"Intelligent Eco Villages In Asymmetric Environments"

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Executive Summary

Throughout history, the stability of a region has relied on the ability of the people at all levels of population centers to sustain themselves and provide tithings to the local and national level. In the last 50 years, we have seen on the world stage Nation states and NGOs repeatedly delivering aid to various "disaster" locations around the world only to have corruption and mismanagement within the local government allow Terrorists, warlords, and other undesirables take control of the aid or worse the government. The infighting over aid alone in Somalia allowed the country to devolve into anarchy for many years and even today Somalia has not achieved stability more than 25 years after aid started arriving. This paper describes the intelligent eco-village which is intended to provide a platform to identify and provide mitigation to crop failures as well as provide long-term Metrological data and Intelligence data in the areas the systems are deployed.

The instrumented eco-village is a logical evolution of the Pre-positioned Expeditionary Assistance Kit (PEAK) program and the Afghan Conex Donation Project (ADCP). The intent is to evolve the PEAK and ACDP programs to provide indigenous villages in asymmetric environments with permanent community centers with PEAK like capabilities (i.e., water purification, power generation, MEDCAP) plus: communications innovations to support the bandwidth necessary to provide agricultural innovations, weather monitoring and intelligence instrumentation to monitor the designated areas around the instrumented eco-villages. This effort will rapidly develop and publish an instrumentation architecture that will tie to the open ISR efforts underway within DOD. The team will deploy multiple instrumented eco-villages on either Army bases or National Guard bases. One site will be a demonstration and Center of Excellence for the eco-village program and will be the plug and play integration and verification center for technologies prior to their deployment to areas of interest. The rest of the CONUS sites will be used as socio-cultural training sites for units prior to being forward deployed. The sites deployed will have reach back capabilities allowing for ad-hoc communications between development sites and for deployed sites to be monitored, receive software updates, configurations changes on instrumentation and manage the sensors on the remote sites.

Figure 1, Remote villages in Southern Afghanistan note the difficult terrain for communications and travel

Introduction

The instrumented eco-village concept is to focus the capabilities of the PEAK program on a specific site for long term use instead of disaster relief. This means water purification, power generation, communications and other capabilities can be limited to specific site requirements thus limiting cost. Taking the focused PEAK capabilities and adding them to the onsite modification capabilities of the ACDP project and we can now put conexes on the ground with MEDCAP, education, sanitation (i.e., water purification, toilet, shower), and veterinarian medicine capabilities where required. By taking donated shipping containers in the ACDP project in Afghanistan the project was able to immediately engage the Afghan government with a Grassroots stabilization method that has an immediate beneficial impact on the villages by:

1. Creating Immediate Jobs
    a. building out the various conex conversions

    b. transporting the conexes
    c. setting the conexes up and maintaining the conex systems
        i. Solar power jobs and innovation
        ii. Water purification and plumbing jobs and innovation
2. Providing educational resources
    a. Education for children through 12th grade to include distance learning capabilities where the communication systems allow
    b. Adult education in Sanitation, Agriculture, nutrition, power and water systems management
3. Providing critical healthcare resources including
    a. conexes setup for medical stability operations
    b. Telemedicine capabilities for Crisis response
4. Enhancing emergency responses

The instrumented eco-village will provide cost-effective enhancements to the ACDP project by providing innovations based on COTS/GOTS technologies integrated into to the eco-village to enhance agriculture yields, remote monitoring of weather and intelligence gathering capabilities. The following sections will show some of the available innovations that are COTS/GOTS and can be deployed in days or weeks. The following technology sections are examples of currently available COTS systems to show the kinds of capabilities other options will be evaluated based on site requirements for each village.

Community Center/ Village Power

From the equator to the Arctic Circle remote power is a complex issue. Power systems engineers must take into account the environmental effects on batteries and power generating systems and then adjust the power system based on these effects to meet the needs of the village to include a percentage for future growth and the planned system degradation of power generation over the life cycle of the power system. The Secure Chain team has systems and power engineering capabilities that span solar, wind, hydroelectric, geothermal, biomass, hydrocarbon and hybrid power generation system that are made up of a mix of the aforementioned systems. Agricultural villages may have the power systems augmented with bio-char power generators that provide power and fertilizer as an output of burning biomass.

The Secure Chain team has experience in deploying remote off-grid power systems in remote locations with difficult logistics tails such as helicopter only access. Sites that required monitoring of endangered species and the very strict environmental constraints that go with working on protected lands. The team designs and builds robust power systems that require little maintenance and what maintenance is required can be accomplished with limited technical knowledge.

Upon receiving the location of a potential eco-village, the team will assess the location for solar isolation and average wind speed as well as the availability of year-round flowing water sources for potential hydroelectric power generation. Once the best power options are identified for the site the team will begin a joint effort with the instrumentation team to assess the power requirements for the communication package and any sensors that will be deployed in conjunction with the site. This effort will define

the systems power requirements for the total site. From these requirements, the team will produce a preliminary design and will be used by the site development team to determine the feasibility of the design. Often time's solar isolation maps and wind speed models fail to account for the real world, so the site development team will take measurements and place logging tools on the site during the site survey to provide real world data to compare to the models and maps to improve the power system design. Once deployed the power system will be able to be monitored via the communications system allowing for system optimization over time and providing data for the future system to be deployed nearby.

Figure 2, an 18KWH Power Pallet system that produces power from biomass

Figure 3, mobile Bio Char system that produces Power and Fertilizer from Biomass

Community Center/ Village Communications

The key to providing stability to the remote villages is to provide good communications and to provide critical services via these communications. The community center by itself does not educate the village in how to use it nor does it provide critical knowledge this must be taught and the communication link to the village and community center is the key to this evolution.

The Secure Chain communication concept is to provide two-way communication capable of at a minimum supporting:

1. News
2. Education supports via remote learning
    a. Interactive adult learning E-Learning Sites for precision agriculture, irrigation instruction, trade, and job training women's literacy
    b. Interactive education
3. Agriculture information (weather data and soil sensor data)
4. Internet access
5. Intelligence data

Technology innovations will be heavily leveraged in the communications space of the eco-village. Currently, Broadband Global Area Network (BGAN) are the primary mover of information to the ACDP project. BGAN links are a pay by the bandwidth system and can add up very quickly when sending video or video teleconferencing data even for short durations. Due to the cost constraints of BGAN systems several options are required to minimize the annual cost of operations. Innovations that reduce bandwidth such as the TVI IP series of video compression systems from Digital Barriers allows for

dramatic decreases in bandwidth while still providing usable video quality. Different transmissions technologies such as Television White Space (TVWS) which use the unused portion of the television bands area being used in Bhutan to solve the last mile transmission issues with the Bhutan telemedicine program. In a TVWS trial in June of 2015 in South Africa, a TVWS link was tested and provided an 18 KM nonline of sight link with a data throughput of 1.5 Mb/s with an EIRP of 15 Watts. During the South Africa trial, a link of 25Kms was established with a data throughput rate of 780 Kb/s. Other potential options include a line of sight microwave and other data radios dependent of spectrum availability and data rates required. The Secure Chain team has a number of communications capabilities that we have worked with and are always looking at new innovations to meet the needs of the eco-villages.

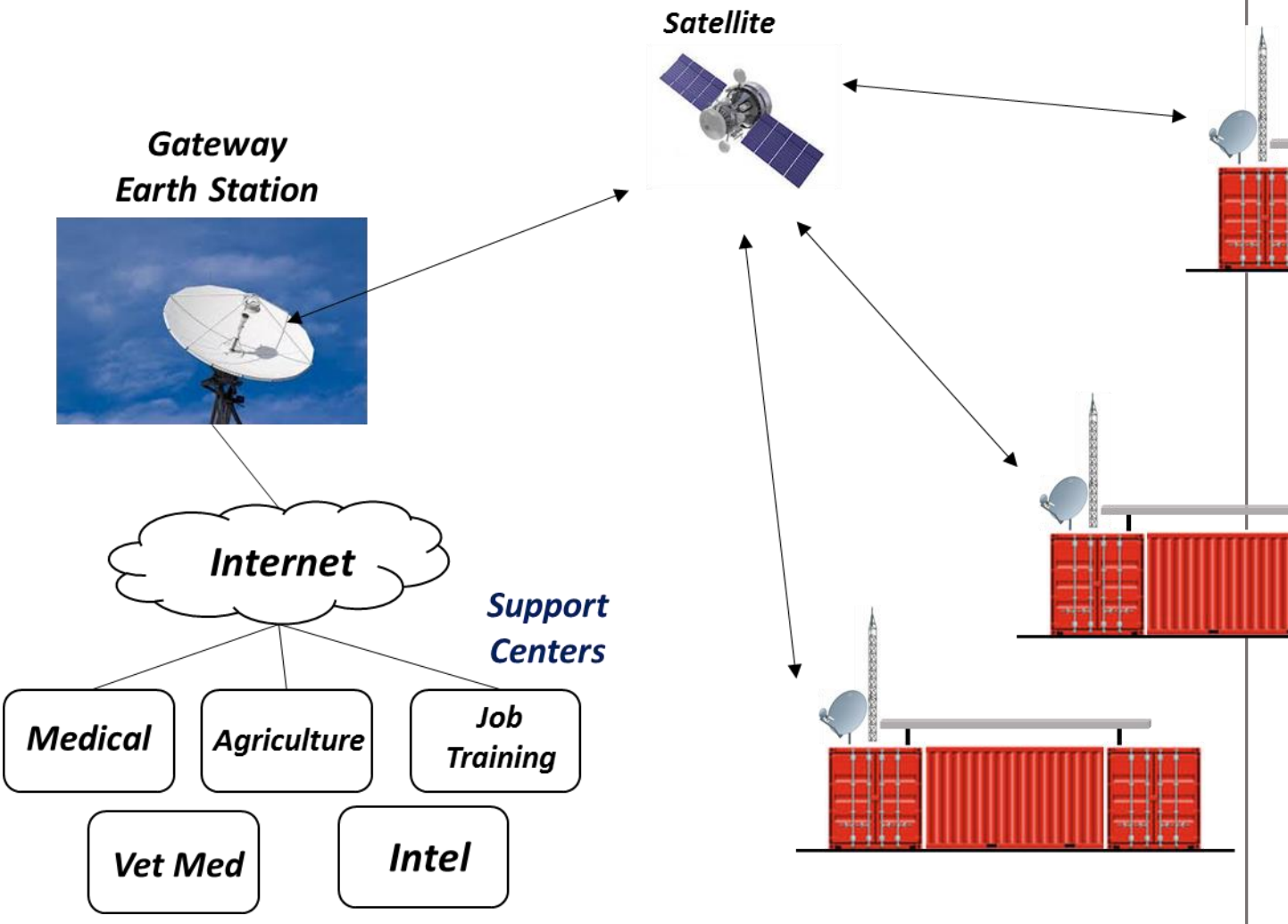


Figure 4, Instrumented eco village communications Connectivity

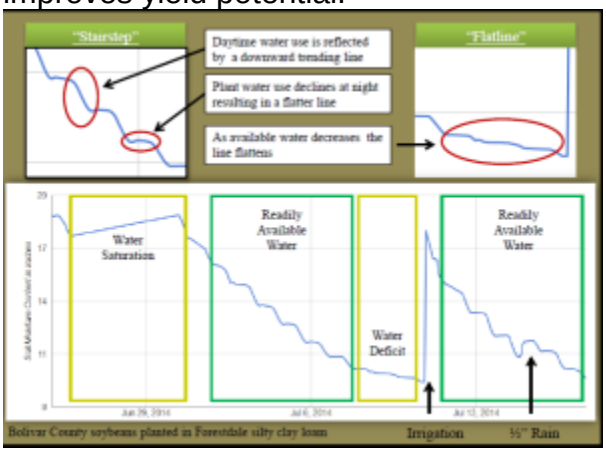
Horizontal Collaboration Environments for Secure Data Exchange and Management

A core foundation of a sustainable EcoVillage Enterprise that seeks to encourage and empower communities to continuously improve their agricultural, healthcare, construction, forestry, renewable energy, water, logistics, and supply, etc to build out an Aid To Trade enterprise is cloud Enabled collaboration services. These collaboration services with simple user interfaces enables the clusters of community groups around various community, workforce and economic development projects to build upon their community coops for various services and trade to collaborate when needed with external agriculture, energy, healthcare, transportation, EcoVillage design architects, engineers, and “Off Grid” green renewable innovations to assess effective community response to scenarios they are not able to analyze effectively and respond to. With this collaborative enterprise and connectivity, they can set up joint EcoVillage Innovation Centers with those in related cultural communities globally. A challenge many federal/NGO funded development programs that waste millions is the stovepiped nature of their work in communities which never enables the communities being served to set up their own EcoVillage Eco-System that fits their culturally based community operations and capacity building approaches they have found work for their cultural. this horizontal multipoint community coordination, cooperation, and collaboration team activities are what are required for community-based logistics and supply operations are also vital for the community to effectively use the agricultural, energy, water, healthcare, etc data that are now available to these communities through many affordable fixed and mobile sensor innovations like those available through Remotely Piloted Vehicles.
Another value of cloud-enabled mobile and collaboration services are the involvement of youth and young adults in Project Based and Community Service Learning Programs. Currently, the First Robotics and Lego League are global education competitions and schools that participate in these could be engaged in Precision Agriculture and EcoVillage construction competitions that involve the communities unique Cultural arts and communication styles.
From a global perspective, the Horizontal collaboration space allows authorized users to access sensor data such as health, weather and soil moisture data for use in Climate modeling and crop advisory roles. Thus, Universities, NGOs, and Governments around the world can help support the eco-village via the cloud. This means the world’s health organizations can see trends in the health issues from villages to regions. This could lead to an understanding of epidemics and controls of health issues prior to regional or pandemics. Weather data can be used by a climatologist, NGOs, and government agencies. Weather data is of great value to climatologist studying climate change, but it is also of great value to all agencies responding to a natural disaster as this data can be used to plan and drive the logistics to the areas affected by the disaster. Having real-time weather data to enhance responders understanding of the environment they will be facing to include video feeds from eco-villages would be of great benefit to the responding agencies. Soil sensor data and weather data can be used by Universities and agronomist adopting regions and having graduate students and professors reviewing and advising on when and how the crops should be managed from the application of fertilizers or pesticides to water management all stress points of the local village’s crops could be reviewed and assessed remotely. This would enable the global

community to know when and if aid will be needed and provide such aid early ahead of the “power curve” rather than after a failure has destabilized an area and or region.

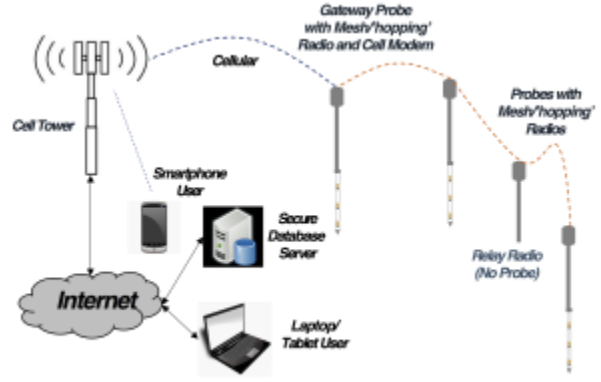
Wireless Crop/Soil Sensors

Crop production is the heart of villages around the world. Crop failures destroy villages and cost millions in aid each year to sustain and relive villages in attempts to prevent infiltration and recruitment of villagers and whole villages into terrorist groups and their networks. At the core of the Secure Chain eco-village concept is a fully-automated network for ‘around-the- clock’ monitoring of soil moisture, Temperature, and salinity levels. This network includes high-resolution probes with 6, 9 or 12 sensors evenly spaced to a depth of 2, 3 or 4 feet below ground level. Moisture readings from all sensors are automatically collected at user-configurable rates and stored in a secure database server with password-protected access. From the authorized user’s web browser, graphs can be viewed over the entire growing season for each probe and sensor clearly indicating crop water uptake and root development at all sensor depths, clearly indicating when irrigation is needed. This not only saves cost but significantly improves yield potential.



The key is knowing when water deficiency stress is acceptable, and when it’s not, so irrigation can be applied only when required. However, each field will likely vary by soil type, tillage, and drainage conditions. Reading and understanding ‘real-time’ soil moisture conditions at depths from 4” to 4 ft allows users to make efficient use of water. With the Soil Moisture Solution, you can make informed irrigation decisions that not only conserve water but help maximize yield potential.

Probes can be installed in multiple fields throughout a farming area covering several square miles. Connectivity options support both contiguous fields and remotely located or isolated fields miles away. Virtually any location can be supported. The wireless network connects these probes to the Internet using wireless links that 'hop' between probe sites until reaching the designated 'gateway' probe which can use a number of technologies to reach the Remote database including but not limited to a cellular modem, narrow band SCADA radios, TV White Space Radios, microwave radio links, SatCom or direct interface to wired infrastructures. This approach allows multiple probes to share the same connection, significantly lower communication costs.



High Yield Ag Solutions Wireless Soil Moisture Monitoring Network

The basic probe provided measures soil moisture and temperature at all sensor depths. Optionally, a more advanced probe can be provided that also measures salinity. The sensors are enclosed in a protective, 1-inch plastic pipe with fully encapsulated electronics. This rugged design provides many years of use. The probe is dropped into a hole made with a cordless drill and specially- tapered bit. This allows for a high-quality, undisturbed installation completed in just minutes. A single, small cable is routed underground to the mast which is installed within a few feet of the probe. The mast consists of multiple, 'stacked', 3 ft sections, typically rising 2 to 12 ft. above the ground. A communications module including a meshing radio or cellular modem (or

both) is dropped into the top of the mast. This module also includes the antennas and battery to power the site for the entire growing season.
Sentek Probes (2', 3' or 4')
Probes can be programmed to collect readings from all sensors every 0.5 to 6 hours and send them to the secure database. The user has access to all collected data at all times.
The typical system is provided with high-resolution, 3 ft., probes (9 moisture/temperature sensors) and the Wireless Agility Sensor Radio (ASR). The Irrometer probes can also be supported with ASR.
In the Secure Chain eco-village plan, these soil moisture sensors would be deployed in agricultural lands and nonagricultural lands allowing data on the soil conditions in both to be available to the user communities studying Climate and soil conditions. By providing soil moisture and salinity data on both agricultural lands and non-cultivated lands enables researchers to understand the effects of irrigation and fertilizers on the crops and may provide agricultural researchers with ideas of corps that could be co-planted to provide better moisture retention and nitrogen-fixing to the soil both of which could dramatically improve crop yields. Additionally, the sensor placement in nonagricultural lands could provide real insights to the water runoff and absorption in remote locations improving our understanding of climate change and drought development throughout the world.

Community Center/ Village Instrumentation

Weather Instrumentation

Deployment of weather stations as a part of the village instrumentation package provides much-needed data for many possible subscribers. High-resolution weather data including:

- Wind direction
- Wind speed/gusts
- Altimeter setting
- Temperature/Dew point
- Relative Humidity
- Density altitude
- Solar radiation
- Latitude & Longitude

The high-resolution weather data could serve multiple consumers to include: Regional governments, Climatologist worldwide, military planners, NGO's, Medical evacuation operators, Transportation industries, and military airlift operations in real-time.
This Weather data would be uploaded via the eco-village communications infrastructure to the cloud and directly into the horizontal collaboration space for use by all user communities. Imagine the impact of real live weather data from around the world on the study and monitoring of climate and the associated environment impacts.

Village and regional threat monitoring

To provide the maximum security to stability in the village, the stresses from external actors must be understood and accounted for in the ECO village ecosystem. To this end, the use of COTS information gather systems can be used based on the threat assessment for the region. In regions where there is a high probability of asymmetric warfare the use of Signals intelligence may be required while in low threat regions information gathering may be limited to agricultural and climate sensors.
In support of US Army customers, our team has a background in spectrum surveillance and monitoring. Our solution focuses on COTS systems, such as the CRFS RF Eye node, shown in **Figure 1**. These devices survey the RF spectrum from 30 MHz tor 6 GHz and are intended to be installed outdoors as shown in **Figure 2**. The units operate from -30°C to +55°C (-22°F to +131°F), and our team has used them extensively at White Sands Missile Range, in support of the Army's Network Integration Event (NIE) test events.

Figure 1 - Remote Spectrum Monitoring Node

Figure 2 - Outdoor Mounting Unit, Remote Spectrum Monitoring Unit

These units can be networked and managed from a centralized location (as shown in **Figure 3**). Specific areas of interest can be identified and tasking for each remote node is managed from the control location. Data from across the entire spectrum can be streamed from each device and viewed and/or recorded. Data can be analyzed in real time or from playback. Once a signal of interest is identified, the user can select from a library of detection and demodulation schemes to further analyze the information.
The unit is powered by Power over Ethernet (PoE) or by a dedicated DC power connection. Data from the remote nodes is carried over Ethernet – the actual transport can be cellular, copper (within 300 feet) or fiber optic cable. The units include a built-in (internal) quad-band 850/900/1800/1900 MHz (GSM/GPRS/UMTS/HSDPA) modem with external access for SIM card installation.

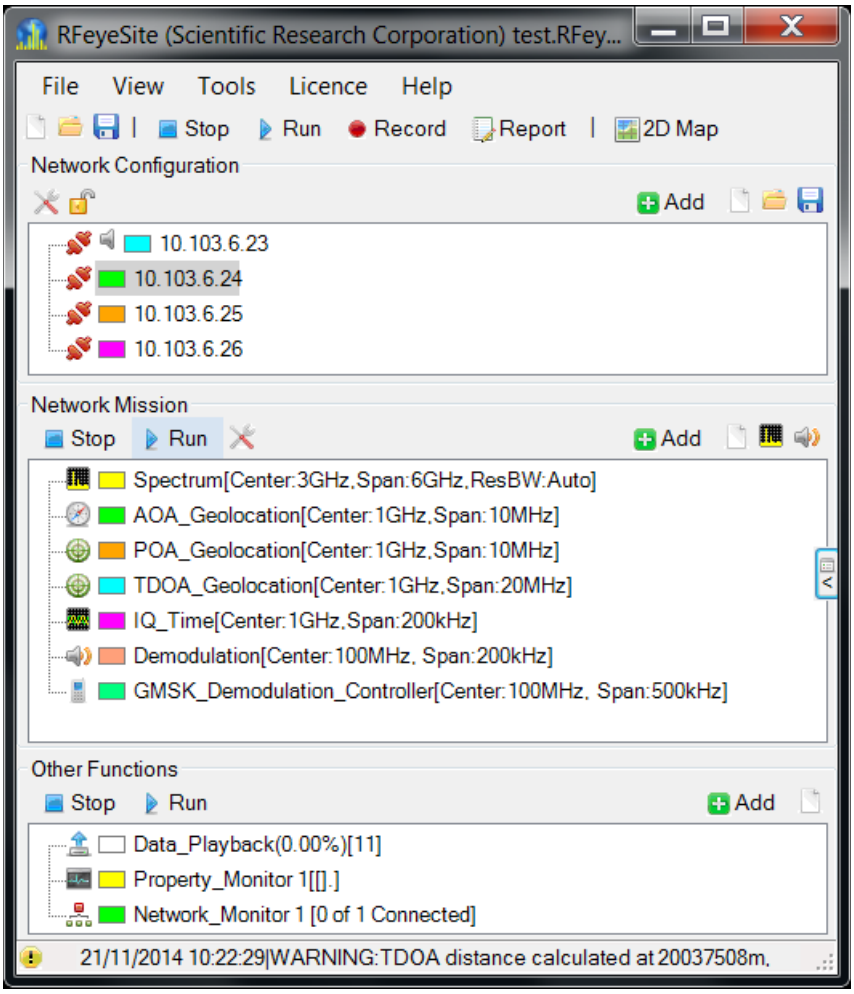


Figure 3 - Remote Spectrum Monitoring Node Network Management System

Optional Sensors

Area surveillance packages that could include:

1. Cellular nodes with intelligence gathering capabilities to include target phone tracking intercept and recording

2. High-Resolution Short-Range Ground Surveillance Radar with Slew to Cue camera control software

   SR-200 radar is a low-cost automated perimeter defense radar for encampments, installations, and critical infrastructure sites. The SR200 radar supports multiple autonomous sensor installations, where each sensor wirelessly communicates with the control center and has an independent solar power supply. The novel system eliminates the need for power and communication cabling infrastructure and offers the best quality system for significantly lower costs

SR-200 radar is a high resolution, state of the art, digital beam forming radar which autonomously monitors detects and alerts on moving or stationary objects in the defended perimeter. A PC located in a central control room controls the entire surveillance system. Due to its extremely low power consumption, SR-200 radar is powered solely by its integrated solar panel and backup battery. SR-200 radar is equipped with wireless communications, enabling quick and seamless installation without any power or communication cabling infrastructure. SR-200 radar can be combined with a day & night electro-optical sensor
enabling automatic targeting and identification of radar detections.

3. Day/night or thermal Cameras
   Depending on export restrictions for each site a suite of Day/Night and thermal cameras will be acquired from commercial sources and placed in ruggedized housings for deployment as needed. Bulletproof housings can be provided for most cameras to protect from up to 7.62x51 NATO or up to .50 Cal if required.
4. Unmanned Ground Sensors (UGS)
   A number of seismic sensors are now available for perimeter security for commercial enterprises and with the proliferation of these sensors the team will determine the best option for each site that requires UGS.
5. Other sensors as available or required
   Other sensor types from UAS to MASINT can be specified as required dependent on the threat environment.

Deployment Approach

To facilitate long-term stability, the deployment of the eco-villages must be approached in a logistically sustainable manner. The approach to deploying Instruments eco-villages differs from prior efforts in that a tiered approach is used. There are two types of instrumented eco-village the core village and the satellite villages. The Core village will be strategically sited to facilitate logistics support to the Satellite villages. This allows for the core villages to be used as the base of operations for medical teams working the region to have a base with high bandwidth communications to use for reach back referrals or for live telemedicine events. The Core village would also have living quarters for the medical teams to use as well as full pharmacy capabilities. The core villages would be

- Core village
  - Strategically sited For PEAK+ deployments and Communications
  - Larger health care/education facility permanent construction
    - Includes living facilities for staff
  - Microwave links to Satellite villages Includes tower
  - Optional garage for PEAK +trailers and prime movers
  - High bandwidth connection to Internet or satellite communications
  - E-learning capacities for Classrooms supporting
    - K-12 Education
    - Adult education
    - Health and sanitation
    - Agriculture

        - Vocational training
    - Large Scale Sanitation facilities
        - Water purification
        - Toilet/shower
    -
- Satellite villages
    - Smaller healthcare facilities with Telemedicine capabilities
    - E-learning capacities/ Classrooms
    - Sanitation facilities
        - Water purification
        - Toilet/shower

Conclusion and Path Forward

Throughout history, regional stability has started and ended at the village level. The purpose of the instrumented eco-village is to provide long-term stability at the village levels and to promote communications, education, and sustainability. All of which provides increased stability and understanding of the cultural viewpoints across the region and reduces targets of recruitment and leverage points for the insurgents or terrorist.

The instrumented Eco Village concept outlined above can be quickly realized. Our approach is for an alpha contract to allow the Team to form an Eco Village Center of Excellence and Integration in the US. This Eco Village Center will be a base for all forward deployed Eco Villages.

Once a contract is awarded, the Team will immediately begin site development and integration of core functions.

We plan to present the Eco Village concept to decision makers in Turkey and Kazakhstan in the next month.

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