Chapter 8—Environmental Case Example—Remote Sensing Sciences, Hyperspectral, Commercialization and Creation of an Institute and *New Science?*

Extracted from the book "Vision – We are Re-Creating the World: A resource manual – "tool-box" – for revitalization and empowerment through grass-roots efforts and environmental awareness."

As mentioned previously, it is absolutely critical for a solid basis in environmental conditions, and to have ways identified for protection an amelioration of the natural environment. That is why "Environment" is one of the three "E´s". We will not be able to go into an extensive discussion of environmental protection because it is such a large topic. However, we will present a detailed case study of a technology and a "new science" that´s primary benefits I believe we will see happen for environmental protection. In a sense, I would say that protecting the environment is one of the pillars of the structures we are building. I will provide a relatively detailed description of this technology called a hyperspectral sensor, and the process by which we can build an "institute" or "center of excellence" for utilizing this and other remote sensing technologies and the science. This really becomes just another function of "Education" in some regards, but it is an important enough consideration that we need to have a separate discussion in detail.

Our relationship to nature is paramount to our survival. And our concepts of how we relate to "her" are so far off base that we need a revolutionary change in how we operate. The evidence of our disconnect is all around us in the various exploitative practices and the extent of the environmental degradation that can been seen in all spheres of the natural world whether it be the water, land or air. There are so many books and organizations working in this area but it is not so much about speaking about another "battle" to wage with some other human group, as to be the harbinger of a entire paradigmatic shift. In this regard we truly are all in this together. One of the ways to awaken people is to have them think of the planet as "our Mother", and imagine how we would treat our own mother. Would we still throw trash on her? Would we pour poisons into her mouth? Imagine how patient she has been with us, continuing to provide us all of our necessities even though we have been the most errant of children.

Another way is to know that really "nature" is God´s expression. This should be taught in all churches, all schools, in all advertising. This idea should be so engrained in our

"systems" and thinking that it should be second nature. We need this kind of shift, now, or else there is no hope.

Again, this could, and likely will become an entire book and it is not the point to get hung up on this topic. As stated previously, there are innumerable authors and books on this subject. One of the best that I have found is "The Great Work" by Thomas Berry. Now to get onto the subject of the Hyperspectral sensor, and the creation of an organization and strategy to begin addressing some of the environmental issues that we need to confront as we move forward, actively, in our relationship to ourselves and the planet. The reason I say, "ourselves" is because, as we have now found, there is only One of us here, and whatever we do to the planet is really just a reflection of how we feel about ourselves. Do we have respect?

A New Science?

In looking at this idea of technologies and their application as "new science" is about the new ways of looking at the natural world, and the subsequent models and procedures that are very different from traditional science. That is because there is a merging of technology and science. With new visualization technologies science changes. How these changes will happen cannot be totally predicted. But previously the scientific method was independent of other factors. Science did not depend on "technologies" per se. But with this visualization science, we are totally dependent on the technologies. And, until we dive in to the use of these, we do not know all of the models and theories that will be developing. This idea can be expressed similarly to how we describe the technology itself. We do not know what we can see, so how can we know what we are going to see if we have never been able to look before. Yes, maybe our intuition has given us glimpses, or as we are realizing the nature of the universe is "holographic" and consistent at all scales, but in the actual application of these technologies to solve problems, this is a new frontier. And what an exciting one it is.

So the same goes for how this "new science", the merging of new exciting technologies, and hopefully, evolving scientific methods cannot be predicted before we see how these dynamics play out. Hyperspectral sensors have been around for a few decades, but their use was limited to military applications. As a result, there was only very limited application. And because of this there has not been a lot of foundational principles or theories put in place. The science, as far as its application for environmental purposes, is just emerging.

As stated before we believe that environmental protection, management and enhancement, and the development of new practices for agriculture and all economic activities must be based on new models, or models using combinations of established methods that perform better for long term environmental sustainability. Why would I make such a claim. Look at the track record of what our current models are. They obviously don´t work. Evidence to this fact can been seen in all areas of natural resource, soil, agriculture, air and water.

Our position regarding environmental protection is based on evidence gathered from throughout recorded human history, and we are irrefutable on this point: that the costs for not protecting and sustaining that where our bounty comes from (Gaia, or the Earth) are exorbitantly high, not only in economic terms but in regards to human, animal and plant health and for the quality of life, and whether or not it can be sustained. The current "human-nature" paradigm of exploitation and dominance has failed. We need new models and practices, and we need them now.

So here I present some discussion of this new technology called a hyperspectral sensor. But it is absolutely key for us to recognize that this technology is not a magic solution. Thus, we do not want to place undue emphasis on it as it stands alone. What is most important is the "thinking" behind the application of these new technologies and processes. That is where we fall back on some of the prior established scientific methods. For my purposes, and because I haven´t found a better model, I am utilizing "Systems Thinking" as a basis for developing initial strategy for using the hyperspectral and other sensors. Now, as we get into a specific application for a particular problem we expect to utilize a variety of theories.

This section introduces the hyperspectral sensor, then I present a "white paper" highlighting the benefits and then we move into more detail of creating a "center, or institute" for expanding on this science for environmental assessment, monitoring and protection. The detailed case study for the application of the sensor is not an environmental case, per se. That is because this example was a real case that was being presented through Dr. Ewing at Texas A&M University, to deal with the Improvised Explosive Device (IED) problem in Iraq. Using this technology in such a complex situation as Iraq, to deal with IEDs is good case. That is because the context has many variables and utilizes a very dynamic application. So, even though we might prefer an environmental case, this case is real, and the important points of how to develop strategy are more than

adequately covered in the proposal.

The Paradox of Technology - New Science & Hyperpectral Sensors

I remember thinking many years ago, as I began to wear my "environmentalist" hat, that the mindless pursuit of technological advancement was the cause of many of our environmental dilemmas. This saga continues.

By the way, a little digression, I don't really call myself an environmentalist anymore, mainly because I don't think the tactics, or mindset contributes to solutions. I think it causes more "separation" and conflict, and the “environmentalists” tend to have a victim mind-set. I have learned through much self examination and observation that victims are really at the center of problems - "wherever I go, there I am". And the traditional environmentalist approach operates from an "us" versus "them" mentality. This will never solve the problems ultimately. Opposing groups, in the end must come together to resolve their differences. Often times, if given the chance, apparently oppositional groups have the same interests they are just seeing things from different perspectives. We discovered this working with “private land-owners” (ranchers) and “environmentalists” (tree huggers) in West Texas. Ultimately both groups were interested in protecting the environment, but their motivations were different. And with some level of dialogue it was easy to come to an understanding. But this could be a topic for an entire book and we need to move forward with this discussion.

So, one side of the paradox is the pursuit of technology and "advancement", (whatever advancement means), causing incredible problems (environmental, social, economic, cultural). It is the “evil” driver of so many issues, too numerous to cite. The scope of these problems today are so vast that it boggles the mind. Scientists as they look at the complexity of just the weather are discovering that mini micro-climates, down to potentially neighborhood sized areas are heavily influential into the making of our weather patterns. Or take any other scientific problem that we are confronted with, global warming, desertification, soil loss, everything that we pick apart with the scientific approach becomes so complex and cumbersome that the human mind cannot manage the quantity of data, processes, or analysis.

This is the paradox. I would contend that computers are probably the pinnacle of technological advancement. Thus, as shown previously associated with the “evils” with

technological advancement. And yet without them we cannot solve the problems we have created. The scales and quantities of information that need to be processed for the various models of natural systems, can only be dealt with by a computer. So paradoxically, technology is our apparent worst enemy, because the pursuit of industrialization has been the cause of most of these problems, but it is also an important part of he solution to our problems.

So what about this hyperspectral sensor? In simple terms a hyperspectral sensor is a very large camera that can take a picture of all that we can and cannot see. Typically the device is flown in an airplane, UAV (unmanned aircraft) or satellite, and is aimed at the surface of the planet, at least in the applications we are interested in. The device captures reflected light - many bandwidths (wavelengths) of data across the light spectrum that can be used to understand the characteristics of the objects and substances captured in the image based on their spectral signature (see Figure C8-1 For an example of a hyperspectral "data cube").

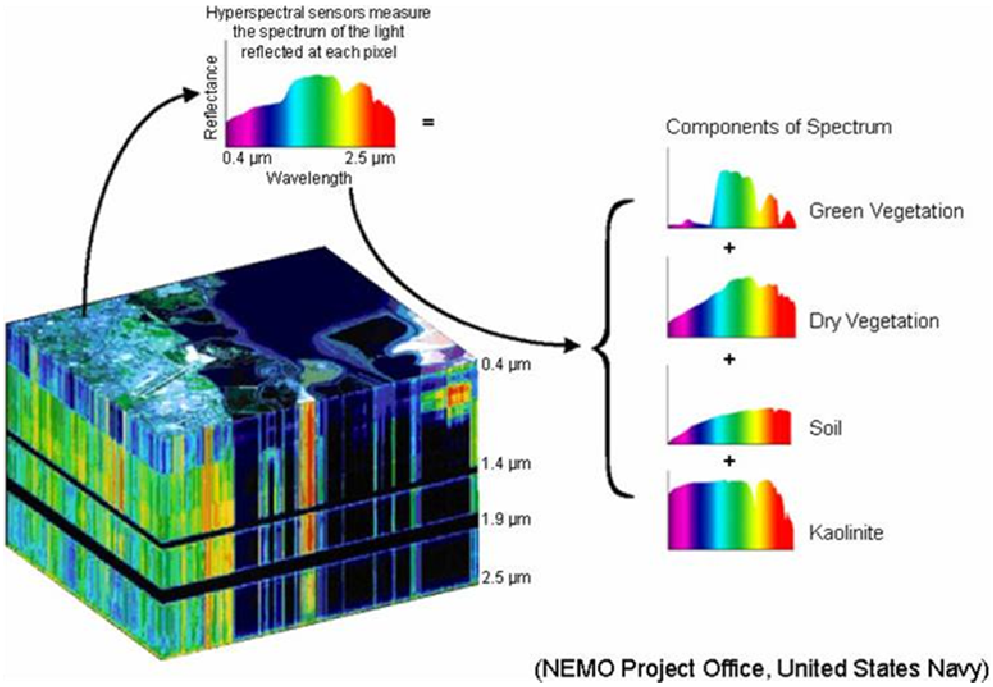

Figure C8-1: Hyperspectral data "cube" with examples of some spectral profiles

The device I worked with at Texas A&M was built by Texaco in the early 1990's, called the Texaco Energy and Environmental Multi-spectral Spectrometer (TEEMS). The device captured about 250 bands (sections of light wavelength) across the ultraviolet, visible,

thermal and infrared spectrums. The bands are critical for seeing the various "substances" that you are looking for. The amazing thing is that these spectral signatures are like "finger prints" for everything. Every substance, including your hair, or my hair, or whatever, each has a unique spectral signature.

So what's the big deal? It's a huge deal! This device can help us see all kinds of phenomena that are invisible to the naked eye, pollutants floating on water, insect infestation in crop fields, fault lines showing up in avalanche prone areas, leachate seeps from landfills polluting a river, etc. etc. In fact, since we haven't even looked very much at what we can see with these devices (except for military applications), the potential is unlimited. The opportunities exist in the questions that we ask, and our willingness and capability to break the data down and analyze it. The more I looked at this device and its potential last year, the more astounded I became.

My imagination was even further fired after listening to the new Albert Einstein biography (by Isaacson). Eighteen CDs - the whole set as I drove from College Station, Texas to Santa Fe, New Mexico and back. I learned emphatically that Einstein's contribution to the world came from his study of light. And here I am looking at a device that tells us, who knows what, and it all is from light.

As the repercussions of all these ideas, these realizations began to “reverberate” in my consciousness, I began to imagine that the light was even intelligent. Trying to communicate with us. Or that it is like DNA, carrying whole new sets of knowledge, asking/inviting us to decipher the puzzle to help save us from our self imposed crises. Embedded in the light is information waiting to be discovered that will tell us the core issues of our misguided ways. Then I concluded that "light is life" - we wouldn't be here if the sun wasn't producing it. To scientists who study this, or spiritually enlightened individuals, this is probably like "duh, so what else is new". But to me, it was a huge awakening, and epiphany (since writing this in 2007, I have discovered that all of this is only a kindergarten understanding, that in actuality everything “manifest” in physicality is actually expressions of light vibrating at different speeds, but this is for another conversation—(author 3-19-2010).

Then amazingly enough a friend, whom I had confided in about my realization, showed me a book that sychronistically validated my thoughts - this quote has been just the first validation of many over the last few years.

"He looked at his hands, he felt his body, and heard his own voice say "I am

made of light; I am made of stars."

He looked at the stars again, and he realized that it's not the stars that create light, but rather light that creates the stars. "Everything is made of light" he said, " and the space in -between isn't empty." And he knew that everything that exists is one living being, and that light is the messenger of life, because it is alive and contains all information.

Then he realized that although he was made of stars, he was not of those stars. "I am in-between the stars," he thought. So he called the stars the tonal and light between the stars the nagual, and he knew that what created the harmony and space between the two is Life or Intent. Without Life, the tonal and the nagual could not exist. Life is the force of the absolute, the supreme, the Creator who creates everything.

This is what he discovered: Everything in existence is a manifestation of the one living being we call God. Everything is God. And he came to the conclusion that human perception is merely light perceiving light. He also saw that matter is a mirror that reflects light and creates images of that light--and the world of illusion, the Dream, is just like smoke which doesn't allow us to see what we really are. "The real us is pure love, pure light," he said.

Don Miguel Ruiz, The Four Agreements

Working with the TEEMS device, I had the great fortune to work with a man who builds these devices for the U.S. government. He has worked with it for most of his life: builds the devices, writes the software, understands the science. I would suspect that this gentleman knows more about the practical application of hyperspectral sensors than any other person in the world.

I called him as these thoughts haunted my mind - I was ranting on the phone, going on and on. And then I said, "you know, after hearing about Einstein's discoveries, I have realized with this hyperspectral sensor - it's like a 'New Science'". His response was ... "Andy, you're preaching to the choir!"

So why hyperspectral sensors with Rural Revitalization and Empowerment Strategies? - well you have read the book until here it should be abundantly clear one of the foundations of our endeavors—is the environment - protecting Mother Nature. And now, we need add to the mix environmental assessments, prediction, etc. utilizing these

exciting new technologies. I had worked to build teams and strategy at Texas A&M, and ran into some challenges. But the efforts to develop those strategies were not in vain. They can be adapted to other situations. And I have realized that these "tools" are far too important to be left unused. So, the next step is to describe in greater detail just how these technologies can be applied, and a very simple description of the processes to make use of this "new science".

New Technologies and Systematic Approaches for Environmental Application

Hyperspectral Imaging Systems – A New Solutions Toolbox for Environmental Problems

Broad-spectrum, hyperspectral Imaging Systems (HIS) flown in aircraft, UAV or satellite provide remote sensed images that can revolutionize how environmental, land and resource management decision makers conduct their activities. HIS can, and have been, used for a wide array of projects, including:

Environmental assessments	Water resource management
Resource management	Waste management and Hazards
Vegetative assessments	Satellite simulation
Mine site monitoring	Mineral exploration, Oil and Gas
Soil survey	Forest management
Geological assessments	Anti personnel devises (IED)
Etc., Etc.	

These broad applications provide a very useful tool for many industries and resource management applications. By using broad-spectrum sensors, there is a vast array of information that can be obtained to address critical areas of concern for an industry, including exploration/discovery, environmental impacts and socio-economic issues.

Environmental Damages – Costs, Savings, and Prevention: A Quick Case-study

In the early 1990's an oil company was mired in a lawsuit with a country in South America. At stake was $10 billion for environmental damages. The oil company hired a pioneer in spectral analysis remote-sensing to determine fault. The case was settled out-of-court for $1 billion – which according to some could have been avoided altogether because what was discovered was no-fault for environmental damages on the part of the corporation. This example illustrates the potential of hyperspectral sensing, because this case did not even involve the utilization of powerful hyperspectral sensing technologies as described in

this document; it only employed the technique of spectral analysis and it **saved the company $9 billion**.

Innovations to Knowledge Generation

Our proposed approach is based on using GIS (Geographic Information System) spatial analysis (utilizing data layers – see Figure 2) within a systems approach to provide powerful tools to gain insights for both short and long-term planning. HIS provides a powerful baseline data layer for GIS. HIS is also an extremely cost effective way for data gathering since a great deal of information is captured in "one fell swoop", eliminating the need to fly multiple passes over the same location.

Because hyperspectral sensors capture a broad spectrum of data for visualization, there is no need to fly sites multiple times for data capture whether the knowledge will be used for exploration or environmental amelioration. While getting a sensor airborne is by far the most costly factor, that cost is mitigated over time as data is acquired. This is because the information actually increases in value over time as it is layered, especially when those additional datasets are acquired for the purpose of measuring the longer-term environmental impact in a region.

We encourage integrating several sensing devices on a single aircraft; including, but not limited to ground-penetrating radar, magnetometer, and a variety of atmospheric condition sensors. The power of these combined technologies is apparent in that spatial data can be fused to improve validation of data sets as well as provide correlating data for concurrent verification. This information then becomes a data library that can be mined extensively in addressing potentially an endless array of questions that might arise.

The Value Proposition

Environmental and natural resource management decision-makers can benefit from remote-sensed HIS data and spatial analysis because of its accuracy and cost-effectiveness. Prior to the development of these technologies and capabilities, land and resource management decision-making has been constrained by access to data (images), the types of data sets available (what can actually be seen), and analytical tools (software, etc.). The advent and development of hyperspectral (HIS) and remote sensing technologies afford considerable opportunities to extend and apply these new tools, data, and processes to a vast array of environmental sectors.

In order to effectively utilize the vast potentials of this powerful "environmental assessment toolbox", the approach must be organized in a systematic way that allows for

proper handling of the information that is acquired. Diagram C8-1 illustrates the primary factors to create products for decision-makers in an example in the mining industry.

The major components include:

- Identifying customer's goals, objectives and needs.
- Data acquisition, storage, management, analysis, and modeling capabilities.
- Integrated collaboration networking capabilities to provide easy access for multiple user groups.
- Modeling using various mathematical and computer simulation methodologies.
- Experts in various disciplines to interpret the information (bull-pen of scientists).
- Delivery of products to the customer—based on needs expressed.

A final critical element is the feedback loop that contributes to a refinement of the services that are rendered.

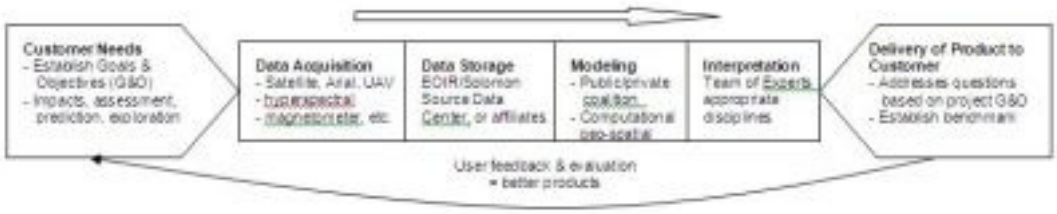

Diagram C8-1: Flow Process for Hyperspectral Products

Systems approach

Systems analysis does not simply entail a multi-disciplinary approach; rather, it contextualizes the real issues related to dynamic and changing conditions in environmental contexts. Effective assessments are dependent on our abilities to synthesize separate findings into a coherent whole. This fact is far more critical than the ability to generate information from different multi-disciplinary perspectives. Our approach will utilize powerful data gathering technologies (hyperspectral, magnetometer, LIDAR, etc.), GIS spatial analysis and modeling, and computational methods to treat the problem comprehensively.

Our systems approach utilizes the "Structure, Function and Process Iterative Model" as described by Gharajedaghi in "Systems Thinking: Managing Chaos and Complexity: a Platform for Designing Business Architecture". In general, scientific research tends to focus on independent multi-disciplinary pieces in which the whole is the sum of its

associative parts. In our systems approach, we can reassemble the puzzle, and then study it as an interactive system—a synthesis of processes, data, and interpretation which sets our approach apart from others.

Spatial Analysis

Spatial Analysis is a powerful tool for decision-makers interested in developing a more comprehensive view for project management. By gathering a variety of data and information sets and then referencing them in a geo-spatial way, considerable insights can be gained for environmental decision-making and problem-solving. Spatial analysis allows for disparate, yet interrelated information to be examined. Depending on the goals and objectives of a specific situation, layered data sets can be examined in many ways to allow for greater flexibility for assessing and managing impacts. GIS spatial analysis allows project managers to play "what-if" scenarios based on a variety of mathematical and computational modeling techniques (see Diagram C8-2).

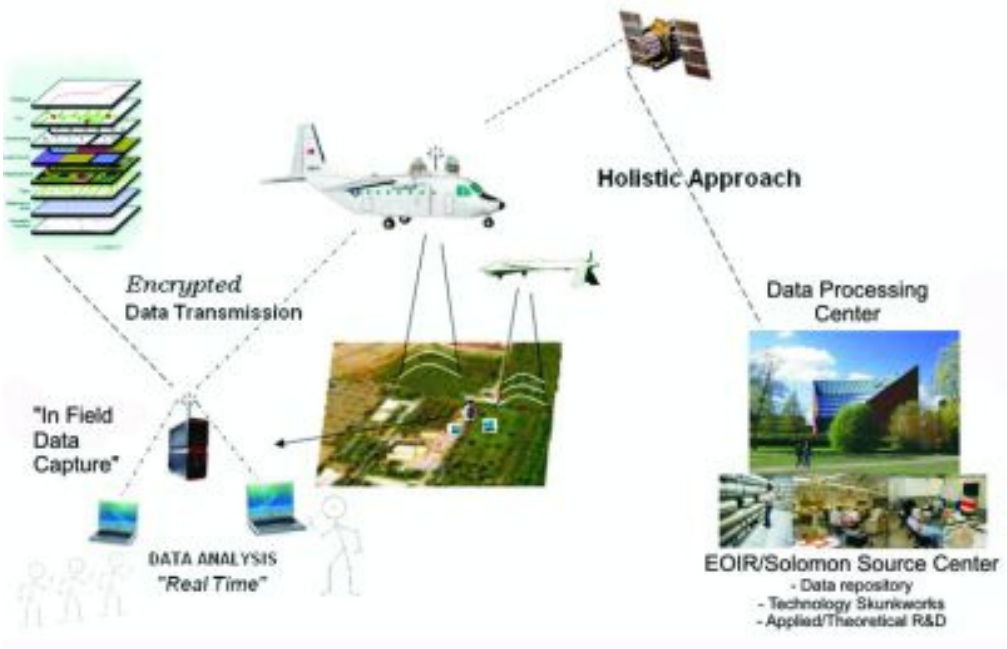

Figure C8-2: GIS Spatial Analysis Using Hyperspectral Data Collection

Proposal to establish an Institute for Geospatial and Remote Sensing Sciences, Technology and Application Development (IGRS-STAD)

So now that we have a working understanding of the process of utilizing these sensors and some of the application areas, how can we develop a larger strategy for them to be

utilized? This was what I was working on for Dr. Ewing at Texas A&M. Built around the donation of the TEEMS device, we were going to create an "Institute" that would develop three primary activities around "remote sensing sciences" and the associated technologies, those being a) education, b) business and commercialization, and c) research and application.

In the following example expand on the ideas developed at Texas A&M for the larger context of Colombia South America. However, one could easily change the name, the country or the context to any scenario.

Executive Summary

Introduction:

Colombia is in a position to establish itself as a leader in the world for the development and application of remote-sensing technologies and analytical processes and services. This document provides an outline for creating an "Institute of Excellence" and associated business enterprises for geospatial and remote sensing science research and technology development.

Mission of the Colombian Initiative and Institute for Geo-Spatial & Remote Sensing Sciences, Technology and Application Development (IGRS-STAD)

To help solve innumerable environmental, social and security problems facing the people of Colombia, using Geo-spatial sciences and technologies. These technologies will be utilized for purposes of sustainable development of natural resources for the economic and social empowerment within the country.

While expanding the application and utilization of geo-spatial sciences and technologies, create the necessary educational and institutional infrastructure to grow the industry within Colombia. Primarily the IGRS-STAD will advance research and scientific inquiry in the area of the geospatial sciences, and expand the utilization and application of what is discovered for resource management decision-making and for commercialization.

We will fulfill this Mission by providing solutions to various *communities of need* (customers/clients). We will utilize an effective business model that will be financially self supporting, profitable and sustainable in both the short and long-term.

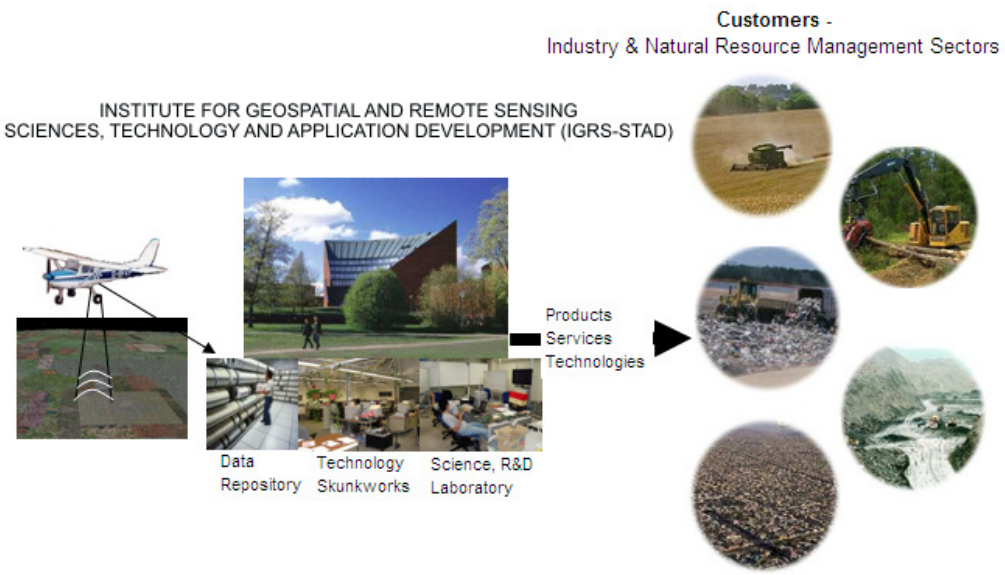

Figure C8-3: Vision for the Colombia IGRS-STAD

Vision:

Within 1 year have completed at least one successful "pilot project" in Colombia. Within 3-5 years to have these "solutions" implemented in numerous applications and locations throughout Colombia.

Value Proposition for Hyperspectral and geo-spatial sciences.

The potential contribution that geo-spatial sciences and associated technologies can make in Colombia is tremendous. Below are some of the most important areas where they have already been utilized around the world.

- Identification- elimination land mines
- Water resource Management
- Agriculture
- Environmental assessments
- Oil and Gas exploration
- Soil survey
- Forest management
- Urban planning
- Mineral exploration
- Geological assessments
- Resource management
- Mine site monitoring

To get started most efficiently we can utilize existing data sets in combination with new data derived from SpecTIR, a company specializing in remote sensing sciences, "flying" Colombia to capture the necessary data to begin working. Additionally, to grow our

impacts quickly, we will be actively prospecting for additional clients while completing the Pilot Project (s).

The IGRS-STAD is the "hub of our initiative" and will have four primary purposes:

Creating a focused, pragmatic initiative to address numerous environmental, social problems facing Colombia, and to create a proactive strategy in the long-term to mitigate future challenges.

Creating a successful business model by which to expand utilization of these technologies.

Creating exceptional hands-on and real-world learning opportunities for graduate and undergraduate students, "pushing the envelope" of research into the geospatial and remote sensing sciences in concert with technology development and commercialization,

Delivering experienced and educated students to the workforce, and to extend research findings, data delivery and analysis services, and business opportunities into the public sector.

Discussion

Environmental and natural resource management decision-makers can benefit from remote-sensed (HIS) data and spatial analysis because of its accuracy and cost-effectiveness. Prior to the development of these technologies and capabilities, land and resource management decision-making has been constrained by access to data (images) and analytical tools. The advent and development of hyperspectral (HIS), remote sensing technologies and their associated analytical processes afford considerable opportunities to extend and apply these new tools, data, and processes. Potential customers/clients include

- Public land management agencies (water, forestry, mining, agriculture, etc.)
- State, local, regional and national governments (military, border security, water management, COGs, etc.)
- Private land owners and managers,
- Scientists, researchers, and
- Corporations, private businesses

The IGRS-STAD's charter will be aligned with the goals of higher-education and commercialization having the three-fold mission to foster education, research, and public

service (extension). The Institute will help Colombia better capitalize on business and commercialization opportunities by fostering ideas from environmental assessment, protection and management into the public/private sector (patents, technologies, businesses) and by creating an end-to-end product development process from research and development (R&D) to product and services delivery, or application.

Components of the Strategy

Institute: This is the heart and soul of the strategy and is described in greater detail below.

Connection to Colombian Institutions: The institute is Colombia based, but much of the expertise in this science is currently out of the country. We are currently building relationships with the appropriate institutions and experts in Colombia. Continuously we will be open to establishing new relationships when deemed appropriate. However, it is also critical to establish a policy of open relations to other nations since expertise and knowledge will improve and accelerate our capacities. A policy of collaboration instead of competition is critical.

Education is Paramount: Preparing for future opportunities we need to have well educated professionals prepared to enter this expanding field of endeavor. To achieve this end, institutional relations have and will continue to be made with a variety of colleges and universities. Our success will be ensured by preparing "young minds" and to have them be actively involved at all levels of this initiative.

SpecTIR strategic alliance: The process of providing these services will be simplified because of our strategic alliance with SpecTIR. A leader in geo-spatial and remote-sensing sciences, SpecTIR can provide quality services to fulfill our client´s needs. SpecTIR´s experience and expertise in the field provides assurance for excellence and quality.

Centered within Colombia: Since this "new science", and the technologies to support it, is new to Colombia, it is necessary to bring in some outside experts while the Institute is being established. However, a primary goal is to "capacity build" here in Colombia allowing for developing the personnel,

expertise and infrastructure to support a significant portion of these efforts in country.

Prospecting customers, projects, etc**.** Even though the IGRS-STAD will act as an institution and bring benefits to the citizens of Colombia, our aim is to have the initiative utilize sound business practices. This means that we do not intend to establish and support the institute on a budget established as a new bureaucracy. The Institute will be self supporting and will have a section of its base of operations dedicated to actively finding customers.

First Steps in Process

- Identify and complete pilot project(s)
- Get Web site/project management portal up and running
- Locate HIS Data Center, lab space
- Start HIS and spatial analysis Service Company
- Fundraising, donor campaign – corporate, institute
- Develop marketing and business plan

Phased approach – to larger initiative: The application of hyperspectral data and geo-spatial sciences for solving problems is well proven. Innumerable examples can be found and SpecTIR can readily supply case studies. However, as we aim to create a national institute we still need to develop the initiative in a "phased", or step-wise fashion. At this point in planning we see three primary phases. Details of Phase 2 and 3 will be developed in detail during phase 1.

Phase 1) The first will be to test the technology, establish processes and procedures to fulfill the needs of our first Colombian "customer".

Phase 2) After we evaluate the first project we will rapidly deploy 3 to 5 additional projects as Phase II. Then,

Phase 3) Phase III we will open up opportunities and projects across Colombia.

More Details about Strategy and Steps

Pilot project: Tentatively we see that one of the most urgent needs to test this technology in Colombia is to deal with the personal land mines. Colombia is under international pressures to come up with a solution in one year or

face fines. Fortunately for Colombia, the project team had prepared a proposal to JIEDDO to go to Iraq and deal with the IED problem there. This proposal can easily be adapted to the Colombia situation. A summary of that document is included.

Building the Team: Currently our team consists of four members and SpecTIR as a sub-contractor performing the bulk of the data capturing, storage and manipulation. For strategy purposes we have included a consultant who was a U.S. Marine who was stationed in Iraq dealing with IEDs. Our interpretative capacity will be supported under the leadership of remote sensing scientist who is a professor at the University of Quindio and an expert in hyperspectral and geo-spatial sciences.

Advisory Board: By the time that the IGRS-STAD is formally established, we will have identified and invited a high level board of advisors to assist in the success of this important initiative. The advisory board will consist of individuals in business, government and educational circles. The board will serve in an important advisory capacity and assist in helping the initiative to make contacts and collaborative relationships with entities to expand the adoption and diffusion of our services throughout Colombia.

Pursuit of Funding: Initial funding can come from any source. Of course we would prefer to have enough funding to start the Institute in a way to build a team and have all of the institutional resources necessary to do the job without financial restrictions. However, we have the alternative strategy to "boot-strap" a pilot project as necessary. It is not important to discuss the details in this book, but simply present that we have a "Plan A, B and Plan C" if necessary. Since we prefer to get significant funding, we will present the rest of this description based on that possibility.

Pragmatic Business Model: It is important to note that we do not intend for the IGRS-STAD to follow the model of most institutions utilizing government funding. The model is to create a strong business function to identify other customers and potential funding sources. This idea is discussed in greater detail in the essay on the "hybridized cooperative model".

Identify who is going to support each of the steps identified in the "process diagram"

Building the Team is organized around the various parts of the Flow Process as depicted in Diagram C8-1. This is a very simplified version of a process that is quite involved and could easily become overwhelming to the reader. For example, discussing the details of creating and supporting the technology infrastructure for "data storage" would be far too technical and not really contribute to this discussion. Thus, the point of this presentation is to give the reader an overview of the important aspects of this process. Three keys for success include:

First, the successful movement through the process of identifying the "customers needs" on the far left of Diagram C8-1, to the creation of production of the end products. In other words, the fulfillment of the customers needs.

Second, is that the various "teams" that are built to support each of the "functions" in the process (i.e. data acquisition, storage, modeling, etc.) know how to do their business, and do it!

Third, absolute effectiveness and efficiency of sharing of information and coordination between each of the teams. This is the responsibility of the procedures and guidelines that are established for the IGRS-STAD, and discussed in some details in other parts of this book. An analogy would be of a football team—we don´t want the ball to be dropped, for example between the "modeling" function and the "interpretation" function.

Of course there are several other factors that are absolutely critical in this process, but we do not want to get bogged down in all of those details. A very important way to understand this model is that of the analogy of "a chain" - the chain is only as strong as its weakest link. And, as we build this chain we want to have as few of links as possible, and that that there are no "weak links". Also, we want to continue of the vein to learn from our mistakes, so the ongoing process of evaluation is built in, and is depicted in Diagram C8-1As the arched arrow from the right of the diagram to the left.

Figure C8-4: Web portal, handling information dispersal, communications, etc.

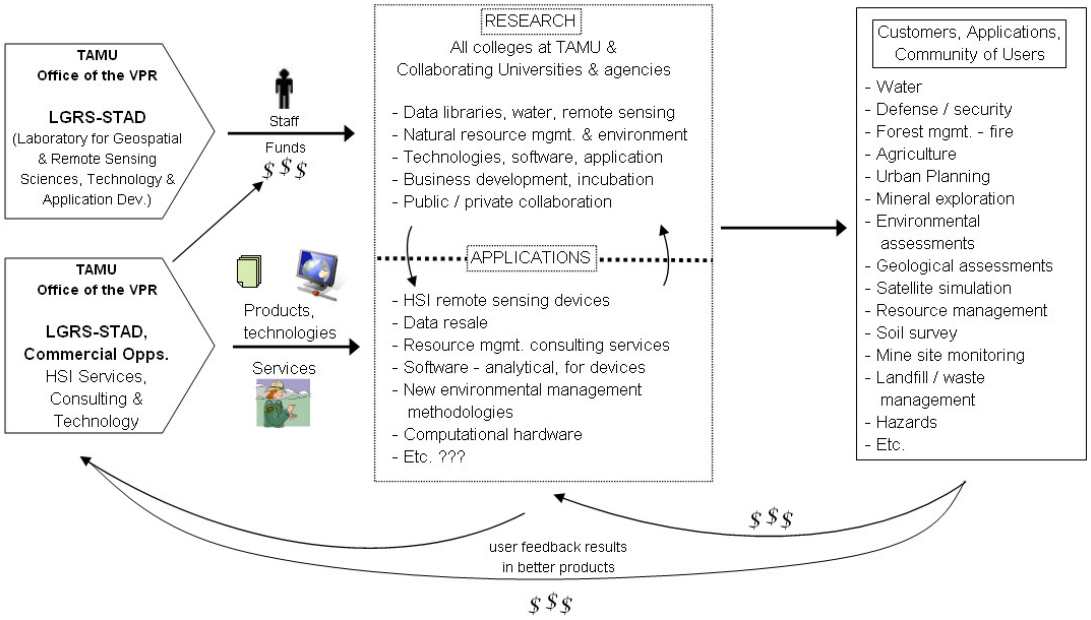

Diagram C8-3: Flow diagram for the IGRS-STAD.

As seen previously in other case examples, this diagram depicts the flow of resources derived from the organizations supporting the initiative on the far left, to the production of practical outputs for a variety of customers. The center box is a type of "black box" where the various functions and assets are converted by a recursive interchange with the expertise and tools that are available both internally and externally to the IGRS-STAD. A key issue that sets the IGRS-STAD apart from traditional institutional entities is the focus on producing revenue to be self sustaining. This is to avoid the constant battle of traditional institutions dealing with the political budget making process. The arrows accompanied by the $ sign on the bottom of the diagram depict the flow of financial resources necessary for each function to be adequately supported. This requires a progressive business model be utilized. Fortunately for hyperspectral and remote-sensing services, the financial returns can be significant, in addition to the development of new technologies, software and commercialization, there should be no concerns for monetary support.

Pilot Project – Personal Land Mines

Co– authored by Robert Moss and J.R. Starch

The following is an excerpt from the actual proposal that was to be presented to the Joint Improvised Explosive Device Defeat Organization (JIEDDO) with Dr. Ewing as the principle investigator. When Dr. Ewing passed away the project came to a standstill. The proposal is presented here as it was written. The reader only need to replace the acronym IED with "anti-personnel explosive device". In fact, application of this strategy in Colombia would be much simpler that Iraq because the situation for the deployment of IED´s is much more dynamic. The "land mine" problem in Colombia is a much more stable environment, along the lines of the more traditional situation.

Executive Summary

Effective strategies to counter the IED problem require a systems theoretical approach. In short, systems theory aims to "contextualize" problems and steers clear of simple multi-disciplinary models. Our strategy, discussed in greater detail below, is derived from scrutinizing the IED threat objectively and comprehensively. Our approach is based on three of our team member's long experience with systems theory and our grounded experience with the IED problem in Iraq. Our approach will utilize powerful visualization technologies (hyperspectral, LIDAR, etc.), GIS spatial analysis and modeling, and

computational methods to treat the problem comprehensively. The theoretical approach follows the design of one of our team member's 1500 hours training at IBM technology centers, an approach that has been applied in numerous complex governmental and private settings (Gharajedaghi, 2006). A few of these settings include ALCOA, Chrysler Corp., Ford Motor Company, and two internationally acclaimed projects: New Economic Order, a United Nations project and Goals for Mankind, a Club of Rome project.

Our systems approach will utilize the "Structure, Function and Process Iterative Model". In general, scientific research tends to focus on independent multi-disciplinary pieces in which the whole is the sum of its associative parts. In our systems approach, we intend to reassemble the "puzzle," and then study it as an interactive system—a synthesis of processes, data, and interpretation which is the key of our theoretical framework. The "system development process" has been used by the military since the second half of the twentieth century and a new version called DoD 5000 was just instated in 2000 (Kossiakoff and Sweet, 2003). Our proposed approach is also well grounded on direct our team's experience with IEDs and the complex and chaotic combat environment of Iraq—a strength we intend to exploit as we study integrated systems to discover new methods for detection and prediction, and to develop effective counter measures.

Utilizing hyperspectral sensors, a technology familiar to and utilized by the Department of Defense (DOD), will provide a broad spectrum of digital intelligence which then can be combined with other data sets. Spatial analysis and computational modeling that is grounded in systems analysis then becomes the process by which we will sift through the "realities" of the IED challenge. The current use of narrowband remote sensing in UAVs and other platforms is well known to DOD scientists and field engineers as a test bed for solving complex problems facing U.S. troops in current and future combat scenarios. Publicized DOD hyperspectral remote sensing is being used to detect substances and devices (known or unknown) in a real-time "data fusion" environment. While these technology products are useful, we will use hyperspectral imaging (and other available data layers) to find the relevant materials, and bound the problem in several ways, ultimately going further back to identify possible sources (e.g. manufacturing, materials, etc.) or organizational infrastructure. .

The Techniques, Tactics and Procedures (TTP) employed in combat tactics has followed the action-reaction model first espoused by Boyd—one of observation, orientation, decision and action. Due the rapidly diminishing time cycle between introduction of new

countermeasures and enemy response to overcome those countermeasures, we see the greatest opportunity for problem solving in two Tenet Lanes: Prediction and Detection. Subsequently, our model potentially introduces a major paradigm shift from traditional analytical scientific research models toward integrated and iterative systems modeling, and one we are certain will provide a new way of fighting insurgency and the IED threat. As stated by Mills, "Within this [intelligence] process, analysts must extract meaning from data and images. Specifically, theory enhances the ability to visualize a battle space. . .to contribute to analytical knowledge integration. . . theories work to bridge practical application gaps in the intelligence community—enhancing our ability to adapt and thwart failure" (Mills 2003). Thus application of systems theory to data collection and data fusion may lead to new ways to extract useful intelligence from geospatial data.

In terms of technology, we have three overall objectives. We intend to focus on the following areas of long-term research in advanced GIS spatial analysis with an emphasis on integrating hyperspectral remote sensing (and other imaging technologies) capability to enhance the mission objectives of JIEDDO:

- ***Classification and target identification using a combination of structure, function, and process methodologies in pattern and anomaly detection, as well as comparative GIS layer analysis using Hyperspectral data in combination with other data sets that help contextualize the problem (i.e. socio-economic, political, environmental).*** This approach will include a number of disciplinary models: Actor-Network Theory, Spatial Analysis, Adoption-Diffusion, and Structural Equation Modeling, etc.. We intend to present to DOD a short-term and long-term scientific-based training program for decision makers that will enhance their ability to predict those elements in a complex and chaotic environment that are likely to increase or reduce IED and other threats to U.S. troops.
- ***Utilization of hyperspectral imaging combined with atmospheric correctional modeling in both laboratory and in situ conditions utilizing current and new instrumentation.*** We believe this approach will enhance real-time data analysis.
- ***Material mapping and image analysis algorithm development, enhancement and improvement in processing.*** We believe this approach will allow us to develop new layers of data, internal and external correlations and anomalies, and a "wider" view of what the data represents.

Modeling and prediction capabilities are based on Texas A&M University's and this

proposal's collaborative team, current operational hyperspectral equipment and research laboratory assets, and the Texaco Energy & Environmental Multispectral Spectrometer (TEEMS) which is currently operational in a laboratory. If necessary this device could be installed in an aircraft and deployed to capture data. However, we believe that current, relevant data may be available from existing government sensors such as COMPASS (Simi, 2001) and, ARCHER (Stevenson, 2005). These new devices can be installed on smaller aircraft than the TEEMS device, but more importantly current data should be accessible. Finally, we have assembled a team of scientists and technicians capable of meeting our stated objectives. Funding is requested to assist the DOD in examining these data, potentially adding new tools that can defeat IEDs and protect our troops through the development of solutions based on the TAMU systems approach.

Technical and Operational Approach

What scientific concept and/or associated technologies are being proposed? How will it contribute to one or more JIEDDO tenet lanes?

The complexity of the IED problem demands that a dynamic approach be used. Systems Theory (or thinking) provides a strong foundation for such an approach. Systems analysis does not simply entail a multi-disciplinary approach; rather, the real issues related to dynamic and changing problems like IED detection and prediction is to develop ways to synthesize separate findings into a coherent whole. This fact is far more critical than the ability to generate information from different perspectives. To illustrate our point, we use the elephant story found in Persian literature and narrated by Molana Jaladedin Molavi (Rumi). It presents the elephant story as a metaphor in which several men are attempting to identify the creature in the dark. The effort proves fruitless until another man shows up with a light. Gharajedaghi (2006) Page 108-109 presents this perspective in the following:

> "The light, which in this context is a metaphor for methodology, enables them all to see the whole at last.
>
> Rumi's version of the story means that the ability to see the whole somehow requires an enabling light in the form of an operational systems methodology." …. For our purpose here, … "one should be able to make one's underlying assumptions about the nature of the socio-cultural systems explicitly known and verifiable to oneself.
>
> Whatever the nature of the enabling light, my contention is that it

> must have two dimensions. The first dimension is a framework for reality, a system of systems concepts to help generate the initial set of working assumptions about the subject. The second dimension is an iterative search process to: 1) generate the initial working assumptions, 2) verify and/or modify initial assumptions, and 3) expand and evolve the emerging notions, until a satisfactory vision of the whole is produced. As Singer put it "Truth lies at the end, not at the beginning of the holistic inquiry" (Singer, 1959).

The problems presented by IED detection and prediction suggest that we consider "stepping-back" to gain new insights into the problem in order to develop more effective solutions. Based on one team member's direct and personal experiences with IEDs, intelligence analysis and application, and complex TTP cycles in Iraq, our approach is well grounded. The effective and efficient use of gathered information is a critical input for any model—analytical or systemic. Under our systems approach, grouping information sources such as HUMINT, SIGINT, and IMINT is not enough. It must be synthesized against a larger backdrop in order to produce a holistic model. According to Steels, "The traditional craft of intelligence has tended to fragment content from its context and be largely oblivious to timing. The new craft of intelligence recognizes that the value of any given information, apart from its relevance to the decision at hand, stems from a combination of the content in context and the content in time" (Steele 2002). Our hypothesis is that hyperspectral remote sensing applied across a wider spectrum may provide that larger correlation backdrop. New and novel approaches not constrained by preconceived ideas may provide significant advances for addressing the IED challenge.

Effective use of GIS spatial analysis that integrates all of the available intelligence (primarily HUMINT) will help us determine *where* we look for materials of interest. Our approach will target the capture of GIS data layers and intelligence and to coordinate that with hyperspectral imaging. Our approach to counter the IED roblem is sensible and efficient, because 1) the pressure to decide on things in real-time is significantly reduced because, practically speaking, it takes considerably more time and equipment to move a significant explosives making effort, and 2) we are aiming at the "source" of the problem rather than just treating a "symptom". Timeliness is still critical, but chances are that what we find will still be there tomorrow because it is just too difficult to move explosive making operations quickly.

Critical to addressing the issue of a timely solution we are proposing a dual-cycle synthesis

and analysis for rapid data fusion, analysis, modeling and decision support. A priority of our proposed approach is a speedy deployment solution to get soldiers in the field better intelligence for improved decision-making. To meet this aim we will perform a short-cycle and long-cycle data processing. In other words, our team of experts will develop a "mini" systems approach (see diagram 2) to create a robust but short-term solution to get this novel technique on the ground in the shortest possible timeframe. The long-cycle will be performed ongoing, constantly upgrading the approach that is developed from the previous cycle. It's focus will be more towards strategies to counter the IED problem, likely using hyperspectral imaging to find and identify various materials which are being used to construct IEDs, and then to use that information to find the persons responsible.

Perhaps tagging, tracking, and locating of these persons or materials will lead to preventative strategies rather than "after-the-fact" reactive strategies. The power of our systems approach is that each time a cycle is run, a new product for "in-theatre" application will be available. We will utilize appropriate mathematical techniques such as principal component analysis to "sift through the haystack" in an expedient fashion.

With systems thinking as a foundation, we propose the following three Focal Areas as strategies for dealing with IED prediction and detection. The first focal area provides an overarching umbrella while the other foci address more specific issues. Not only does our proposed approach have a strong theoretical grounding through the use of "enabling tools" (hyperspectral sensors, LIDAR, GIS analysis, Intelligent Transportation Systems, etc.) but also it has the experience of "in-the-field" operations. We are proposing a novel and reality checked approach for systematically studying and analyzing the IED problem. The ultimate aim will be to generate effective, timely solutions. Diagram C8-4 depicts the structure of the Systems Approach that is outlined in more detail in Focal Area 1 below.

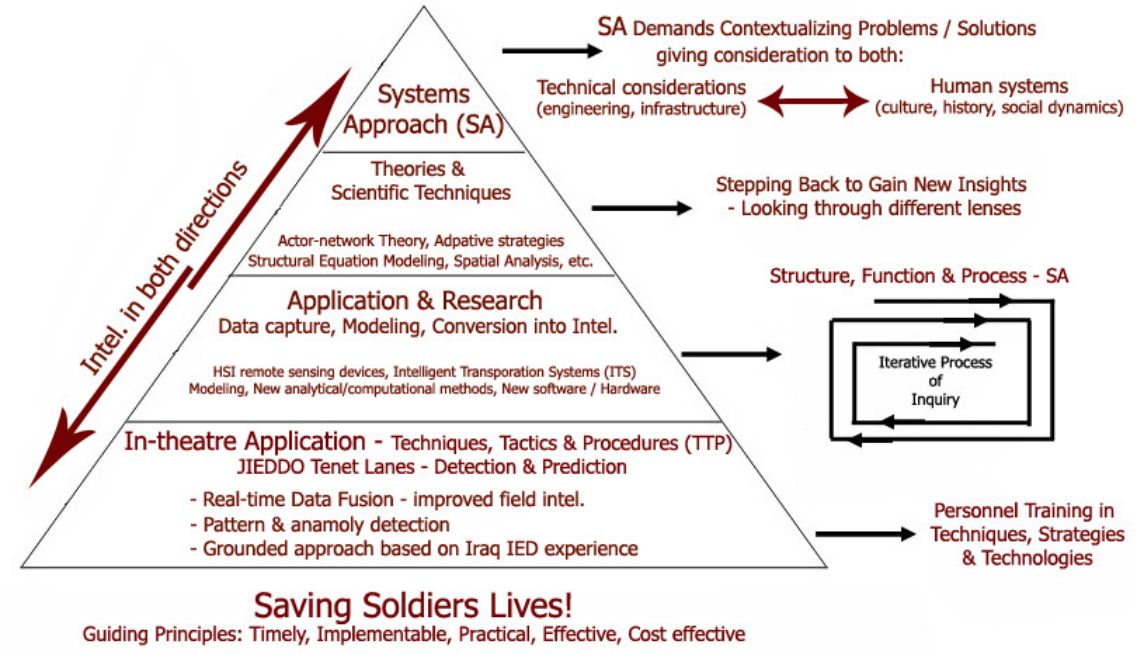

Diagram C8-4: Structure and details of TAMU Systems Approach to defeat IEDs

Working with a Private Sector Hyperpectral Company

Due to the complexity of hyperspectral imaging and remote sensing sciences, in order to be most efficient at the start we will utilize the services of private companies.

Currently we have a relationship with a company SpecTIR, which is a leader in the industry providing end to end services. Below find a short description of the company and some of their services.

www.spectir.com

SpecTIR specializes in the collection and analysis of remote sensing data utilizing our full suite of VNIR and SWIR sensors for airborne and industrial applications.

High quality spectral and spatial imagery is the most critical aspect of any remote sensing project. SpecTIR provides mission planning, data acquisition, and post processing of the data. The standard products are radiance, reflectance and GLTs for navigation. Other options include flight line mosaics, orthorectification and generation of custom spectral products.

SpecTIR works with clients to provide answers to their unique questions. Spectral scientists will combine data sets from multiple sensors, as well as the data from ground

truthing campaigns. The data is calibrated and GIS ready at delivery.

The company maintains a calibration facility with a NIST traceable sphere for hyperspectral calibration of any spectral sensor.

SpecTIR provides end to end spectral solutions for your remote sensing needs.

Company Summary

SpecTIR is a service-disabled veteran owned, small business concern (SDVO SBC) headquartered in Reno, NV with offices in Easton, MD, Manassas, VA.

SpecTIR has its foundation in the specialized design and construction of advanced hyperspectral and polarimetric imaging systems. Over the past decade, SpecTIR has advanced to the collection of hyperspectral data, the generation of imagery products from multiple data sources, and industrial solutions for manufacturing processes.

SpecTIR's staff and partners consist of engineers, spectral and optical scientists, project managers, field and data collection personnel, and a data exploitation division. The firm offers a full array of remote sensing services with expertise ranging from system design, fabrication, and calibration, to data collection and the processing/exploitation of imagery and geodatabases.

- Industrial QA/QC	- Oil/Gas Exploration	- Mineral Exploration
- Fire-fuels Mapping	- Forestry	- Invasive Species Mapping
- Infrastructure Planning	- Water Quality	- Disaster Response
- Geology	- Agriculture	

Some current customers

U.S. Dept. of Energy	U.S. Dept. of Defense	Universities	NOAA
U.S. Dept. of Agriculture	U.S. Geological Survey	Private Sector	