Alpine Monitoring System Proposal

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The Alpine Monitoring System (AMS) is a collection of telemetered meteorological (MET) stations situated along the North-East aspect of Gravenstafel Ridge (South-South East of Syncline Mountain). This report is intended to provide project context and motivation, as well as an overview of the current and proposed state of the AMS. We define project completion as the state in which all three MET stations are collecting, and transmitting the data via the RF telemetry system to the parent node, where said data can be accessed from outside the Local Area Network.

Motivation

Environmental monitoring is essential in understanding the processes and metrics studied under the umbrella of Geography, Ecology and Environmental Sciences (GEES). Hydrologic processes and monitoring, snow pack analysis, vegetative metrics, and geomorphologic phenomena are but a few examples of the research areas ARTeMiS graduate and undergraduate students are involved in. Additionally, the ARTeMiS lab is heavily invested in environmental monitoring and remote sensing hardware; more specifically, with respect to multi-sensor integration for mobile and *in situ* data collection. Beyond laboratory testing, a field site is required for the testing of hardware with respect to environmental applications, as well as to support current and future graduate and undergraduate research, in the form of case studies, for example. We envisage the site as an educational tool whereby students gain hands-on experience with professional research grade environmental monitoring and remote sensing equipment. An ideal site would be ecologically and geologically diverse with a variety of geomorphological features, as well as logistically feasible in terms of site access, safety and distance from the University of Lethbridge. We see government and industry partnerships as a valuable extension of the research and development aspirations of the ARTeMiS laboratory. The symbiosis between parties eases logistical constraints as well as bridges the ever present gap between academia and the public and private sectors, and as such, the ideal site would be of significant interest to government and or industry.

Field Site Selection

West Castle Watershed, an ecologically rich region West-Southwest of Lethbridge Alberta, is home to the West Castle Field station owned and operated by the University of Lethbridge. The research station currently sleeps six[E1]* and provides hot water and electricity, with plans for expansion and upgrade currently in the process of negotiation. Only ninety minutes from the University of Lethbridge, situated 200 m from Castle River, and within a watershed of significant importance to the health of the Old Man River, the facility is an ideal base camp for the support of GEES research. Furthermore, West Castle Ski Resort is located approximately 3 km south of the field station, on the East facing aspect adjacent to the West Castle protected Wetland. In April 2014, Dr. Christopher Hopkinson (Principle Investigator) and Reed Parsons (laboratory technician) approached Castle Mountain Resort (WCR) with a proposition to install three meteorological towers on the Resort property as a first phase of the AMS project. Temperature, wind speed and wind direction data as wells as manual snow depth measurements, are used extensively byWCR management and the Ski Safety Patrol team in a variety of daily decision making processes, directed towards the safety of the Resort's patrons; for example, wind run, snow loading and snow pack stability. Recently, the resort installed meteorological sensors on top of several

lift towers, but have indicated the sparse acquisition does not provide a complete description of the meteorological processes over the Resort property. Management were quick to see the value additional data would have in the contribution to, not only their operations and safety protocols, but to the gaps in the Resort's annual climate record. The partnership agreement was such that the University would provide the tower and footing infrastructure, MET sensors, and human resources, while the Resort would provide mountain access and transit, footprint excavation as well as the provision of Wide Area Network (WAN) access. Tough Country Communications Ltd.(TCCL), based out of Pincher Creek, Alberta, are the internet service provider for the Resort. The company have recently expressed an interest in the AMS project, with respect to in-situ RGB imaging. The intellectual resources and remote sensing expertise within the ARTeMiS lab in conjunction with the communications industry expertise demonstrated by TCCL, provide a symbiotic framework on which a strong industry partnership could be formed. We have demonstrated West Castle Watershed to be the ideal field site, as it fulfils the logistical, research, as well as current and future industry partnership objectives.

Alpine Monitoring System

The alpine monitoring system (AMS) in its envisaged state of completion, is a network of in-situ meteorological stations, comprising of highly accurate environmental sensors, remotely accessible via a Campbell Scientific (CS) 900 MHz RF401 telemetry system. Each station *(Table I)* is defined as a node, collectively forming a Packbus mesh network *(Figure I)*; the network protocol proprietary to Campbell Scientific sensors and dataloggers. In addition to initiating a scheduled remote data collection sequence, a parent node, implemented using a windows based PC, executes several automated tasks. The parent formats and stores the collected data as comma delimitated ASCII files; aptly named with respect to the concatenation of the station name, as well as the time and date of the collection. The parent then pushes each text file to a server outside the Local Area Network (LAN) via the Secure File Transfer Protocol (SFTP). Server-side scripting provides an online resource representing current (relatively) and historic values for wind speed and direction, albedo, lapse rate, snow depth and the like, for the area of interest.

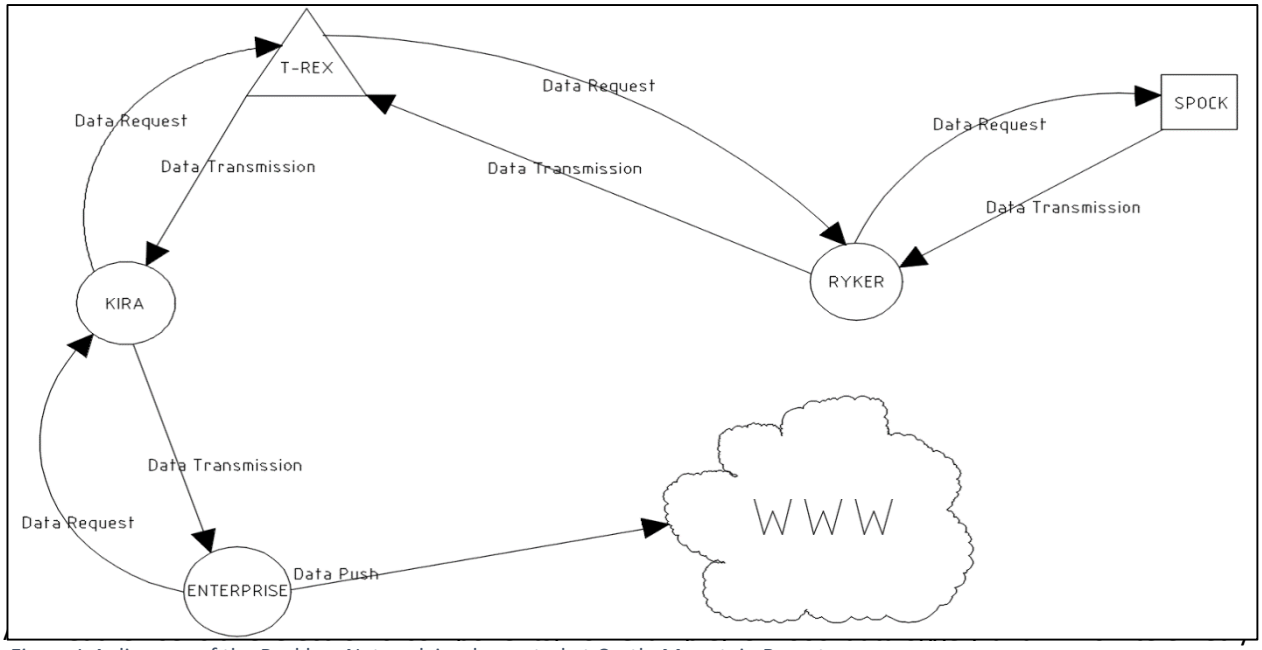

Figure I. A diagram of the Packbus Network implemented at Castle Mountain Resort

to each tower. In the

event that a remote connection cannot be established, each station stores its data locally via the CFM100; a compact flash CR1000 peripheral manufactured by CS. Using proprietary CS software (PC200W, Loggernet), individual station data can be downloaded locally by connecting to the external RS232 port located on the outside of each enclosure. Having the port externally accessible allows data to be collected without opening the enclosure door, exposing the sensitive components to potentially harmful conditions.

The sites for the individual node installations, were selected using the knowledge of the CMR maintenance staff in order to satisfy the following criteria: node infrastructure must not impose any risk to patron safety nor impede CMR trails or runs[E2]; sites shall be representative (within reason) of the elevation band on which it is located within the West Castle Watershed; sites requiring tower erection must be accessible by Utility Terrain Vehicle (UTV) in order to facilitate installation of the concrete foundation and footings required for structural support.

Node Description

Table I: West Castle AMS individual station overview

	Geogrphical Coordinates*	Aprox. Elevation*	Location Description	Sensors	Equipment	Special Functions
ENTERPRISE	49°19'6.95"N 114°24'51.67"W	1420 m	West Castle Resort Lodge	N/A	Toshiba Toughbook (loggernet) CR1000 RF401 Yagi Antenna	Parent node • Initiates MET station data collection routine • Receives, concatenates and formats data Network interface • Pushes formatted data to external web server
KIRA	49°18'59.29"N 114°24'39.67"W	1418 m	Valley	2 x CMP3 TR-525USW HMP45AC RM-young NRLite	CR1000 RF401 Omnidirectional Antenna PV Cell	Packbus Router • Routs data from RYKER, SPOCK (relayed via T-REX) and KIRA to ENTERPRISE
RYKER	49°19'3.20"N 114°25'47.90"W	1867 m	Mid-Mountain	2 x CMP3 TR-525USW HMP45AC RM-young SR50A NRLite	CR1000 RF401 Omnidirectional Antenna PV Cell	Packbus Node • Sends data to T-REX for routing
SPOCK	49°19'14.87"N 114°26'17.11"W	2135 m	Amature Radio Repeater Tower; North Peak	2 x CMP3 TR-525USW HMP45AC RM-young SR50A NRLite	CR1000 RF401 Yagi Antenna PV Cell	Packbus Leaf Node • Sends data to T-REX for routing
T-REX	49°18'56.38"N 114°25'54.52"W	1948 m	Top of 'T-Rex' tee-bar	N/A	Omnidirectional Antenna RF401	Repeater/Router node • Relays data from SPOCk and RYKER to KIRA

*Source: Google Earth

ENTERPRISE

ENTERPRISE is the root node, located within the Resort Lodge IT rack room, is designed to collect the data from the three remote met stations via RF401 telemetry. A PC running Loggernet receives data from the met stations by way of the RF401. The RF401 is connected to a yaggi antenna mounted to existing infrastructure on the lodge roof, directed toward KIRA. Following the standard Client-Server model, the PC initiates a data push via SFTP to a PC residing at the University of Lethbridge. Data is then be post-processed and selectively displayed on a the ARTeMiS web site through an automated scripting process.

T-REX

This node is not a MET station. Its purpose, is to route data from SPOCK and RYKER to KIRA, with the use of an RF401 in 'repeater mode'.

KIRA

Located within the valley, approximately 315 m from the CMR lodge, this node has twofold purpose; first to act as a MET station akin to RYKER and SPOCK, second relay data from T-REX to ENTERPRISE. The MET station sensors, enclosure, and telemetry equipment are mounted upon a 50 m radio communication tower, of which is owned and maintained by CMR the height of the tower provides a direct line of site to the yagi antenna connected to ENTERPRISE (described above).

SPOCK

This MET station was temporarily installed using the existing amateur radio infrastructure, of which, is not conducive to accurate meteorological data collection. The adjacent anthropogenic features, for example, obstruct, interfere with, or otherwise disturb the sensors. However, another location 500 m South has been selected, with installation tentatively scheduled for summer 2015.

Current Status

Unresolved issues with the Campbell Scientific Packbus telemetry system have yet to be resolved and thus communication between nodes is either non-existent or unreliable. However, KIRA, RYKER and SPOCK are collecting data and storing locally. Since the installation, TCCL have erected a tower adjacent to the existing amateur repeater tower. They have offered the use of their new tower for the AMS project, and although SPOCK will need to be relocated over the summer, the installation of RGB and/or thermal imaging systems on the new infrastructure is of considerable interest to both parties. It is important to note, that due to recent attacks on the CMR network, accessing the ENTERPRISE PC remotely is not currently permitted. CMR and TCCL will be providing a WAN connection independent of the Resort LAN, and dedicated to secured remote access to the AMS.

In order to begin moving the project into the completed state, communication between nodes must be well established; transmit and receive data through a complete data collection sequence without error. Furthermore, the link must remain well established over the varying weather and ground cover conditions representative of the AMS footprint. To meet these objectives, each link pair must first be established individually, starting with ENTERPRISE-KIRA through to SPOCK-RYKER. The current communication failure is thought to be caused by either improper antenna alignment or the link receive signal at the two nodes is not above the minimum noise floor. Thus, shortening the link through the installation of a repeater node may be necessary. Once a reliable communication network has been establish, the AMS can be monitored through the aforementioned dedicated WAN connection. The

peripheral tasks such as, server scripting, automation of the data processing workflows, as well as the webpage design and implementation can all be completed on Campus using the laboratory computer resources. We estimate troubleshooting and repair of the telemetry network will require four individuals including meals and lodging for two to five days, with an additional five days for the completion and troubleshooting of the peripheral tasks. Provided the necessary resources and funding are available to support such activities, a comprehensive workflow will be created to outline procedures and assign tasks. If this project is to move forward, additional funding shall be allocated to support annual and unexpected AMS maintenance.