Strategic Multilayer Assessment (SMA)

The Use of Remote Sensing to Support the Assessment of Political Durability: A Pilot Workshop

Observable Manifestations of
Hearts & Minds: Identifying Opportunities for Remotely Sensing Popular Perceptions Effort

7-8 DECEMBER 2010

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This report represents the views and opinions of the workshop participants. The report does not represent official administration policy or position.

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EXECUTIVE SUMMARY

The *Use of Remote Sensing to Support the Assessment of Political Durability Pilot Workshop* was held jointly by the Strategic Multilayer Assessment (SMA) Office and the US Army Corps of Engineers (USACE) Engineer Research and Development Center (ERDC) from 7-8 December 2010 in Arlington, Virginia. The workshop is part of a proposed effort called *Observable Manifestations of Hearts & Minds: Identifying Opportunities for Remotely Sensing Popular Perceptions Effort*.

The goal of the proposed project is to develop regionally tailored, global remote sensing[1] collection requirements and strategies in order to identify the sources of fragility and, potentially, early action when fragile states show vulnerability. The first step is to take a deep dive into the use of remote sensing technologies to assist social science assessments in the areas of governance, security, and development.

Environmental conditions manifest constraints and enablers on human activities, community resilience, and regional situations. At the same time, humans exert influence on the environment, which reflect changes in agriculture, development and, indirectly, population-based characteristics, behaviors, and trends. This conceptual bridge points to the potential that one can use remote sensing as proxies or compliments for political, social, military, economic, and other variables of concern to the evaluation of stability and resilience. Accordingly, measurable environmental change exhibited on the Earth surface may provide an important, though indirect, indication of state stability or potential conflict, acting in combination with other social-economic and institutional factors.

Over the past decade, several major research efforts link natural sciences through the study of land-use and land-cover change with the social sciences. However, many of the efforts result in models generally too complex for non-researchers. We urgently need to adapt and accelerate the convergence of social and physical data into a coherent implementation strategy, which, for example, the US Government can use today in the Counterinsurgency (COIN) environment and which can also extend globally to provide more robust indication of stability indices in areas of national concern. In a COIN environment, the potential role of remote sensing becomes very important due to the cost and risk associated with gathering information and making assessments using deployed forces.

In Afghanistan, transition decisions by the International Security Assistance Force (ISAF) involve identification of "stable" governing and economic systems, as well as resilience of that (stable) condition. We define political durability as a function of governing, economic, and social stability. In this case, why do we think that "durability" rather than just stability has critical importance? A system that proves stable under a given set of conditions can nevertheless contain latent drivers of instability, which emerge once conditions become different. Transition from ISAF to local leadership in Afghanistan represents such a change in conditions.

For determining when a political system has stability and resiliency sufficient for self-sustainment in the face of internal and external shocks, we can use a conceptual framework called a Durability Model. For Afghanistan, the Durability Model aims to support ISAF transition decisions by providing decision makers with a theoretically rigorous, yet intuitively reasonable, framework for

[1] unclassified stand-off collection through the use of a variety of devices for gathering information on a given object or area (e.g., satellite measurements)

understanding the complex Afghan environment. Indicators lead to derived operationalized variables and to suggestions for data requirements and collection methods, (e.g., social services--water measured as an observable plus a survey item). The degree to which remotely-measured environmental indicators can support a durability framework remains unexplored.

The workshop had a two-fold objective:

(1) to provide a pilot forum to discover, explore, and develop the nexus between remotely-sensed environmental indicators and population-based metrics using the situation in Afghanistan as a use case; and
(2) to set the scope, terms, and charter for subsequent efforts across the DoD, inter-agency community, and the science academies to learn and discuss the potential of remotely-sensed physical/environmental data in a surrogacy or complimentary role for operational metrics in stability operations (tactical) and/or in a role as a long-term indicator of political durability (strategic).

On the first day, participants shared their expertise in remote sensing technologies, operational objectives and metrics, social and cultural data from the Pakistan and Afghanistan Rich Contextual Understanding (PAKAF RCU) Study, causes of state failure, and related agency initiatives and research. By the end of the first day, items of interest for further recommendation to ISAF were identified for development.

On the second day, participants broadened the discussion to explore the feature space of situations not particular to the Afghanistan case study. Participants examined similarities and dissimilarities between the case study and the wider global situation. In the afternoon, participants developed the concept and charter for a second workshop in early spring 2011 to take some of the salient generalities and specific recommendations from this effort to a broader dialogue.

Understanding the spectrum of remote sensing opportunities in the context of population-based frameworks constitutes the long-term goal. The effort also seeks to develop regionally tailored, global remote sensing collection requirements and strategies in order to identify the sources of fragility and early action when fragile states show vulnerability. Accordingly, the learning, outcome, and recommendations from this pilot event will lead to a more broad-based workshop early in 2011 and associated white paper.

7 DECEMBER 2010

OPENING REMARKS (DR. HRIAR CABAYAN & DR. BERT DAVIS)

Dr. Hriar Cabayan, Strategic Multi-Layer Office (SMA) Office of the Secretary of Defense (OSD), and Dr. Bert Davis, US Army Corps of Engineers (USACE) Engineer Research & Development Center (ERDC), welcomed participants to the *Use of Remote Sensing to Support the Assessment of Political Durability Pilot Workshop* in support of the proposed *Observable Manifestations of Hearts & Minds: Identifying Opportunities for Remotely Sensing Popular Perceptions* effort.

Dr. Cabayan gave an overview of the SMA mission. The SMA program provides planning support to COCOMs (Combatant Commands) and war fighters. The program coordinates with the Office of the Secretary of Defense, the Joint Staff, and STRATCOM to support global mission analysis and joins with STRATCOM analytic teams to develop new analytic capabilities in support of specific tasking. These analytic capabilities seek to orient the commander to a decision for action. SMA develops multi-disciplined, multi-organizational teams for specific projects. It emphasizes the integration of human, social, cultural, and behavioral factors through participation of sociologists, anthropologists, and economists, as well as universities, non-governmental organizations, and various interagency partners. SMA efforts produce focused, multi-disciplined strategic and technical assessments. The output results in training and education in the development and application of new analytic tools.

The purpose of the Remote Sensing workshop was to initiate the development of a regionally tailored, global remote sensing[2] collection requirements and strategies in order to identify the sources of fragility and, potentially, early action when fragile states show vulnerability. The workshop was the first step in taking a deep dive into the use of remote sensing technologies to assist social science assessments in the areas of governance, security, and development.

Dr. Cabayan welcomed participants representing diverse communities ranging from academia to industry to government. The workshop brought together the social science and the remote sensing communities. Advances occur when you get multidisciplinary groups together. New sparks of creativity emerge from working together on efforts like this. This multidisciplinary effort, which seeks to use remote sensing technology to better understand the hearts and minds of Afghans, fits the vision espoused in MG Michael Flynn's book *Fixing Intel: A Blueprint for Making Intelligence Relevant in Afghanistan*.

Dr. Cabayan noted that SMA is involved because this kind of study is difficult for troops on the ground to do when their lives are in danger. The remote sensing effort will help the warfighter understand how remote sensing can aid their ability to understand the population. Remote sensing will not replace the intelligence gathered by boots on the ground, but will take the pressure off so that they can focus on their mission.

Dr. Cabayan expressed two goals of the project. First, the effort should demonstrate how remote sensing tools could help warfighters understand the population in Afghanistan. Second, the effort should more broadly look at how remote sensing can be used in future war-fighting environments

[2] unclassified stand-off collection through the use of a variety of devices for gathering information on a given object or area (e.g., satellite measurements)

where the US has fewer people on the ground. The ultimate objective is to identify emerging crises and, where able, to move the situation back to phase zero.

Dr. Cabayan stated that the social science and remote sensing communities can work together to help inform one another. It could open up a whole new avenue of research in terms of global trends. He suggested that the workshop participants read the Office of the Director of National Intelligence's (DNI) Global Trends 2025 report to understand the challenges facing the United States in the near future. The report should drive the thinking of tomorrow.

Dr. Bert Davis also welcomed the workshop participants. He spoke about the field of cultural geography that marries both the cultural and physical aspects of geography, which is highly relevant to this effort.

Dr. Davis spoke about an ongoing Defense Science Board (DSB) study that is exploring how intelligence, surveillance, and reconnaissance (ISR) can improve support to counterinsurgency (COIN) efforts especially in light of the joint campaign plan signed by GEN Stanley McChrystal and Lt. Gen. Karl Eikenberry a year ago. He said that the panel has a lot of ideas with respect to counter-terrorism, but few ideas with respect to counterinsurgency, development, or building respect and trust.

Dr. Davis stated that there has long been a void between the social science and remote sensing communities. Therefore, this effort will first socialize the two communities to free them from the tethers that bind them so that they can think creatively about the complex problem of remotely sensing the human terrain.

While there is currently no system in existence that proposes to use remote sensing data to understand the hearts and minds of the populations in COIN environments, remote sensors are used for a number of humanitarian functions, such as famine or drought early warning systems.

The remote sensing effort will be guided in part by the Political Durability Model created for the SMA Rich Contextual Understanding effort, which Dr. Allison Astorino-Courtois, NSI, would brief to the group later in the day.

The first day of the workshop was scheduled so that participants could share their expertise in the following fields:

- social and cultural data from the Pakistan/Afghanistan Rich Contextual Understanding (PAKAF RCU) Study;
- remote sensing technologies;
- operational objectives and metrics; and
- related agency initiatives and research.

By end of day, participants coalesced items of interest for recommendation to ISAF for further development. Day two of the workshop broadened the discussion to explore the feature space of situations not particular to the Afghanistan case study. The participants were asked to examine similarities and dissimilarities between the case study and the wider global situation. They were also asked to develop the concept and charter for a second workshop in early spring 2011 to take some of the salient generalities and specific recommendations from this effort to a broader dialogue.

INTRODUCTION (DR. ALLISON ASTORINO-COURTOIS)

Dr. Allison Astorino-Courtois, NSI, briefed the participants on the Pakistan and Afghanistan (PAKAF) Rich Contextual Understanding (RCU) effort conducted under the SMA program. The RCU effort had three components:

1. PAKAF RCU I & II Study
2. PAKAF RCU Metrics and Indicator Development
3. Political Durability Model

PAKAF RCU I

In the PAKAF RCU I effort, COMISAF GEN Stanley McChrystal argued that overwhelming amounts of classified and open-source information failed to supply a broad, foundational understanding of the COIN environment in Afghanistan & Pakistan. The SMA's objective was to help provide a "rich contextual understanding" of the population (i.e., the political and social environments) to support conduct of COIN operations. The focus was on understanding the interrelations of social, economic, and political events with security factors down to the district level in Afghanistan.

RCU I lasted from August 2009 to February 2010. It covered 16 districts in Afghanistan and produced the following deliverables:

- (U) and (C) PAKAF **Data Holdings SharePoint** – 'one stop shop' of 1500+ AFG-related documents from US, international, academic, military, commercial, web, etc., sources plus all project-developed documents and reports
- 27 independent **Sub-team Reports**
- 25 **"Flynn 40 Questions"** white paper responses
- 3 province and 16 district-level **"Baseball Card" Summaries**
- 18 Additional **Information Bin** write-ups
- 11 **Quick Look** White Papers

PAKAF RCU II

The purpose of RCU II was to assist the ISAF Information Dominance Center (IDC) in developing metrics and measure of improvement in districts and provinces in Afghanistan. This effort lasted from January to October 2010 and resulted in the following deliverables:

- IDC District and Provincial Metrics & Assessment **Framework & Methods Review**
- **Out-of-the Box Analyses**
    - Empirical Analyses
    - Academic Consortium Reports + Crowd-sourcing
- **Catalog & Critical Review** of Utility of SIGACTS, KLE ,TCAPF & Survey Data population-centric analyses
- Development of **Generic Durability Conceptual model** with supporting source documentation and citations and "user's guide"
- **AF-specific Durability model** including a key Indicators of Durability list with measures specific to assessing AF context, including data source suggestions

Dr. Cabayan noted that the effort was always focused on the population base. It did not look at red activities at all. Political durability is important for ISAF because it influences the transition decision of when to hand power over to the government in a region or district.

One participant asked what was meant by population. Did the SMA team conduct demographic analysis? Dr. Astorino-Courtois responded that the team did not do demographic analysis, but it is an example of a source one might tap to discover more information. The team was more focused on behavioral indicators.

One participant also noted that Dr. Astorino-Courtois was using military terminology, which has a different meaning on the civilian side. The problem is that the effort only makes sense if you know the DoD meaning. Therefore, the point of this discussion—to increase multidisciplinary understanding—is defeated by the terminology used. Dr. Astorino-Courtois conceded the point and warned that it would only get worse before it got better and asked the participants to speak up if they do not understand how a term is used.

Dr. Cabayan pointed out that many of the terms used are widely understood by the US government actors, including the US Departments of State and Treasury. They are not just military terms, and they are well defined.

Mr. Collin Agee, National Geospatial Agency (NGA), stated that the objective of the remote sensing effort is to look at pre-crisis situations, but what was done for RCU I and II was for transition, which is very different. It is the inverse of what the remote sensing effort is trying to do. Dr. Astorino-Courtois responded that the RCU team took that into consideration by changing the question to be more general. The Political Durability Model and the indicators were designed to be independent of certain contextual factors, while still being customizable to the situation.

Dr. Davis stated that political durability is an interesting nuance. If you think about what would happen if NGOs stopped providing food aid in some parts of Africa, people would starve. There is no durability in that model. What the US does and what actions it takes need to be designed so that when the force leaves, the situation does not revert to crisis. The concept behind durability is to look at long-lead indicators of the physical environment, which tells you something about the population's environment.

Political Durability Conceptual Model

Dr. Astorino-Courtois stated that the Political Durability Model was created in response to a query by MG Flynn (ISAF J2) on how to measure the impact of ISAF actions to strengthen stability in Afghanistan prior to transition. The SMA team built a parsimonious generic conceptual framework for assessing political durability as a function of three necessary, but not sufficient, factors: economic stability, social stability, and governing stability. The team used model assumptions and concepts founded in 1) prior academic theory and research from a wide range of fields; 2) US policy and official documents; and 3) reports and sources specific to the Afghan context.

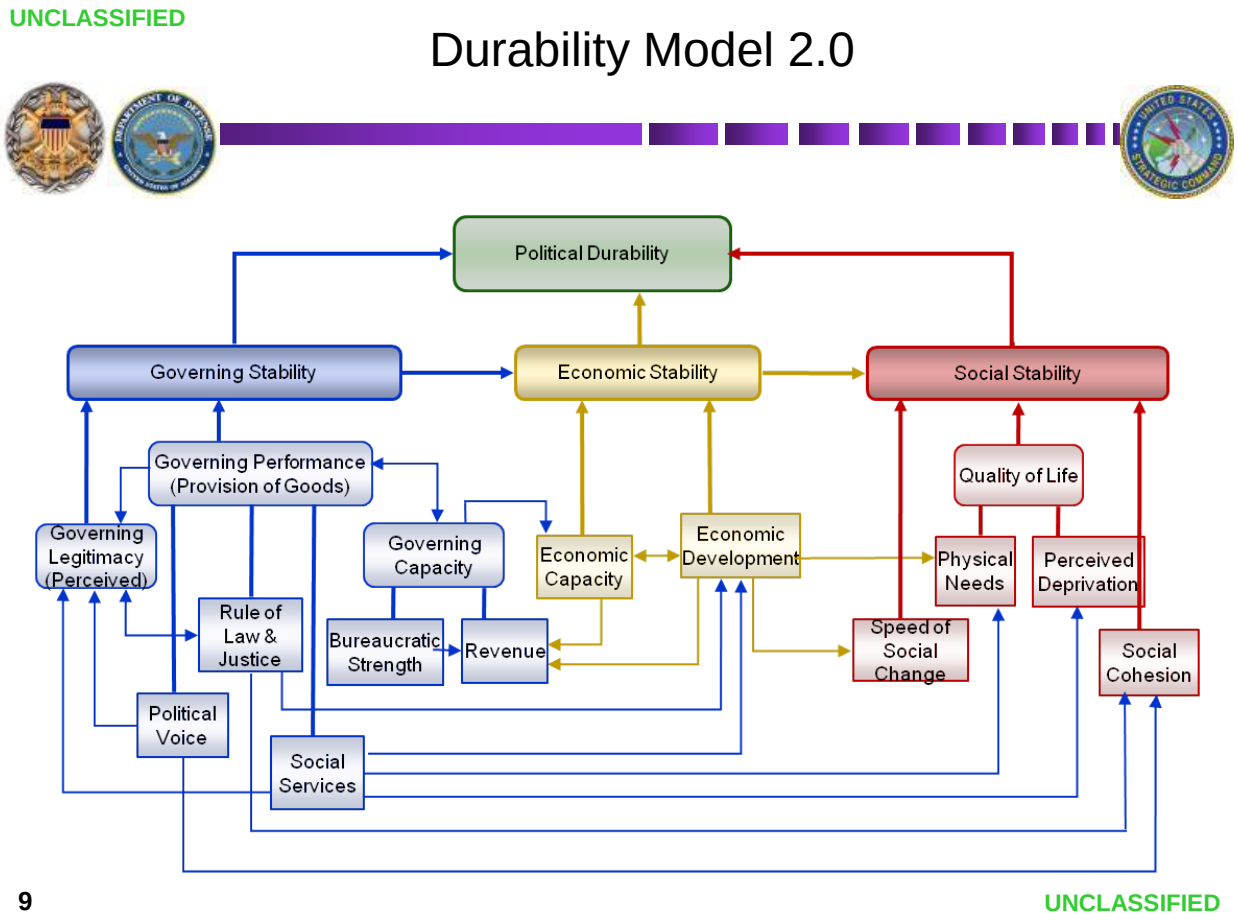

FIGURE 1. POLITICAL DURABILITY MODEL

The model showed that the necessary condition for transition is political durability; stability is not sufficient. A system that is stable under a given set of conditions can nevertheless contain latent drivers of instability, which emerge once conditions are altered. Transition from ISAF leadership certainly is such a change in conditions. Three attributes of the Durability Model make it a particularly flexible tool. These attributes include:

- independent of level-of-analysis;
- applicable to formal or informal systems; and
- independent of direct effects of most exogenous factors (it depicts necessary factors for stability and durability).

One participant asked if the SMA team considered land ownership. Often, land disputes are at the root of political instability in Afghanistan. Dr. Astorino-Courtois replied that the team did look at land ownership, but it was not specifically built into the model because it is specific to Afghanistan and the model was built to be general and parsimonious.

The model was created so that durability was a function of three types of stability: governing, economic, and social. Since the SMA team did not test the model, the team does not know the relative importance of the variables, but Dr. Astorino-Courtois suspected that they are variable.

One participant suggested that the model has a Western bias. It might be useful to test the model from a different cultural perspective.

Dr. Somnath Sengupta, BAE, asked whether there was any attempt to validate the model. Dr. Astorino-Courtois responded that this is a conceptual model. The SMA team would love to test it, but the data is lacking in Afghanistan. Therefore, the team substituted face validity and construct validity instead. The components of the model were heavily sourced based on prior research.

Dr. Cabayan stated that the model was reviewed by many experts. He suggested that the participants not get mired in questioning the validity of the model, but use the time to figure out if the model can be exercised using remote sensing data.

Dr. Astorino-Courtois walked the participants through the model. The SMA team first started with concepts and then broke them down into different dimensions relevant to Afghanistan. The dimensions were then broken down into indicators. Indicators were broken down into multiple perceptual or observational variables. These data are collected. The model specified for Afghanistan produces 46 indicators measured by 83 operationalized variable types.

Dr. Astorino-Courtois stated that because the model is generic, it could be applied to formal, informal, religious, or secular authorities. The trick is that the analyst identifies and uses only one level of analysis so that they compare apples with apples. If you want to compare the formal and the informal government system in Helmand, an analyst would have to first use the model to think through the informal and formal system separately and then compare the results.

Dr. Curtis Woodcock, Boston University, stated that he was struggling with understanding the difference between political stability and societal stability. Dr. Astorino-Courtois replied that political stability is support for governing structures. Social stability, which you could have absent of government stability, is defined in terms of social change, quality of life, and social cohesion. You could have a stable government and ethnic conflict. Conversely, there could be a homogeneous society and an unstable government. Dr. Woodcock stated that society durability might be more important as a goal than political durability.

Mr. Tom Bozada, USACE, said that what he was hearing was that there is an inherent social governing structure that already exists and the group is trying to implement a formal state in its place. In some areas, this could be a good thing; in other areas, this could be bad. We have to try to understand what is normal for the population in order to operationalize the variables appropriately. Dr. Claudio Cioffi-Revella, George Mason University, stated that the most appropriate term for this might be political culture. That is how society defines acceptable norms.

Dr. Astorino-Courtois suggested that government legitimacy could be measured through polling since it is perceptual. Those conducting polls include Gallup, Glevum Associates, the Canadians, ISAF, the Provincial Reconstruction Teams, and ASCOR, among others.

The participants agreed that there were no obvious sensing opportunities for governing capacity.

Mr. Bozada stated that in terms of economic stability (economic capacity and economic development), there are many remote sensing proxies, especially in rural areas.

Dr. Somnath Sengupta, BAE, stated that under economy and infrastructure, the model lists legislation. However, under rural, the model needs an indicator of availability of funds to women.

Dr. Cioffi-Revella asked whether we know if relative deprivation matters for Afghans. Do we have cross-cultural validation? It is true under cross-cultural global, but sometimes patterns break down when you localize them. The assessment of quality of life is highly dependent on local political culture. Dr. Astorino-Courtois replied that it is included because we do know, anecdotally, that there is competition or jealousy between groups. There is dissatisfaction when one group receives a benefit that the other group did not. In addition, we have seen that people who are educated switch their referent group from people in villages to the city, but we do not have quantitative data on that.

One participant asked why food security was located under social stability instead of economic stability. She suggested that food stability has to do with food prices. Dr. Astorino-Courtois responded that food security is included as a measure of quality of life because of the security aspect of obtaining food. It reflects the perception of safety in traveling to the market to buy or sell food.

Mr. Christopher Stewart, Gallup Consulting, asked how the model calibrates the shifting or sliding scale relating to perceptions. He suggested that one indicator is to look at how well a city is lit up at night. However, it is important to keep in mind perceptions. Some people are happy with 18 hours of electricity, while others think 22 hours of electricity is insufficient. Dr. Astorino-Courtois stated that the model is designed to be used to take snapshots over time. Therefore, the amount of electricity provided becomes a reference point that changes over time.

Mr. Bozada suggested that when people start expecting services from the government, not ISAF, then the government is mature enough for ISAF to detach itself. He said that the end state is providing information to ISAF on how to make transition decision. The important piece to know is what is missing out of normal life and culture in Afghanistan. The government should be supplying what is missing, not ISAF. What we need to know is whether the system is internally working. Dr. Cioffi-Revella stated that this could be measured through surveys. Ms. Pascale Siegel, Glevum Associates, stated that this could also be measured by observation.

Dr. Cioffi-Revella stated that at the end of the day, ground truth is what the population believes and expects. ISAF cannot impose expectations, because then it is put in the position of determining whether Afghanistan should be modern or traditional. It cannot decide that.

Dr. Astorino-Courtois stated that with regard to social stability, if social change occurs rapidly, there is an increased capacity for social disruption and instability. There are psychological and physical aspects of this issue.

Dr. Astorino-Courtois then shared her thoughts on remote collection. First, variables are not static but can be defined in many ways. For example, level of analysis, time frame, and the geographic region of interest for any particular project matter; they shape indicators and variables. Second, the class of variables requiring observation of change in conditions over time may be the most amenable to remote sensing. These are most likely economic and social conditions. However, political factors may be more difficult but not impossible to collect remotely, such as the provision of certain goods and services or evidence of a population taking advantage of government-provided services. Third, even if not sufficient by themselves, remotely sensed political, economic, and social

information may be a powerful value-add when used in combination with polling and typical sources of population data. They may improve explanatory power and robustness of analyses.

Dr. Davis then introduced Mr. Michael Campbell who gave a presentation on remote sensing 101. He stated that the first take away was that the connection between social science and remote sensing is tenuous, but the participants will identify threads to build upon.

IMAGE PROCESSING 101 (MR. MICHAEL CAMPBELL)

Mr. Michael Campbell, ERDC, presented a briefing of a basic overview of remote sensing entitled Image Process 101. Remote sensing is described as the gathering of any information about an object without physical contact. Our eyes are essentially complex remote sensing devices that we use every day. In a general sense, passive remote sensing picks up light that is reflected or emitted off the object. Active remote sensing emits energy in order to detect the light that is reflected off an object. Human eyes are passive remote sensors. This briefing focused on reflected light.

The scale of reflected light, a specific range of the electromagnetic spectrum, illustrates the range of wavelengths of electromagnetic radiation. Only part of the spectrum is actually visible. Human eyes see between 0.4 μm and 0.7 μm (micrometers). Another part of the spectrum that is pertinent to remote sensing is the infrared section: near-infrared (NIR) which covers 0.72-1.30 μm and short wave infrared (SWIR) with wavelengths 1.30 to 2.5 μm.

Remote sensing data is affected by spatial, spectral, radiometric, and temporal resolutions. Spatial resolution is the size of the pixel in an image. Pixels vary in size, depending on how the data is collected, but are always square in the imaging world. Spectral resolution depends on the number and width of the spectral bands recorded. Radiometric resolution is the range of intensity of color in each band. Temporal resolution is the rate in which a sensor is able to collect data of an area. Remote sensing data is typically collected by sensors that are either air or space-borne.

Mr. Campbell proceeded to describe some of the remote sensing systems in use. First, he described MODIS (Moderate Resolution Imaging Spectrometer). MODIS satellites can cover the Earth's surface every one to two days. MODIS is considered to have a coarse resolution with pixels ranging in size from 250 to 1000 meters. MODIS utilizes 36 different spectral bands. Considering the coarse resolution of the data and the speed of data collection, MODIS is great for large area images, for instance to see food production or food scarcity and looking at atmospheric conditions and bodies of water. Mr. Campbell showed an image of the Helmand River and pointed out the green vegetation, which is dark in the image. He compared this to a zoomed-in image of the same area. The pixels were blurry, and there was less level of detail.

The second device Mr. Campbell described was Landsat, "Land Satellite". Landsat offers repeat coverage of an area every 16 days. Landsat is considered to have a medium resolution with 30-meter pixels and seven spectral bands (six of which are optical). Landsat was launched in 1984 by NASA and continues to be a viable imaging sensor, even outlasting more recent replacements. Mr. Campbell provided image examples of the city of Lashkar Gah, the capital of the Helmand Province in southwest Afghanistan. Pixels are smaller and more clear and crisp, as compared to the MODIS image. Agricultural regions, desert, rivers, and the urban areas are seen in the image.

Commercially built and launched satellites are also in use. Mr. Campbell discussed one of these, Geoeye. This satellite provides multispectral data with 1.55m pixels and four spectral bands. It also

captures single band, panchromatic (black and white) images with 0.4m pixels. Areas can be revisited every two to three days. There is also a lot of data to visually interpret. Zooming in on an image, one can see streets, various structures, and irrigation channels. Because the Geoeye can handle multispectral and panchromatic data, the two kinds of images can be merged together to produce a very high-resolution multispectral image.

Mr. Campbell then described an airborne optical remote sensing system. Buckeye is a digital airborne camera that has been flying since 2004. The Buckeye is affixed to an airplane and, thus, can fly to any area and is not constrained to satellite orbits like space-borne systems. It was first deployed as an IED detection device and it successfully located IEDs.

Dr. Claudio Cioffi-Revella asked for the approximate flying elevation that the images were taken. Mr. Campbell said it depends on the aircraft, so elevation can change depending on the conditions and the intent.

The Buckeye system utilizes only in visible range of the spectrum. This system is very valuable in theater. Images produced are higher resolution than what is produced by satellite data. Mr. Campbell said that individual frames are digitally combined using standard photogrammetric techniques. Mr. Bozada said that traditional analysts should know what they are seeing, but knowledge is enriched when images are "ground truthed." Ground truthing is actually looking at what is going on "on the ground", a visual, human confirmation or analysis of what the image portrays. Mr. Campbell illustrated this by pointing out rows of objects in an image that are currently not positively identified. Ground truthing would be when someone could actually be in that location and could, with certainty, say the objects are rows of water canisters, for example. Dr. Davis added that there are troops on the ground available for ground trothing, but that presence will vary on a district-by-district basis.

A participant added that if an image of the ground is taken, the temporal aspects need to be known. For example, if the satellite passes over at one time of day but the market does not open until three hours later, then this information is pertinent.

Dr. Cioffi-Revella stated that social scientists discovered that many social concepts occur within simple distribution over time. However, some concepts tend to fall under a power law or other skewed distribution.

Dr. Davis stated that the workshop's intent is to work at the unclassified level and stay away from the "pattern of life" data. Remaining at the unclassified level allows the academic community to be involved. Unclassified data also means baseline data can be established in areas that were not of interest before. Mr. Bozada added that the intent is to use a baseline and look at changes over time. Change can then be examined and analyzed as either positive or negative, and patterns may be identified. Dr. Davis asked what remote sensing can reveal. Dr. Cabayan said a familiar issue throughout the workshop has been the idea of information in context. For example, there has been a 10-year drought going on in Afghanistan. Dr. Cabayan rhetorically asked what effect this even has had on patterns and what has this done to Pashtun upheaval. It is not enough to go back one year and look at what happened. The remote sensing community can be a very powerful tool to take into consideration and look at the long-term issues, while other projects look at more current issues. If only the current data is examined, much of the bigger picture is missed. It is vital to examine on and across multiple layers.

Mr. Campbell continued his briefing. He said that it is important to consider the size of the pixel and how that might affect interpretation. Mr. Campbell described spectral resolution as the digital powerhouse. Images are taken using different spectral bands, some of which are visible to the naked eye like blue, red, and green, and others which are not, like infrared. The fourth spectral band, infrared, adds a different composite, which Mr. Campbell called a false color composite, that shows vegetation components. Mr. Campbell provided an example of how different spectral bands are and how they can be viewed in different combinations to enhance unique earth surface features within images.

Mr. Campbell said that spectral curves, called spectra, show the ways different objects reflect electromagnetic energy (i.e., sunlight). Different features have a different spectral curve. For example, asphalt, made up of rocks and petroleum, shows up as black and has a low reflectance. Over time, as the asphalt breaks down, its spectral curve will change and an asphalt road will look more like soil in a spectral image. Hyperspectral images can have hundreds of bands.

Mr. Campbell did not review radiometric resolution.

Mr. Campbell then discussed temporal resolution. Temporal resolution refers to how often sensors capture data. Earth-monitoring satellites are in a near-polar orbit. One revolution around the Earth takes approximately 100 minutes. It is vital to understand how often and where a satellite can pass over an area. More passes over an area can mean more precision.

Mr. Campbell then described the differences between active and passive systems. Radar, LIDAR (Light Detection and Ranging), and sonar are examples of active systems. These instruments actively send out a pulse of energy and then measure the return of that pulse. Passive systems measure the energy reflected or emitted from an object. Examples of passive systems include optical, thermal, and passive microwave systems. This remote sensing primer is focused on optical remote sensing.

Mr. Campbell stated the geospatial product is a thematic map. Image processing algorithms are applied to the multispectral images to create single-band thematic images. Each pixel is put through statistical analysis and classified, or assigned to a discrete class. The raster product can then be turned into vector data and be ingested into a decision support system. In other words, the map or image is used to help someone to make a decision.

Mr. Campbell cited an example of being able to identify date palm and citrus groves using Buckeye images. Ms. Molly Brown, NASA Goddard Space Flight Center (GSFC), asked how the trees were identified as date palm forests. Mr. Campbell said the very high-resolution image showed that their tree crowns had palm-shaped leaves, which led to the identification of the date palm groves. Statistical analysis allows particular areas to be examined, and then estimations are made of what is nearby. Dr. Davis said that given the restraints of remote sensing, knowing a baseline of what to expect from crops, etc., and then what that cycle looks like over time is just as important to vegetation knowledge as it is to having knowledge about those crops in the marketplace.

Dr. Devin White, NGA, said the method used depends on the scale that is used. A problem can be approached in two different ways and yield the same outcome. Other information can be leveraged from different images. Dr. Curtis Woodcock said that there are three different kinds of imaging that can be produced: common, low-resolution with blurry images; more sophisticated images; and high quality, expensive images. Because the high-quality images can be hard to acquire, often

analysis is made of what is available, which will be made up of various kinds and quality of imagery. Ms. Brown stated that the smaller the pixel, the fewer the bands and, conversely, with more bands, you have to accept larger pixels. It is a trade-off.

Mr. Campbell reviewed high-resolution Digital Elevation Model (DEM) creation from airborne LIDAR data. Then Mr. Campbell discussed Quickbird, which acquires four-band multi-spectral images. Quickbird, LIDAR, and Buckeye images were used to create a terrain data set. Several months were required to determine which data sets and statistical analyses provided the best imagery. Then the image still needs to be manually tweaked and repaired.

Mr. Campbell stated that the questions that need to be asked are: (1) what land cover variables can be directly measured that provide useful data, and (2) what surface features must be indirectly measured and then modeled. Cartographic parameters need to be considered as well. Parameters are scale (e.g., 1:100 is larger than 1:100,000), attribution (the detailed descriptive information that accompanies the thematic maps), and land use/coverage change. Dr. Cioffi-Revella asked if this is from object-oriented analyses. That is, the pixels are objects that have attributes and dynamics. Dr. Davis said that from the baseline, temporal change can be examined. Temporal analysis can show the impact or how a population manifests itself on its environment. The temporal change can help to infer economic inferences. Mr. Campbell said that this goes back to land cover change detection. Images from different sources (e.g., Quickbird, Landsat) can be used to see the earth feature changes over time.

ACTIVITY-BASED INTELLIGENCE: NGA INITIATIVES (MR. COLLIN AGEE)

Mr. Collin Agee, NGA, reviewed Activity Based Intelligence (ABI) and current efforts and future plans of the National Geospatial-Intelligence Agency (NGA). ABI is defined as a discipline of intelligence where the analysis and subsequent collection is focused on the activity and transactions associated with an area of interest. An activity is a recognizable movement or change conducted by an entity that is an indicator or has a specific meaning when viewed within a relevant concept.

Currently, three papers using ABI are coming out from the Office of the Under Secretary of Defense Intelligence (OUSDI). Of the two that are published, one is unclassified and the other is secret. A third paper is in progress and is set to be released in February.

Constant Hawk was originally conceived as an IED (Improvised Explosive Device) hunter, but it has tremendous potential beyond that use. Constant Hawk is game changing in that it is improving the form of data that is being received. It has potential to be able to perform functions and put out usable data more quickly.

A current focus is wide area airborne surveillance (WAAS). There has been an evolution of motion imagery from the Predator, a pixel-based PED, through to Constant Hawk and forward to WAAS systems due out in the next couple of years. Constant Hawk covers a 6x6km area. It can track vehicles, as well as dismounts. Future systems will have better resolution with the intent to be able cover a 10x10km area.

Dr. Kirsten De Beurs, University of Oklahoma, asked what is done with the data now. Mr. Agee said the data is given to an analyst, and they use increasingly sophisticated tools to analyze it. Constant Hawk started as an IED hunter. If an IED went off in the field view, the images could be played back up until the time of the explosion. There is a myriad of behaviors that characterize an IED attack. Constant Hawk video was used to identify three enemy vehicles and track them back to eleven different terrorist sites related to the IED network. Mr. Agee described this as treating the disease, not just the symptoms.

Mr. Agee said that a 30x30km area would cover metro Baghdad.

Dr. Tim Gulden, George Mason University (GMU), asked about the number of vehicles that can be identified. Dr. Agee said that everything that moves is captured in the video. The PED aspect, which is important to NGA, is the sensor that captures reams of data. An algorithm is used to cut down the amount of information that is dispersed to analysts; otherwise, the amount of data would be overwhelming. Mr. Agee said this system is not Buckeye. There are already ways to capture information on infrastructure and roads. The data of interest is now the things that move and what information that can provide on demographics or communities.

Ms. Brown asked who has access to this data, since the interest is in identifying change. Mr. Agee said that NGA has the foundation data, a geospatial layer upon which other information can be laid. NGA tried to have that information available so raw data does not have to be sent out to those that are interested.

Ms. Brown asked if the area covered is just limited to cities or everywhere. Col Reichman pointed out the "everywhere" means different things to different people.

Mr. Agee said that this sensor has the whole area. The original system covered a 6x6km area at 0.8m resolution. Mr. Campbell pointed out that the human eye is the best sensor. We chose not to do better. Computers are needed to track vehicles. If there is a moving target that someone is interested in, that target can be tracked and see what building he goes into. The idea is to apply the algorithms on the aircraft as it is capturing images so that only the important data is saved. Compromises are made, and it is more important to extract the pertinent data.

Dr. Bacastow asked about the transition from machine to human. Dr. Davis used a metaphor to describe how this helps the analyst. He described it as being able to hone in on watching individual bees instead of looking at a bunch of hives.

Mr. Agee went on to discuss the Argus sensor. The Argus can sense an entire field of view with humans setting the areas of interest. The algorithms can be created to identify and watch areas and targets of interest, as well as setting up watch boxes, alerts, and alarms.

Mr. Agee said that there are two ways to reduce data. The raw data is visible underneath, but the analyst also sees the dot that highlights the vehicle. The vehicle dot is not lost when the vehicle travels under a bridge or a tree.

The intent is to unravel an IED network, in addition to defeating a single IED attack.

Mr. Agee said that other entities have used this data, like the US Department of State and USAID. However, he could not comment on how they used the data except that they are able to find value in it.

Mr. Bozada asked how day-to-day activities are altered because of US presence. If troops go into a previously unoccupied area and try to establish what is normal, their observations are skewed because the presence has changed the areas behavior. How much of the change can be attributed to reactions to troop presence versus local improvement. The factors in the Political Durability Model need to be defined so that improvement, if any, can be identified.

Dr. Davis asked how many of the Constant Hawks are being used. Mr. Agee said that there are four in Iraq and three in Afghanistan. He said at some point in the future, this kind of resolution will be available from space. Mr. Agee continued that with the current level of automation, analysts can look for behaviors associated with terrorist attacks. A small subset of a million users can be examined to find suspicious activity or, more specifically, a known target can be tracked. The ability to analyze in real-time means those significant actions can be correlated with specific behaviors. Positive identifications can be made, followed by tracking of the live target, and finally capture.

Mr. Allen asked if this data is classified, since it is intelligence, surveillance and reconnaissance (ISR)-related. Mr. Agee said that the raw data is unclassified and only becomes classified once a target is identified.

BREAKOUT SESSION 1: REMOTE SENSING METRICS

Dr. Davis reviewed the goals of the afternoon breakout sessions. Panel discussions after lunch were cancelled and, instead, participants were asked to disperse into groups. Groups were made up of even numbers of social scientists and remote sensing experts. Dr. Davis asked the breakout groups to consider remote sensing possibilities in the context of the Political Durability model. The model is in place to help focus thinking and discussion. He clarified to focus on the unclassified methods and data.

Dr. Davis asked the groups to think about building a bridge between what can be seen in the environment using remote sensing and tying it to the population and its impact. Dr. Cabayan told participants to start with the model and work down into the proxies.

Dr. Gulden asked what a sensor can be and if information taken from newspapers, for example, can be merged or used, along with remotely-sensed information. Mr. Bozada said that ultimately, these all need to be bridged together. Dr. Gulden stated that remote sensing could see if farmers are being displaced, but it cannot identify if the farmers are angry and armed. Dr. Davis recommended letting the social scientists drive the breakout session to get at what is needed from the remote sensing community.

GROUP 1 (DR. ALLISON ASTORINO-COURTOIS, MODERATOR)

The first breakout group was chaired by Dr. Allison Astorino-Courtois, NSI.

Participants:

- Dr. Allison Astorino-Courtois (NSI- Moderator)
- Col Jeff Reichman (NGA)
- Ms. Laurie Fenstermacher (AFRL)
- Dr. Somnath Sengupta (BAE)
- Dr. Kirsten De Beurs, (University of Oklahoma)
- Dr. Pascale Siegel (Glevum Associates)
- Mr. Collin Agee (NGA)
- Dr. Curtis Woodcock (Boston University)

Dr. Astorino-Courtois asked the group to first consider remote sensing measures for political indicators, since this is the most difficult category to conceptualize.

Participants agreed that polling data is the best measure of the percent of the population who believes that the government currently represents or serves their interest.

Traffic in and out of Government Buildings

Dr. Gary Condon, MIT Lincoln Laboratory, suggested that trust in government could be measured by keeping track of the connections between government buildings and unique residences. Remote sensing tools could track a vehicle from origin to destination. A good indicator of trust is when the population will willingly interact with the government on its own turf. One could also measure traffic into and out of a government building, like a courthouse or a regional government facility.

Ms. Laurie Fenstermacher, Air Force Research Laboratory (AFRL), stated that in a society with high reliance on informal governance, there might be less traffic than you expect. Dr. Condon responded that trend analytics would show derivations from normal. This technology could also be used to track traffic in and out of informal governance institutions, like a Taliban leader holding court.

One participant stated that you cannot make the assumption that, because people go into a government office for services, they trust the government. Dr. Astorino-Courtois suggested that this could be understood in terms of social service. People walking into government buildings may only mean that people are accessing services, not that they trust the government.

Dr. De Beurs stated that traffic in and out of buildings cannot be obtained on the unclassified level. Dr. Sengupta stated that if you can tell what model what to look for, it can efficiently identify trends. However, Dr. Condon stated that a video camera, not a remote sensing tool, would be the most appropriate way to gather this information.

Dr. Astorino-Courtois stated that a command could get polling data that says that 75% of the population says they trust the government, but no one ever goes into government buildings. That suggests there is a disconnect.

Ms. Siegel suggested that another explanation for why people do not go into government buildings is that they are content with their services. People only go to see the government when they have a problem. More traffic could mean more problems.

The group concluded that traffic in and out of government buildings is an indication of a willingness to interact with the government, not an indicator of trust.

Frequency and Intensity of Rallies

Dr. Sengupta stated that in many parts of the world, the people hold rallies. Can rallies tell us anything about trust in the government? Dr. Condon said that frequency and scale of civil protest could be measured. He hypothesized that if people trust the government, they would use formal versus informal methods to protest.

Traffic in Relation to Social Services

Mr. Collin Agee stated that traffic, or freedom of movement, is not always a good indicator of stability. In Iraq, when traffic was allowed to cross zones, security deteriorated because the have-nots were able to see what they were missing.

Dr. Sengupta stated the MG Flynn stated that the right metric is not about movement, but motion. Mobility of the populace indicates something about how it sees itself. It reflects their psyche on risk and the ability to move around. When normalcy returns, nightlife returns.

Nighttime Mobility

Dr. Cabayan stated that in rural areas, the Taliban rule the ground during the night. What can be inferred if the Taliban are not moving freely? It might mean that they do not have the support of the population in remote areas. It could also mean that they have the support of the people and do not need to bother with them. Either way, nighttime activity is an indicator of something.

Ms. Siegel stated that in Helmand, the farmers water their crops at night because it is too hot to do so during the day. Therefore, movement at night may be an indicator of normal life.

Distance Traveled outside of House as a Proxy for Security

Dr. Siegel suggested that travel may be a proxy for security. How far people move from their house is an indication of how secure they feel.

Dr. Cabayan stated that if you establish a baseline for the average distance people travel, if the average increases, it is a good indication that people feel more secure in their lives. Dr. Astorino-Courtois stated that you do not need a baseline; you just need change.

Dr. Condon stated that travel could be an indicator of food insecurity--that people have to travel further afield to find food. Dr. Cabayan responded that the availability of food could be remotely sensed, so you could correlate the two.

Frequency of Travel

Dr. Astorino-Courtois suggested that the frequency of travel outside of the house might be an indicator of security. It might even be better than distance. Dr. Astorino-Courtois suggested that

the frequency of travel,, coupled with polling data may provide insights. If people say they feel secure and yet do not frequently leave their house, there is a disconnect. One could also look at the quality of roads or the price of gasoline.

Types of Vehicles

Ms. Pascale suggested identifying the types of vehicles on the road. Dr. Cabayan suggested that by monitoring commercial trucks, we could learn something about the economy.

Building Construction

Dr. Condon stated that building construction says something about security and the economy. It is also easy to access with remote sensing data. Dr. Cabayan stated that Afghans would not build a house if they did not expect it to be there in ten years. Dr. Condon stated that it is easy to tell the difference between a building constructed by an NGO and one built by a local.

Land Use

Dr. Condon also suggested that land use could say something about the economy and security. Dr. Davis stated that USAID already collects information about what kinds of crops are planted where, especially poppy.

Access to Water

Dr. Astorino-Courtois suggested that the state of the irrigation system could tell us something.

Access to Basic Services

Dr. Agee suggested that access to basic services (electricity, water, sewage, etc.) and whom the people receive the service from is telling.

New Asphalt

Dr. Davis stated that it is easy to tell remotely whether asphalt is new or not. New asphalt is correlated with development.

Agricultural Development

Agricultural yields can be measured, and improvements can be made to crop productivity. However, Afghanistan lacks sufficient storage facilities and is challenged in getting food to the market. The government could give farmers greater agricultural capacity, but it may not increase the population's quality of life or living standards.

Discussion:

One participant stated that almost all of the variables were attitudinal in the Durability Model. If you want to get at perception, you have to calibrate the behavior observed against known attitudinal observations. Dr. Condon responded that there is quite a bit of literature on how to tease out intentional versus unintentional deception in polling data. Dr. Astorino-Courtois qualified that the statement is only true if there is a lot of aggregate data and one can run statistics on it. In this case, it is not clear that the data is available.

Dr. Condon stated that the group was going about it the wrong way. The group identified the variable it wanted to exercise and then figured out behavioral aspects of it. However, people do surprising things. The group is better off measuring the behavior, no matter what it means, then use machine learning or data mining techniques to find out what the correlates are. Dr. Astorino-Courtois responded that an effort like that is outside the scope of the SMA project.

Dr. Cabayan suggested that if good ideas come out of this workshop, there could be a proof of concept in theater to see if the concept holds. It must be done empirically.

Dr. Davis stated that what remote sensing can do now is map where people live, where schools are, where people work, and where retail is. It sets up conditions for movement on a normal day. There are models that can use discrete choice theory to help monitor where people go.

Dr. Davis stated the belief that you do not need persistent stare to get a feeling for movement. However, it is essential to have a kinetic model to set up prior in terms of geographic and geospatial analysis to track movement.

Dr. Cabayan concluded that the three main indicators the group settled on were movement, construction, and land use.

Dr. Condon stated that there is no silver bullet and many of the indicators will have to be grouped in order to draw conclusions.

Dr. Cabayan stated that in Afghanistan, there are several years of polling data available. The SMA effort could look back historically for remote sensing data and see what kind of conclusions can be drawn from it.

Dr. Condon stated that the effort should measure inputs and outputs. The effort should not focus solely on outputs; inputs, like new schools, are important too.

Dr. Condon spoke about an investment bank called UBS. Recently they commissioned an analysis over many months of Wal-Mart parking lots to determine how badly Wal-Mart was hit by recession. Before Wal-Mart release its quarterly earnings, UBS was able to tell investors whether to buy or sell Wal-Mart stock.

Dr. Woodcock asked what progress looked like. Dr. Condon responded that you want to be able to observe whether outcomes are heading in a bad direction, whether you are making good choices on COAs to changes those outcomes, and whether the outcome will really change.

GROUP 2 (DR. GEORGE CYBENKO, MODERATOR)

The second breakout group was chaired by Dr. George Cybenko, Dartmouth University.

Participants:

- Dr. George Cybenko (Dartmouth University- Moderator)
- Dr. A. David Adesnik (OSD CAPE)
- Dr. Budhendra Bhaduri (ORNL GIST)
- Mr. Michael Campbell (ERDC)
- Dr. James Frank (TSWG)

- Dr. Tim Gulden (GMU)
- Dr. Ashley Holt (NGA)
- Dr. Sue Numrich (IDA)
- Ms. Swathi Veeravalli (AGC)
- Dr. Clifford Weinstein (Lincoln Lab)

With the understanding of using the Political Durability Model (not analyzing it), participants discussed the ways in which remote sensing could be used to operationalize some of the social science concepts highlighted in the model. Remote sensing cannot be viable in all areas discussed in the model. As Mr. Campbell noted, remote sensing is limited to three layers: air, what is on the ground, and what is underneath. Dr. Numrich remarked that adding remote sensing allows for fusing information from a variety of sources. The group's job in the breakout session is to marry different disciplines and find ways to use remote sensing to see lifestyle patterns.

Dr. Bhaduri pointed out that it is important to remember that remote sensing capabilities capture an image, one point in time, whereas society is made up of processes, not just moments in time. A time series is needed to capture and characterize a process. Even images captured every 24 hours are missing information on events that may only last a couple of hours. However, if a time series is captured, then there is possibility of seeing change over time.

Going back to the goal of the breakout session, Dr. Cybenko reminded the group that the aim is to come up with ways to quantify the Political Durability Model. Dr. Bhaduri said that remote sensing capabilities are good at measuring infrastructures, such as transportation or electricity. Dr. Weinstein asked if it is possible to plot as a function of time, the number of utilities and kilowatts used. Mr. Campbell responded that it is possible to measure kilometers of wire or the number of new electrical poles. Dr. Gulden added that remote sensing could measure nighttime lights. For example, one study compiled weather satellite data over the course of a year, compiled the images, and then generated a statistical analysis that provided a propensity of nighttime lights. Analyzing amount of nighttime lights could be an indicator of economic stability.

Dr. Numrich added the idea of using cell phone information into the discussion. Cell phone usage could be an indicator of stability. Dr. Bhaduri mentioned that cell phone towers could be seen using remote-sensing capabilities.

Discussion turned to an example from Mr. Campbell's presentation earlier that day. He showed an image of a location that exhibited marked construction over a period of eight years. In his presentation, the purpose of the market-like area was unknown, but a Ferris wheel was tentatively identified. Dr. Numrich was able at this point to identify this area as a special market place for Afghan women and children. These amusement areas were built by the British. Mr. Campbell said that remote sensing would be able to pick up this change in land use, and Dr. Gulden added that this kind of identifiable change could act as an indicator for economic development in the Durability Model. Dr. Bhaduri said that a behavior analysis could be developed using MODIS and track pixels at that resolution. It should be noted that identifiable structure depends on the resolution being used. For example, using MODIS, a large complex could be seen, but not small homes.

Dr. Cybenko posed a question asking for the indicators of inequality. He proposed that inequality could be surmised by taking multiple images to compare, as well as overlaying demographic information. Mr. Campbell posited using MODIS to identify a spectral change according to a user-defined parameter. This will identify a pixel color change from light to dark, from vegetation to

non-vegetation. A second source with smaller pixels and, thus, higher resolution, like Landsat, can see change over time. Dr. Bhaduri added that the higher-resolution images could be used to characterize smaller areas of interest. Dr. Gulden said that low-resolution data is then used to drive higher-resolution sampling, identify the lower-resolution pixel change, and then further explore it with higher-resolution sampling.

Dr. Cybenko asked if backyard vegetable gardens could be seen remotely using higher-resolution data. Mr. Campbell said that looking at a city in Iraq, palm and fig trees could be seen in personal residences. Dr. Gulden added that this infers access to water, feelings of safety (to be outside), and time to care for growing a garden. Ms. Veeravalli mentioned that in Kenya, groups that had produce were able to sell it in the market and were able to make income. She replied that you could identify what groups had access to services but asked if things like water pipes or pumps can be remotely sensed. Dr. Gulden noted that water source knowledge is very valuable. Dr. Numrich said that if you can tell what land is being worked versus un-worked, recovery levels could be inferred. At this point, Dr. Bhaduri said that soil wetness could be measured.

In the final minutes of the breakout session, the group reviewed the ideas for finding remote sensing capabilities to be able to produce data for the dimensions (the 3rd layer) in the Durability Model. It was reiterated that the remote sensing data should be unclassified. Dr. Adesnik summarized that there were three layers of the discussion: 1) discuss and explore the possibilities of remote sensing, 2) examine how much cultural interpretation and context is necessary to be able to infer meaning from available remotely-sensed data, and 3) make the connection between the data and political durability and stability. Dr. Cybenko said that some of the concepts of durability and stability are rich and are beyond the scope of the issue at hand and of this workshop. Dr. Bhaduri mentioned that remote sensing overall has improved, is still adept at identifying infrastructure and mobility, and also can provide insight into change over time.

GROUP 3 (MR. THOMAS BOZADA, MODERATOR)

The third breakout group was moderated by Mr. Thomas Bozada, USACE.

Participants:

- Mr. Thomas Bozada (USACE -Moderator)
- Mr. Tom Allen (NSI)
- Dr. Todd Bacastow (PSU)
- Ms. Tessa Baker (NSI)
- Mr. Tom Behling (CENTRA)
- Ms. Molly Brown (NASA GSFC)
- Ms. Kea Duckenfield (NGA)
- Mr. Chris Stewart (Gallup)
- Mr. Kevin Stofan (CENTCOM)
- Dr. Devin White (NGA)

Mr. Bozada began the breakout session by introducing the notion of Priority Information Requirements (PIR) and Information Requirements (IR), which, in the intelligence community, drive what the analyst needs to know. If there are gaps in the available information, indicators

must be specified to fill the gaps, which in turn raise the question of how to measure them. Remote sensing can help fill the apparent data collection gaps in the durability model.

Ms. Brown noted that the indicators observable from space (like rainfall, agriculture, etc.) have multiple veins of utility. There is no one-to-one connection between an observable factor and an indicator.

Mr. Bozada focused the discussion by noting that if group A were to focus on what is collectible with current technology, participants have to know what the means are to access and collect this information. As an example, "is farming successful?" is a question asked by the durability model; therefore, it might be an information requirement. Measuring the success of farming is easy based off imagery.

Ms. Brown interjected that there are multiple livelihood approaches.

Mr. Allen noted that remote sensing does not have to fix the entire problem. There are other measures that might be appropriate. Remote sensing should complement available data streams.

Mr. Bozada recalled that during the large-group discussions, farming had come up. Farming, nevertheless, raised other related questions like: Are there roads? Is there cold storage? For farming to be successful, several things are necessary, like land, farmers, water, transportation infrastructure, equipment, and time. Remote sensing can address some of these issues. For instance, remote sensing can define arable/farmland, and the availability of historic data could detail the seasonal planting of crops and explain land use over time. Yet, remote sensing is unlikely to address complicating factors like issues pertaining to the ownership of land and what kind of policies deal with ownership and who creates the policy.

Dr. White added that underlying this discussion is the assumption that farming is successful when it is maintained.

Ms. Brown said that if the breakout group was to discuss water as a remotely captured indicator, the issue then becomes the sources of irrigation water. The one issue that is not included is the population and other sources of food. There is also food that is brought in from other countries.

Mr. Bozada emphasized that policy is not accessible by means of remote sensing.

Dr. Bacastow, PSU, noted that remote sensing could supplement the content.

Ms. Brown asked whether the discussion should be focused solely on the Durability Model. The group determined that the Durability Model should be used as a framework for further discussion.

Ms. Baker noted that the focus should not be on individual indicators for specific variables, since there were many confounding influences. For instance, farming is not just predicated on the availability of irrigation water; it depends on the availability of seed, tilling equipment, and other needs. Likewise, water as an indicator implicates the availability of drinking water and sanitation, among other things; none of these can be considered in isolation. Instead, this discussion should focus in on what remote sensing can provide in terms of data and supplemental information streams. Ms. Brown agreed that it is not possible to base one of these particular indicators solely on the availability of water.

Ms. Duckenfield noted that the purpose of this workshop is about providing remote sensing expertise to social scientists who do not necessarily know what is available to them. It may be better to say that these are the kinds of things that are available through remote sensing and note that there can be data fluxes, etc. The social scientists need to have a sense of what is available, which, in turn, facilitates discussion and allows the social scientists to seek refinements from the remote sensing experts. By identifying the types of data and information available through remote sensing, this workshop will allow the conversation to begin.

Mr. Bozada noted that there was a specific request and then there was a more nebulous request. If the operational variables were in a matrix, then the group could identify what might be most readily accessed via remote sensing.

Ms. Brown took issue with the construction of the durability framework noting that the way this durability model is conceptualized without regard to the weather or environmental constraints is problematic. Remote sensing specialists know that environmental constraints matter and that these environmental elements are eminently observable.

Dr. White noted, following Brown's statement, that the important issue is establishing realistic expectations. He mused aloud about how realistic it might be to include full environmental context in a political durability model.

Ms. Brown noted that the famine early warning system monitors how much snowpack melt reaches the low-lying areas of Afghanistan. The variable has a huge amount of variance inter-annually.

Ms. Duckenfield stated that many of these operational variables fail to capture what might potentially be available from remote sensing. Mr. Bozada noted that these variables are not tailored operationally.

Mr. Stewart added that with regard to water, there are three key issues that are important: access, availability, and quality. Ms. Duckenfield added energy as a key facet of the water discussion. Mr. Stewart noted that water quality is important, particularly from the perspective of the population (waterborne illnesses, etc.), which is an issue that is difficult to assess from a remote sensing perspective. When Stewart has conducted research in Afghanistan or Yemen, he looks at water quality, because it is a more significant driver of a person's quality of life than many other factors.

Mr. Bozada retold the example of an Afghan village in which children were getting sick because of poor sanitation. The Taliban were able to convince the villages that it was the United States' fault for polluting the water. What was needed was for someone to come in and teach sanitation management and help the village establish water quality control.

Ms. Brown noted that water availability underlies access, and it is significantly affected by climate factors, which can undermine water availability.

Mr. Bozada commented that snowpack data, on its own, does not tell an analyst very much, but if it is translated into river flow, it starts to mean something. Ms. Brown added that it is not just the observation of how much precipitation has fallen; indeed, the information becomes useful after social science models translate the data into actionable information. It is also important to note that snowpack and precipitation data are often modeled outputs rather than direct collection and/or observation.

Dr. Bacastow asked how to answer these questions using remotely-sensed data.

Ms. Brown noted that information is obtainable from DAC. There is a huge amount of correlation between pixels.

Dr. Bacastow said that the indicators should be driving the remote-sensing data collection. However, it is also important to recognize the organizational component. There can be massive amounts of data, but if it is not actionable or available to an end-user, it is useless.

Mr. Bozada agreed that the data has to be transformed and other content has to be added to it to make it useful to the social scientist. Dr. Davis has already stated that there will be follow on workshops, but the question is whether this might work. At its core, the question is whether remote sensing has applicability to these issues.

Mr. Stewart began to discuss the importance of the level of analysis. Based upon Gallup's work in Afghanistan, they learned the importance of focusing at the district level.

Ms. Brown agreed that it was important to identify the level of analysis, because it directly implicated the resolution of the data required.

Dr. Bacastow put Mr. Stofan on the spot, by asking about his experience on the ground as a platoon leader. Mr. Stofan responded by noting that the task for the breakout groups is to look at the operational variables. He concluded that there are very few that could be addressed by remote sensing. Data and analyses derived from remote sensing are likely to be only proxy indicators of the nodes in the durability model. Food security and economics have the most potential for using remotely-sensed indicators.

Mr. Allen noted that many of the operational variables in the durability model are perception-based.

Mr. Bozada concluded that remote sensing cannot provide physical measures of behaviors, beliefs and means. Nonetheless, before the United States intervenes anywhere, it is important to capture baseline measures of these items. Africa is going to be the next sandbox. It will be a big mess, and military planners do not know a lot about Africa. It is not possible to conduct a US-like census in Sudan, nor is it possible to ascertain the natural resource endowment, but the question is what can remote sensing tell us before a boot hits the ground? Answering his own question, Mr. Bozada noted that remote sensing could provide information about the climate and the hydrology, the geography, etc. Additionally, remote sensing can provide information about lifestyle in terms of roads, huts, and roof types, etc. This is the long-term future for what remote sensing will have to do. In Afghanistan, all sorts of data have already been collected, and the question is what can be done with this information.

Dr. Bacastow believes that the task to do strategic is a lot easier than the tactical component. Ms. Brown agreed and noted that high resolution is what is needed at the tactical level; whereas, strategic data is much more process-oriented.

Mr. Bozada asked whether it might be helpful to focus on one geographic region for the sake of an example. Additionally, once the group focused regionally, they could divide this into large-scale assets versus small-scale assets. The large-scale assets have models and data.

Ms. Brown noted that the analysis has already been done to determine whether there is an adequate level of irrigation.

Mr. Bozada added that when areas of interest are found, the appropriate methods to obtain more data would be tailored to the data requirement. It is this whole concept of the haystack and which areas matter and which areas do not. Daily coarse resolution is at 250 meter sweeps, which will help the analyst determine what portion of the haystack to focus on. For the purposes of this workshop, it might have been more helpful to match remote-sensing assets with obtainable observational variables. Remote sensing can contribute to the Political Durability Model, but there are many process and organizational issues that need to be resolved, and the process seems to be the most significant sticking point. Overall, the breakout group had found that there are many ways to pull taskable information. For instance, market operations can be done.

Dr. Bacastow encouraged Mr. Bozada to say something about the differences between strategic and tactical elements. Mr. Bozada stated that if water plays a huge role in Afghanistan, then it would make sense to understand that backdrop and look at the country level and then focus on the specific localized concerns. The group is, thus, building a way to separate out where attention needs to be focused.

Ms. Duckenfield noted that it seems they are looking for means to find collectibles, and the remote science experts are taking issue with the model. Dr. Bacastow agreed and reiterated his point about the organizational component: there needs to be an interdisciplinary team.

Mr. Bozada emphasized that the key issue is not asking specific questions, but finding proxy observables, which is a critical element of the utility of remote sensing to these areas. Context is critically important to the applicability of remote sensing.

The group began discussing the creation of specific proxies, and Mr. Bozada interjected that he did not think there was enough time or a specific-enough problem to ascribe proxies to. If there were an actual problem, then each person could apply his or her knowledge. Instead, Dr. Davis wanted to see from the chaos of throwing different people of different expertise together what could be created. To make this work, the group would really have to spend some time going into the weeds. He could not see doing this without a use case.

Ms. Brown added that the idea of observations versus models to the group's out-brief. Models take observations and turn them into processed understandings (snow becomes drinking water), which means those models could be tuned to the observational needs of those on the ground. She added that there was no need to worry about resolution; with models, the process can be refined to acquire finer-detail resolution. She concluded that the use of remote-sensing models is a great opportunity for this community. It takes a conversation and sustained interaction to tailor a model to a specific requirement. There must be sustained interaction to understand what is needed.

Nearing the conclusion of the breakout period, Mr. Bozada went around the room and asked each participant to briefly summarize their impressions thus far.

Mr. Allen noted that as an engineer, he wanted equations to be associated with the model. Nonetheless, the Durability Model is an influence model, but if it was taken as a black box, anything that has a correlation on an input and the output would be a useful contribution of remote sensing. If the remote sensing experts can at least enumerate the correlations between remote sensing

measures and other measures, that alone would be tremendously helpful. Dr. Astorino-Courtois had no idea what remote sensing was when she built this model, which is where many social scientists are coming from. If someone could provide a list of things that remote sensing could measure, then a model can be built around it. This is an iterative process, which will result in modifications.

Mr. Bozada added that the group had focused on water because Ms. Brown is in that community. In an ideal world, he would focus on population density and take census data with household survey data and layer them on top of one another and see how that relates to transportation networks, which is relevant to what he generally works on. For his purposes, Mr. Bozada does not necessarily need high-resolution data, because he has other information that connects the pieces. Problem orientation has a lot to do with this.

Dr. White was next to offer his thoughts and noted that he has a unique perspective, because he has been trying to marry anthropology and remote sensing. It is a small community, but it is a very complex problem space. He did not believe that it would be wise to come up with an exhaustive laundry list, but it would be helpful to construct a small usable list that can be put in the appropriate toolbox to facilitate the work of social scientists. The critical thing is the theoretical linkage. Spatial resolution matters differently depending upon the problem. These building blocks can operate at different levels (differentiating the fine versus coarse resolution). It would be extraordinarily useful to address a practical problem to provide a set of building blocks. The remote sensing experts need to be able to answer the "so what" question regarding their data streams for the social scientists and analysts who will be using the data.

Ms. Duckenfield contributed that there are, at this point, very wide gaps between social science and remote science. Therefore, it would be impossible to bridge the gulf in one fell swoop and just hand over something that can be directly plugged into what they may need. Duckenfield deployed as a Geospatial (GIS) analyst and spent much of her time explaining to her customers what she was capable of. This capabilities discussion and basic education needs to happen first, and the lines of communication have to be maintained. Much of the remote sensing discussion has been very macroscopic. Remote sensing involves many different platforms with many different bandwidths. The discussion and collaboration between the remote sensing folks and the social scientists has to include asking questions about why a specific measure is desired, because that can help identify alternative measures. On both sides of the divide, each party does not know what the other does or how they do it.

Dr. White agreed, noting that some of the most productive time has been when he was embedded with analysts, who asked for his help, which, in turn, allowed them to innovate collaboratively. It has to be a much more sustained dialogue. The consumer needs to be educated, but it is an active, engaged process.

Mr. Stewart noted that he probably had a unique perspective. Civilian assets could be used for strategic efforts. One-third of the Political Durability Model could be filled in through some sort of sensing asset on classified systems, but there will be no substitute for ground collection (collecting data on the ground). Adding remote sensing, however, can allow the ground collection to be more effective/focused. Nonetheless, the integration of remote sensing data with other data streams may be different in another country with different metrics.

Mr. Bozada agreed that Afghanistan is a unique situation, but it is a data-rich environment where the theoretical linkages could be explicated.

Mr. Stofan added that it is good that this is going to be an iterative process and that remote sensing scientists are going to provide the categories of measures available. When Mr. Stofan was in Mizan district in Zabul province, areas where recruitment was perceived to be highly correlated with low agricultural output. While Mr. Stofan did not know the direction of causation, whether they were not farming because of environmental causes or whether they were not farming because of Taliban recruitment, it is an interesting question that should be explored further. Spatial and temporal autocorrelation are going to be important indicators of stability and durability of remotely-sensed data.

Ms. Brown noted that temperature is a case-in-point of temporal autocorrelation. Vegetation data is an example of spatial autocorrelation, because the climate is so homogeneous over a given sample space.

Mr. Behling, Centra, added that this has been an interesting discussion. He agreed with others that there is a huge gap between the social science conceptualization of these issues and remote sensing's view on these matters. This seminar was a vital step. Mr. Behling resonated with the strategic vs. tactical issues. The strategic use of remote sensing to determine water availability is very useful, because it allows the commander to see ahead 6 to 12 months and see the effect of water over time. In terms of tactical considerations of water, there are likely to be other exogenous factors at play. Land ownership is important to this consideration. Ownership of parcels of land, coupled with vigor of crops on that land, would be an important thing to consider. Other issues include who is in control of water and who controls market access. Understanding the level of control of these issues is important. It is unclear whether remote sensing can get at these two variables. Looking at that change over time can help provide a view to whether the village is stable over time.

Dr. White added that there is a lot of anthropological theory related to that. The hydrologic hypothesis states that whoever controls the water controls the land. When everyone has a stake in the water network, there is significantly more agricultural productivity, which differs from the reverse, when one individual controls the water access.

Mr. Behling concluded that remote sensing provides us with half a loaf, an important half, but it does not address the social drivers of change.

Dr. Bacastow, the final group member to speak, noted that it has almost all been said. Remote sensing without the social scientists is just data; there is no context. The problem is not technical; it is organizational, which really necessitates the creation of a multidisciplinary approach and methodology.

GROUP OUTBRIEFS

Dr. Cybenko presented the findings from Group 2. He reiterated that the group's first charge was to explore and identify challenges of study of political durability and using remote sensing capabilities. He referred to Dr. Adesnik's parsimonious summation from the session. Dr. Adesnik acknowledged the three challenges as: 1) identify what needs to be measured and how it can be measured? 2) what is the significance? and 3) what implications does this have with stability and the model?

Dr. Cybenko stated that it is important to match the phenomena and the sampling (or resolution) rate with what is appropriate for the date and what that might actually tell us. With regard to Afghanistan, one issue is the lack of things like a census; so instead of relying on a census to generate population estimates, remote sensing would have to pick up types and number of structures to possibly infer family size and population.

Discussion also touched on the nature of change that could be sensed and how to tell if that change was due to internal or external forces. Some data will have to be supplemented by human knowledge; for example, the structure that looked like a Ferris wheel in a market place. Remote sensing data could not identify this as an actual Ferris wheel. During the discussion, Dr. Numrich claimed that the structure was indeed a Ferris wheel in an activity area for women and children that was recently built by the British.

There is value and need in overlaying imagery over the demographics in a sort of ethnographic analysis.

Dr. Davis asked what the group would need to be able to prioritize what really matters from what is interesting to researchers. Dr. Cybenko replied that examples are needed to really get at what would fit into and be used by the Durability Model. Social scientists could provide information on change; for example, what Somalia was like in the past or what is seen when durability is high or low.

Dr. Davis summarized that the group discussed matching trends with trends. Next, that if process is an important proxy, it is important to be able to do something with the imposed measurement. Finally, that if there are areas on the ground that exhibited durability, with reasonable data, an analyst could identify when durability is high or low. A time series of remotely-sensed data could be added in as another measurement. Dr. Gulden stated that the group also discussed how to operationalize the variables. If remote sensing could use coarse data to identify or lead to more directed data collection, then the more high-resolution data could be given to an analyst for interpretation. In other words, let computers analyze the high-level data, then give low-level data to the analyst.

Dr. Davis asked Dr. Astorino-Courtois to review her session's discussion.

Dr. Allison Astorino-Courtois stated that Group 1 began with the governance indicators and then discussed what remote sensing could do and see. They had to identify how the capabilities of remote sensing could be folded into the different kind of indicators, such as traffic movement, patterns of population, or movement in and out of government buildings, with this last idea being an indication of people being engaged with the government. Looking at patterns of life or the distance people travel from their homes can indicate a person's sense of security.

Dr. Astorino-Courtois also said the group talked about building construction with an emphasis on local construction versus non-governmental organization (NGO). Building construction could be viewed as an indicator of hope for the future. There was a suggestion about looking retroactively at Iraq or Afghanistan data to see if there are any relationships between any of these indicators.

The group then discussed other indicators of the economic sphere, such as what kinds of crops are being cultivated, as well as the health of the crops.

Dr. Cabayan stated that these hypotheses need to be validated through correlate reports, polling data, and images, and then make a case for doing a study in theater. The idea is to use assets already in theater and to at least do a short-term demonstration to get a handle on quality of life. Mr. Agee added that some of the data could be made readily available, including work being done commercially and already at the universities. Dr. Cabayan said it is important to go in and get the data to be able to later validate the model.

Dr. Davis summarized that this group had several foci: movement, development (such as land use and construction), and the idea of trend comparison rather than isolated snapshots. Of course, it is important to avoid spurious correlation.

Dr. Davis asked Mr. Bozada to present Group 3's findings.

Mr. Bozada stated that the BLUF (bottom line up front) is that remote sensing can contribute to understanding political durability, but how is not concrete. The group discussed a seven-step process:

1) determine area of study,
2) collapse operational variables (observables),
3) determine available data,
4) cleaning and normalizing data,
5) correlate data,
6) validate, and
7) iterate.

Mr. Bozada mentioned that this exercise would look different if the area in question had not been affected by foreign forces versus something like the past and present situation in Afghanistan. The problem is not a technical problem; it is an organizational one. There are information gaps due to the organizational issues, not for lack of data. Mr. Bozada said that a particular challenge problem would be helpful to build a toolbox of tools that can be used to validate a theory. For example, there is a social theory hydraulic hypothesis that helps to investigate a connection between water and stability. There are natural linkages.

Remote sensing can ultimately be used to narrow down the effort or identify the particular areas that matter; additionally, remote sensing to study an area before troops are on the ground to facilitate more effective and successful ground efforts.

Additionally, Mr. Bozada said that it would be helpful to be able to look retroactively using remote sensing data to examine things like relationships within agricultural success, such as what crops are successful and who is doing the cultivating.

Dr. Davis summarized the group's discussion. He said that there needs to be a connection between remote sensing and what is deemed important. Next, there is a concern with what and how environmental drivers affect the system. These can be used to drive out other patterns in land use or other changes that can be seen on the ground. Mr. Bozada added that what could be remotely sensed can also be considered to be effects. Dr. Davis said that the patterns on the ground function as an integrator between the natural and the human system.

Mr. Bozada said that if there is a focus on one area, then one indicator could answer many different variables. A specific problem is needed to help define what data is required. Dr. Cybenko asked if

this could be a project to build a notational sample of a consensus of what is durable and what is less durable. Dr. Astorino-Courtois said that that data set probably already exists. There is a study that looks at conflict in a society over time. Dr. Cabayan started by mentioning that this discussion thread would also be appropriate for December 8th's more global focus. He continued by saying that the collectors are collecting data, but not necessarily with these concepts in mind. Ms. Duckenfield said to compare observables, it is important to know what is durable versus what is not. Dr. Astorino-Courtois added that the commander's subjective assessment of an area must be taken into consideration. Dr. Davis said that a commander's assessment would go back and forth from red to green (bad to good) corresponding with the in-and-out rotation of the commanders. Dr. Astorino-Courtois said there is no standard for this assessment. Dr. Cabayan asked a question to the people from the NGA. He asked if a hypothesis was posited and a study area (e.g., districts in Afghanistan) and identifiers named (e.g., construction, movement, and energy use), would this data be easily retrieved and, secondly, if the data could be correlated and reported, would this be useful. Several NGA attendants responded in the affirmative.

Mr. Agee said that the commander needs to be considered, as well as questions concerning investment required and the economy of the force area. Dr. Davis said that this all bears consideration but that also the patterns will reveal information as well. Ms. Duckenfield said for this to be a viable project, good cases will need to be found and variables, such as roads, movement, etc., will need to be identified. The project will have to be run tightly if a goal deadline of spring was determined. Dr. Cabayan said that reported quality of life might have to be used. Gallup and others say that we can do some statistical analysis on these self-reports. He added there are at least some consistencies if long-term groups are doing the data collection, rather than commands that change every six months. Dr. Davis clarified that this project would be proposed as unclassified. Dr. Cabayan agreed and said that the goal is to validate a hypothesis, not try to prove a theory. An issue repeatedly discussed is that there is some civilian activity discernible at the remote sensing level. Dr. Davis asked about the scholarly information that is available on uses of remote sensing. Ms. Duckenfield replied that most scholarly literature focuses on remote sensing and warfare. Mr. Agee said that showing a correlation, demonstrating a trend overall, would be a useful product.

Dr. Davis reviewed the tentative plan for the following day. In the morning, workshop attendants will hear reports of real-world applications. Another breakout session is scheduled to explore/answer the following questions: what kind of analysis would be practical and what could be accomplished with a spring deadline, what are the global implications, what would interest the COCOMs, and what can be conceived as a collection plan in the areas of interest.

8 DECEMBER 2010

OPENING REMARKS (DR. BERT DAVIS)

Dr. Davis welcomed participants to the second day of the workshop and reviewed the agenda for the day. He said that Ms. Sarah Canna will provide a summary of 7 December and then ten brief presentations are scheduled afterwards. These presentations will begin with Afghanistan and then branch out with propositions for answering questions concerning next steps. After lunch, groups will break out to discuss two points: what are the salient ideas and what kinds of questions should

be discussed in order to pursue pilot studies and analyses to prepare for a workshop in the spring that broadens the scope of this workshop.

Dr. Cioffi-Revella asked for clarification regarding finding a nexus between the Political Durability Model and remote sensing. Dr. Davis said that the purpose of the review of the Political Durability on 7 December was to establish the bridge between the conceptual framework and to look at what considerations could drive the framework and what variables could be operationalized. A goal is to connect what remote sensing data can be tied to variables of the model. There is a possibility that the gap between these two things is too broad or too much of a stretch, but there may be connection in some of the variables, such as the economics or agricultural-based variables. A review of the model would be sufficient for those new to the model to be able to make connections between what is possible via remote-sensing data collection and applying this data to the framework of the Political Durability Model. Dr. Cabayan said that political durability requires a country to be able to defend itself, and this workshop is to look at durability from a population perspective, as requested by ISAF.

Dr. Davis introduced the speakers of the briefings that were to take place next. Dr. Davis asked the audience to keep several things in mind. First, he asked the audience to think of specific recommendations for Afghanistan. Secondly, he asked the audience to keep with unclassified data and remote sensing methods. While unclassified is only part of what is available, the goal is to keep the data, analysis, and conclusions as transparent as possible.

LAND SURFACE PHRENOLOGY (DR. KIRSTEN DE BEURS)

Dr. Kirsten De Beurs, University of Oklahoma, presented her briefing, Land Surface Phrenology. Dr. De Beurs works with very coarse data, approximately 8km pixels. Change is examined over time. For example, at this coarseness, Dr. De Beurs looks at when plants "green up" and "brown down." The Normalized Difference Vegetation Index (NDVI) is used to evaluate a growing season. Images are taken every one to two days. Images are then combined (with cloudy images removed) to create a composite. A time-integrated NDVI begins with the start of the season, through the period of "green up" to the maximum NDVI, followed by the period of senescence and the end of the season. Dr. De Beurs reviewed images of the United States' growing season in 1982 and 2006.

Dr. De Beurs moved on to images from Afghanistan. Because of the mountains, larger data could be used. She had examined data from 1982 and on, looking to see the effect of war and drought on the Earth's surface. Darker green in an image corresponds to a higher NDVI. Grey corresponds to desert areas and mountaintops without vegetation cover. The 2001 image of Afghanistan has less dark green than the 2003 image. The year 2003 had sufficient precipitation, while 2001 was an extremely dry year.

Dr. De Beurs then went on to discuss the Qandahar timeline. Using 8km data and starting in 1982, the purpose of this examination was to see the effects of fighting on the land surface following the Soviet invasion. Before the Soviet invasion,

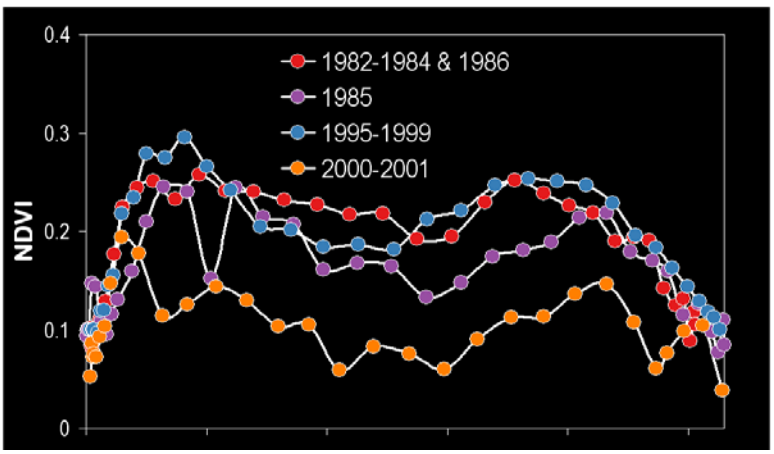

FIGURE 2 NDVI LEVELS IN QANDAHAR

Qandahar was known for its fruit orchards. During the Soviet war, the fields were mined heavily by the Mujahedeen and the Soviet Army. Much of the orchards were abandoned. Heavy fighting continued into 1985. Dr. De Beurs stated that draught and fighting decreased the NDVI. The NDVI from 1985 shows a slight drop. An extreme draught during 2000-2001 caused an even lower NDVI (see Figure 2).

Dr. De Beurs stated that the coefficient of variation (CV) also reveals a change in land cover during this time. There is a decrease in the CV during times of heavy fighting and drought, which indicates a reduction in the amount of green land cover.

Dr. De Beurs stated that this research was funded by the American Institute of Afghanistan Studies. She said that coarse data could provide information and show the effects of warfare. The NDVI is used because it shows the amount of vegetation. In the data, snow and water are negative numbers, the desert and other areas with lack of vegetation are in the 0.1 range, and the index number increases towards 1.0 as vegetation increases.

Dr. Bacastow asked what has happened in the past few years since US involvement. Dr. De Beurs did not know, since she has not looked at recent data.

CHANGE MONITORING IN NEAR-REAL TIME USING LANDSAT AND MODIS (DR. CURTIS WOODCOCK)

Dr. Curtis Woodcock of Boston University presented a review of the efforts monitoring in near real-time using Landsat and MODIS. Dr. Woodcock said that recent trends in unclassified remote sensing would be helpful to efforts that intend to integrate remote sensing into analysis of political durability. First, there is better availability of existing data. Second, data can be accessed more quickly as it is collected. Third, there is better integration of data across platforms (and resolutions). Finally, there is more data available from non-US sensors.

Dr. Woodcock described the remote sensing community as a group of historians, because of the tendency to look at data retroactively. Dr. Woodcock states that the community needs to work more in near real-time. However, he still supports the idea of looking at data retroactively, as it is very important to be able to identify and study change over time, knowing change adds to the ability to work in near real-time.

Dr. Woodcock explained MODIS data (500m pixels) taken in 2001. The correlation between observations at the same place on the ground varies from one day to the next with R squares mostly below 0.5. R square values closer to 1.0 indicate stronger correlation. Dr. Woodcock shared an image with the MODIS observation footprints during one week. Footprints are the areas on the ground actually covered by the sensor. While MODIS makes a daily pass over the area, time, amount of area, and path of sensor varies each time. The MODIS footprints do not precisely overlap for each pass. There is variation in the areas that are sensed.

Dr. Woodcock then explained how data could be used to predict images from Landsat. A time series of Landsat data was created. From that time series, an image can be predicted for any day and then this can be used to figure out what can be expected from MODIS data. Dr. Woodcock stated that this can be done fairly well. Mr. Tom Allen asked if R Squares were predicted. Dr. Woodcock responded

that an R Square value of 0.95 was found between the Landsat-predicted MODIS pixels and the actual MODIS pixels. This is a high, strong correlation between the predicted and actual values.

The benefit of being able to predict an image is that an image can be "created" in case of a disturbance or to fill in as what the next image should look like in absence of change. The ability to predict at Landsat spatial resolutions and then aggregate to MODIS resolutions is possible. Dr. Woodcock said that there is a need to move into working in a more near real-time domain. Baseline data needs to be established before change can be examined.

Dr. Numrich asked if different topography affects the ability to make predictions. Dr. Woodcock responded that mountains might be a little more difficult to do, but not by much.

CENTCOM AFGHANISTAN AND PAKISTAN CENTER OF EXCELLENCE (MR. KEVIN STOFAN)

Mr. Kevin Stofan stated that he is a part of a team of Human Terrain and Geospatial analysts at CENTCOM. They are mapping tribal affiliations, key leaders, and other important attributes at the tribal level. He said that not a lot of remote sensing is used for the information they gather. In his personal research, Mr. Stofan has found that at the village level, they do look at remote sensing data to identify the ratio of land use to the population. Based on his personal experience, security incidents seem to be associated with areas that had low agricultural output. He proposed to examine a small province, east of Qandahar, and compare baseline data of the vegetation index taken from Landsat with security incidents to see if there is a correlation between lower agricultural output and security issues. Mr. Stofan stated that temporal and spatial correlation are important to examine. Temporally, some of these measures can show signs of stability and durability. Leaders will be more informed and make decisions based on changes in village agricultural outputs if the baseline index is known.

Dr. Cabayan asked what village-level parameter is being used. Mr. Stofan replied that the cumulative NDVI, as a surrogate for biomass, will be looked at for each village. Dr. Cabayan asked if this comes into play in the model as an indicator for something else. Dr. Astorino-Courtois said that the percentage of land being used versus not used is examined. She then asked if the amount of land being used for grazing could be identified. Dr. Campbell said that the health of grazing land could be measured.

Dr. Davis asked how the relationship between measured agricultural productivity and the variable in question, Mr. Stofan's security incidents for example, could be examined. Mr. Bozada said that maybe causality could be looked at. We can ask if the crop is failing because it does not make money or because the land could be better used for something else. Col Reichman said that suppose there is correlation between low agricultural rates and SIGACTS, what questions can be asked. He asked what effect taking out US military personnel would have on this instead. Mr. Stofan said the data set is biased because of US presence. Dr. Fenstermacher said the correlation is not that high. Other indicators need to be incorporated. Mr. Stofan said that his personal experience is that there is a relationship at the village level, but it is not possible to say that the SIGACTS correlate perfectly; they may be correlated at some spatial or temporal lag from the observed. Col Reichman asked if any comparison has been done between Afghanistan and the rest of the world. Mr. Stofan replied that the village level data is too coarse, and no global comparison

has been done. It would be more appropriate to do such kind of comparison at the district level. Mr. Stofan said that to validate this, the work and results might not stay at the unclassified level.

GEOGRAPHIC INFORMATION SCIENCE & TECHNOLOGY (DR. BUDHENDRA BHADURI)

Dr. Budhendra Bhaduri, Oak Ridge National Laboratory (ORNL) Geographic Information Science and Technology (GIST), presented a brief on geographic information science and technology. He spoke about ORNL's geographic information system, LandScan. It is the community standard for global population distribution. At approximately 1 km resolution (30" X 30"), LandScan is the finest resolution global population distribution data available and represents an ambient population (average over 24 hours). The LandScan algorithm uses spatial data and imagery analysis technologies and a multi-variable dasymetric modeling approach to disaggregate census counts within an administrative boundary. Since no single population distribution model can account for the differences in spatial data availability, quality, scale, and accuracy, as well as the differences in cultural settlement practices, LandScan population distribution models are tailored to match the data conditions and geographical nature of each individual country and region.

Dr. Bhaduri stated that LandScan evolved from a remote sensing tool used to look at lights at night and to a mapping too, because so much imagery was being collecting. The mapping function allows the analyst to determine many things about people's activities.

Dr. Bhaduri showed a model of San Diego that estimates population movements between the city and the suburbs over the course of a night and day. A similar effort was conducted for Washington, D.C.

Dr. Cybenko asked how the model estimates population. Dr. Bhaduri responded that there is a paper than explains that, which he would share with the group. In general, though, once you have identified a type of building, like a school, one can determine how many kids are enrolled. If school starts at 8 AM, there will be a large movement of parents and children toward the school and then on to the workplace.

Mr. Stewart noted that Gallup uses density population data to validate and refine census data for sampling purposes. It is extremely useful to Gallup, especially in conflict zones.

Dr. Cabayan tried to relate this model to the Political Durability Model. He asked Dr. Bhaduri whether that would be possible. Dr. Bhaduri responded that it depends. There are many things that one can do with simple video, especially in terms of determining mobility. One can see the number of cars and distinguish types of cars. Then one could start tracking increases or decreases in traffic. Those are secondary indicators of commerce. If you see personal vehicles on the road, then you know that people are moving. With imagery, it is very difficult to get to that level of detail. Video shows origin and destination connections better than imagery.

Dr. Cabayan stated that one of the proposed metrics was to determine distances traveled from the home by the population of interest. Dr. Bhaduri stated that an activity model helps one understand movement. For example, the market would not exist if people did not use it. Therefore, one can see whether distance traveled to and from the market is increasing or decreasing. If a market is located closer to one's home, mobility may not increase, but quality of life will. Those kinds of things can be

accessed by imagery. Imagery can also show whether people are using better or cheaper building materials and can see differences in shelters (tents versus buildings).

Dr. Astorino-Courtois stated that Dr. Bhaduri showed the participants a model of where people should be. She asked if there was a way to capture where people actually are and compare the two. Dr. Bhaduri responded that with videos, there are a lot of possibilities. With regard to pattern of life, you can characterize a school in your video. If you have feeds from the morning and afternoon, you can use a model to look for patterns in the data that you might not otherwise see. The patterns and diversions away from it can be characterized.

Dr. Cabayan asked Mr. Stofan whether CENTCOM has tried to do correlation between polling data and other types of data to get the sentiment of the population. Mr. Stofan responded that CENTCOM has just scratched the surface of that at the village level. Dr. Cabayan asked if CENTCOM would be interested in doing this. Mr. Stofan replied that they absolutely would.

Mr. Stofan asked about the ease or difficulty of estimating populations in Afghanistan. He argued that rural areas are an ideal place to estimate the population. Pashtuns are a classless society, so variation between low and high classes are less likely. Dr. Bhaduri responded that you could not use the national census. However, the ONRL uses data from the International Census Bureau. Furthermore, the Afghan Electric Board has numbers for administrative boundaries.

Dr. Cioffi-Revella stated that there is a very small, highly specialized field of statistics that estimates populations that are difficult to count: for example, counting fish in a coral reef. Those methods exist, and there is literature to support it. He added that the statistical office of the United Nations (UN) has developed clever ways of counting people in parts of the world where a census is not advisable. For example, in the rural, jungle areas of Brazil, they will fly a plane over an area and count the people that come out of their homes to look at the plane. Furthermore, the US Census Bureau has a huge international census program; it is not well known.

THE RIFTLAND MODELING EFFORT (DR. TIMOTHY GULDEN & DR. CLAUDIO CIOFFI-REVELLA)

Dr. Tim Gulden, GMU, spoke about the Riftland modeling effort. The Riftland modeling effort seeks to create an integrated model of sources of violence in East Africa. The model represents actors like farmers and herders with a simple set of behavioral roles. The model created dynamics between the herders and range management in terms of dealing with drought and stock reduction. The model is enhanced by a series of ground surveys conducted in four countries resulting in approximately 10,000 photographs and seven hours of high-resolution video clips.

In the Riftland model, each pixel is an agent. The model is written in Java by a computer scientist at George Mason. A base feature of the model is a map of traditional cultures from Yale University. The data can be as old as 100 years old.

The model contains information about the measure of greenness (vegetation) in two-week intervals over the last 12 years. The model can determine forest, prairies, etc., from the greenness map. Rainfall data is also contained in the model. The model also contains population densities based on

nighttime lights. There are 400 areas that have light at night. These areas were used to establish a light threshold.

The model also uses a system dynamics model in each city to help understand population mobility. He stated that it bears a striking resemblance to the Political Durability Model; the two efforts should work together.

Dr. Cioffi-Revella stated that there are a couple of links that may be useful for Afghanistan and the decision maker. First, it is important to note that a defining feature of the project is that the political system of these countries is modeled after political science theory on how a polity operates. Recognizable model and behaviors are under the hood of this model. In the standard model of a polity, a population is affected by particular issues. These issues threaten the population. Public policies are created to manage the issue on behalf of society. The important thing to note is that the generic theoretical model needs to be specialized to the idiosyncrasies of each country. Additionally, the structure of government is determined by local political culture. He warned that the human and social dynamics of remote sensing are sufficiently new to warrant testing and validation.

Dr. Cabayan agreed that SMA is not going to make claims about remote sensing's ability to determine or understand human and social dynamics. What it can do, though, is support the decision maker. By itself, no commander will make a decision based on remote sensing data correlated to social science. However, it informs the decision maker and validates feedback from the decision they are making.

Dr. Cabayan asked how long it took GMU to create the model for East Africa. Dr. Cioffi-Revella stated that the effort is in its third year and still ongoing. However, the Riftland effort will be done in a few months. These models are built around questions. The purpose of the model is to understand social consequences of various stresses, like long-term drought, and determine how the population is affected. Other questions may generate different models.

Mr. Allen asked how the model was validated. Dr. Cioffi-Revella stated that it is a difficult topic. The validation program encompasses validation of basic data, which GMU validates through fieldwork. The team spent the month of August in the field. The other kind of validation is using socio-cultural rules guiding when groups decide to move, comply with rules, fight them, etc. GMU has several papers dealing with validation that it could distribute.

Mr. White applauded GMU for using Human Relations Area Files (HRAF) data. It is a fantastic resource.

Dr. Davis stated that one of the main concerns of the effort is bridging the air gap between the academic community and decision makers and end users in the military. The SMA team and its modelers must be able to speak to the end user in their lexicon or the effort will fail. That is why the Political Durability Model is a core component of this effort—because it is well socialized with MG Flynn and the IJC.

CONFLICT ANALYSIS—A THOUGHT PROCESS (DR. SOMNATH SENGUPTA)

Dr. Somnath Sengupta, BAE, said there is an attempt to understand the international defense market for the next five to fifteen years. It requires an understanding of the conflicts that will arise in the future; what can threaten the durability of a region.

There are complex regional trends. One trend is that conflict is more resource-related than defense-related. Second, people are forming relationships to protect resources. This is leading to unlikely relationships, such as between China, Russia, and Iran. Future conflict may not be about land, but rather control and use of resources.

Dr. Sengupta stated that in drilling down at the individual country level, internal unrest is becoming the norm. Every country must consider the uneasiness within its borders and the unrest within other countries.

Dr. Sengupta said that it is harder to distinguish between friend and foe in any region. This is where ISR and long-term socio-cultural modeling can be amalgamated.

Dr. Sengupta said that the challenge is to develop and identify capabilities that understand, predict, and prevent future threats and do so 10 to 15 years before the threat happens. It is important to enable the military to act within the enemy's decision cycle. There are three different approaches that come together like three legs of a stool to form threat assessment. Two of these, PMESII and persistent ISR, occur in very different time scales, years versus hours. It is also difficult to predict what triggers a person, tribe, or group of people. Finally, a problem exists as there is an attempt to parameterize and form a super model that combines PMESII and persistent ISR with weighting parameters.

Dr. Sengupta said that one component is tactically persistent ISR. Persistence is used to refer increase the working timeline from hours to weeks. Also, resolution will move from vehicles to individuals. The tracking lifeline will also be lengthened from minutes to hours with coverage across the electromagnetic spectrum.

A second component is classic PMESII modeling. The tracked lifetime is measured in years. The resolution level works at groups or "national" level.

Dr. Sengupta said the third component is the trigger or the event or reasoning that triggers someone to act. There are efforts in DARPA that are focused on examining the internal threat. The trigger mechanism is very important and also very hard to understand, as it changes for all people. The literature says that a human is triggered, amongst other factors, by greed, humiliation, poverty, and exploitation.

Technology and what it does is also considered to be a component. Wireless technology has expanded so much recently. The creator of the cell phone was even surprised by the proliferation of wireless technology and usage that happened during his lifetime. Not only has wireless technology proliferated, this technology is being used in new ways, such as cell phone triggers. Wireless has made the war very asymmetric. The question that needs to be considered now is what is the next "thing" that will make insurgency (terrorism) even cheaper to do, easier to recruit, and easy to execute.

Dr. Sengupta went over a step-by-step notional approach to validating the model. , An analysis of COIN dynamics will lead to an expansion of RSTA/ISR (Reconnaissance, Surveillance, and Target Acquisition/ Intelligence, Security, and Reconnaissance) needs as well as identifying the requirements for the new parameter space. The next step is to work towards forming a credible method to create a combined, "Super-Fusion" polynomial expression. The predictive qualities of this polynomial expression can be tested by using past, real-world "surprises" or events. Finally, the model can be validated to try to predict near-term events.

NGA OVERVIEW (DR. ASHLEY HOLT & DR. DEVIN WHITE)

Dr. Ashley Holt is in the Basic and Applied Research Office at NGA. Dr. Holt is involved with a working group that focuses on social science and remote sensing. The group plans to put out a white paper over the long term. The near-term goal is to discuss hard problems and go over methodological issues. Dr. Davis asked if a proceedings or any other output was prepared from their endeavors. Dr. Holt said that a few slides were put together to distribute.

Mr. Devin White said that he is with the NGA's Sensor Geopositioning Center (SGA), which is a Center of Excellence in Photogrammetry. He described the work as figuring out where a sensor is actually pointing as it looks towards the Earth. Lately, the group has been looking at data fusion. Mr. White stated that there are challenges in closing the gaps between the experts that work with the data and the social scientists that could use the data. The SGA is able to solve sensor issues and figure out how to make data sets align. The intent is to try to get the group's expertise out into the community so that more data can be used. Mr. White says that on a practical level, the SGA is interested in uncertainty propagation. He said that previous speakers have discussed resolution and pixel size, but where that pixel is actually located on the ground is overlooked. Other speakers have discussed fusing data sets together despite if they are vector or pixel data sets. Mr. White says that each method and data source has its own error, and there are issues with combining these data. Mr. White said he wants to engage with the remote sensing and social science community to make sure both groups use the uncertainty that is built into the analysis.

Dr. Gulden asked if the errors compound as data sets and methods are combined or do they average themselves out. He asked if it is multiplicative and how error behaves. Mr. White replied that this depends on the pedigree of the data, how it was collected, and the systems it was collected in. Mr. White described this field as very niche, but that it is a niche that is understood. Dr. Bacastow asked where Mr. White saw the human analyst stepping in to this information and being able to understand the error of propagation. Mr. White said that his group is trying to understand where the cutoff takes place. The group can automate some of the steps, as long as the correct initial steps are taken.

Dr. Bacastow asked if error propagation matters to the analyst. Mr. White replied that the group is still working on that question. They are trying to figure out what matters to Command versus what matters to the remote sensing expert.

Dr. Davis asked Dr. Astorino-Courtois how well the polling data is located in space and at what level (district or village) is the polling data. Dr. Astorino-Courtois replied that there are national polls, as well as district and province. Oftentimes, they are not used correctly. It is inappropriate to pull out district data from a national poll. She stated that she did not know of any systemic polling efforts below the district level. There may be the ability to geo-tag the data. Ms. Tessa Baker stated that at

the district level, there is sometimes a sampling data, but not necessarily with GPS. Dr. Astorino-Courtois said an issue with polling in Afghanistan is that there are not many robust polling waves, even from within the same poll. Questions change from one wave to the other. Sampling frames change within the same poll. This all makes it difficult to use the data to inform the models.

Dr. Davis stated that the reporting unit is now at the district level. Dr. Cabayan said that transition is at the provincial level. District level assessments appear, but decisions are made at the provincial, not district level. Dr. Cabayan said that Afghanistan is the most polled country. There is enough data for a proof-of-concept. Dr. Davis said that simple variables work best. It is untenable to try to collapse the nuance. Dr. Astorino-Courtois stated that it is important to see if the general connections can be made between observable behavior and perceptions. She said that if those connections were there, then information can be inputted to areas without data. There are too many gaps in the data. Dr. Davis asked if unused remote sensing data could be used as gap filler.

Dr. Cabayan said that there are approximately 400 districts in Afghanistan, and Dr. Astorino-Courtois added that the military tries to do district level reports. However, Dr. Siegel stated that the military does 49 district-level reports.

SOCIOLOGICAL SENSING PROJECT OVERVIEW (DR. GARY CONDON)

Dr. Gary Condon, MIT Lincoln Laboratory, reviewed the motivation for attitude polling. He rhetorically asked why there is a focus on the population versus the red targets. He stated that our behavior has not necessarily reflected this need. Dr. Condon quoted GEN S. A. McChrystal and CSM M. T. Hall 2009's statement, "We must know the people, their environment and aspirations, and work together with them to meet their needs. Strive to focus on 95% of our energy on 95% of the population that deserves and needs our support." In addition, Dr. Condon quoted a statement from MG M. T. Flynn, CAPT M. Pottinger, and P. D. Bathchelor in 2009, "The emphasis on force protection missions by spy planes and other non-HUMINT platforms should be balanced with collection and analysis of population-centric information. Is that desert road we are thinking of paving really the most heavily trafficked route? Which mosques and bazaars attract the most people from week to week?" Dr. Condon asked how should the sensor data be collected and analyzed to best estimate sociological factors relevant to counter-insurgency operations.

Dr. Condon stated that the current practice is to gather information regarding socio-cultural attitudes and trends through polling. Mature methodologies provide reliable data over a wide range of topics. Gallup uses local personnel to conduct polls worldwide, including areas that have limited access. By necessity, polling relies on periodic interviews of small random samples of the population of interest. Even then, collection may take weeks to months, and sampling may be as low as a few thousand to represent the population. Dr. Condon said that remote sensing could supplement these pieces of information.

Dr. Condon stated that "Sociological Sensing" applies to technical collection and analysis methods to the estimation of local attitudes with the idea to win "hearts and minds" surveillance and reconnaissance assets. Sociological sensing reallocates some intelligence capacity from "red" to "white." The intent is also to provide the atmospherics needed to design effective counter-insurgency operations. Dr. Condon identified two challenges, the estimation problems and the observables. First, a challenge is to figure out how to estimate sociological factors from sensor data.

Second, a challenge exists in figuring out how to design collections to maximize the accuracy and precision of those estimates.

Dr. Condon then illustrated a notional flow of the process. First, the idea is to know the locations of schools. Then flights are planned to observe locations at appropriate times. Then data collection occurs with the product being some kind of image or photo. This information will go into an intelligence cell where it can be analyzed. Next, trend analytics are done to facilitate the understanding of trends and what blue (friendly) forces can do with that trend information. A single trend cannot fully or even partially answer a question. Instead, this approach examines how to go about finding information to inform these questions. The aim is to provide estimates of attitudinal information that support COIN operations.

Dr. Condon reviewed the research plan for 2010. Topic areas such as stability, basic services, and safety and security were selected. These topics led to a two-pronged approach. First was to select poll inputs and outputs and then select intelligence, surveillance, and reconnaissance (ISR) data sources. In the end, correlation analysis examined the relationship of the variables. There are three planned spirals of study. Dr. Condon said they are currently in the first spiral in which they look at the areas in which there has been significant change.

BREAKOUT SESSION 2: REMOTE SENSING METRICS TO FEED THE POLITICAL DURABILITY MODEL

GROUP 1 (DR. ALLISON ASTORINO-COURTOIS, MODERATOR)

Dr. Allison Astorino-Courtois chaired the first breakout group.

Participants:

- Dr. Allison Astorino-Courtois (NSI- Moderator)
- Mr. Collin Agee (NGA)
- Dr. Hriar Cabayan (OSD)
- Col Jeff Reichman (NGA)
- Dr. Somnath Sengupta (BAE)
- Dr. Curtis Woodcock (Boston University)

The group identified several goals for the breakout session. First, the group needs to choose provinces. The second task is to identify operational variables in the Durability Model. Next, the group discussed correlating the Durability Model with remote sensing data. The two types of data to be used are remote sensing and polling data.

Remote sensing data is made up of zeros and ones. It could be a picture where people are seen, but this is less likely. In addition, remote sensing data can look similar to Google Earth images where buildings and agriculture can be seen. Mr. Agee said that a laity study could be done that periodically revisits an area, counting vehicles or watching dismounts.

One participant asked for clarification about what kind of data is desired. She said that human intelligence would be an asset to collecting data more so than remote sensing. Col Reichman said that data will be collected via plane or satellite.

Dr. Astorino-Courtois said if variables are pulled from the Durability Model that have academic and research support, this effort still might not be feasible, even if the time frame is two to three months. The variables may not have an observational component, nor may it be possible to get data that has not been looked at constantly over the last few years.

Dr. Astorino-Courtois said that the social science data is available, but the remote sensing data is still unclear. For example, if images from a province were available from every month for the past five years, someone would have to code everything. That would be a huge coding undertaking. Col Reichman said there are algorithms that will go through the data. With Landsat, certain pixel values represent bare ground, while others represent vegetation, etc. The computer will identify the land for the analyst. This cuts out hours' worth of human work.

Dr. Woodcock said that currently the group is attempting to find trends in the data. However, he asks if the group should bother with the immediate step of trying to collapse polling data into specific components of the model.

Dr. Astorino-Courtois said that an explanation of how the remote sensing data fits into the framework is required. The challenge is discovering what data is available that has persistent coverage, adequately high resolution, and enough variation, beyond seasonal changes or long-term events like droughts.

Col Reichman said that tents can be counted. The United Nations Children's Fund (UNICEF) has done this in the past.

Dr. Woodcock said that movement has to come from the high-resolution images. There should be ways to track movement in higher resolution data. He recommended using a paired sample approach based on attitude. The first step would be to identify change in attitude in select locations. Dr. Astorino-Courtois said that locations that have not changed too much, like Kandahar, Kunduz, or Helmand, should be looked at first. Examine these areas before and after the insurgency to see the physical changes. She asked if building construction could be seen. Dr. Woodcock said that construction could be seen with high-resolution data, but not with Landsat.

Dr. Sengupta asked if three to six months will be enough time to look at the data. Dr. Astorino-Courtois said that this project would be extended to several years and would include historical data.

Col Reichman said urban growth studies were completed for ISAF and NGOs and all had to be done in unclassified products, including Google Earth. Dr. Astorino-Courtois said Google Earth is too old. Dr. Woodcock said that Google Earth is good at having multiple dates of imaging. NGA should be the source of data, not Google Earth. NGA has higher resolution imagery at the unclassified level. Dr. Cabayan said that the data needs to remain unclassified. Dr. Woodcock confirmed there are plenty of unclassified imagery sensors and products available.

Dr. Astorino-Courtois said that a problem is that polling data is aggregated by province. Dr. Woodcock added that it is not useful to look for new houses in areas where houses are not built. There will not be repeat images every month, although bigger cities will be more likely to be covered.

Mr. Agee said that for most of the observables discussed for the model, it would not be useful to look at the entire province. There would be a lot of inactive areas. He said that it would make more

sense to do an informed sampling. For example, if school attendance was to be tracked, every school in the province could be identified, and then the sampling would be statistically reliable.

Dr. Woodcock said that traffic levels could be estimated from the current images. One participant added that there is plenty of unclassified data, including GIS, pictures, etc. Items can be sorted by attribute, year, and tribe from within GIS layers. Dr. Astorino-Courtois asked if this counts as remote sensing data. One participant said that it was geo-coded satellite data. Is the Durand line, which splits Pashtuns in Afghanistan and Pakistan, in the area of interest? Dr. Astorino-Courtois said that there is no polling data from that area.

Dr. Astorino-Courtois said that SCL recently did a study in Pakistan. Col Reichman recommended using one stable and one unstable province for comparison. Dr. Astorino-Courtois said that Kandahar would be interesting over time in that it used to be stable and now it is not. Dr. Woodcock put forth that an area could be identified that would show the change from stable to unstable.

One participant said that there are people on the ground that go into Fatah and talk with people. This is the data that is out there, but it is hard to generalize this kind of information. Dr. Astorino-Courtois said that there are those in-depth interviews in Fatah, but they are stuck on getting data for Afghanistan.

Dr. Astorino-Courtois asked what kind of data can be obtained quickly that does not need extra processing or analysis that can be turned into a spreadsheet and put into a statistical package. She said that the land use data seems promising in this capacity.

Col Reichman said that in Nangahar, images show that the agricultural teams have been in an area and improved the orchards. Five to six years ago, the orchards were in a poor state, but these teams have helped and contributed to the stability of the orchards. This shows positive economic growth and change.

One participant said that wells are also visible. Dr. Astorino-Courtois asked about irrigation being visible. One participant said that there is unclassified data that shows where the wells are located. Dr. Astorino-Courtois asked what the improved land, canals would tell us. One participant said that anyone close to water is better off. Without water, nothing can be grown.

Col Reichman said the Russians destroyed the bulk of the canal system. Rebuilding and improving the canal system makes vegetation bloom again. Dr. Astorino-Courtois asked if anything can be correlated with this. Dr. Woodcock mentioned changes in agricultural productivity. Col Reichmann said that for an agrarian society, this is a major measure.

Dr. Woodcock mentioned food aid. He said that when discussing attitudes, their diet is not based on what they are growing. There could be a disconnect between what people are seeing in terms of diet and how productive agriculture is. The fact that people can grow sufficient crops is an indication that the state of things is not too bad.

Dr. Astorino-Courtois said that the assumption that everyone has some amount of food is useful. The psychological aspect of quality of life can be associated with actual agricultural production versus actual caloric intake.

One participant added that land ownership is key. Not only can a person make a better living, but social status is increased. Land is worth investing in if there is extra money.

Dr. Astorino-Courtois asked if a request for information, such as people's access to water in Kunduz over time, was made to NGA, would it be specific enough to actually be fulfilled. Col Reichman asked for clarification regarding what access to water really means.

Dr. Sengupta said that access to water should be examined over time. He said to look at access to water over five years and to also compare access from five and ten years ago. This could be correlated with people's stability. Col Reichman said that this could be seen using remote sensing. He said that in Nangahar, people started cultivating after work was done on the local canal system. Dr. Sengupta said that access to water gives an area and its people stability. The more a person owns, the more likely a person will stay away from destructive and non-productive activities.

Dr. Astorino-Courtois stated that the group needed data that it could grab quickly that does not need much processing or analysis that could be imported into a statistical package. It sounds like land use might be the best source of data.

Col Reichman stated that the agriculture teams have been working for the last five year in Nangahar, and the improvements can be seen on imagery. That shows positive economic growth.

One participant stated that imagery also shows wells. Unclassified data will tell you where the wells are too. This information suggests that populations close to water are better off. Col Reichman stated that in Herat, the canal system was destroyed by the Russians. It was a Garden of Eden. The region is now blooming again due to recent improvements. He argued that changes in agricultural productivity are key for agrarian societies like Afghanistan.

Dr. Woodcock stated that the Afghan diet is not based on what they are growing, so there could be a disconnect between crops and food security. However, the simple fact that people are growing healthy crops is a good sign.

Dr. Astorino-Courtois stated that the model is based on the assumption that everyone has some amount of food. Then the model can tap psychological aspects of quality of life that would be associated with productivity, as opposed to daily calorie intake.

One participant noted that land ownership is key. Not only do Afghans make a better living if they own land, but it adds to their social status. If Afghans get any money, they invest it in land.

Dr. Sengupta stated that measuring people's access to water is important. If the model looks at trends over time, it might correlate to stability.

Dr. Astorino-Courtois asked if there was a physical indicator of land/farm ownership by size of plot or other characteristic. Dr. Davis stated that if people farm for themselves, they live on the farm. An image of local farms would show heterogeneity. Large compounds suggest group or industrial farming.

Dr. Astorino-Courtois asked if there is a positive correlation between Afghan's property ownership and their support for government. Dr. Condon stated that he attending a talk at USDI a few months ago called *The Value of Cadaster*[3] that addressed this question.

One participant suggested that size of house over time is an indicator of prosperity. Dr. Woodcock stated that the high-resolution commercial imagery at NGA would be very useful to this effort.

Dr. Condon suggested that one could measure the number of buses at a depot as an indication of how well public transportation is working. Mr. Agee stated that the growth of the public transportation fleet and the usage rate could be an indicator of stability.

Dr. Davis suggested looking at major supply routes every six weeks for the number of cars on an overpass. If movement is up, then stability is up. A single number would not mean anything, but the trend would mean something. He also suggested that the number of cars on the road could be correlated with crop productivity or other indicators of growth and stability. Dr. Astorino-Courtois stated that the size of the truck would have to be accounted for. Fewer big trucks could mean that the economy is not doing well.

Dr. Davis stated that the value of the project is to improve confidence in assessments at the provincial level. The way to accomplish this is through non-population based correlates that show trends over time. Remote sensing data goes back in Afghanistan to 2000. A lot of compressed data has also been stored. It may not be at a great resolution, but since it is free, it could be worth looking at.

Dr. Davis suggested that another metric to look at is urban renewal in general, including new roads, new roofing materials, etc.

One participant suggested that other indicators could be the number of tent cities, livestock, or schools.

Dr. Davis stated that the effort wants to test the remotely sensed correlates of perceptual data.

GROUP 2 (DR. GEORGE CYBENKO, MODERATOR)

The second breakout group was chaired by Dr. Cybenko, Dartmouth University.

Participants:

- Dr. George Cybenko (Dartmouth University- Moderator)
- Dr. Budhendra Bhaduri (ORNL GIST)
- Mr. Michael Campbell (ERDC)
- Dr. Tim Gulden (GMU)
- Dr. Ashley Holt (NGA)
- Dr. Sue Numrich (IDA)
- Ms. Swathi Veeravalli (AGC)

[3] Douglas Baston, The Value of Cadaster, http://www.ndic.edu/press/10279.htm

Dr. Cybenko proposed two phases for the breakout session discussion. First, the group would review the Durability Model and its parameters and then identify the ways remote sensing can provide data to this model. Mr. Campbell stated that the group should come up with a list of essentials. Dr. Numrich added that a list of the observables should also be compiled. This would remove the model variables about the government that cannot be observed.

Dr. Gulden asked if it is possible for one observable to fit into several places on the Political Durability model. He asked if a parsimonious causal model of durability could be created. Durability can be defined, but there are no causal models out there, just models of correlation. Dr. Cybenko said that a model cannot be validated at this point because there is only one country, Afghanistan. The model can be validated in the future with another country or region.

The group went through the Durability Model and tried to either identify possible remote sensing techniques that could be used to operationalize the variable, or the group would determine that remote sensing would not be viable.

The group began with the Governing Stability concept, one of the three multi-dimensional concepts that make up Political Durability. Dr. Numrich started with the Political Voice dimension. She said there are no observables of Political Voice.

Dr. Numrich said that there are observables under the Social Services factor. A participant asked if it is possible to infer access to water, one of the dimensions of Social Services. Dr. Gulden said that the general water situation can be seen (e.g., if lake levels are low). Dr. Campbell brought up the karez water system. He described it as an underground water transportation system with a system of aboveground access points that connect to adjoining underground tunnels. Dr. Gulden asked how it could be detected. Dr. Campbell said that the access points could be seen in Google Earth. Dr. Gulden added that the green areas around the access point would imply which ones are functional versus the ones that have dried up.

Education is another dimension of Social Services. Dr. Cybenko asked the group if schools could be identified via remote sensing. The general consensus was no, not in Afghanistan. Dr. Bhaduri said that in the U.S., high schools are identified by their tracks and adjoining fields. In Afghanistan, there are no indicators like that.

Dr. Cybenko brought up the next dimension listed under Social Services, Physical Security. Dr. Gulden asked if cars could somehow be used to measure physical security. Dr. Campbell said that cars can be identified. Dr. Holt said that car size can be measured, which can be used to classify vehicle type. Dr. Bhaduri added that the number and size of cars on the street has increased. Dr. Cybenko said that transportation could be either an indicator or its own dimension. Dr. Bhaduri said that remote sensing could identify how far people live from roads and how many miles/km of road have been built or repaired over time.

Dr. Numrich moved on to the next dimension, Justice, and asked if border security can be sensed over time. Dr. Campbell said this would be a surveillance technology, not remote sensing. Dr. Bhaduri said that modern security is more controlled along borders and at checkpoints. Dr. Campbell asked if measuring footpaths along and around checkpoints could be an indicator of border security. Dr. Bhaduri responded by asking if the footpaths would be a sign of security or mobility. Dr. Numrich pointed out that Border Security is a dimension under Rule of Law & Justice, but that there is a Justice dimension under Social Services. The Justice Dimension deals more with

perception of government in providing justice and fighting corruption. Remote sensing methods can sometimes see borders.

Dr. Holt mentioned that the borders are sometimes visible (for example, in LandSat and MODIS imagery) due to deforestation or differences in land use, such as the borders between the Dominican Republic and Haiti or between the U.S. and Canada. She proposed that retroactively examining images could provide information about when distinct differences in bordering countries arose.

Dr. Bhaduri said that terms in the operationalized variables in the Rule of Law and Justice dimensions, like satisfaction and perception, cannot be measured remotely. The group returned to the idea of Border Security and, more broadly, the other Rule of Law and Justice dimensions. Mr. Campbell brought up urban land classification and how that could be used as an observation of the government having some rule of law and justice. Distinction between land areas, land zoning, and use can be identified. Dr. Gulden said that polygons identifying areas of low, medium, and high-density built-up land zones (BTZ), open space, communication buildings/areas, power lines, government buildings are used in US urban planning. Dr. Cybenko stated that identifying government and military buildings could be a way to operationalize these dimensions in some way. Dr. Gulden added that monitoring the changes in government and military buildings could be useful.

Dr. Cybenko moved on to the next dimension, Governing Legitimacy. Dr. Bhaduri and the rest of the group agreed that this dimension could be ruled out because remote sensing cannot measure legitimacy.

The next dimension discussed was Governing Capacity, which is comprised of two components, Bureaucracy and Revenue. Dr. Cybenko stated that these cannot be measured by ISR. Mr. Campbell asked if the condition of roads could be an indicator of either. Maybe the time lag between productivity and observed improvements of the roads could indicate towards amount of bureaucracy or revenue available. Dr. Gulden said that it would be easier to measure agriculture instead of roads for revenue and productivity. Dr. Campbell pointed out that agriculture exploded when the Taliban took over ten years ago.

Dr. Cybenko proceeded to the next dimension, Economic Capacity. The group put forth several ideas about what could be sensing remotely that could be applied toward this dimension. Some of the initial ideas were overall agricultural production, electricity use, how busy the markets are, and vehicle counts in an area.

The next dimension is Economic Development, which includes the physical capital of the Urban dimension [of Economic Development]. Dr. Cybenko asked if there is a way to use remote sensing to infer how many people are employed in an aggregate way. Dr. Bhaduri proposed that an idea of how many people are employed could be estimated; for example, using the number of houses surrounded by farms could lead to associating those homes with working farms and, thus, employment. Dr. Cybenko then asked about the accuracy of the idea that the countryside gets depopulated at night. Dr. Bhaduri said that in Pakistan, there are large industrial places with neighborhoods around it. It is assumed that the industry supports and employs the surrounding neighborhoods. Dr. Bhaduri added that also under the Urban dimension is electric power consumption. He proposed identifying kilometers of electric power lines. Dr. Numrich added identifying cell phone towers as an indicator of this dimension. Dr. Bhaduri said that by

crosschecking imagery and using electric power, it is possible to back calculate the two commodities.

Dr. Cybenko asked if water surveys could identify what is happening upstream. Dr. Campbell said that water sampling techniques are taken by hand or using water buoys. Results can be processed within minutes for that particular part of the river, but not a general condition of the body of water. Water sampling is very spotty. Dr. Bhaduri stated that the census gathers data on whether a person has access to municipal water sources or if water has to be sought out. Dr. Campbell shared an anecdote from Afghanistan that if water is moving, it is clean enough to drink. Dr. Bhaduri commented that the Physical Capital of Rural areas is a dimension that can be measured using remote sensing. Dr. Gulden said the state of the irrigation system would be important to know. He said the functioning of a community irrigation system could indicate levels of cohesion. Dr. Bhaduri said that the functionality of different tribal irrigation systems could be compared to see which ones are working.

Still discussing Economic Development, Dr. Bhaduri moved on to Services indicator of the Infrastructure dimension. The reach of communication technology could be sensed by looking at cell phone towers.

The group moved on to the final main concept in the model, Social Stability. Crime is an indicator under the Physical Security dimension of Physical Needs. Dr. Bhaduri proposed that remote sensing could gather information on how much roads are used. Overall road usage might be able to indicate levels of security. There are possible multiple indicators that road usage could be linked.

Dr. Bhaduri said that land classification and refugee camp identification could be measures of Physical Displacement dimension of the Speed of Social Change. Dr. Gulden said that slums in urban areas can be identified. Dr. Cybenko asked if neighborhood boundaries could be discerned. In addition, he asked if it is possible to determine middle class from upper class, etc., based on building size or number of cars. Dr. Bhaduri pointed out that this is what NGA is doing. He said that the wealthy neighborhoods were virtually untouched by shelling. Dr. Gulden said that investment is purely private, and there is no shared investment in public areas. Dr. Bhaduri added that this information could be combined with the information that identifies which parts of society are growing. Dr. Gulden said that the changing sizes of slums or camps are important, as are the areas that have new building and home construction. He said that these two areas would be good to follow through on. Dr. Cybenko brought up the idea of delineation between properties. He asked how that is generally accomplished. Dr. Campbell said that the Buckeye system can see walls, but that it is expensive. Buildings in Afghanistan all generally have walls.

Dr. Cybenko moved on to Inter-Group Integration dimension under Speed of Social Change. Dr. Gulden said that residential micro-data is not possible, especially in areas that have not had a census since 1979.

GROUP 3 (MR. THOMAS BOZADA, MODERATOR)

On the second day of the Remote Sensing Workshop, Breakout Group 3 was chaired by Mr. Thomas Bozada, USACE.

Participants:

- Mr. Thomas Bozada (USACE-Moderator)
- Mr. Tom Allen (NSI)
- Dr. Todd Bacastow (Penn State University)
- Ms. Tessa Baker (NSI)
- Dr. Kristen De Beurs (University of Oklahoma)
- Dr. Pascale Siegel (Glevum Associates)
- Mr. Chris Stewart (Gallup)
- Mr. Kevin Stofan (CENTCOM)
- Dr. Devin White (NGA)

Mr. Bozada began the second breakout group by asking what the group's product to Flynn should be. He noted that Tessa Baker's idea was for a fused product of data collection that includes remote sensing and sentiment data to improve the transition decision at the provincial level. He sought feedback from others in the group.

Dr. Davis noted that there is some aggregation of data here at the provincial level; battalions are reporting up to brigade. One might assume that there is some averaging that goes along with that. The transition decision is at the provincial level, which is also, therefore, a multiple battalion level, which makes the problem more tractable, because it makes the argument for aggregating and correlating the results. There may be things going on at a regional, multi-district level like "it's dry" that affect either systematically. It would be useful to know to what degree these large economic or environmental drivers change things in individual districts.

Mr. Stewart, Gallup, asked whether the group should identify some provinces for a proof of concept effort. Mr. Bozada responded that the provinces selected might be a result of what was ultimately decided in terms of the product. Dr. Davis suggested that it might be useful to have a few provinces identified to be better prepared to brief to MG Flynn in early January. He will tell us what he wants us to do.

Mr. Stewart recommended that the RCU provinces be used. He argued that these three provinces might be a good starting point, since there would already be a depth of social-cultural data (atmospherics, tribal data) and Helmand and Paktika will likely have coverage. Dr. Davis interjected that if the remote sensing group went to Flynn with just a more intense or concentrated version of something that has already been done or thought about, it will be more of a sales pitch; but if the group goes to him and says that they want to take a new look at data that already exists and no one has evaluated closely, Flynn might be more responsive. Agriculture has not been looked at. It does tie into areas where there are not robust censuses.

Mr. Bozada summarized the previous few minutes of discussion, restating the group's conclusion regarding the purpose of the group as using data that has not been previously evaluated in the durability model. The critical selling point is that there is a potential treasure trove of data that has

not yet been exploited. The question is how to do this, how do we integrate across methods and analytical techniques?

Dr. De Beurs noted that there is a lot of research looking at agriculture from space.

Dr. Davis agreed with Bozada's assessment, noting that the data has already been vetted, but it has not been used. This approach adds value by finding trends/correlates with population-centric data streams, thereby adding confidence. Confidence is improved in two ways: 1) by correlating with already existing polling data and 2) adding a spatially exhaustive element with an ability to fill in geographic data gaps.

Mr. White concurred that remote sensing data has a longitudinal aspect; data is available going back to 1982.

Dr. Davis added that he oversees four SBIRs that look at climate change vulnerability. There are four different approaches. One of the SBIRs is focused on content scrubbing and vector analysis, and then there are climate experts, who cannot get a handle on the uncertainty. The retrospective opportunity of remote sensing is huge. There are multi-scale looks with near-perfect time series that can fill gaps, in particular, parts of the model. Furthermore, it is free, since the data has already been collected, but not used. It may also cue to indicate where we need to learn more about an area.

Mr. Bozada asked Dr. Davis about how much of a description of what the group proposes to do should be brought back into the room. Dr. Davis replied that the output should be appropriate for a three- or four-star general. The output should be boiled down into a few charts and 10 minutes; verbs matter.

Mr. Allen noted that in order to do this, the group needed to reduce the parameters to what was already provided by the data.

Ms. Siegel noted that most of the polling is done for ISAF, whose perspective is operations now and tomorrow. The focus changes the questions asked over time; consequently, there is very little consistent polling data.

Mr. Bozada asked whether anyone else in the group had words to contribute to the product or purpose statement. As a reminder, the product is a fused remote sensing and sentiment data product that fills gaps, correlates with existing data, and addresses broader exogenous factors that influence population centric data.

Mr. Stofan added that if consistent polling data is lacking, showing differences in signatures in the data would be exceedingly useful.

Mr. Bozada sought to capture some of the issues that the group had identified. Among the concerns were inconsistent polling data in terms of level of resolution and the availability of trending data over time, as well as identifying the appropriate analytics for the remote sensing data. On the positive side were the availability and completeness of coarse remote sensing data.

Mr. Allen noted that the imagery is there, whether the analytical products necessary already exist is the outstanding question. The data has many pixels, but the useful information to extract the information there is something that will need to be done.

Ms. Siegel noted that polling is generally a small component of the commander's assessment. The commanders will have harder metrics on Taliban strength, for instance, which complement the polling data. Polling is nice to know.

Mr. Bozada summarized that the group had heretofore established that the objective is to fuse different products together, which is good because it helps to identify and/or cover other gaps. Remote sensing data may overcome some of the gaps in the polling data. The other thing is the cuing aspect of some of these things.

Mr. Stewart indicated that cracking the code on economics and what can be sensed remotely that can capture things that impact economics would be an interesting element. If the United States begins to pull out some troops this year, the economies may start to collapse. When the United States begins to suck all of this money out with no more reconstruction projects going on, it becomes a durability concern. Other interesting areas include reviewing safety and security from a seasonal perspective.

Mr. Bozada agreed that the seasonal aspects of security and safety are an interesting question, much like a discussion he had with Mr. Stofan about men in low-yield agricultural areas being more supportive of anti-government elements, which has a seasonal aspect. That might be a tier two activity, but that is critical, because when the United States transitions, it ought to be a function of what Stewart just described. With regard to the polling data, it sounds as though it will need significant work in terms of combining the multiple data sets and normalizing the scales, etc., within the area of study.

The group began to discuss process. Mr. Stewart noted the importance of identifying the area of study first, which Mr. Bozada agreed with. Additionally, Mr. Bozada noted that once the relevant polling data is identified and compiled, correlation analysis should be conducted.

Mr. Allen asked how remote sensing might improve the process of producing a better product. He noted that it is not only about the product being made better. Dr. White responded that it is a virtuous circle.

Mr. Bozada responded that the intelligence process is being re-imagined. The group has to take the fusion process and revamp it. With the remote sensing fusion process, correlation will be critical. Analysts will do initial correlation analysis and draw some initial conclusions. Mr. Allen interjected that there has to be a sanity check, because correlation does not necessarily imply causation.

Mr. Bozada agreed that validation has to occur. If the product improves the commander's assessment, this group will be successful. If it augments the commander's assessment with additional information, that is even better. It makes more sense to do this at the district level, but he did not think that is feasible. He noted that the group's task is to figure out how the remote sensing data support the decision on whether or not transition should take place. He then summarized the process that had been discussed by the group:

1. Identify Area of Study in terms of a specific geographic focus;
2. Collapse Operational Variables (Observables) to what is germane to the area of study;
3. Determine available data by identifying the available data sources over time in the given area of study;
4. Clean and normalize the data, particularly the relevant survey data;
5. Correlate data and conduct other analytical tests to determine associations;

6. Validate results for face validity;
7. Iterate .

After delineating the initial process approach, Mr. Bozada asked what kinds of correlations might be apparent.

Kevin Stofan noted that one of the operational variables was perceived deprivation, which could be matched against Normalized Difference Vegetative Index (NDVI). In order to do this sort of analysis, it may be necessary to establish a baseline or expected NDVI.

Ms. Siegel noted that personal deprivation is not just about crop yields. Analysts can test for a correlation between high NDVI (high crop yields) and personal deprivation, but that may not be true.

Mr. Bozada asked about canals. He stated that canals could be evaluated prior to US intervention and compared to canals today, which may be a good proxy for government efficiency and success.

Both Ms. Siegel and Mr. Stofan interjected that the Afghan government has no role in the maintenance of irrigation systems. There is one individual who takes care of the network of irrigation in a given area, often as part of the tribal system.

Dr. White added that the anthropology literature looks at the formation of power at the local level, which can aggregate up to other leadership roles. Many cultures have mechanisms built in that no one can really peek their head above everyone else. If the irrigation is not working, it is an indication that the previously existing cultural construct has collapsed.

Ms. Baker asked whether it might be useful to just focus on poppies in terms of potential correlations.

Mr. Stofan noted that for much of Regional Commands South and Southwest, it is not necessary to directly observe canals; any growth is a result of irrigation because it is so arid there. Poppies leave a significant signature after the growing season, because the cultivation process leaves a large amount of organic matter on the ground which appears dark in satellite imagery.

Mr. Bozada added that if there is a lot of poppy growth relative to subsistence farming, then there generally is either corrupt behavior, because the government is allowing that to happen, or Taliban pressure ~~is~~ motivating the activity. Is the reason they are choosing to grow poppy due to the fact that the farmer can get enough or more money from growing poppy to offset the loss of subsistence?

Mr. Allen added that it is the change in the observed that will the biggest issue; the fact that poppies have changed from something else or vice versa, that is an indicator that analysts should be looking more deeply in that area.

GROUP OUTBRIEFS

Dr. Davis asked each of the three groups to summarize their findings very succinctly. He asked for their bottom line up front (BLUF) with strong verb to subject/object relationships. He asked the groups what could be done in the next three months using existing data sources.

Breakout Group 2

Dr. Cybenko presented the findings from breakout Group 2. He stated that the only area the group felt it could not address was government legitimacy. He stated that his BLUF is that there are many proofs of concept possible within the constraints of the effort. He proposed a two-stage plan. First, in the short term, the decision maker could talk about what we can actually measure to support the independent variables in the model. Second, he suggested that the long-term effort look for resolution, sampling rates, etc. to support the model itself.

Dr. Cybenko stated that his group came up with several measures of stability.

1. Transportation infrastructure and ability to measure vehicles and types (security, economics)
2. Trend in multiple use of vehicles, e.g., people using private vehicle to transport commodities, military use, etc. (security)
3. Change in urban terrain/usage, e.g., change in quality of housing, location of government facilities in relation to residential areas, etc. (economy, security)
4. Existence of irrigation systems , e.g., water infrastructure and use
5. Availability of grazing land/livestock density
6. Change in government land use, e.g., new government buildings (measure of vitality of government)
7. Agricultural productivity (ties to tax revenues, economics)

Mr. Agee stated that Beth Driver at NGA is running a project to look at the geography of urban areas. Areas that are more affluent tend to be more symmetrical and spread out. Impoverished ones are cramped and asymmetrically located.

Dr. Gulden stated that the construction of big houses indicates something as well.

Breakout Group 3

Mr. Bozada presented the findings from breakout Group 3. He stated that the group proposed to use data not previously considered during the durability analysis, including scientifically vetted techniques to identify trends in time and space. These include:

1. Correlated data (polling gap data)
2. Exogenous factors (drought)

He suggested that the effort look at agricultural indicators, such as changes to irrigation infrastructure over time.

Mr. Bozada stated the difficulty of using polling data is that the various surveys would need to be normalized.

He suggested the following approach. First, identify an area of study to determine if there is sufficient data available for the scope of inquiry. Second, he suggested that the effort collapse operational variables that are applicable to areas of the study and relevant to the commander's assessment. Third, the effort should scope available data. Fourth, the effort should clean and normalize data. Fifth, it should conduct data analysis through correlational or regional analysis. Proxy indicators could be used as intervention factors. Sixth, validate with SME participation. Finally, the analysis should be open to receiving feedback.

Breakout Group 1

Dr. Astorino-Courtois presented the findings from group 1. She stated that the group came up with four hypotheses that have to do with testing and finding physical manifestations of perceptions.

1. Land ownership: Does that correlate to SIGCACTs or heightened self-report of quality of life?
2. Increase movements: Increased movement is a signal of self-reported quality of life and perceived security
3. Change in number and size of markets over time and an indicator of economic growth
4. Internally displaced populations are negatively related to changes in perceived security and SIGACTS

CLOSING REMARKS (DR. BERT DAVIS)

Dr. Davis outlined the way ahead.

1. The proceedings will be sent out for participants to review and redact.
2. Dr. Davis will email group to ask for volunteers for specific tasks.
3. A workshop will be planned in the spring to bring the COCOMs (AFRICOM and EUCOM) on board.
4. Dr. Davis and Dr. Astorino-Courtois will prepare briefing slides for larger effort, including project objective and technical approaches.

Dr. Davis stated that in the long term, ERDC is being asked by the Army to help set up brigade centric assessment. Dr. Cabayan suggested that TRADOC should be brought into this effort. Dr. Davis stated that in the long term, a combat developer at the war colleges is interested in creating doctrine around this.

Dr. Davis stated that it has been his experience that ERDC puts out a huge toolbox of decision and planning aids that it has transitioned and used in theater. The use of the tools depends on the mission set of the commander on the ground.

Dr. Davis thanked all of the participants for their contributions. He stated that the workshop results exceeded his expectations. He anticipated that a vast field of research between the social science and remote sensing communities is about to open up. He warned the participants that there will be a lot of near-term follow up.

Dr. Davis stated that the workshop was, in a sense, a social experiment in bringing together various disciplines.

APPENDIX A: CONFERENCE AGENDA

Day One: December 7, 2010

8:00am - 8:30am **Check-in**

8:30am - 9:00am **Welcome, Workshop Introduction and Purpose**

9:00am - 10:00am **Introductory Briefing (Dr. Allison Astorino-Courtois, NSI)**

- PAKAF RCU Study
- PAKAF RCU Metrics and Indicator Development
- Political Durability Model
- Thoughts on Remote Sensing Measures

10:00am - 10:15am **Break**

10:15am - 11:45pm **Introductory Briefing**

- Remote Sensing 101 (Michael Campbell, US Army ERDC)
- NGA Presentation (Mr. Collin Agee, NGA)

11:45am - 12:45pm **Lunch**

12:45pm - 4:00pm **Breakout Session 1 (Moderators: Dr. George Cybenko, Dartmouth; Dr. Allison Astorino-Courtois, NSI; Mr. Tom Bozada, USACE)**
Participants will be divided into three groups (governance, security, and development)

4:00pm - 5:00pm **Breakout Session 1 Outbrief & Day 1 Wrap-up**

Day Two: December 8, 2010

8:00am - 8:30am **Check-In**

8:30am - 9:00am **Review Day 1 Activities (Ms. Sarah Canna, NSI)**

9:00am – 10:45am **Selected Case Studies and Briefings From Other Than the AFPAK Region**

- Land Surface Phenology (Kirsten de Beurs, U of Oklahoma)
- Change Monitoring in Near Real-time Using Landsat and MODIS (Dr. Curtis Woodcock, Boston University)
- CENTCOM Afghanistan and Pakistan Center of Excellence (Mr. Kevin Stofan, CENTCOM)
- NEXUS 7 (Dr. George Cybenko, Dartmouth)
- Overview of Geographic Information S&T (Dr. Budhendra Bhaduri, ORNL GIST)
- The Riftland Modeling Effort (Timothy Gulden & Claudio Cioffi-Revella, GMU)
- Conflict Analysis - A Thought Process (Somnath Sengupta, BAE Systems)
- NGA Overview (Devin White & Ashley Holt, NGA)

- Sociological Sensing Project Overview (Gary Condon, MIT Lincoln Laboratory & Christopher Stewart, Gallup Consulting)

12:00 – 1:00 PM **Working Lunch**

1:00 – 2:30pm **Breakout Working Group Session 2 (Dr. George Cybenko, Dartmouth Dr. Allison Astorino-Courtois, NSI, Mr. Tom Bozada, USACE)**
Participants organized into working groups to develop needed follow-on activities (e.g., analyses) and terms and charter for more general workshop.

2:30pm - 3:00pm **Workshop Wrap-up and Way Ahead**

APPENDIX B: PARTICIPANT LIST

Adesnik, A. David	OSD CAPE
Agee, Collin	NGA
Allen, Tom	NSI
Astorino-Courtois, Allison	NSI
Bacastow, Todd	PSU
Baker, Tessa	NSI
Behling, Tom	Centra
Berry, Nina	JIEDDO
Bhaduri, Budhendra	ORNL GIST
Bozada, Tom	USACE
Brown, Molly	NASA GSFC
Cabayan, Hriar	OSD AT&L
Campbell, Mike	USA ERDC
Canna, Sarah	NSI
Chesser, Nancy	DTI
Cioffi-Revella, Claudio	GMU
Condon, Gary	Lincoln Lab
Cybenko, George	Dartmouth
Davis, Bert	USA ERDC
De Beurs, Kirsten	U. Oklahoma
Duckenfield, Kea	NGA
Fenstermacher, Laurie	AFRL
Frank, Jim	TSWG
Gulden, Tim	GMU
Holt, Ashley	NGA
Madore, Jeff	MCIA
Murphy, Justin	MCIA
Numrich, Sue	IDA
Reichman, Col Jeff	NGA, St Louis
Roman, Elmer	OSD AT&L
Sengupta, Somnath	BAE
Siegel, Pascale	Glevum Assoc
Stewart, Chris	Gallup
Stofan, Kevin	CENTCOM
Veeravalli, Swathi	USACE
Weinstein, Cliff	Lincoln Lab
White, Devin	NGA
Woodcock, Curtis	Boston U
Yager, Mariah	NSI

APPENDIX C: ACRONYMS

ABI	Activity Based Intelligence
AF	Afghanistan
AFRICOM	United States African Command
AFRL	Air Force Research Laboratory
AGE	Anti-government elements
BLUF	Bottom Line Up Front
CENTCOM	Central Command
COA	Course of Action
COCOM	Combatant Command
COIN	Counterinsurgency
COMISAF	Commander ISAF
CV	Coefficient of Variation
DDGO	Deputy Director for Global Operations
DDRE	Defense Research & Engineering
DNI	Office of the Director of National Intelligence
DOD	Department of Defense
ERDC	United States Army Engineering and Research Development Center
EUCOM	United States European Command
GIS	Geographical Information System
GIST	Geographic Information Science and Technology
GMU	George Mason University
IDC	Information Dominance Center
IED	Improvised Explosive Device
IR	Information Requirement(s)
ISAF	International Security Assistance Force
ISR	Intelligence, Surveillance and Reconnaissance
KLE	Key Leader Engagement
Landsat	Land Satellite
LIDAR	Light Detection and Ranging
MODIS	Moderate Resolution Imaging Spectrometer
NASA	National Aeronautics and Space Administration
NDVI	Normalized Difference Vegetative Index
NGA	National Geospatial Agency
PAKAF	Pakistan and Afghanistan
PIR	Priority Information Requirement(s)
PMESII	Political Military Economy Social Infrastructure Information
RCU	Rich Contextual Understanding
SBIR	Small Business Innovation Research
SIGACTS	Significant Activities
SMA	Strategic Multilayer Assessment
SME	Subject Matter Expert
TCAPF	Tactical Conflict Assessment and Planning Framework
US	United States of America

USAID	United States Agency for International Development
USG	United States Government
WAAS	Wide Area Airborne Surveillance