectiveness of sensor nets and the lifecycles of individual sensors
- Understand how protocol behaviors at the application, routing, media access and physical layers of the network stack and the interactions between layers affect sensor net lifetime. The result is to develop cross-layer methods to maximize the effective lifetime of sensor nets.

Benefits to DHS
- Extended life-time technologies for sensor networks operating in the US Southwest border environments.

Project Description
We will identify the relationship between the detection and tracking effectiveness of a sensor net (probability of detection, tracking success rate, etc.) and the lifetimes of individual sensors. Complex interactions can occur among energy-conserving methods operating at different layers. We will seek to understand the cross-layer interactions and their implications for sensor net lifetime, and based on such understanding, will develop an integrated cross-layer suite to extend sensor net lifetime. Sensor nets are often battery powered. In Southwest border environments there are ample opportunities to use renewable energy sources, solar energy being the most obvious choice. In this project, we will demonstrate the feasibility of using solar cells to power sensor nodes, develop methods, suitable in the Southwest border environment, to utilize hybrid solar cell and battery energy sources to extend sensor net lifetime and quantify the energy saving benefits.

The difference with prior work is that we will investigate technologies for extended-life sensor nets that use hybrid battery and solar energy. This is expected to impact and interact with technologies that we previously developed to extend lifetime, especially the adaptive sleep technology. The technologies to be developed will take advantage of the unique weather
condition in the US Southwest, and will be optimized across all network layers. We are not aware of any similar projects that are currently being funded by DHS.

**Leverage**

This project leverages off the following projects funded by US government agencies: 1) A 2-year project (2006-2008) funded by Los Alamos National Laboratory to investigate low-power methods to collect data in sensor nets. 2) A 1-year project (2004) funded by Sandia National Laboratories to investigate target tracking in sensor nets. 3) An on-going project (2007-2012) funded by US Army to investigate secure sensor data dissemination and aggregation.
### Deliverables and Schedule (Project 2.2)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
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<tbody>
<tr>
<td>A</td>
<td>White paper describing mathematical and simulation models</td>
<td>1 2 4</td>
</tr>
<tr>
<td>B</td>
<td>Database of energy conservation methods</td>
<td>3 5</td>
</tr>
<tr>
<td>C</td>
<td>Report investigating effective utilization of solar cells and batteries</td>
<td>5 6</td>
</tr>
<tr>
<td>D</td>
<td>White paper describing results of cross-layer optimization studies</td>
<td>2</td>
</tr>
<tr>
<td>E</td>
<td>Final report on extended sensor nets in harsh environments</td>
<td>3 4</td>
</tr>
</tbody>
</table>

#### Completed Deliverables – Year 1 (June 2009)
- White paper on mathematical models relating sensor net effectiveness and lifetime

#### Specific Deliverables – Year 2
- Mathematical models relating sensor net effectiveness and lifetime
- Simulation results validating the developed mathematical models relating sensor net effectiveness and lifetime
Project 2.3: Smart Border System for Localization and Tracking

Investigator
- Demoz Gebre-Egziabher, University of Minnesota

Introduction

Robust, accurate and ubiquitous localization is an important element for border security initiatives in that it allows tracking and accounting for anything that enters the country via automobiles, trucks and trains. It is also an enabling technology for implementing novel concepts such as autonomous processing of vehicle ingress and egress at the borders (or “smart borders”). The goal of this project is to:

- Design, evaluate, and demonstrate systems and algorithms for robust (fault-tolerant), accurate and ubiquitous localization and tracking of vehicles, personnel and assets

The work will not only focus on developing new sensors, algorithms and approaches but also demonstrate how already existing and proven technologies can be adapted for this particular application.

Benefits to DHS

- Localization and tracking of cargo/assets, are enabling technologies for smart borders. This will allow commercial border operations efficient and secure.
- Being able to track each and every item from its point of origin, across the border and to its final destination can enhance safety and streamline inspection procedures at borders.

Project Description

The approach involves exploring the integration of traditional navigation sensors with other sensors and signals of opportunity using efficient and reliable sensor fusion algorithms. An indispensable ingredient for realizing ubiquitous and accurate localization and tracking systems will be efficient algorithms for navigation sensor fusion. What sets these algorithms apart from other sensor fusion algorithms is that they must be capable of running in real-time on processors with limited computational capabilities such as those found in hand-held devices (cell-phones) that would be used by border patrol agents. Thus, an important focus of this research will involve developing methodologies for implementing such algorithms in real time. This will include developing efficient FPGA-based navigation sensors which combine software and hardware into one entity (e.g., GPS software receivers) and sensor fusion (e.g., particle and Gaussian sum filtering) algorithms suitable for real time implementation.

Methodology

Our overall approach consists of the following three steps: First, we will identify the required performance for localization and tracking in border security applications. Second, we will identify candidate methods for sensing. Third, we will develop the algorithms and systems to integrate the various sensors for tracking and localization.

Leverage
- Using GPS Reflections for Proximity Sensing (AFOSR)
- Personnel Navigation Systems (Honeywell International)
- Networked GNSS navigation (Lockheed Martin)
- Open source Guidance Navigation and Control Sensor Suite for Small UAVs (Lockheed Martin)
Deliverables and Schedule (Project 2.3)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>White paper on methods for robust and accurate vehicle tracking</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>White paper on methods of robust and accurate asset tracking</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>Report on personnel navigation systems</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>Prototype/live demonstration</td>
<td>4</td>
</tr>
<tr>
<td>E</td>
<td>Manual of efficient navigation sensor-fusion algorithms</td>
<td>5</td>
</tr>
<tr>
<td>F</td>
<td>Final report on Robust, Accurate and Ubiquitous Localization and Tracking</td>
<td>6</td>
</tr>
</tbody>
</table>

Completed Deliverables – Year 1 (June 2009)

- Quantify the performance required by localization and tracking systems for various border security operations.
- Identify candidate sensing methods.

Specific Deliverables – Year 2

- Develop a computational framework for integrating the various sensors that will be used in localization and tracking.
- Vehicle localization & tracking methods
Project 2.4: Fault Tolerant Sensor Networks for Border Activity Detection

Investigators
- Bojan Cukic, West Virginia University
- Arun Ross, West Virginia University

Introduction
Distributed sensor networks are especially applicable to border environments due to the fact that the distributed sensors can cover a large space and by integrating the information obtained from all sensors, sufficient and precise information about the environment can be collected. Robustness and reliability are crucial parameters in the effective operation of distributed sensor networks. The goals of the project are to:

- Determine factors influencing the robustness and fault tolerance of sensor networks, specifically in the case of networks where the number of sensors is large
- Explore the applicability of new sensor fusion algorithms robust to sensor failure to new sensor platforms

Benefits to DHS
Develop methods that supplement wireless camera sensor networks with communication and analysis algorithms that succinctly interpret the data yielding intelligent surveillance.

Project Description
Distributed multi-sensor networks must be designed in order to ensure adequate performance is maintained through the occurrence of natural and unnatural faults. We developed a novel linear sensor fusion algorithm based on randomized voting which improves on the time bounds of the existing algorithms for sensor fusion where the number of sensors is large. We will explore the utilization, extension and adaptation of this sensor fusion algorithm for sensor networks characterized by many diverse sensors. We will also explore the viability of alternative sensor platforms for multi-sensor systems.

Traditional definitions of reliability in fault tolerant sensor network applications address (a) the incidence of outages in nodes (hardware issues), (b) the ability to incorporate a large number of sensors in a region (scalability), and (c) the need for ad-hoc sensor associations and communication protocols between sensor nodes (quality-of-service).

In this project, emphasis will be placed on the assessment of the network’s ability to acquire data from different sensing modalities deployed across multiple platforms and to succinctly interpret the ensuing information in order to analyze the intent of individuals and groups through the development of sophisticated identification and/or intent profiles. Thus, notions of reliability and robustness will depart from the traditional definitions and will be used to describe the success in delivering the aforementioned service to the users (stakeholders) of border surveillance systems. In addition to hardware and protocol issues, this service is characterized by the system’s ability to coordinate information capture across nodes while filtering out noise.
and performing intelligent fusion of sensed data that would enable the successful characterization (command, control) of border activities.

This project’s activities are intertwined with several other projects in the CoE BSI proposal, which are developing unique types of sensors and algorithms for identification of intent and identity. Its contributions, while having “stand-alone” research relevance, will be closely related to the outcomes of these related projects.

We have limited information regarding similar-sounding work currently funded by DHS. Generally, certain aspects of reliability and robustness analysis are likely to be included in any project dealing with the design and deployment of a distributed array of sensors. However, based on our survey of research literature, the design of sensor networks that support semi-to-fully automated analysis of human intent and identity from large geographic areas through unconstrained capture is relatively immature. This project attempts to fill this gap thereby advancing the state-of-the-art in border surveillance systems.

Methodology

We will use on-board scene analysis for reduced communication. Frames from cameras will be fused. Collaborative detection and human identification for improved coverage, robustness, and resilience will be employed.

Leverage

The research proposed here is leveraged through the following grants funded by US government agencies at West Virginia University and its partners:

- Ascertaining Identity within Human Networks in Night Environments, funded by the DoD - Office of Naval Research, PI: Hornak, Cukic, Ross, Schmid, Adjeroh, Li, 2008 – 2011, $681,000. The goals of the project include capture, analysis and evaluation of a broad range of electromagnetic bands suitable for night-time image acquisition, including visible light, near IR, extended near IR and thermal IR. The WVU team is developing algorithms for human detection and tracking from night-time imagery at ranges between 5 and 200 meters. Identification algorithms will include face and iris recognition, supplemented by so called soft biometric features. While not utilizing sensor networks, this project explores the acquisition of surveillance information in unconstrained (outdoors) night time conditions. The results from this project are directly related to the understanding, fusion and interpretation of complex surveillance information.

- ITR Collaborative Proposal: Biometrics – Performance, Security and Social Impact, funded by the National Science Foundation, PI: Hornak, Cukic, Ross, and colleagues at Clarkson University, Michigan State University, St. Lawrence University and the University of Pittsburgh, 2004-2009, $1,639,197. Among many activities involved in this project, in 2008 and 2009, we are investigating dynamic decisional fusion based on distance multibiometrics. This task requires the collection of surveillance video sequences using multiple cameras in stand-off scenarios. Video sequences will contain multiple human subjects and the goal is to develop real-time analysis methods to detect suspects in watch lists.
While human detection and identification aspects are similar to the proposed CoE BSI project, the scale of the acquisition systems (the number of sensors) is very limited (two or three cameras) and the movement of human subjects is highly constrained.

Center for Identification Technology Research (CITeR), funded by the National Science Foundation with sites at West Virginia University and University of Arizona. 2006 – 2001, $991,253. Center affiliates from the US Government include DHS, several NSA and DoD organizations, FAA, FBI and major US system integration companies (Lockheed Martin, Northrop Grumman, Computer Science Corporation, SAIC, etc.). CITeR is a National Science Foundation Industry University Cooperative Research Center. Its major research emphasis is on human identification and surveillance (WVU), and human credibility assessment (U Arizona). Several research projects address the design of surveillance networks and the real-time interpretation of information through fusion. Some recent projects are addressing the design of wireless multisensor networks for human identification. In one such project, Dr. Ross and collaborators at the University of Virginia are developing a low cost sensor network for face and human activity recognition.
Deliverables and Schedule (Project 2.4)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>White paper assessing opportunities for fault tolerant networks in multi-sensor networks</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>Manual of fault tolerant design methodologies and fusion algorithms</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>Report evaluating performance and reliability improvements</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>Demo proof of concept using multi-sensor demonstration system</td>
<td>4, 5, 6</td>
</tr>
<tr>
<td>E</td>
<td>Final report on Fault Tolerant Sensor Networks for Border Activity Detection</td>
<td></td>
</tr>
</tbody>
</table>

Completed Deliverables – Year 1 (June 2009)

- Laboratory set-up
- Face detection and tracking algorithms

Specific Deliverables – Year 2

- Initial fusion algorithms
- On-board processing
- Hand-off protocols on fault tolerant design methodologies and fusion algorithms
Project 2.5: Advanced Imaging Approaches for Detecting Obscured Objects

Investigators

- Sumit Roy, University of Washington
- Yasuo Kuga, University of Washington

Introduction

Reliable detection of humans and goods crossing any perimeter continues to be a largely unsolved problem. The reasons for this are multi-faceted, but mostly lie in the limitations of sensing modalities in complex, unknown environments. The lessons learned suggest that a collaborative networking architecture along with appropriate algorithms and decision mechanisms are essential to reliable detection for secure border security. Our investigations will focus on the use of electromagnetic (E-M) approaches for enhanced remote imaging in conjunction with an airborne cum-terrestrial support infrastructure.

This research seeks to develop novel approaches based on the synergy between E-M based imaging and network techniques, which are needed to solve the challenging problem of reliable detection in complex, unstructured environments. We will presume that a network of such airborne and terrestrial sensors is present to enable tomographic reconstruction. We first undertake a system-level study to assess the impact of network topology (node location and orientation) and the characteristics of the modality of the E-M interaction with the target of interest. This will lead to advanced imaging approaches to objects obscured by rough surfaces and random media, and effective signal design and communication techniques. Finally, the design of suitable source and channel coding approaches along with its implication for multiple access protocols will be investigated to complete the overall system design.

We propose to use existing communication methods for the detection. The current passive radar technique has limited spatial resolution and does not meet specification requirements for border security applications. Our research will be aimed at solving this problem and giving DHS the ability to identify objects obscured by terrain, walls, or other physical entities.

Benefits to DHS

- Provide reliable, persistent methods to detect, track, and image occluded targets-of-interest crossing a perimeter in a realistic environment

Project Description

Detection and imaging of objects hidden behind obscuring media is depicted in Fig. 6. Recent advances consist of broadband signals (short pulses) emitted by a focused square array of transmitters and the received pulses are processed to obtain the image of the object in space and time. Theoretically, this requires the study of pulse wave scattering and propagation in random media, and the development of the generalized two-frequency mutual coherence function. While initial studies are promising, we have not fully explored the degrees of freedom available in the design of UltraWideBand (UWB) waveforms nor have we investigated two-frequency rough surface mutual coherence functions.
The imaging radars have been used extensively for the detection of airborne targets such as missiles and aircrafts. During the past several decades, the extensive research has been performed to detect targets embedded in clutter such as ground cover and trees. It is still a challenge to detect small, non-metallic TOIs such as human and goods crossing borders. A new detection technique is needed to obtain an accurate image of small targets in clutter.

![Image: Time-reversal techniques applied to communications and imaging in complex environments](image)

Figure 6: Time-reversal techniques applied to communications and imaging in complex environments

Recently, we have also investigated optimizing the communications waveform design based on the eigenvector-eigenvalue formulations similar to that used in time-reversal imaging. The method consists of measurement of the transfer matrix, forming the time-reversal transfer matrix, calculating eigenvectors and eigenvalues and using the eigenvector of largest eigenvalue for transmitter excitations as shown in Figure 7 below. An important application of time-reversal technique is its potential for producing “super resolution”. However the impact of target movement and intervening random media remains to be investigated.

Our investigations need to be expanded into the study of broad-band, coherence length, coherence time, objects with different sizes and shapes, conducting and dielectric materials, and polarimetry for rough surfaces, terrain, voids, cavities, and wave guide geometries. The creation of realistic images of targets of interest camouflaged by clutter and/or obscuring objects is essential for testing the sensor systems and training operators. Images obtained at different spectrums can be substantially different, and a unified method to model the interaction of sensor wavelength and physical structure is needed. We will use a physics-based EM scattering model which includes rough surface scattering effects and volume scattering at different wavelengths.

Unlike the tradition radar detection method, we will use several new approaches including the correlation methods to suppress signals from clutter, time-reversal imaging, and array coherence imaging. Our objects are to create high resolution radar images using the diversity method which includes signal processing, array antennas, multiple-frequency, and polarization. We also
intend to combine the diversity method with passive radar detection technique. We are not aware of any similar projects currently funded by DHS.

We have no access to specific literature or RF systems in operation for the northern border, that is known to be unprotected for several stretches. Clearly, the types of advanced electronic surveillance/imaging techniques proposed here will be an important component of any border security apparatus.

We are proposing comprehensive studies of detection of targets in clutter environment. This has important applications not only for border security but also for IED (improvised explosive devices) detection and homeland security in general. While the proposed work seeks to refine techniques developed at UW over many years of research, we believe that these are ready to transition to practical systems. DHS funding will be a key enabler for such technology transfer. A good benchmark would be to field test our methods on data made available from any DHS database.

**Methodology**

We will develop new model-based signal processing techniques based on random scattering. We will design new transmit waveforms for multi-static configurations for enhanced detection. We will develop methods for distributed network coding and detection.

**Leverage**

- Imaging and communication in complex clutter environment (Sponsor: ONR)
- Detection and modeling of IEDs camouflaged by obscuring layers (Sponsor: ONR)
- Wireless communications and detection through obscuring environments (Sponsor: NSF)
- Waveform Diversity of Networked Radars (Sponsor - AFOSR) [pending]
### Deliverables and Schedule (Project 2.5)

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<tr>
<td>A</td>
<td>White paper on Imaging Using UWB: Waveform Design</td>
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<tr>
<td>B</td>
<td>White paper on Imaging Using UWB: Impact of 2-D random scattering</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Demonstration of Imaging Using UWB</td>
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<tr>
<td>D</td>
<td>Technical report on Imaging Using UWB: Full system Level Study</td>
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<tr>
<td>E</td>
<td>Demo of Time Reversal Communications: Impact of Target Motion on Super Resolution</td>
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<tr>
<td>F</td>
<td>Final report on Time Reversal Communications: Impact of intervening media</td>
<td></td>
</tr>
</tbody>
</table>

### Completed Deliverables – Year 1 (June 2009)
- White paper on developing new model-based signal processing approaches
- Site visit to University of Washington labs by DHS S&T personnel

### Specific Deliverables – Year 2
- Hand-off protocols on Imaging Using UWB: Waveform Design and Impact of 2-D random scattering
- Demonstration of Imaging Using UWB
Project 2.6: Multi-Functional Autonomous Sensor Networks

Investigators

- Nasser Peyghambarian, University of Arizona
- Axel Schülzgen, University of Arizona
- Robert Norwood, University of Arizona
- Stanley Pau, University of Arizona

Introduction

The US has approximately 2,067 miles of border with Mexico, 5,526 miles of border with Canada and approximately 12,380 miles of coastline. As of April 30, 2005, the total number of Border Patrol agents along the Northern and Southern Borders was 10,664, with approximately 1,031 at the Northern Border and 9,633 at the Southern Border. It is impossible to have direct human surveillance of the perimeter at all times under all conditions with existing infrastructure and personnel. A secure border necessitates the development of new technology for remote sensing and surveillance. The objective of our project to set-up and investigate sensor arrays using a combination of ground, water and subsurface autonomous sensor nodes.

We will develop wireless sensor network technologies consisting of spatially distributed self-sustainable sensor nodes that can monitor locally various environmental parameters including motion, vibrations, temperature, humidity, and pressure and to take images at multiple locations over long time periods with minimal human intervention and maintenance. We will leverage our extensive experience in sensor components and systems to integrate multiple sensors, microcontrollers, energy sources and a radio transceiver into each node. We will evaluate the communication requirements for each node, i.e. bandwidth, power-distance coverage tradeoffs and the scalability of the sensor network, including cost and compatibility with existing wireless system.

Benefits to DHS

- A state-of-the-art wireless sensor network that applies forefront networking technologies to the best available sensors, all within the framework of a low power consumption physical plant that relies on photovoltaics.

Project Description

Sensor networking has been an area of research interest for some time. The majority of existing networks use either electrical or optical fiber cables to connect the sensor to the data network, and generally require dedicated power supplies.

We propose to build a multi-functional sensor network based on self-sustainable sensor nodes using commercially available components. We will utilize expertise in the areas of sensor components, solar energy, communications networks, and data aggregation to build a highly reliable network on a platform that is flexible enough to integrate various existing sensor technologies: motion sensors, vibration sensors, temperature sensors and imaging arrays into autonomous sensor nodes with wireless communications. The sensor network will initially be a
benchtop laboratory demonstration that will use a diversity of off-the-shelf sensors. As the program progresses we will increase the size and move toward demonstrations in outside environments. The network will be located initially in the University of Arizona College of Optical Sciences.

Energy consumption for sensing and data communication will be minimized and combined with photovoltaics to approach the ultimate goal of rendering external power supplies at the sensing nodes unnecessary. We will apply principles known from optical communications networking to increase the networks reliability and robustness against intended (intruders) as well as unintended (accident/breakdown) single point failures and to reduce the complexity of data from the multitude of sensors leading to relaxed requirement in communications bandwidth. We will test sensor nodes, wireless network and data aggregation moving from a laboratory setting to Southwest desert environments with emphasis on tracking, border security, and intrusion applications. The sensor array will be optimized for functionality, reliability and interoperability while maintaining low component costs and scalability to cover large areas. The current TRL level is between 4 and 5.

While sensor networking has been a research area for some time, the concept of combining low power consumption wireless sensors, photovoltaics and state-of-the-art communications network technology has not been previously put forward. We have considerable expertise in access data networks, as evidenced by the recent founding of an NSF Engineering Research Center at the University of Arizona in integrated access networks. We will apply our considerable knowledge of networks to integrate commercially available components in a wireless network that will take advantage of advanced data aggregation techniques and predominantly photovoltaic power supplies. We are not aware of any similar work that is being funded by DHS at this time.

This technology addresses a large range of sensor technologies and networking strategies to be implemented at the Canadian and Mexican border. This project will create a new paradigm in sensor networking technology that will create opportunities for these networks to be used in situations and locations that were previously inaccessible. In particular, the network will be able to be rapidly deployed with minimal existing infrastructure, which will allow its use along many remote border points of interest.

**Methodology**

We will combine low power consumption sensors, photovoltaics, and state-of-the-art communication network technology for detection of chemicals relevant to DHS and measurement of intrusion. We will develop sensor network platform and technologies. We will develop scalable manufacturing processes, focusing on large area deployment.

**Leverage**

The task will leverage substantially off of our recent $18.5M grant from the NSF to form a Center for Integrated Access Networks. We have numerous other grants and contracts that are related, but this is the most significant.
### Deliverables and Schedule (Project 2.6)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
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<tr>
<td>A</td>
<td>Build low-energy consumption multi-sensor network</td>
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<tr>
<td>B</td>
<td>Report on self-sustainable sensor array development</td>
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</tr>
<tr>
<td>C</td>
<td>Report on sensor data accumulation and aggregation</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Implementation of on demand sensing functions into network</td>
<td></td>
</tr>
</tbody>
</table>

**Completed Deliverables – Year 1 (June 2009)**

- White paper on building a low-energy consumption multi-sensor network

**Specific Deliverables – Year 2**

- Hand-off protocols on self-sustainable sensor array development
Research Area 3: Fusion: Tools and Approaches

All of the projects in Research Area 3 are closely related and add to the overarching theme of successful data fusion, effective decision support, and appropriate resource allocation. Project 3.2 deals with fusing data from disparate sensors over space and time while project 3.5 works to reduce the false-alarm rate of the sensor data. After the data has been fused, project 3.3 integrates the information into a model-driven, data-oriented decision support system that enables DHS decision makers and provides a Common Operating Picture. Project 3.4 looks at real-time information demands from users and implements market-based models to aid in appropriate and dynamic resource allocation.

End-users:

- U.S. Immigration, Customs, Enforcement (e.g., field operations, intelligence specialists)
- U.S. Customs & Border Protection (e.g., field operations, intelligence specialists)
- DHS Counter Narcotics Enforcement
- Drug Enforcement Agency
- Federal Bureau of Investigation
- Central Intelligence Agency
- State Department
- State and Federal correctional administrators
- Local law enforcement
Project 3.2: Fusion of Spatial-Temporal Sensor Data

Investigators
- Daniel Zeng; University of Arizona
- Hsinchun Chen, University of Arizona

Introduction
With large sensor networks in use at ports of entry and along the large stretches of border, massive amounts of data must be evaluated to identify immediate concerns. In homeland security applications, raw data may be contradictory or inconclusive, and proper data fusion is necessary to provide clear situational awareness. The numerous types of data including video, biometric, and acoustic data compound this problem. If large sensor networks and other data-gathering devices are to fulfill their potential as a significant force multiplier, proper evaluation, synthesis, and summarization of data are crucial. Raw data generated by different types of sensors may be contradictory and inconclusive. Therefore, proper data fusion that can operate in real-time dynamic environments is necessary to support situational awareness and decision-making. Intelligent fusion of sensor data will have specific impact on DHS by helping provide a complete picture to aid in operations.

The primary objectives of this project include:
- Develop novel spatial-temporal data analytical techniques to identify and summarize patterns from dynamic and noisy data generated by sensor networks
- Evaluate different formalisms and computational techniques for representing and reasoning about uncertainties in data of different granularity and modality.

Benefits to DHS
- Providing a spatial-temporal data analysis and fusion framework for situational awareness and actionable intelligence
- Providing noise-tolerant data representation and evidence-based fusion techniques for data with different resolutions and modalities
- Enabling additional operational opportunities when the processed capabilities are in place

Project Description
In many data streams generated by sensor networks, observations are made at various locations both in space and in time. Analyzing data with such prominent spatial and temporal components and developing related predictive models are of great practical importance. Frequently occurring questions include:
- How to identify areas and time periods having exceptionally high or low measures such as vehicle movement?
How to determine whether the unusual measures can be attributed to known random variations or are statistically significant?

How to identify any statistically significant changes in the timely manner in geographic areas?

How to analyze multiple spatial-temporal data streams to identify correlations among them for further investigation?

The proposed work addresses the unique challenges arising from the application of integration of data from various sensors with different resolutions and signal/noise ratios. In particular, the proposed techniques are different from existing methods in the following regards: (a) Our methods are designed to be prospective methods that can handle continuous data streams and detect unusual patterns from these streams in real time or near real time. (b) Our methods explicitly consider the uncertain nature of the data sources and develop a unified representational framework to process such data. (c) Our methods will explore an expanded set of spatial-temporal data analysis tasks (e.g., regress and cross correlation analysis) which have not been explored in existing work. We will experiment with a selected set of formal methods including Bayesian networks and granular computing to represent uncertainties prevalent in border security-related datasets. We will identify an efficient computational representational framework and related techniques that can support a wide range of datasets to facilitate data fusion and provide evidence-based integrated reasoning capabilities. This research will (a) develop novel prospective spatial-temporal data clustering methods based on support vector machines, (b) construct theory-based measures of spatial-temporal correlation and develop inference and computational methods, and (c) test the data integration methods as a reusable software library.

Spatial and temporal data play a critical role in many border security data sources. The proposed method will set up a foundation for analyzing such data in a meaningful and integrated manner for actionable intelligence and decision support. We envision that many interesting research and operational opportunities will surface when the proposed data process capabilities are in place. Future research on how to leverage data integrated through the proposed effort will be both exciting and practically relevant.

Leverage

Various scientific communities including, but not limited to, statistics, data mining, environmental sciences, Geographic Information Systems (GIS), and public health, have been developing computational methods for such spatio-temporal data mining tasks as (a) identifying areas having exceptionally high or low measures and (b) discovering statistically significant changes. As mentioned previously, this project is unique in that it is prospective and in real time, but prior research will be leveraged including two grants from the National Science Foundation, “ITR-(NHS)-(DMC): A National Center of Excellence for Infectious Disease Informatics” ($1.25 M) and “Transnational Public Health Informatics Research” ($90K).
### Deliverables and Schedule (Project 3.2)

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<th>Deliverables</th>
<th>Schedule (Year)</th>
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<tr>
<td>A</td>
<td>White paper on sensor data clustering</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>White paper on sensor data correlation</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>White paper spatial-temporal data integration implementation</td>
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<tr>
<td>D</td>
<td>Report on data uncertainty representation</td>
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<tr>
<td>E</td>
<td>Report on data uncertainty reasoning</td>
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<tr>
<td>F</td>
<td>Final report on Spatial-Temporal Sensor Information Integration and Data Uncertainties</td>
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</table>

#### Completed Deliverables – Year 1 (June 2009)
- Data characterization and analysis contexts
- Sensor data spatial-temporal clustering

#### Specific Deliverables – Year 2
- Data uncertainty representation
- Sensor data clustering with unified uncertainty representation
- Sensor data correlation analysis and fusion methods
**Project 3.3: Data Fusion for Decision Support**

**Investigators**
- David Hall, Pennsylvania State University
- Isaac Brewer, Pennsylvania State University

**Introduction**

While extensive techniques exist to combine data from traditional sensors, little work has been done on combining human and non-human sensors. Issues include how to quantify the uncertainty of human data, how to model humans as sensors, how to task humans as sources of information, and even how to elicit information. This task will develop techniques and methods for creating and supporting a Common Operating Picture (COP) at tactical, operational and strategic levels.

Objectives include:
- Fuse heterogeneous data from diverse sensors and human reports
- Develop effective data displays and representations to support the full range from agent/officer in the field to DHS Operations Center.

This project will help DHS employees make better decisions by helping to create and support a Common Operating picture with effective displays and representations. A data-driven Decision Support System (DSS) or data-oriented DSS emphasizes access to and manipulation of a time series of internal and external data. Major issues include: architectures for distributed sensing and processing, selection and integration of algorithms, the role of the human-in-the-loop for analysis and decision-making, degree of automation and computer-aided cognition.

**Benefits to DHS**
- Improved situation awareness and coordination at all levels from individual agents to DHS operations
- Demonstration of key technologies for data fusion and distributed situational awareness and decision making
- New techniques and methods for creating and supporting a Common Operating Picture (COP) at the tactical, operational and strategic levels
- New methods for effectively utilizing humans as “soft” sensors for inputs to situation reports

**Project Description**

This project will develop a basic processing approach and implement selected algorithms to support data fusion. The project will:
- Survey current systems used by DHS, and obtain user needs and requirements
- Assess the availability of data and information for border surveillance and situational awareness
- Develop an appropriate architecture for a prototype system
- Select algorithms to process the available data and information; and finally, demonstrate selected techniques.

The project will develop techniques to fuse heterogeneous information sources to produce the most timely and accurate estimates of the on-going situation; including tracking and identification of vehicles, individuals, and emerging activities and events. Events represent an abstraction of heterogeneous sensor data streams into new information units with common properties.

**Leverage**

- Defense University Research Instrumentation Program (DURIP) – *Extreme Events Laboratory* ($200K)
- Rapid Reaction Technology Office (RRTO) - *Understanding the Human Terrain* ($430 K)
- Army Research Office (ARO) – *Modeling & Mapping* ($252 K)
## Deliverables and Schedule (Project 3.3)

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<td>B</td>
<td>Report on sensor data integration</td>
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<tr>
<td>C</td>
<td>Architecture design</td>
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<tr>
<td>D</td>
<td>Manual of algorithm selection</td>
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<tr>
<td>E</td>
<td>Software implementation</td>
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<tr>
<td>F</td>
<td>White paper on test and evaluation</td>
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<tr>
<td>G</td>
<td>Report on refinement</td>
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<tr>
<td>H</td>
<td>Prototype field demonstrations</td>
<td>1 2 3 4 5 6</td>
</tr>
</tbody>
</table>

### Completed Deliverables – Year 1 (June 2009)
- Development of architectural/operational concepts
- Identified displays, tools, appropriate data sets and appropriate subject matter experts

### Specific Deliverables – Year 2
- Validate operational concept, SME
- Experimental design / IRB
- Demonstration of COP displays and algorithms
Project 3.4: Dynamic Resource Allocation Using Market-based Methods

Investigators

- Tracy Mullen, Pennsylvania State University
- Isaac Brewer, Pennsylvania State University

Introduction

Rapid developments in communications and the evolving Internet infrastructure have provided the ability to link multiple types of heterogeneous data sources (including sensors and human observers) to support border surveillance and monitoring. As data is fused and sorted, and information extracted, the challenge is to dynamically allocate multiple information collection and dissemination resources to meet the needs of multiple users and decision makers.

To optimize border surveillance, techniques are needed to maximize the use of information resources. The evolving infrastructure allows multiple decision makers and analysts to request information from multiple sources, and multiple sources to supply multiple users. Traditional optimization methods are not suited for resource allocation to satisfy multiple users when user needs and target priorities are rapidly changing. This project will demonstrate new “market” based algorithms that dynamically link users (information consumers) with sensors (information suppliers) to meet the needs of the users in a rapidly changing tactical environment. It will develop techniques and methods for dynamic allocation of resources such as sensors, tasking human observers, and network communications for improved situational awareness.

Benefits to DHS

- Improved use of sensing, communications and human resources for more accurate situational awareness and effective decision-making
- New sensor management architectures that effectively tasking fundamentally different types of sensing entities.

Project Description

Formulating the sensor management (SM) problem as a competitive market provides a new algorithm for information sharing. For example, a sensor manager holds a combinatorial auction to “sell” the information “products” produced by the sensors and the communication channels. A combinatorial auction allows for the expression of synergistic resource allocation constraints such that bids can be for bundles of sensor data and bandwidth. In addition, the approach provides for dynamic re-allocation of resources as mission needs and observation conditions change. A natural approach is to allow consumer agents to bid on high-level tasks.

The market-based architecture for sensor management (MASM) takes this approach. Consumers bid on high-level task bids, and the SM translates the task bids into resource bids. A combinatorial auction then determines an optimal allocation for the resource bids. In non-commercial distributed sensor network systems, the relevance and importance of
mission goals must be explicitly defined to determine a reasonable budget allocation. A final task is to extend this to other data and information types relevant to DHS.

**Leverage**

- Builds on findings from task 3.3
- Army Research Office – Center of Excellence in Battlefield Sensor Fusion ($378 K)
- Defense University Research Instrumentation Program (DURIP) – *Extreme Events Laboratory* ($200K)
## Deliverables and Schedule (Project 3.4)

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<td>B</td>
<td>Manual of algorithm selection</td>
<td>2</td>
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<tr>
<td>C</td>
<td>Software implementation</td>
<td>3</td>
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<tr>
<td>D</td>
<td>Report on test and evaluation</td>
<td>4</td>
</tr>
<tr>
<td>E</td>
<td>Report on refinement</td>
<td>5</td>
</tr>
</tbody>
</table>

**Completed Deliverables – Year 1 (June 2009)**

- None (begins Year 5)

**Specific Deliverables – Year 2**

- None (begins Year 5)
Project 3.5: Reduction of False Alarm Rates from Fused Data

Investigators
- Huan Liu, Arizona State University
- George Runger, Arizona State University
- Jeremy Rowe, Arizona State University

Introduction
Sensors and state-of-the-art video technology are being deployed to improve border security and consequently enormous databases are being generated. However, very few alerts lead to captures. False alarms erode agent confidence in these systems. New tools and techniques are needed to autonomously organize and transform this data into reliable information that can inform operational, tactical and strategic decisions for actionable responses. The goals of this task are:

- Intelligent fuse data from hybrid sensors
- Minimize false alarms when detecting changes and anomalies to improve reliability
- Extend the solutions to current and new border security data applications

High-quality sensors can be triggered by many factors, and sheer numbers of sensors (SNS) that are monitored in isolation can result in high false-alarm rate (HFAR). We will represent the massive, hybrid sensors in reconfigurable sub-graphs at different levels and apply two suites of novel and intelligent techniques.

Benefits to DHS
- More effective tools and techniques to find meaning in the large, heterogeneous datasets
- Improved efficiency of human responses
- Increased agent confidence
- More effective tactical and strategic information to guide operations

Project Description
Our approach to solve this problem will be two pronged. First, we will use hierarchical Bayesian reasoning about uncertainty with noisy information. Effectively attacking HFAR and SNS, requires systematically and efficiently using the rich sensory information from multiple sources in two tasks:

- Cliques of neighboring sensors will be formed to discover reliable local patterns via data fusion, cross validation, and level-0 Bayesian network inference. The more reliable alerts from each clique will be used for next decision-level (ith level) fusion.
- In the hierarchy graph, clique outputs will be integrated at the next level with level-i Bayesian network inference about global patterns for intelligent monitoring.

Level-based fusion and inference significantly reduce the network complexity and allow field agents to flexibly determine:

- Size of neighborhood
- The level to focus on
- Area to zoom in/out, to accurately and efficiently discover and verify critical patterns, detecting deceptive variants, and predicting new trends.

Second, we will use efficient feature-level data fusion. Effective integration of multi-source information requires removing irrelevant/redundant features while retaining relevant and complementary information. Three research tasks will address these problems:

- Develop tools and techniques to select complementary features; instead of working on each feature of individual sources, we will consider features from different sources based on canonical correlation analysis while minimizing the number of features.
- Surrogate scores obtained from ensemble models have been successfully used to extract and reduce features (e.g., by orders of magnitude in semiconductor manufacturing) for dirty, missing, and noisy nonlinear and heterogeneous data. These methods will apply to homeland security repositories and improve extraction of relevant information, and potentially providing some data compression
- Dynamic time warping (DTW) has been used to coordinate, synchronize, and evaluate signals in manufacturing applications to detect changes and anomalies. Also, the transform of the problem to supervised learning has successfully addressed data quantity, mix, and the detection/false alarm trade-offs in process control.

These techniques will permit the Border sensor networks to provide real time monitoring/responses and improve their accuracy, efficiency, and reliability.

**Leverage**

- Data Mining and Information Fusion
- Hierarchical Bayesian reasoning about uncertainty with noisy information
- Canonical correlation analysis
- Feature level data fusion
### Deliverables and Schedule (Project 3.5)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Report on domain and design comprehensive representation of border sensors for effective data fusion, and design metrics</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>White paper on feature-level data fusion study for a hybrid data fusion system using cliques of neighboring sensors.</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Design evaluator and simulator to study system design alternatives, integrate with presenter to describe and summarize system performance/capabilities</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Tools and techniques for complementary information extraction and initiate ongoing evaluation and refinement cycle</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>Final report on surrogate scores for noisy heterogeneous data and work with domain experts for comparative study and evaluation</td>
<td></td>
</tr>
</tbody>
</table>

### Completed Deliverables – Year 1 (June 2009)

- Identified user population and current sources and uses of sensor data and examples of false alarms
- Obtained sample data sets, applied existing algorithms, and identified false alarms as ground truth for testing during development
- Developed initial cliques of neighborhood sensors and began to develop/refine algorithms

### Specific Deliverables – Year 2

- Apply existing algorithms and identify (or insert) false alarms as ground truth for testing during development
- Develop initial cliques of neighborhood sensors and begin to develop/refine algorithms
- Conduct feature-level data fusion study for a hybrid data fusion system using cliques of neighboring sensors
Research Area 4: Risk: Assessment, Mitigation, and Alignment

The culmination of Research Area 4 is a prototype border security risk monitor. Projects 4.1 and 4.3 are the foundational research initiatives to build the necessary maturity models, appropriate risk assessment techniques, and decision frameworks for border security risk. Project 4.5 focuses on risk assessments to inform resource allocation, which is directly related to the risk mitigation framework. This project focuses on reducing human cognitive effort to make informed, risk-based resource allocation.

End Users:

- U.S. Immigration, Customs, Enforcement (e.g., field operations, intelligence specialists)
- U.S. Customs & Border Protection (e.g., field operations, intelligence specialists)
- DHS Counter Narcotics Enforcement
- Drug Enforcement Agency
- Federal Bureau of Investigation
- Central Intelligence Agency
- State Department
- State and Federal correctional administrators
- Local law enforcement agencies
Project 4.1: Border Security Risk Assessment and Mitigation Decision Framework

Investigators

- Larry Head, University of Arizona
- Ferenc Szidarovszky, University of Arizona
- Jian Liu, University of Arizona
- Rick Van Schoik, Arizona State University

Introduction

Balancing the level of acceptable risk with physical security technologies, cost, and appropriate countermeasures is one of the most challenging responsibilities DHS faces. How much security is enough? How should high-tech security systems be integrated into low-tech response? There are no ideal approaches for assessing and addressing security issues on the border or looking at responses from a quantified cost-benefit perspective. Evaluating cost effective security technologies is important because security competes with operations, maintenance, and other limited financial, staff, and material resources. Security costs should be in proportion to the value or criticality of the protected asset and the acceptable level of acceptable risk. Typically, a border agent relies on a "gut feeling" to decide where to allocate scarce security resources and to determine the amount of security needed. This is exacerbated by uncertainty about available security resources. We will develop a decision framework to consider risk and risk mitigation that includes:

- Characterization of border risks
- Value or cost assessment of the risks
- Policies
- Mitigation systems including technology, policies, and procedures

Benefits to DHS

- Concentrate on border specific risks that include health, environmental, immigration, and terrorism in an integrated and structured framework that will support evaluation of policies and technologies for improved security

Methodology

- Review risk assessment frameworks from security, health, immigration, etc. areas
- Define taxonomy of risks and impacts
- Establish decision framework
- Perform case studies
- Evaluate technologies and policies

Project Description
- Develop a literature review and summary of Risk Analysis Methodologies relevant to Border Security. This will focus on probabilistic modeling of border risks as activities (versus events), the valuation of risks (economic, legal, etc.), the role of information and policies, and decision rules.

- Determine what access to DHS data, reports, personnel, etc. is necessary to assess risk.

- Conduct an inventory of security procedures and technologies at U.S. borders related to risk mitigation systems and technologies.

- Develop an ontology and taxonomy of border risk. This will focus on the special issues of border security and address policy/legal issues relating to risk management, including the issues of culture and leadership as they impact risk management decision-making by law enforcement.

- Align Technology and Policy Responses and Capabilities to Risk. This will consider the interacting roles of technology and policy in protecting the border and will incorporate this interaction into the decision framework for risk assessment. The value of mitigation strategies (i.e. combinations of policy and technology) will be evaluated as a basis for comparison of new approaches.

- Formalize Risk Assessment and Decision Framework. The Risk Assessment and Decision Framework will consider the inventory and probabilistic models of border risks, the inventory of security procedures and technology, and the alignment of policy and technology into a decision theoretic framework were the value of risk and risk mitigation strategies can be estimated and alternative policies, procedures, and technologies can be compared and assessed.

- The Risk Assessment Framework will be validated work through case studies, offering an assessment of the effectiveness of layers of process, policies, and technological systems intended to improve Protection in Depth (PID). The strengths and weaknesses of the methodology to address changing policies, processes, and technological developments will be documented.

**Leverage**

We will coordinate and cooperate on this task with CREATE at USC which deals with risk models and evaluation to avoid duplication of efforts and ensure consistency of approaches.
### Deliverables and Schedule (Project 4.1)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Survey of risk literature</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Report: needs for DHS data/information</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Inventory of security procedures and technologies</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Manual taxonomy and ontology of border risk and security</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>White paper on policy and technology alignment</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>Risk assessment framework</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>Final report, participate in COE workshops and conferences</td>
<td></td>
</tr>
</tbody>
</table>

**Completed Deliverables – Year 1 (June 2009)**

- Survey of risk literature
- Report: needs for DHS data/information

**Specific Deliverables – Year 2**

- Manual taxonomy and ontology of border risk and security
- Inventory of security procedures and technologies
- White paper on policy and technology alignment
- Risk assessment framework
Project 4.3: Border Security Readiness Assessment and Maturity Model

Investigators
- Larry Head, University of Arizona
- Murray Jennex, San Diego State University

Introduction
Maturity models are a structured collection of elements that describe certain aspects of maturity in an organization. A maturity model may provide:

- Organizational baselines
- Common criteria, language, and shared vision / direction
- A framework for prioritizing actions
- Definitions for organizational improvement

A maturity model can be used as a benchmark for comparison and as an aid to understanding. Maturity models are often used for comparative assessment of different organizations where there is something in common that can be used as a basis for comparison. The objective of this task is to develop a Border Security Readiness and Maturity Model that can be used to assess border security operations across all operating sectors. Maturity models can be used to determine the level of operations based on the use of tools, technology, and process to help organizations plan for growth and increase maturity. Readiness models are useful in assessing technology before it is deployed in a system that is dependent on its reliable operation. Both of these models are necessary to ensure effective and efficient border security operations.

Benefits to DHS

- Provide a process for determining the readiness of an organization to use new technologies
- Provide a process for assessing the overall readiness of an organization
- Provide a process for improving an organization’s readiness through manageable steps

Methodology

- Survey current readiness and maturity models
- Define levels / methods for a border readiness assessment and maturity model
- Conduct assessment in selected case-study locations to validate model
- Ready assessment process for hand-off to DHS/other partners

Project Description

- Identify benchmark measures for border security status “dashboard”. Key summary measures will be identified based on the availability of source data from key border security sectors and operations.
• Create Annual Report Format and Sample Report. The format of the report will remain essentially fixed over the years to ensure consistency. A draft format of the report will be presented to DHS for review and approval.

• Perform Analysis using All-Hazards and Design-Basis Approach. An All-Hazards approach will consider all possible border security risks, including those that are currently protected against using some form of policy, procedure, and/or technology and those that are not currently protected. A Design-Basis approach considers only those risks that are specifically protected against. Both of these approaches will be used to assess the effectiveness of current systems to protect the border against protected risks and the potential risks from unprotected threats.

• Perform Annual Assessment and update the report. The Annual Assessment report will be updated annually and provided to DHS.

Leverage

We will leverage other maturity models like the Software Engineering Institute Capability Maturity Model, People Capability Maturity Model, or Service integration Maturity Model.
Deliverables and Schedule (Project 4.3)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Manual of existing readiness and maturity models and tools</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>White paper on readiness and maturity levels for border security</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Case study reports</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Final report with recommendations for improvement and wider application; implementation guidelines</td>
<td></td>
</tr>
</tbody>
</table>

Completed Deliverables – Year 1 (June 2009)

- None (begins in Year 2)

Specific Deliverables – Year 2

- Manual of existing readiness and maturity models and tools
- White paper on readiness and maturity levels for border security
- Case study reports
Project 4.4: Prototype Border Security Risk Monitor

Investigators
- Murray Jennex, San Diego State University
- Eric Frost, San Diego State University
- Robert Judge, San Diego State University
- Larry Head, University of Arizona

Introduction
This project will develop an on-line Border Security Risk Monitor system that will provide DHS management with a tool to determine the status of border operations based on updated risk assessments, current operational, and maturity and readiness of operational systems. The Border Security Risk Monitor will integrate the findings from the other projects into an online tool that will support operational management of Border Security Systems to mitigate risk.

Benefits to DHS
- Provide a tool that assists management in assessing border risks (more than immigration and terrorism) and risks of new technology
- Provides an automated system that provides current assessment of risk that can be used to improve resource allocation.

Methodology
- Assist in the development of a risk assessment model
- Create a simulation of the risk assessment model
- Prototype risk monitor
- Finalize risk monitor

Project Description
We will utilize research from the above projects to design a Border Security Risk monitor. This design will define how the system will operate from an end-users perspective and how data will be collected and updated using use cases and prototype user interfaces and system architectural designs. Following the formal design, we will develop a basic prototype Border Security Risk Monitor. Its basic operational features will be developed into a prototype system that can be demonstrated and evaluated by DHS. The basic features will include models and data from the other risk management projects. Finally, we will enhance the prototype Border Security Risk Monitor to include advanced features such as an on-line Resource Allocation capability to assist DHS Management in the deployment of assets in response to changing risks and system status.

Leverage
We will leverage other maturity models like the Software Engineering Institute Capability Maturity Model, People Capability Maturity Model, or Service integration Maturity Model.
## Deliverables and Schedule (Project 4.4)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Develop risk assessment model for monitor</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Prototype risk monitor tool</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Field test tool</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Report on prototype design, field test, and capabilities</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>Final report: analyze ways the tool can be used for adaptive resource allocation/deployment</td>
<td></td>
</tr>
</tbody>
</table>

### Completed Deliverables – Year 1 (June 2009)

- None (begins in Year 2)

### Specific Deliverables – Year 2

- Develop risk assessment model for monitor
Project 4.5: Adaptive, Risk-Informed Resource Allocation

Investigator
- Henry Willis, RAND Corporation
- Joel Predd, RAND Corporation

Introduction
At the “tactical” level, achieving border security will require personnel to integrate a variety of intelligence (e.g., satellite and other sensor systems) and security (e.g., border patrols) assets first to monitor, and then to interdict, emerging threats to border security. Therefore, the objectives of this project are:

- Evaluate how the adaptive allocation of intelligence and security assets may make available surveillance tools and border patrols more effective at reducing risk
- Develop advanced machine learning-based technologies to facilitate such an allocation

DHS operational demands require a methodology for allocating border security assets and to answer the seemingly simple questions: Where and when should we conduct surveillance? Where and when should we patrol? This discussion inspires this project’s key research question: How can emerging patterns in border-crossing behavior be identified and exploited to enable adaptive allocation of intelligence and other border security assets?

Benefits to DHS
- The Office of Border Patrol and the Secure Border Initiative program office will have tools to dynamically allocate assets in the tactical environment

Methodology
- Phase 1: Field studies to CBP sites to understand border operations, environment, and available intelligence data and collection assets
- Phase 2: Develop and evaluate machine learning-based prototype tools using simulation tools
- Phase 3: Field studies to deploy prototypes

Project Description
This research will take a three-phased approach. In the first phase, we will study the feasibility of a data-driven approach to automated adaptive resource allocation and potential benefit in terms of risk management. In particular, we will map out the available intelligence assets that may provide the data which drives our machine learning-based approach; we will study the extent to which current intelligence and border patrol assets can adapt; and we will study how future technologies and policies, perhaps developed within the COE, may provide new data sources to assess risk and new levels of adaptability.

The second phase will involve developing prototype technologies to detect emerging trends in illegal border crossing and to integrate those technologies with resource allocation problem.
These methods will be assessed based on how effectively they contribute to risk reduction at borders and will be compared to other approaches such as random assignment and allocation based on Bayesian Stackelberg games. The specific methods and technologies used will be driven by the findings in phase 1, but are likely to include methods from machine learning including online learning, Bayesian networks, and boosting. The prototype technologies will be assessed with real data as available, or with simulated data as necessary.

The third phase will involve deploying the prototype technologies in the field in collaboration with Center partners. Each phase is expected to last approximately 1 year. Members of the project team are currently developing situational-awareness tools to track an adaptive insurgency in Iraq. These tools are being used in various ways to allocate scarce military resources. We expect that the techniques and lessons-learned from these effort will be naturally transferred to the border protection project proposed here.

**Leverage**

- JIEDDO-funded RAND IED research
  - Tactical support
  - Analysis of Alternatives
- Risk analysis work with USC-CREATE
  - ARMOR and Border Risk Model
Deliverables and Schedule (Project 4.5)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Inventory: available intelligence assets</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Prototype of technologies and integrate with resource allocation</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Prototype technologies in the field</td>
<td></td>
</tr>
</tbody>
</table>

Completed Deliverables – Year 1 (June 2009)

- Visit DHS, CBP Sites; review literature
- Document findings

Specific Deliverables – Year 2

- Inventory: available intelligence assets
- Prototype of technologies and integrate with resource allocation
Immigration Project Details

Research Area 5: Population: Methods, Metrics and Estimates

Population dynamics, migration flows, and the use of public services by undocumented and legal entrants are not adequately quantified in current literature and data sets. As a result, it is difficult to describe current status, projections and modeling of trends, and scenarios for strategic tactical and policy purposes. This project will obtain accurate estimates on the undocumented population, including illegal crossers and visa overstays.

End-users:

- U.S. Immigration, Customs, Enforcement (e.g., field operations, intelligence specialists)
- U.S. Customs & Border Protection (e.g., field operations, intelligence specialists)
- U.S. Customs and Immigration Statistics
- Federal Bureau of Investigation
- Central Intelligence Agency
- State Department
- Bureau of the Census
- Department of Labor
Project 5.2: Estimates of Visa Overstay Population

Investigators

- Frank D. Bean, University of California-Irvine
- Jennifer Van Hook, Pennsylvania State University

Introduction

The unauthorized population of the United States is made up of two major components – persons who enter the country illegally (i.e., who “enter without inspection,” to use the language of the government) and persons who enter legally and then overstay their visas. The latter component is thought to constitute about 40 percent of the total population, but this figure is based on research that is now nearly two decades old.

The objectives of this project are to conduct research on what data and information might be used to update and/or improve estimates of the unauthorized population, develop methodologies for using this information to calculate new estimates, and calculate new estimates based on the information and methodologies. A final objective will be to carry out these same tasks with respect to estimating how long on average visa overstays remain in the country in that status and/or remain in that status. As a result of this project DHS will be able to make more informed policy decisions with an accurate view of the visa overstay population.

Benefits

- Accurate and detailed estimates of the number and the duration of stay of visa overstayers
- Will help DHS prioritize adjustments in the number and type of slots made available to non-immigrants

Project Description

This work will extend the techniques and approaches we pioneered and introduced in the Binational Study and in work we have conducted for the U.S. Bureau of the Census on emigration. We will conduct a systematic search for new data and information that can be used to estimate this important sub-population. We will also use the longitudinal data from the New Immigrant Survey (NIS) to calculate how many persons (and what kinds of persons) spent time in the country as illegal migrants after having entered as legal non-immigrants. We will also conduct demographic analyses using synthetic cohorts from decennial census data to ascertain the relative magnitudes and change of key demographic components likely to reflect the presence and growth in the country of persons who are (or once were) visa overstays (e.g., such as foreign-born persons with college degrees who are in cross-nativity intermarriages within and outside their national origin group). We will also conduct sensitivity analyses on the estimates of overall unauthorized migration using different estimated levels of visa overstays in the calculations. We will also assess the implications for the overall estimates of unauthorized stock of assuming (or using empirical information on different levels of) duration of stay for visa overstays (i.e., different policy implications would follow if we found that visa overstays tended to remain in that status only about a year versus staying in that status about three years or more).
## Deliverables and Schedule (Project 5.2)

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<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Report: Calculate simulations showing how much difference length of visa overstay and overstay exit rates makes for stock and flow estimates</td>
<td><img src="#" alt="Green boxes indicating completion" /></td>
</tr>
<tr>
<td>B</td>
<td>Report: Begin the search to find new data and information on over stays</td>
<td><img src="#" alt="Green boxes indicating completion" /></td>
</tr>
<tr>
<td>C</td>
<td>Synthetic cohort studies to show effects of visa over stays</td>
<td><img src="#" alt="Green boxes indicating completion" /></td>
</tr>
<tr>
<td>D</td>
<td>Models of new methodologies for estimating over stays</td>
<td><img src="#" alt="Green boxes indicating completion" /></td>
</tr>
<tr>
<td>E</td>
<td>Guidelines for calculating new over stay estimates, including subpopulation estimates</td>
<td><img src="#" alt="Green boxes indicating completion" /></td>
</tr>
<tr>
<td>F</td>
<td>Sensitivity analyses</td>
<td><img src="#" alt="Green boxes indicating completion" /></td>
</tr>
</tbody>
</table>

### Completed Deliverables – Year 1 (June 2009)

- Visa overstay simulations
- Stock and flow estimates
- Identify new data sources

### Specific Deliverables – Year 2

- Literature review of prior estimates
- Gather components of prior population estimates
- Develop report summarizing new data and information on overstays
Project 5.3: Determinants of Migrant Population Flows

Investigators

- Christopher Timmins, Duke University
- Brooks Depro, RTI International

Introduction

This research will develop appropriate data sets and documentation for initial qualitative and quantitative assessments of immigrant population flows and determinants. The principal end users will be the Office of Immigration Statistics and Citizenship and Immigration Services at DHS, though this work could help inform a variety of short-term activities and longer term strategic, policy planning.

This study provides a new measurable way policy makers can determine the extent to which immigrants are flowing into labor markets. In particular, to what extent might non-random sorting by immigrants be mistaken for assimilation?

The proposed economic model will enhance the Department’s ability to interpret immigrant labor market data that is collected from publicly available databases and use it for understanding the labor market consequences of immigration policies. Previous projects suggest that using raw labor data without accounting for role of selection bias may lead policy makers to conclude immigrants have successfully assimilated when in fact they have not.

Project Description

Empirical models evaluating immigrant assimilation have a long history in economics (e.g. Borjas, 1994). More recent work has been conducted by Jacob Vigdor. He measures assimilation on economic (employment, education, homeownership), cultural (speaking English, number of children), and civic (naturalization, military service) grounds.

We focus on identifying, collecting, and organizing data sets describing immigrant population characteristics. Initially, we will use these data to examine characteristics of immigrant population flows and perform comparisons of immigrant populations with their home populations. The approach leverages existing U.S. Census micro data (Integrated Public Use Micro Series, or IPUMS) that describe all types of immigrants in different ways (e.g. socio-demographic attributes, education, health, birthplace, and current residences). These data provide information on an individual’s location at a detailed level of spatial resolution (e.g., MSA or county) as well as at a broader scale (e.g., state or census division).

Next, we use an alternative existing data set that focuses on Mexican migration patterns (Mexican Migration Project [MMP]) to examine other factors that influence immigrant choices and assimilation. The MMP data set is better suited to address several types of questions that IPUMs cannot. For example, the MMP can show how documented and undocumented immigrants differentially use public services in the U.S. It also allows us to look for differences in assimilation patterns of different types of immigrants. For example, are immigrants who make multiple crossings over their lifetime more likely to assimilate less? Are people coming from border towns less likely to assimilate because they return to their hometown more easily?
Both IPUMS and MMP data sets will be prepared with appropriate documentation of any modifications and or variable additions with sufficient documentation so that other researchers can use it to replicate the research. The research community will benefit from having such information for future external policy analysis. We are unaware of any similar work being funded by DHS at this time.

This approach can be used to assess immigration issues regardless of source country of immigrants. The only issue is whether there is available data describing illegal immigrants. Legal immigrants from any country could be included by using publicly available Census data. The methods described and implemented in this project can potentially be to look at immigrant flows in other dimensions.

**Leverage**

This work follows on to a project carried out by Timmins with the support of the World Bank. The goal of that project was to determine the extent to which rural-urban migrants in Mexico and Brazil had successfully integrated into local labor markets. The project concluded that the role of selection bias was significant. While it appeared in raw data that those who had migrated from rural to urban areas were doing quite well (relative to those born in urban areas), the econometric model revealed that they were predominantly individuals who had received particularly attractive wage draws in the urban area. This has important consequences for migration policy -- a policy designed to encourage more rural to urban migration based on the success of past migrants would likely not be successful, as the new migrants would likely not benefit from the same good wage draws.
Deliverables and Schedule (Project 5.3)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Manual: Organize IPUMS and MMP data sets. Draft and final reports on documentation of any modifications and or additions</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Manuscript comparing of population flows and economic characteristics associated with datasets in subtask a. When making these comparisons, we will consult with DHS staff on the appropriate scope (e.g. number and types of comparisons and variables examined) given the existing project resources and a review of outputs from subtask a.</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>Poster and/or presentation slides that could be used in future workshops or conferences sponsored by DHS and/or economics community.</td>
<td></td>
</tr>
</tbody>
</table>

Completed Deliverables – Year 1 (June 2009)

- Organized IPUMS and MMP data sets.
- Draft and final reports on documentation of any modifications

Specific Deliverables – Year 2

- Literature review of prior estimates
- Gathered components of prior pop estimates
Research Area 6: Immigration: Economics, Policies and Alternatives

Research Area 6 analyzes the economic incentives driving migration in the global economy and the implications to various approaches to immigration policy. This area also studies immigration policy implementation at the state level and will report findings from three states with diverse immigration enforcement plans. The lessons from this study hold powerful implications for the study states themselves, for other states considering enacting new enforcement related legislation and, importantly, for the Congress and Administration, in proposing comprehensive immigration reform.

End-users:

- U.S. Immigration, Customs, Enforcement
- U.S. Customs & Border Protection
- U.S. Customs and Immigration Statistics
- Central Intelligence Agency
- State Department
- Local law enforcement agencies
- Department of Labor
- Federal and State Legislators
Project 6.1: Econometric Analysis of Immigrant Assimilation

Investigators
- Christopher Timmins, Duke University
- Brooks Depro, RTI International

Introduction
We will enhance understanding of the long term effects of migration on stakeholders—immigrant and recipient populations. We will develop appropriate empirical tests of immigrant assimilation. We will assess the likelihood of migrants successfully assimilating into labor markets and consider feasibility of assessing assimilation patterns on other dimensions (e.g. health).

The proposed economic model will enhance the Department’s ability to interpret immigrant labor market data that is collected from publicly available databases and use it for understanding the labor market consequences of immigration policies. Previous projects suggest that using raw labor data without accounting for role of selection bias may lead policy makers to conclude immigrants have successfully assimilated when in fact they have not.

Project Description
Empirical models evaluating immigrant assimilation have a long history in economics (e.g. Borjas, 1994). More recent work has been conducted by Jacob Vigdor. He measures assimilation on economic (employment, education, homeownership), cultural (speaking English, number of children), and civic (naturalization, military service) grounds.

Our empirical strategy combines a microeconomic model of the sorting process in labor markets, a novel econometric approach to modeling selection bias; and can be applied to assess immigration assimilation in other dimensions (health, education). The estimation strategy recovers "unconditional" wage distributions for individuals. A new technique purges out the effect of sorting. People actually “draw” from unconditional wage distributions when they consider moving. This requires internally developed computer programs not available in standard statistical packages such as SAS or STATA.

We propose a new estimation strategy that can answer the assimilation question. Previous research has not considered seriously the fact that immigrants are selected group. Those who chose certain occupations in which to work and locations in which to live likely did so because they had good opportunities there – i.e., they self-selected. More than 50 years of theory in labor economics has dealt with this type of sorting problem. It has the potential to skew estimates of the distribution from which immigrants receive wage draws. Without recovering unbiased estimates of these distributions, it is impossible to determine how well immigrants assimilate in the labor market.

Although the broad research community uses the data sets we propose to use to answer a variety of questions, we are not aware of any similar work that applies this estimation framework to answer assimilation questions.
This approach can be used to assess immigration issues regardless of source country of immigrants. The only issue is whether there is available data describing illegal immigrants. Legal immigrants from any country could be included by using publicly available Census data.

The methods described and implemented in this project can potentially be expanded to look at immigrant assimilation in other dimensions.

**Leverage**

This work follows on to a project carried out by Timmins with the support of the World Bank. The goal of that project was to determine the extent to which rural-urban migrants in Mexico and Brazil had successfully integrated into local labor markets. The project concluded that the role of selection bias was significant. While it appeared in raw data that those who had migrated from rural to urban areas were doing quite well (relative to those born in urban areas), the econometric model revealed that they were predominantly individuals who had received particularly attractive wage draws in the urban area. This has important consequences for migration policy – a policy designed to encourage more rural to urban migration based on the success of past migrants would likely not be successful, as the new migrants would likely not benefit from the same good wage draws.
### Deliverables and Schedule (Project 6.1)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Report describing new econometric estimation strategy used to answer this research question</td>
<td>1, 2</td>
</tr>
<tr>
<td>B</td>
<td>Report describing and comparing estimated &quot;unconditional&quot; wage distributions for individuals by origin and socioeconomic characteristics. This will discuss feasibility of future work addressing assimilation in other dimensions</td>
<td>3, 4</td>
</tr>
</tbody>
</table>

#### Completed Deliverables – Year 1 (June 2009)
- Review econometric estimations of immigrant assimilation

#### Specific Deliverables – Year 2
- Draft manuscript describing microeconomic model of the sorting process in labor markets and econometric approach to modeling selection bias
Project 6.2: Economic Impacts of Immigration Policy

Investigator

- Judith Gans, University of Arizona

Introduction

The purpose of this research is to analyze the economic incentives driving migration in today’s global economy and their implications for enforcement of U.S. immigration laws. An initial report will describe large economic and demographic trends in the U.S. and immigrant-sending countries and what these realities suggest for key ingredients of a successful immigration policy. Subsequent reports will analyze the implications of various approaches to immigration policy and enforcement such as a merit-based (point) system, interior vs. border enforcement, the effect of changes to quotas of various visa categories on illegal immigration, and so forth.

These analyses will provide insight on the role of immigrants in the U.S. economy, the likely magnitude of demand for immigrant labor, what’s at stake in eliminating illegal immigrants from the U.S. labor force, and shed light on the magnitude of “pull factors” for immigration to the U.S. Because the success of any immigration policy depends on the extent to which it is congruent with the large forces driving immigration, these analyses are important background to understanding key elements of successful immigration policy and illuminating the enforcement challenges inherent in various approaches to immigration policy that Congress might consider.

By identifying the “pressures in the system”, the project can deepen DHS’s understanding of the enforcement challenges it faces under various immigration regimes considered by Congress.

Benefits to DHS

- Measures of what is at stake in enforcing immigration policy
- Understanding of winners and losers from immigration policies considered by Congress
- Insights to “pressures in the system” which may result from various approaches to immigration policy

Project Description

A number of studies have been done to assess the economic impacts of immigrants. These include national-level analyses by economists such as George Borjas, Giovanni Peri, and David Card on the impacts of immigrants on native-born wage as well as state-level analyses examining the economic impacts of immigrants on state and local economies.

This research will use demographic data and projections combined with employment, income, and other data available through the U.S. Census Bureau and other federal sources to perform the various analyses. These include (1) examining the role of immigrants in the US economy; (2) comparing the demographic and labor force roles of immigrants and native-born workers; (3) examining the relationship between immigration levels, wages, and the supply of native-born workers; and (4) quantifying the contributions of immigrants to the economic performance of various sectors of the US economy.
Selection of specific immigration policy scenarios to analyze will be informed by several considerations including the elements of comprehensive legislation recently considered by Congress and options short of comprehensive reform that Congress may consider including:

- The economic implications of changes to the basic architecture of the immigration system from a family-based immigration to merit-based immigration through a point system;
- The economic implications of interior enforcement as an alternative to or in conjunction with border enforcement in light of specific numerical limits in various visa categories;
- The work-force implications of immigration policies privileging high-skilled immigrants over low-skilled immigrants (or the inverse).

This project is different from prior work because it will focus specifically on “pressures in the system” and examine the enforcement challenges that are likely to result from the incentive structure inherent in a given immigration regime. For example, our current legal immigration system does not allow many legal channels for immigration by low-skilled workers yet recent economic and demographic trends have generated significant demand for these workers. With relatively few low-skilled native-born workers available, employers have turned to the immigrant community. Because current enforcement policy has focused primarily at the border, it has been relatively easy for low-skilled immigrants in the country illegally to find work. The combination of the structure of our legal immigration system, policy decisions on where to focus enforcement, and US demographic trends have combined to create tremendous economic incentives for low-skilled immigrants to enter the country illegally and for employers to hire them. These incentives have been overwhelming the system.

This project will examine current U.S. demographic trends and projections by age and skill level. It will identify how these trends fit the likely needs of our economy. It will examine how well the immigration system as currently structured or envisioned by Congress can fill any gaps between demographic trends and the needs of the economy. Once the large economic incentives are identified, the implications for effective enforcement will be identified.

While most illegal crossings occur along the southern border, as long as illegal immigrants can find work once in the U.S., we can expect points of entry to shift to new areas as enforcement is increased along the southern border. We are unaware of any similar projects being funded by DHS at this time. This project allows for analyses that respond to changing economic and policy conditions so that DHS can stay current in its understanding of these trends.

**Methodology**

We will combine demographic data with data on labor market participation and growth to examine the role of immigrants in the economy. We will model the economic contributions of immigrants.

**Leverage**

The project will leverage Brown Foundation funded research on the role of immigrants in Arizona and on the enforcement mechanisms in Arizona’s Legal Arizona Workers Act. It will provide insights to challenges resulting from the economic role of immigrants and various approaches to enforcement.
### Deliverables and Schedule (Project 6.2)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>White paper outlining key elements of a successful immigration policy</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Report on enforcement-based reform without changes to the immigration system</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>White paper on temporary worker program with limited permanent migration</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>White paper on merit-based compared to a family-based immigration system</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>White paper on Interior enforcement as an alternative to or in conjunction</td>
<td></td>
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<tr>
<td></td>
<td>with border enforcement</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>White paper on Work-force implications of policies privileging high-skilled</td>
<td></td>
</tr>
<tr>
<td></td>
<td>over low-skilled workers</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>White paper on Provision for temporary workers that does not include a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>legalization mechanism for immigrants in the United States illegally</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>White papers as suggested by immigration legislation considered by Congress</td>
<td></td>
</tr>
</tbody>
</table>

PLEASE NOTE: Timing of these and other analyses will depend in part on specific legislation being considered by Congress and the priorities of the DHS.

### Completed Deliverables – Year 1 (June 2009)

- Compilation of relevant demographic and economic data
- Report on immigrant participation in labor markets by industry
Specific Deliverables – Year 2

- Report on economic and demographic trends and implications for sustainable immigration policy
- Examination of aspects of immigration policy and implications for enforcement
Project 6.3: Assessing Migrant Impacts on the U.S. Criminal Justice System

Investigators

- Kevin J. Strom, RTI International
- Pamela Lattimore, RTI International
- John Hollywood, RTI International

Introduction

Estimating the impact of the illegal immigrants on the U.S. criminal justice system, particularly state and local justice systems, is a highly challenging problem because of the number of agencies affected, differences in administrative data collection, and the lack of indicators in many extant data systems of legal status. This project will seek to develop a national system for monitoring and estimating the number of illegal immigrants at each stage of the criminal justice system. As part of this process, we will prototype a web-based survey tool that will collect the data needed to estimate the cumulative costs of handling these populations. The costs will include those associated with arrest, prosecution, community supervision, and incarceration. The project will seek to achieve the following objectives:

- Gain an improved understanding of the characteristics and impact of migrant populations on the criminal justice system in selected counties located in border states.
- Develop estimates of the number and cost of illegal immigrants at each stage of the criminal justice process in these counties.
- Develop lessons learned on the availability and quality of data on immigration status maintained by local law enforcement, prosecutor offices, local jails and state correctional agencies.

This project will benefit DHS by facilitating longer-term solutions for assessing the impact of migrant populations on state and local criminal justice systems as well as the effectiveness of federal and state policies targeting illegal immigration.

Project Description

To design the proposed system, we will conduct a variety of site visits and interviews to identify relevant data that is already being reported to DHS, the key issues and barriers involved in collecting justice system-related data that includes immigration status, the issues and barriers involved in reporting the data on a regular basis, and considerations that would make the systems most useful for the participating jurisdictions.

Data will be collected from two jurisdictions in Texas and Arizona selected to provide adequate variation in size and location. We intend to use the prototype system to collect quarterly data on the numbers and types of illegal immigrants at each stage of the criminal justice system. The quarterly data from the sites will be used to estimate the rate of flow between stages of the justice system, as well as potential for changes over time. We will then use existing cost estimates of criminal justice case processing (e.g., cost per prosecution) to calculate the unit costs associated with handling an illegal immigrant at each stage of the process, and from there estimate the total
costs to each of the three pilot jurisdictions. We are unaware of any similar research being funded by DHS at this time.

**Leverage**

RTI has significant experience in creating web-based reporting systems that enjoy very high levels of participation. A notable example is the DEA’s National Forensic Laboratory Information System (NFLIS), which collects forensic analysis data concerning drug seizures from over 90% of the state and local forensic laboratories across the US.
# Deliverables and Schedule (Project 6.3)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Description</th>
<th>Schedule (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Report on site visits and interviews with the two pilot jurisdictions and DHS</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>B</td>
<td>Model of design of the web-based system, develop procedures for using it, and validate the design with the jurisdictions</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>C</td>
<td>Manual for collection system, and conduct initial verification and validation tests</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>D</td>
<td>Prototype system using feedback from jurisdictions and other subject matter experts</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>E</td>
<td>Database of prototype’s collection of quarterly data from the jurisdictions</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>F</td>
<td>Report analyzing data to estimate numbers and types of illegal immigrants at various stages in the criminal justice system</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>G</td>
<td>Cost calculator for estimating the number of illegal immigrants in the criminal justice system as well as the associated costs of handling these populations</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>H</td>
<td>Report on the impact and cost of handling illegal immigrants in the Criminal Justice System for the two pilot jurisdictions. The report will also provide an initial assessment on what would be involved in scaling the system to operate statewide</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>I</td>
<td>Validation tests of the system with 2-3 additional local jurisdictions</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>J</td>
<td>Pilot tests to scale the system statewide in either Arizona or Texas</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>K</td>
<td>Report: Assess requirements to scale the system nationwide</td>
<td>1 2 3 4 5 6</td>
</tr>
</tbody>
</table>

**Completed Deliverables – Year 1 (June 2009)**

- Initial interviews with partners

**Specific Deliverables – Year 2**
• Site visits
Project 6.4: Immigration Enforcement Policies at the State Level

Investigators
- Michael Fix, Migration Policy Institute
- Doris Meissner, Migration Policy Institute

Introduction

The de facto devolution of immigration enforcement to state and local governments over the past several years is arguably the most important development in immigration policy since the enactment of the Immigration Reform and Control Act in 1986. As some states enact stringent enforcement legislation and others choose not to, differences among state policies offer the opportunity to greatly expand our knowledge of the consequences of different enforcement approaches -- knowledge that will be extremely useful not only to states but also to policymakers considering next steps at the federal level. As with prior studies of devolution in other social policy areas, particularly welfare reform, implementation research is crucial if we are to understand what has actually happened (that is, whether and how the laws have been implemented) and with what consequences, both intended and unintended. The importance to DHS and the national policy debate include potential positive and negative effects on employers, taxpayers, authorized as well as unauthorized immigrants, children, and community agencies and institutions (such as schools, hospitals, and nonprofit social services agencies).

Project Description

MPI’s research will build on current studies to explore the implementation of new enforcement related laws in three states as implementation regimes mature and as sanctions penalties are, in theory, increasingly broadly applied to employers. We anticipate that:

- One of the three states will be Arizona (where our work will complement the separate but coordinated research plan of the University of Arizona and Arizona State) because of the great significance of the state’s employer sanctions law (The Legal Arizona Workers Act) that, among other things, makes the use of the federal E-VERIFY program mandatory for all new hires in the state. The significance of the law cannot be underestimated: the law expanded the number of firms required to use the federal verification program from 30,000 to 650,000; and the legislation was signed by a prominent and rising Democratic governor, Janet Napolitano. Arizona law also severely restricts access of unauthorized immigrants to government services, criminalizes transportation and “harboring” of unauthorized immigrants, and requires state and local police to enter into 287(g) agreements with DHS to enforce federal immigration laws.

- We will select a second state that has also enacted stringent employer sanctions legislation and other provisions similar to Arizona’s, in another region of the country to provide a somewhat different economic, social and political picture; the likely candidate is Mississippi, which like Arizona has enacted a mandatory verification statute that will apply to all state employers in July 2011.

- The third state will be one that has not enacted stringent employer sanctions or other restrictive provisions and that is probably in either the Northeast or Northwest. Of
course, this state too will be operating within the national context of more stringent enforcement measures at the national level, such as the REAL ID Act, the possibly-imminent issuance of Social Security “No Match” letters, and the growing use of 287(g) agreements allowing state and local police to enforce immigration laws. The comparison among the three states will allow us to identify differences in economic and social changes depending on state policy choices.

We would undertake a study of intermediate term implementation in the three states following on initial work conducted by the University of Arizona and others. We would like to explore the following key questions which are important to informed policy choices going forward.

What is actually happening with regard to the “mid stream” implementation of the laws? How are they operating on the ground? Does their implementation vary by jurisdiction within the state? What kinds and levels of resources are being devoted to implementation? Based on evidence from earlier implementation studies, to what degree are the laws succeeding in achieving their goal of employer accountability regarding the employment of unauthorized workers? How effective is E-Verify as an enforcement tool? Is the size of the unauthorized immigrant population declining?

The lessons from this study hold powerful implications for the study states themselves, for other states considering enacting new enforcement related legislation and, importantly, for the Congress and Administration, if they take up the next round of comprehensive immigration reform.

**Leverage**

To be supplied.
### Deliverables and Schedule (Project 6.4)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Description</th>
<th>Schedule (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Report on research, using both field interviews and intensive review of administrative data</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Report of findings and issues to continue to track</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Follow-up report that updates the earlier research and provides policy recommendations for national policy regarding employer enforcement and mandatory worker verification, as well as an analysis of the respective roles and strengths of both state and federal agencies in employer-focused immigration enforcement</td>
<td></td>
</tr>
</tbody>
</table>

**Completed Deliverables – Year 1 (June 2009)**

- None (begins in Year 4)

**Specific Deliverables – Year 2**

- None (begins in Year 4)
Research Area 7: Governance: Law Enforcement and International Cooperation

Increasing border security while maintaining the efficient flow of trade is a challenge to the U.S., Canada and Mexico. The recent upsurge of drug-related violence and migrant smuggling in Mexico illustrates the ability of agile, stateless, and resourceful networks to exploit North American borders. Increased border security is best addressed through robust strategies of cooperative border risk management and international governance. This research will examine the multiple ways that trade, security and immigration are connected, as well as methods for cooperative border management and crime containment in North America.

End-users:

- U.S. Immigration, Customs, Enforcement
- U.S. Customs & Border Protection
- U.S. Customs and Immigration Statistics
- DHS Counter Narcotics Enforcement
- Drug Enforcement Agency
- Federal Bureau of Investigation
- Central Intelligence Agency
- State Department
- Local law enforcement agencies
- Department of Commerce
- Department of Transportation
- Trade Authorities
Project 7.1: Optimizing Inter-agency Coordination

Investigators

- Kevin J. Strom, RTI International
- John Hollywood, RTI International

Introduction

Multi-agency coordination is a challenge when agencies do not routinely work together and have different mandates and procedures. Immigration enforcement is an area that requires effective inter-agency coordination, as various amendments to the Immigration and Nationality Act have broadened the authority for state and local law enforcement. Federal agencies such as ICE and CBP must communicate effectively with each other and state and local agencies playing vital roles in border communities.

The goals of this project, therefore, are to:

- Identify and characterize the needs for multi-agency coordination in the area of northern and southern border security
- Identify and characterize the barriers leading to shortfalls in coordination across the four areas described above
- Develop and validate recommendations to improve multi-agency coordination

The principal end users for the results of this project will be DHS and constituent federal agencies involved in declaring standards and training for multi-agency coordination, or determining what state and local grants to improve coordination and communication should be improved. The results will also be of high interest to state and local border agencies, although their abilities to implement some of the recommendations directly (especially recommendations involving nationwide technical standards) will likely be limited.

Project Description

This project will identify and characterize the following barriers to coordination:

- **Legal and structural barriers** – Agencies have unique hierarchies and processes for navigating the chain of command, legal limitations, and varying geographical and topical jurisdictions. These differences can discourage, delay, or prohibit joint planning initiatives.

- **Communication barriers** – Agencies tend to develop their own jargon, which can inhibit cross-agency communication. Communication is often delayed or limited because agencies have their own protocols for sharing information.

- **Cultural barriers** – Agencies have cultural standards that reflect their staffs’ educational and social background, as well as the organizational hierarchy, leadership styles, and core agency mission. These standards can include approaches to interacting with the public, problem solving, and decision making.
• **Leadership barriers** – Coordinated planning and response requires a significant ongoing commitment to support multi-agency activities that may be different from those generally required to support core agency missions. Leadership becomes a barrier if they will not commit staff and resources to coordinated solutions.

In addition to exploring the barriers, we will perform an in depth analysis and characterization of needs for multi-agency coordination to ensure security along the northern and southern borders. Following this analysis we will develop, validate and provide recommendations for the improvement of multi-agency coordination.

This project builds off of previous projects funded by the US Department of Justice which focused on interagency coordination among law enforcement and public health agencies, as well as a project that examined coordination among London emergency response agencies following the 2005 London transit bombings. As part of that work, major barriers and potential solutions to interagency coordination were identified, along with a conceptual model for improving interagency coordination. The current project is different in that it will focus specifically on multi-agency coordination among U.S. agencies tasked with border security. One of our major goals will be to identify common barriers to coordination among border agencies (including federal, state, and local agencies) as well as promising strategies for bypassing these barriers.

To our knowledge we do not know of any other work being funded by DHS that is duplicative to this project. DHS has funded projects related to developing technical solutions to improving agency coordination (e.g., interoperable systems) however the current project is quite different in that it will identify higher-level barriers to coordination (i.e., cultural, legal, communications) in addition to technical networking issues. Furthermore, the project will identify strategies or technical mechanisms that have been successfully used in U.S. border jurisdictions to solve common coordination-related barriers.

**Leverage**

This project will build on past grants from the U.S. Department of Justice that focused on interagency coordination. Specifically, we can use the data collection protocols and basic research design employed in these past projects in our current project. While some revisions will be necessary to reflect the focus on border security, these past efforts will greatly facilitate the current work.

The approach to this project derives from two earlier sets of research. The first includes prior research by RTI into multi-agency coordination, culminating in a detailed review of London’s successful response to the 7/7 bombings, and the development of a standard model for multi-agency coordination. The second includes prior research sponsored by the Department of Defense on developing requirements for, and assessing the performance of, network-centric operations, culminating in a detailed assessment of the DoD’s ground blue force tracking portfolio. We will conduct a “light” version of the DoD’s capabilities assessment methodology, JCIDS (Joint Capabilities Integration and Development System).
### Deliverables and Schedule (Project 7.1)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Literature review</td>
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</tr>
<tr>
<td>B</td>
<td>Report: Identify project stakeholders and assemble the expert panel</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Report on preliminary review of interview instrument with DHS and expert panel</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Case studies in 3 to 5 border jurisdictions</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>Report: Identify, and conduct interviews in, major infrastructure sites for border security and immigration information</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>White paper: requirements for multi-agency coordination</td>
<td></td>
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<tr>
<td>G</td>
<td>White paper: shortfalls for multi-agency coordination</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>Work with subject matter experts to identify and characterize options for improving coordination</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Report: Apply systems analysis techniques and predictive modeling to identify the most promising recommendations and optimal tradeoffs</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>Final report; educational and training modules</td>
<td></td>
</tr>
</tbody>
</table>

**Completed Deliverables – Year 1 (June 2009)**

- Assemble and review literature

**Specific Deliverables – Year 2**

- Conduct initial interviews at border security and immigration locations
- Conduct case studies
- White paper on requirements for multi-agency coordination
Project 7.2: Central American Gangs as a Proxy for Criminal Activity and Terrorism

Investigators

- Charles M. Katz, Arizona State University
- David Schaefer, Arizona State University

Introduction

Going beyond a doorstep defense of U.S. security requires developing strategic responses to serious threats at some distance from both U.S. borders. One such threat is that of third-country nationals who use Mexican territory as a gateway to enter the United States, often legally, to engage in criminal activity or to commit political violence. The two goals of this study are to:

- Understand the organizational structure and sophistication of transnational criminal gangs and their capacity to facilitate mobility and migration through Mexico into the United States
- Understand the dynamic social networks of transnational criminal gangs and their capacity to facilitate mobility and migration through Mexico into the United States.

Accordingly, this project will provide policymakers a description of the migration and mobility patterns of transnational gangs between the U.S. and Central America through Mexican territory and a framework for understanding the mobility patterns of third country nationals and how such persons, using methods similar to those of transnational gangs, enter the United States.

Benefits

- Provide policymakers with information related to the various methods terrorists might use to enter the United States for the purpose of engaging in politically-motivated violence
- Potential end users include field operations, intelligence specialists with U.S. Immigration, and Customs Enforcement, U.S. Customs and Border Protection, and the Drug Enforcement Administration

Project Description

*Interviews with Local Gang Experts* – Based on work developed by the Euro-gang program and US scholars, in-depth interviews will be conducted with local gang experts to describe the migration and mobility patterns of transnational gangs between the U.S. and Central America. Initial contact will be made with those who have been determined to have expert knowledge on either gangs or migration/mobility patterns. These will include individuals from sectors such as: law enforcement, corrections, military, immigration, social services, NGO’s, and researchers. These individuals will be asked to nominate others who have significant contact with gang members or who have substantial expertise in gang-migrant/mobility patterns.

*Central American Detainee Survey* – Surveys will be conducted with recently detained Central American gang members, including Mara Salvatrucha (MS-13) and the 18th Street gang (Barrio 18). This particular method will be modeled after National Institute of Justice’s (NIJ) Arrestee Drug Abuse Monitoring (ADAM) Program, which was designed to collect, analyze, and report
on the criminal behavior of recently booked arrestees. In-depth survey interviews will focus on migration and mobility patterns of transnational gangs between the U.S. and Central America, including co-occurring criminality, organizational structure and sophistication, and social networks.

Field Surveys – The research study will employ the use of a snowball sample to identify, recruit, and interview Central American gang members. Similar to prior gang research in the United States and Europe, a select number of individuals will be identified through social service agencies. These individuals will be recruited and interviewed and new subjects will be recruited through their nomination/friendship networks. While the instrument and methodology will be developed by Drs. Katz and Schaefer, local research firms familiar with the population will be selected to carry out the field study.

This research is not duplicating any work being done at the DHS. This project provides a unique focus on understanding the organizational structure and sophistication of transnational criminal gangs and their capacity to facilitate mobility and migration through Mexico into the United States.

Methodology

- Tripartite approach to identifying the methods, patterns, and scope of transnational gang migration
- Semi-structured interviews with gang experts and stakeholders
- Personal network interviews with gang members in U.S. detention facilities
- Field surveys of Central American gang members

Leverage

This project extends existing studies of transnational criminal gangs in Central America to anticipate methods and approaches that could be used by third-country nationals to commit politically-motivated violence in the United States. Additionally, this project will benefit from investigator experience in multi-site studies of gang task forces and surveys of arrested and incarcerated individuals (including gang members and illegal immigrants).
Deliverables and Schedule (Project 7.2)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Survey instruments</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Transcript: Interviews with gang experts</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Transcript: Interviews with gang members in US facilities and field surveys</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Final report</td>
<td></td>
</tr>
</tbody>
</table>

**Completed Deliverables – Year 1 (June 2009)**

- Assemble literature on social networks and transnational/Central American gang activities and mobility patterns
- Develop list of stakeholders and gang experts for interviews
- Create semi-structured interview protocol
- Identify subcontractor for international data collection

**Specific Deliverables – Year 2**

- Interviews with experts on gangs
- Interviews with gang members in US facilities
Project 7.3: Local Law Enforcement Collaborations to Identify, Investigate, and Prosecute Criminal Aliens

Investigators

- Charles M. Katz, Arizona State University
- Nancy Rodriguez, Arizona State University

Introduction

This project will be concerned with advancing the understanding of how decisions to collaborate with federal immigration authorities impact law enforcement agency’s response to criminal aliens. It will have four major objectives. The goals of this project are to:

- Identify and examine the factors that have led to local law enforcement collaborations with federal immigration authorities (including the creation of 287(g) agreements). Specifically, we will focus on the nature and extent of the criminal alien problem prior to such collaborations; significant events that preceded the decision to collaborate; and internal and external pressures placed on the local law enforcement agency that might have influenced the decision-making process.
- Identify the activities that local law enforcement agencies have been engaging in, to clarify conceptually the roles of police to enforce federal immigration laws.
- Examine alternative ways in which police have organized resources to respond to criminal aliens. A variety of organizational configurations are in use, yet little attention has been paid to how the specific configuration within a police organization might affect the organizational perception of the problem and shape the specific programs and practices of the response.
- Examine the relevant beliefs of local and federal law enforcement officers, and how their beliefs might affect the response to criminal aliens.

Benefits

- Provide DHS information on how local law enforcement decisions to collaborate with federal immigration authorities
- Impact immigration enforcement of criminal aliens

Project Description

The proposed project would bring together multiple sources of data from three jurisdictions to help explain, clarify, and corroborate issues of question. Semi-structured interviews would be conducted in each of the three sites. Additionally, official documents and newspaper articles will be analyzed for historical context, description of the agency’s official mandate, and discussion of the common practices and beliefs of police officials.

Semi-structured Interviews – Personnel representing key stakeholders in the response to criminal aliens will be interviewed. The main purpose of the interviews will be to add insight into the law enforcement response to the community's criminal alien problem and advance our understanding of how decisions to collaborate with federal immigration authorities impact law enforcement.
agency’s response to criminal aliens. First, in-depth interviews will be conducted with those who are “primarily responsible” for the local law enforcement response to criminal aliens. Law enforcement officers will be interviewed to aid in understanding the criminal alien problem from the perspective of the local officials. In particular, the interviews will be designed to extract subjective reactions from officials regarding what they consider to be the realities of their work situation, what they feel that they must do to effectively perform their job, and what they perceive they actually do on the job. Second, and related, we will ask those who are primarily responsible for the local law enforcement response to criminal aliens to nominate other key stakeholders. These individuals will be interviewed to gain additional information on the local response to criminal aliens and to further understand how federal authorities influence local law enforcement agency’s response to criminal aliens.

Official Documents and Statistics – Official documents and statistics produced by police and prosecutors will be used for the present study. These will include such documents as Standard Operating Procedures (SOP), annual reports, inter-office communications, intelligence and training bulletins, sign in sheets, grants obtained by police and prosecutors, booklets, and statistics kept by police and prosecutors. These documents are intended to serve as both primary and secondary research materials. They will serve as primary research materials in that they will be used to document how police and prosecutors have been directed to conduct themselves and issues that may influence their behavior. In other words, the documents produced by law enforcement officials are expressive of organizational arrangements and may also place the organization in a historical context.

Newspaper Articles – The study will make use of newspaper articles obtained from local newspapers. The newspaper articles are not only intended to provide a historical record of the development of the local law enforcement response to illegal immigrants in terms of its organizational mandate and role, but also to provide additional insight into the various external forces that may have impacted the response to the city's problem. Because the newspaper serves as a forum for the community to speak about its concerns, newspaper articles may also provide a rich source of data on how those in the community feel about the police response to immigrants. Accordingly, the newspaper articles offer a different view of the city’s problem and may offer different opinions as to how the problem should be approached and how police and prosecutors should respond to the city’s immigration problem.

To our knowledge, this project does not duplicate any research efforts currently being conducted at the DHS or elsewhere.

Leverage

This project will leverage off various associations, task forces, and the following previously funded grants:

- Previous Grant 1: West Valley Information Sharing Enterprise – funded by DHS
- Previous Grant 2: Understanding and Improving Law Enforcement Responses to Human Trafficking – funded by DOJ
Deliverables and Schedule (Project 7.3)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>Report: Three sites selected, interview instruments developed, official documents and newspaper articles will be collected</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Report: Interviews data will be collected along with additional official documents and newspaper articles</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Report: Data analysis, follow up site visits to clarify issues of importance, and report writing</td>
<td></td>
</tr>
</tbody>
</table>

Completed Deliverables – Year 1 (June 2009)

- Site selection (3 sites)
- Instrument development

Specific Deliverables – Year 2

- Interview data collection
- Document collection
Project 7.4: Balancing International Trade and Border Security

Investigators

- Jason Ackleson, New Mexico State University
- Yosef Lapid, New Mexico State University
- Scott Whiteford, University of Arizona
- Elyse Golob, University of Arizona
- Raquel Rubio-Goldsmith, University of Arizona
- Anna Ochoa O'Leary, University of Arizona
- Rick Van Schoik, Arizona State University
- Kevin O'Shea, National Law Center for Inter-American Free Trade

Introduction

The underlying premise of this project is that in the emerging international security environment, unilateral efforts to provide northern and southern border security will need to be augmented by cooperative measures and judiciously selected tools of international governance. The goals of this project are to:

- Survey, inventory, and assess international governance concepts, institutions, agreements and legal mechanisms, analyzing the role they currently play in governing US border security, trade facilitation, and cross-border mobility/migration. Develop a useful model for understanding transnational issues and international governance in the US border context

- Identify gaps in existing frameworks and catalogue pressing international governance challenges including human smuggling, narcotics trafficking, terrorism, other criminal activity, and trade barriers. Apply conceptual tools to relevant case studies in areas of border security, trade, and migration. On that basis, provide policy options for enhanced effective international cooperation to help manage the border domain and address these key transnational issues, thus filling identified gaps. Remaining barriers to cooperation will be catalogued

- Establish a COE “North American Security Cooperation Forum” that includes DHS and other border security practitioners, stakeholders, and COE specialists—as well as their international counterparts—to foster a sustained dialogue and create a framework for enhanced cooperation

- Compile “Best Practices” for managing the US-Mexico and US-Canada border domains on the basis of O1-O3, and fold these into a summary report detailing policy options for DHS

Benefits to DHS

- Enhanced awareness of best practices to manage mobility/security tradeoffs
- Improved understanding of intended/unintended and domestic/international aspects of border security
- New approaches to border security for identifying policy gaps

Project Description

Objective 1:
- Recent years have witnessed a surge in innovative scholarship on international governance. We will survey, inventory, and assess this literature, examining its relevance and ramifications for North American border practices. This will include an analysis of the institutional frameworks govern cross-border relations, such as NAFTA, the Smart Border Accords, and other legal mechanisms.
- Researchers will develop a model to understand transnational issues and international governance in the US border context. Results will be summarized in a White Paper.

Objective 2:
- We will catalogue the key public policy challenges to effective border management, e.g., organized crime, terrorism, narcotics smuggling, trade facilitation, and related transnational concerns. We will then use the risk analysis model produced by COE project 4 to evaluate the risks to US security and prosperity prompted by these issues and which may be addressed through international governance measures.
- Researchers will identify gaps in the institutional governance framework and practices at US borders in solving these problems. We will apply relevant conceptual tools to a selected set of case studies in policy areas of border security, trade, and migration. Specific issues of concern may include data sharing, joint law enforcement, Visa Waiver Program reform, US-VISIT and WHTI implementation. The list of policies will be partly contingent on DHS-identified priorities.
- On this basis, the results of this analysis will be compiled into a cross-border “scorecard” that assesses cooperation on major identified cross-border issues.
- Through a White Paper, we will also provide policy option analysis to overcome obstacles and develop cooperative international border management and security systems, including threat awareness, cooperative border management, information exchange (law enforcement, customs, etc.) and joint law enforcement against shared threats. Remaining barriers to cooperation will be identified.

Objective 3:
- In order to craft the framework to address remaining barriers to cooperation, we will plan and then hold a major COE “North American Security Cooperation Forum.”
- We will identify, contact, and invite relevant officials from DHS, other law enforcement agencies, stakeholders (business interests, civil society, border community members), scholars, and institutions. This list will have a major international dimension (e.g., representatives from analogous organizations in Canada, Mexico, and Europe).
The Forum will include presentation and dialogue sessions that will establish a framework for collaboration and productive dialogue between scholars, practitioners, stakeholders, and policymakers who are dealing with border governance challenges facing the US and its allies in the post-9/11 strategic environment. It will bring together a high-profile international and multidisciplinary group of scholars, experts and practitioners involved in different ways and at different levels in cross-border governance.

The Forum will be recorded and presentations will be synthesized into summary conclusions that will be forwarded to DHS.

Objective 4:

- Project researchers will conduct a comprehensive international survey of cross-border security cooperation practices, policies, and institutions.
- Project researchers will then generate a final White Paper report that compiles “Best Practices” for DHS to cooperatively managing the border domain.

Objective 5:

- Researchers will develop new conceptual and methodological tools to examine bi-national borderland governance mechanisms already in place.
- We will host two Methods Research Workshops drawing on ongoing border research with an emphasis on new methods, instruments, and ethics issues. These will focus on three borders, U.S.-Mexico, Canada-U.S. and Mexican-Guatemala.

Methodology

- Case study
- Literature review
- Surveys
- Structured interviews

Leverage

This project leverages a robust record of externally-supported research as well as institutional and strategic assets. Project PIs have received funding for related work from both DHS as well as other agencies such as the U.S. Army War College Strategic Studies Institute, and the US Department of Education. PIs are collaborating with other DHS COEs, including the National Center for Food Protection and Defense. In addition, the project will utilize institutional resources at the North American Center for Transborder Studies (NACTS), the Southwest Consortium for Environmental Research and Policy Border Institute, and the Center for Latin American Studies at the University of Arizona. Finally, the project will draw on insights from a global network of scholars engaged in international governance, security, trade, and immigration research.
## Deliverables and Schedule (Project 7.4)

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Deliverables</th>
<th>Schedule (Year)</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>Inventory of major international governance (IG) concepts and their application to the US border domain</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>Model development</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Summary white paper</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Catalog of transnational challenges</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>White paper: Identification of gaps in the IG framework</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>Methods Workshop #1: focus on distinct challenges concerning interdisciplinary, mixed-method survey research in border region. Goal is to develop flexible methodological model to apply in different regions</td>
<td>1, 3, 5</td>
</tr>
<tr>
<td>G</td>
<td>White paper: Identification of DHS priority issues</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>Case studies</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Scorecard and white paper</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>Report: Identification of remaining barriers</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>Methods Workshop #2: explore how proposed methodological approaches from 1st workshop can be successfully applied to study mixed immigration-status families in relationship to border security policies</td>
<td>1, 3, 5, 6</td>
</tr>
<tr>
<td>L</td>
<td>Security forum planning</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Forum scheduling and invitations</td>
<td></td>
</tr>
</tbody>
</table>
### Specific Deliverables – Year 2

- Begin first case study on trade
- Methods Research Workshop #1
  - Finalize topics and date
  - Distribute call for papers
  - Distribute invitations to selected scholars and Center partners
  - Implement organizational and logistical plans
  - Convene workshop
  - Compile results for publication