http://www.isr.uc.pt/HRATC2014

**The Vallon VMP3**
The Vallon VMP3 in Figure 1, is a pulse induction, three-coil metal detector. The metal detector is composed by 3 parts, the antenna, which holds the 3 coils, the rod which allows the operator to hold the antenna, and the processing unit.

![Figure 1. The Vallon VMP3 metal detector.](image)

For the HRATC’14 the Vallon VMP3 was installed on a Clearpath Husky robot (Figure 2).

![Figure 2. The Vallon VMP3 installed on the Clearpath Husky.](image)
**Pulse Induction Metal Detectors**

This technology sends powerful, short pulses of current through a coil of wire. Each pulse generates a brief magnetic field. When the pulse ends, the magnetic field reverses polarity and collapses suddenly, resulting in a sharp electrical spike. This spike lasts a few microseconds and causes another current to run through the coil. This current is called the reflected pulse and is extremely short (lasting only a few microseconds). Another pulse is then sent and the process repeats. About a thousand pulses are sent every second.

If the metal detector is over a metal object, the pulse creates an opposite magnetic field in the object. When the pulse’s magnetic field collapses, causing the reflected pulse, the magnetic field of the object makes it take longer for the reflected pulse to completely disappear. In a pulse induction metal detector, the magnetic fields from target objects affect the reflected pulse, making it last longer than it would in the absence of a metal object. High speed electronics monitor the length of the reflected pulse. By comparing it to the expected length, the circuit can determine if another magnetic field has caused the reflected pulse to take longer to decay. If the decay of the reflected pulse takes more than a few microseconds longer than normal, there is likely a metal object present.

Pulse induction detectors do not excel at type of metal discrimination because the reflected pulse length of various metals are not easily separated. On the other hand they are useful in many situations in which other metal detector technologies would have difficulty, such as in areas that have highly mineralized soils. Furthermore pulse induction systems can detect metal objects at greater depths when compared to other metal detector technologies.

**Data Structure**

The Vallon VMP3 aggregates three coils. Each coil outputs 3 channels of raw data plus an alarm channel. Each of the 3 channels is evaluated separately (in an analog switched integrator circuit). Those are A/D converted and then filtered in the DSP, preprocessed and combined to the alarm channel. Each coil publishes at a rate of 10Hz, thus the total data flows at a rate of 30Hz.

**Operations**

This section contains some of the operations that Vallon suggests. Note that you can use whichever technique you see fit with the raw data coming from the sensor.

**Detection Alarm with Soil Compensation**

Soil compensation can be accomplished using the following formula:

\[ \text{detection\_alert} = \alpha \times \text{ch1\_data} + (1 - \alpha) \times \text{ch2\_data} \]

With \( \alpha \) chosen so that detection\_alert is zero for ch1\_zero and ch2\_zero, the response to soil without any metal samples.

**Signature**

Calculating the signature of a metal sample can be accomplished using the following formulas:

\[ \beta = \frac{\text{ch2\_data} - \text{ch2\_zero}}{\text{ch1\_data} - \text{ch1\_zero}} \]
\[ \text{signature} = \frac{\beta}{1 - \beta} \]

Different metals should have different signatures. This works well for simple targets but goes awfully wrong with complex shaped targets.

**ROS**

A ROS package called metal_detector_msgs was created to lodge the Coil message:

```
Header header
int32[] channel
int32[] zero
```

You’ll find further information regarding the metal detector and ROS on the hrac2014_entry_template examples:
FAQ

What is the behaviour of any given channel to a metal sample?
It depends on the type of metal: for some metals one channel may rise while the other falls, both channels.

What is the purpose of each channel?
Channel 1 and 2 are used for soil compensation while channel 3 (low sensitivity) can be used to get an alarm if channel 1 and 2 are overloaded.

What is the relation between channels?
The channels differently weigh the object's pulse decay waveform. There is no analytic relation - the relation depends on the object's decay waveform.

How does the speed of movement of the metal detector influence each channel's readings?
Channels 1, 2 and 3 are static (they work if the detector is standing still). The alarm channel is dynamic (and therefore the detector has to move). The upper speed of movement is limited by the bandwidth of the electronics (approximately 6 Hz).